

Universidade Federal de Juiz de Fora  
Pós-Graduação em Ecologia Aplicada ao Manejo e Conservação de Recursos Naturais

**Diego Raymundo Nascimento**

**ARTIFICIAL RESERVOIRS AFFECT TREE FUNCTIONAL COMPONENTS OF  
TROPICAL DRY FORESTS**

Juiz de Fora

2017

**Diego Raymundo Nascimento**

**ARTIFICIAL RESERVOIRS AFFECT TREE FUNCTIONAL COMPONENTS OF  
TROPICAL DRY FORESTS**

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

**Orientador: Prof. Dr. Fabrício Alvim Carvalho**

Juiz de Fora

2017

Ficha catalográfica elaborada através do programa de geração automática da Biblioteca Universitária da UFJF, com os dados fornecidos pelo(a) autor(a)

Raymundo Nascimento, Diego.

ARTIFICIAL RESERVOIRS AFFECT TREE FUNCTIONAL COMPONENTS OF TROPICAL DRY FORESTS : Effects of reservoirs on tropical dry forests / Diego Raymundo Nascimento. -- 2017.

34 f.

Orientador: Fabrício Alvim Carvalho

Coorientador: Jamir Afonso do Prado-Junior

Dissertação (mestrado acadêmico) - Universidade Federal de Juiz de Fora, Instituto de Ciências Biológicas. Programa de Pós Graduação em Ecologia, 2017.

1. Traços funcionais. 2. Diversidade funcional. 3. Disponibilidade de água. 4. Represamento. I. Alvim Carvalho, Fabrício , orient. II. Afonso do Prado-Junior, Jamir, coorient. III. Título.

**ARTIFICIAL RESERVOIRS AFFECT TREE FUNCTIONAL COMPONENTS OF  
TROPICAL DRY FORESTS**

**Diego Raymundo Nascimento**

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

---

**Prof. Dr. Fabrício Alvim Carvalho**

Universidade Federal de Juiz de Fora – UFJF (Orientador)

---

**Prof. Dra. Simone Jaqueline Cardoso**

Universidade Federal de Juiz de Fora – UFJF

---

**Profa. Dr. Marcelo Leandro Bueno**

Universidade Federal de Viçosa - UFV

## AGRADECIMENTOS

Primeiramente, agradeço ao Prof. Dr. Fabrício Alvim Carvalho pela oportunidade e confiança desde os primeiros períodos da graduação.

Ao Programa de Pós-Graduação em Ecologia Aplicada ao Manejo e Conservação de Recursos Naturais (PGECOL-UFJF) e à Universidade Federal de Uberlândia, pela infraestrutura, auxílio financeiro e apoio logístico.

Ao grande pesquisador, amigo e co-orientador Dr. Jamir Afonso do Prado Junior, por todos os ensinamentos, contribuições e horas de café no laboratório, fundamentais para a construção do manuscrito.

Ao professor Vagner Santiago do Vale (UEG) pela oportunidade de continuar a remedição nas áreas de estudo e pela imensa ajuda nos trabalhos de campo.

Aos pesquisadores e amigos do laboratório de Ecologia Vegetal da UFJF e UFU

Aos amigos do Laboratório de Ecologia Vegetal, Thiago, Lucas, por todos os ensinamentos e parcerias. Ao amigo Norberto, por todo apoio e animação desde a época da graduação, fundamental como motivação para seguir a ecologia vegetal.

Aos membros da banca pela disposição, solicitude e contribuições na dissertação.

Ao Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), por intermédio do PGCOL-UFJF, pela bolsa concedida.

Aos meus familiares, por todo o investimento que me proporcionou a entrada na Universidade e formação pessoal.

Aos meus amigos de Juiz de Fora e Uberlândia, pelo apoio, motivação e horas de diversão. À minha namorada Daniela, por todo apoio nos trabalhos de campo, pelo amor e compreensão em todos os momentos felizes e também nos momentos de ausência e stress.

“Ninguém caminha sem aprender a caminhar, sem aprender a fazer o caminho caminhando, refazendo e retocando o sonho por causa do qual se pôs a caminhar.”

(Paulo Freire, *Pedagogia da esperança*)

**Abstract:** Reservoir construction is one of the main ways humans alter ecosystems by damming rivers. Understanding how reservoir dams affect forests is essential once they are usually in the highest impact areas of the world. We aimed to evaluate to what extent an artificial reservoir affected changes in the structure, species diversity and components of functional diversity of a tropical dry forest after 10 years of the dam construction. In the patches of the tropical dry forest we present dynamic data of 120 permanent plots that were far ( $> 700$  m) from the watercourse before damming and are now on the edge of it (0 to 60 m). We evaluated how changes in community structure, taxonomy diversity and functional components were related with distance of the reservoir shorelines. Plots closer to the reservoir showed higher increase in functional diversity but do not showed significant relationships with taxonomy diversity. Plots closer to the reservoir also showed higher decrease in wood density (related to high water availability), higher decrease in specific leaf area, and increase in compoundness (possible due to increase in light incidence due to reservoir edge). Our results suggest that reservoirs can alter functionality of tropical dry forests over time and highlight the importance of more studies relating these changes with demographic process.

**Keywords:** Functional traits; species richness, water availability, functional diversity, damming

**Resumo:** A construção de barragens é uma das principais formas em que o ser humano altera os ecossistemas. Entender como reservatórios advindos da barragem afetam florestas tropicais secas é essencial, uma vez que essas florestas estão localizadas em áreas de alto impacto de barragens no mundo. Nosso objetivo foi avaliar até que ponto reservatórios podem afetar mudanças na estrutura, diversidade taxonômica e componentes da diversidade funcional de florestas secas após 10 anos da construção de uma barragem. Em fragmentos de florestas tropicais secas nós apresentamos dados de dinâmica temporal de 120 parcelas permanentes que estavam longe (>700 m) do curso de água antes do represamento, e agora estão na borda (0 to 60 m) do reservatório. Parcelas mais próximas ao reservatório apresentaram um maior aumento na diversidade funcional, mas não apresentaram relações significativas na diversidade taxonômica. Parcelas próximas ao reservatório também apresentaram uma maior diminuição em densidade de madeira (relacionado com alta disponibilidade de água) e uma maior diminuição em área foliar específica e maior aumento de indivíduos com folhas compostas (possivelmente relacionado à maior disponibilidade de luz, criada pela borda do reservatório). Nossos resultados sugerem que reservatórios podem alterar a funcionalidade de florestas tropicais secas ao longo do tempo e evidencia a importância de mais estudos que relacionem essas mudanças com processos demográficos.

**Palavras-chave:** Traços funcionais; riqueza de espécies; disponibilidade de água; diversidade funcional; represamento.



## SUMMARY

Introduction .....	9
Methods .....	10
<i>Study site</i> .....	10
<i>Experimental design and plots</i> .....	11
<i>Soil moisture and plots distance from the reservoir</i> .....	11
<i>Forest structural and taxonomic diversity</i> .....	11
Results .....	14
Discussion .....	18
Reservoirs increase functional diversity of dry forests, but do not influence taxonomic diversity or structural parameters.....	18
The reservoir reduces the importance of drought-adapted traits and increase importance of high-light traits .....	19
Concluding remarks .....	20
Appendix 1. ....	25
Appendix 2. ....	31

## **Introduction**

Artificial reservoirs provide water supply for important social services as hydroelectric power (FINER; JENKINS, 2012), agricultural irrigation systems, human consumption (FITZHUGH; RICHTER, 2004; LÓPEZ; VINCENT; RAP, 2015), navigability and recreation activities (GRAF, 1999). They are usually created by regulating the river flow building a dam, and an increasing number of water artificial reservoirs have being built around the world to attempt the needs of the growing human population (GRUMBINE; PANDIT, 2013; NILSSON et al., 2005). Nevertheless, reservoirs have been related to significant social and environmental impacts, as increasing greenhouse gas emissions (ALMEIDA et al., 2013; TRANVIK et al., 2009), mosquito-borne diseases and fragmentation (GREATHOUSE et al., 2006; NORRIS, 2004), reducing fish migration and reproduction (FINER; JENKINS, 2012), and impounding barriers for fauna foraging and seeds dispersion (NILSSON et al., 2005).

In plant communities, reservoirs increase deforestation by suppressing the vegetation in the flooding area (GRUMBINE; PANDIT, 2013) and to build new roads and access to the dam (LAURANCE; GOOSEM; LAURANCE, 2009). However, long-term indirect impacts may occur because the surrounding vegetation, once far from the watercourse before damming, becomes close to the water. This creates a new riparian zone, increasing soil water availability (VALE et al., 2013), altering species performance and, therefore, the natural successional in these plant communities over time (JANSSON et al., 2000; NILSSON; SVEDMARK, 2002).

Most community-level studies that indicate how artificial reservoirs affect plant communities were conducted in temperate regions with low diversity, based on grasses, herbs or shrubs performance (JANSSON et al., 2000; MALLIK; RICHARDSON, 2009; NILSSON; JANSSON; ZINKO, 1997). Yet, most dams are located in tropical regions, covered by high diverse forests (GUO et al., 2007). Thus, reservoir effects on tropical forests should be fundamentally different because tree species experience differences in environmental conditions (e.g. rainfall, temperature and soil types), and present different growing rates and life strategies compared to temperate plant communities.

Tropical dry forests are located in the most impacted areas by dams in the world because they usually occur in slope valleys with high drainage, ideal for hydroelectric dams (NILSSON et al., 2005). In dry forests, water availability is a major limiting resource due the strong seasonal variation in rainfall over the year, leading to lower values of tree density, basal area and species diversity compared to wet forests (LOHBECK et al., 2013). Besides, dry forest species possess a suit of morphological and physiological traits associated to

drought avoidance and/or resistance such as deciduousness, higher wood density and specific leaf area (PRADO-JUNIOR et al., 2016). Thus, increasing in soil water availability promoted by the reservoir in these forests may increase species growth and recruitment and allows the colonization of new species less adapted to drought stress, leading to higher tree density, basal area, species diversity and functional diversity.

The aim of this study was to evaluate to what extent an artificial reservoir affects changes in structure, species diversity and functional diversity attributes of dry forests after 10 years of the dam construction. We present dynamics data of 120 permanent plots that were far (> 700 m) from the watercourse before damming, and now are on the edge of the reservoir (0 to 60 m). Once plots closer to the reservoir have more soil water availability, we predict 1) higher increase in tree density, basal area, species diversity and functional diversity indices in plots closer to the reservoir; and 2) decreases in abundance of species with functional traits related to drought avoidance and/or resistance (i.e., lower specific leaf area, higher wood density, deciduous and with compound leaves) in closer plots.

## **Methods**

### *Study site*

This study was conducted in two patches of seasonal tropical dry forests (Figure 1, Minas Gerais state, Southeastern Brazil). These forests were affected by the construction of a hydroelectric plant reservoir (Amador Aguiar Dam Complex, Figure 1). The dam was built in Araguari river and reservoir flooding occurred in the end of 2006, covering an area of approximately 45,11 km<sup>2</sup>. Before the dam, forests patches were located at 700-1100 m from the riverside, and after reservoir flooding, they became closer (0-60 m) to the reservoir margin (Figure 1).

The region experiences a tropical savanna climate (Aw Megathermic climate of Köppen), characterized by rainy summers (October to March) and dry winters (April to September). Mean annual rainfall is 1524 mm, dry season length varies from 4 to 6 months (period with <100 mm rainfall) and mean annual temperature is 21 °C (Hijmans et al., 2005; <http://www.worldclim.org/bioclim>). Soil type in the studied areas is primarily rodric ferralsols, with 84% of sandy, pH around 5.7 and soil CEC around 5.6 cmol.Kg<sup>-1</sup> according to the Harmonized World Soil Database (HWSD version 1.2; FAO, 2012). The study areas are secondary forests with around 50 years of agricultural abandonment before the first sampling (KILCA et al., 2009). We did not find any sign of tree stumps or logging since our plots were established.

### *Experimental design and plots*

Before dam construction, a previously topographic study estimated the quota where water would reach after flooding, allowing us to establish our plots in a distance gradient from the reservoir shoreline. In the first census ( $t_0$ , 2005, before reservoir flooding), 60 permanent plots (20 x 10 m) were established in in each forest (1.2 ha), and they were 700-1100 m distant from the river (Figure 1). All trees with stem diameter at breast height (DBH, 1.30 m)  $\geq$  5 cm were tagged, their diameters were measured, height estimated and identified to species level. After reservoir flooding, our plots (originally in forests core areas) became “riparian”, distributed in a distance gradient from reservoir edge (0-60 m). In the second census, after ten years ( $t_{10}$ , 2015), all trees were re-measured and growing, dead and recruiting trees were evaluated.

### *Soil moisture and plots distance from the reservoir*

Changes in soil moisture before and after reservoir flooding and in different seasons (dry and rainy) has been previously reported for the study areas (VALE et al., 2013). These authors found that soil moisture in plots closer to the reservoir increased on average 101% in dry season and 35% in rainy season. Conversely, in plots far from the reservoir, soil moisture increased on average 5.5% and 2.4% in dry and rainy season, respectively. Because mean annual rainfall during the first soil sampling (1713 mm) was higher than in soil sampling after reservoir flooding (1369 mm), VALE et al. (2013) concluded that plots distance from the reservoir are negatively related with increases in plots soil moisture. Additional information on soil moisture measures can be found in VALE et al. (2013).

### *Forest structural and taxonomic diversity*

We described structural and species diversity attributes per plot at  $t_0$  and  $t_{10}$  as tree density (number of individuals.ha<sup>-1</sup>), basal area (m<sup>2</sup>.ha<sup>-1</sup>), rarefied species richness ( $S'$ , from a random sampling of 12 individuals, as this number of individuals was found in all plots) and Shannon species diversity index ( $H'$ , which incorporates species abundance). We used rarefied species richness rather than species richness to account for a possible confounding positive effect of number of individuals in species richness. All parameters were calculated in R 3.1.2 (R Development Core Team 2014), using the “vegan” package (Oksanen et al 2014). Addition information on structure and species diversity attributes per plot can be found in Appendix 1.

### *Functional traits*

We evaluated four functional traits that can be associated to drought avoidance and/or resistance and hence should indicate species response to changes in water availability (CHAVE, JEROME et al., 2009; VAN DER SANDE et al., 2016): a stem trait (wood density WD) and three leaf traits (specific leaf area SLA; deciduousness Dec, and compound leaves Comp). Plant traits were evaluated for most species (133 for Dec and Com; 129 for WD; and 75 for SLA out of 133 species) and these species covered together 85% (range 54-100%) of the individuals in each sampling plot. Traits were obtained from the global wood density database (WD, g.cm<sup>-3</sup>, ZANNE et al., 2009; available online), from previous studies in the areas (SLA and Dec, PRADO-JUNIOR et al., 2016), or classified according to species phyllotaxy (% Com).

Wood density is an indicator of plant carbon storage, demographic rates and hydraulic adaptations (PÉREZ-HARGUINDEGUY et al., 2013; SANTIAGO et al., 2004). We used wood density data of genus rather than species because it was available for most species rather than species wood density. Specific leaf area is the ratio between leaf area and its oven-dry mass and indicates leaf light interception efficiency and transpiration rates (BAKKER; CARREÑO-ROCABADO; POORTER, 2011). Deciduousness is an important trait related with drought tolerance and species growth length period, and was calculated as the percentage of deciduous species per plot (POORTER; MARKESTEIJN, 2008). Compound leaves are related to species heat balance (VAN DER SANDE et al., 2016) and desiccation avoidance by folding leaflets rather than the whole leaf, and was calculated as the percentage of deciduous species per plot (POORTER; MARKESTEIJN, 2008). Additional information on species functional traits can be found in Appendix 2.

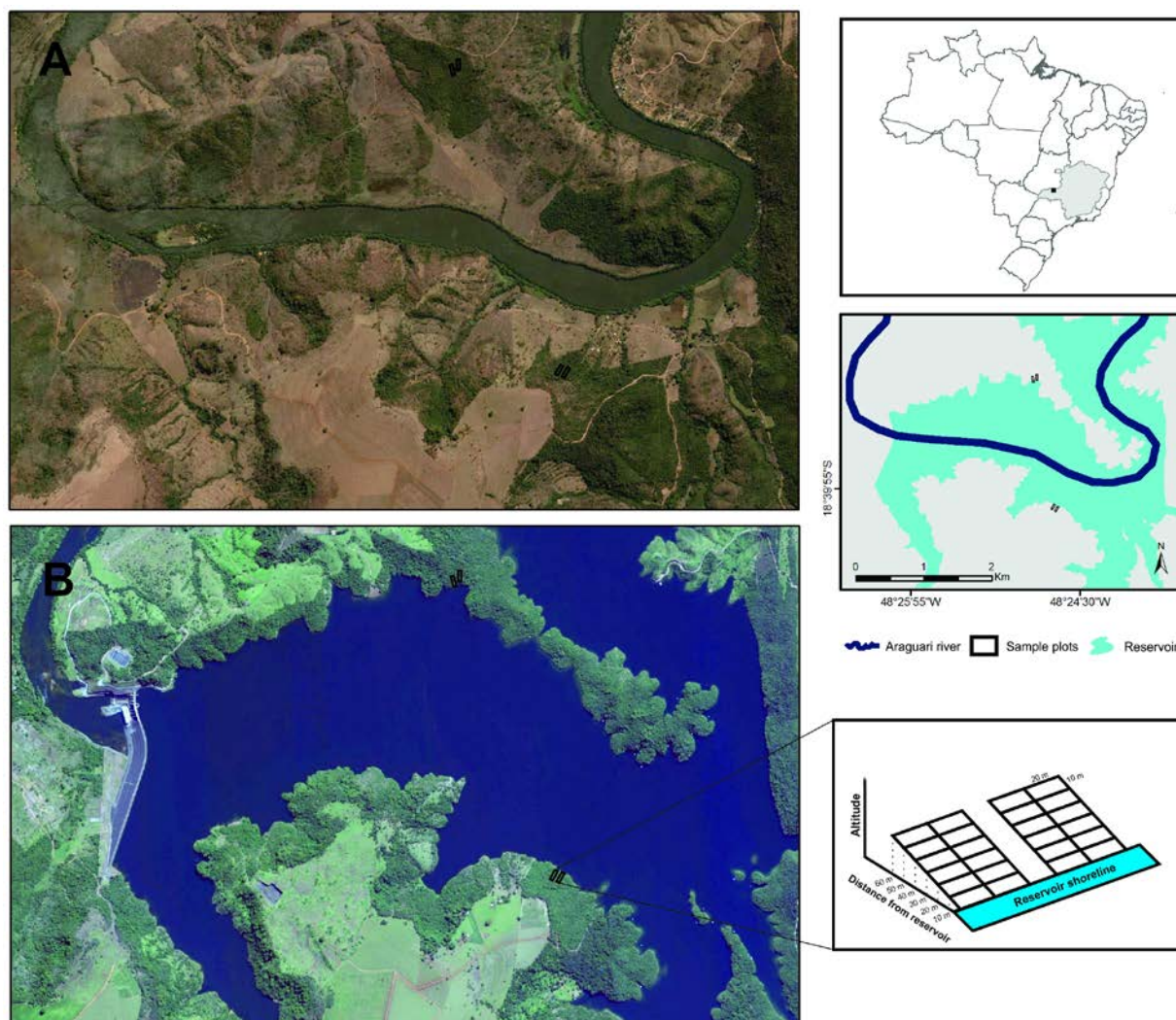
### *Community-weighted mean traits and functional diversity indices*

Community-weighted mean (CWM) trait values and functional diversity indices (FD) were calculated per plot at  $t_0$  and  $t_{10}$ , weighted by species abundance. We weighted by species abundance rather than by species basal area to give equal weight to recruiting and dying trees on changes in mean trait values (VAN DER SANDE et al., 2016). CWM was calculated for WD, SLA, Dec, and Comp. For functional diversity indices, we excluded Dec and Com because they are categorical traits. Two indices were used to measure functional diversity: functional richness ( $F_{Ric}$ ) as the volume of multivariate-trait space occupied by the community and identifies the extreme species functional traits values but not their relative abundance (VILLÉGER; MASON; MOUILLOT, 2008); and functional dispersion ( $F_{Dis}$ ) as an average

distance of individual species to their central group in response to trait space, taking into account species abundance (LALIBERTÉ, ETIENNE; LEGENDRE, 2010). Functional diversity attributes (CWM and FD indices) were calculated using the 'FD' package in R (LALIBERTÉ, E; SHIPLEY, 2011). Additional information on CWM and FD indices values per plot can be found in Appendix S1.

### *Data analyses*

To evaluate how communities structure, species diversity and components of functional diversity changed over time, relative changes ( $\Delta$ , in %) between plots attributes in  $T_0$  and  $T_{10}$  were calculated as:  $\Delta = (T_{10}-T_0)/T_0*100$ . We used relative changes rather than absolute changes to control the effects of differences in the initial attributes amongst plots. To evaluate the effect of reservoir on these changes, we performed bivariate relationships between plots distance from the reservoir and  $\Delta$  of plots attributes: tree density, basal area,  $S'$ ,  $H'$ , CWM trait values (WD, SLA, Dec, Comp),  $F_{Ric}$  and  $F_{Dis}$ . Bivariate relationships were performed using linear mixed models, including plots distance as fixed factor and areas as random effects. When necessary, data were  $\log_{10}$  or square root transformed prior to analysis, to meet the assumptions of normality, homoscedasticity, control for the effect of outliers and to account for possible nonlinear relationships between variables. Mixed-effects regressions were performed using R 3.1.2 (TEAM, 2013) using the "lme4" package (BATES; MAECHLER; BOLKER, 2012).

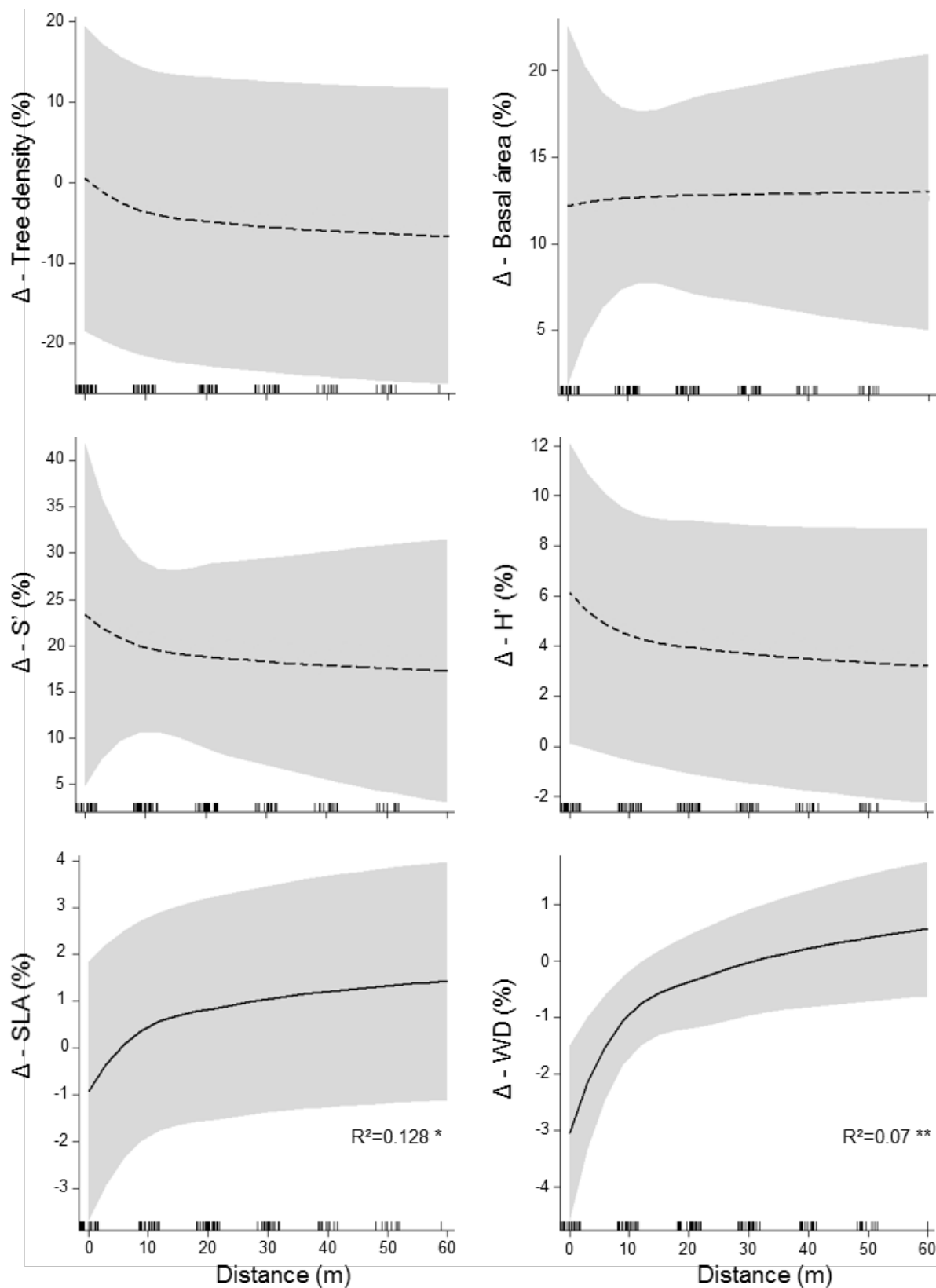


**Figure 1** – Sample plots before (A) and after (B) dam construction in Amador Aguiar Dam Complex, Minas Gerais state, Southeastern Brazil. 120 sample plots were located far from the river before damming and after damming these patches become closer to the reservoir (0-60m).

## Results

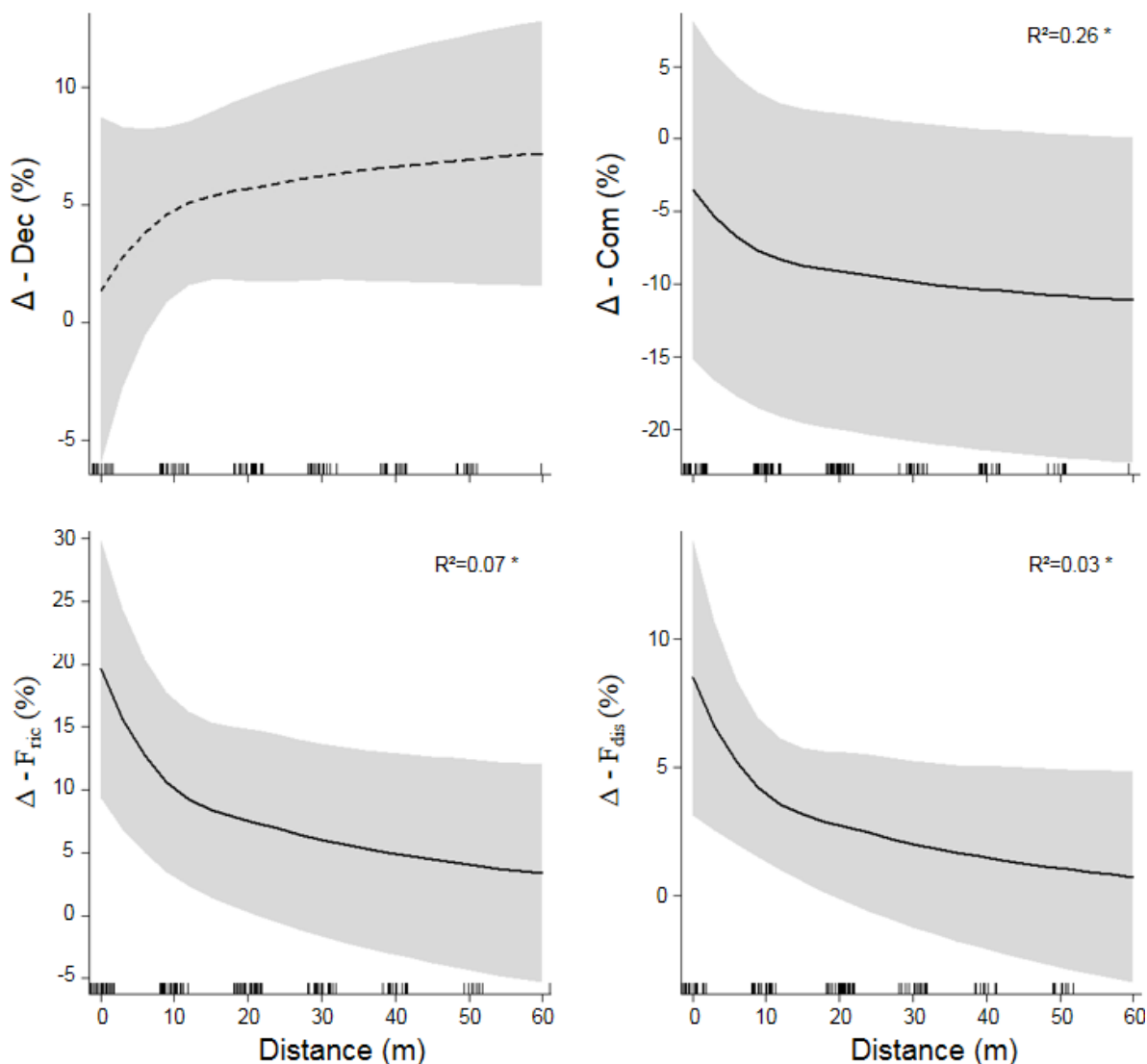
Bivariate relationships between plots distance of the reservoir and  $\Delta$  of functional diversity indices were significantly negative for functional richness (standardized regression coefficient  $\beta = -0.228$ ), and functional dispersion ( $\beta = -0.178$ ) (Fig. 2). No significant relationships were found between plots distance of the reservoir and structural (number of individuals and basal area) and taxonomy diversity parameters (rarefied species richness  $S'$  and Shannon diversity  $H'$ ) (Fig. 2). Bivariate relationships between plots distance of the reservoir and  $\Delta$  of CWM traits were significantly negative for compoundness ( $\beta = -0.181$ ) and positive for SLA ( $\beta =$

0.168) and wood density ( $\beta = 0.283$ ) (Fig. 2). No significant relationships were found between plots distance of the reservoir and  $\Delta$  of deciduousness.









**Figure. 2.** Bivariate relationships between plots distance of the reservoir and changes ( $\Delta$  in %) in community parameters: structural (tree density and basal area), taxonomic diversity (Shannon diversity  $H$ , and rarefied species richness –  $S'$ ), community-weighted mean (specific leaf area SLA, wood density WD, deciduousness Dec, and compoundness Com), and functional diversity (functional richness  $F_{ric}$ , and functional dispersion  $F_{dis}$ ) over a 10 year period. Areas were included as random effect to account for the nestedness of the plots within sites. Regression lines (continuous for significant relationships and broken for non-significant relationships) and coefficients ( $R^2$ ) of determination are given. \*\*  $P < 0.01$ ; \*  $P < 0.05$ .

## Discussion

We assessed how changes in structure, species diversity and functional diversity components of dry forests were affected by the construction of an artificial reservoir after 10 years of damming. We found that the distance from the reservoir influenced changes in functional diversity components (increase in  $F_{ric}$ ,  $F_{dis}$ , and compoundness and decrease in WD and SLA in plots closer to the reservoir), but did not influenced structure or taxonomy diversity.

### *Reservoirs increase functional diversity of dry forests, but do not influence taxonomic diversity or structural parameters*

We hypothesized that plots closer to the reservoir would show a higher increase in community functional and taxonomic diversity, basal area, and tree density due to more soil water availability than plots more distant to reservoir. We indeed found a higher increase in functional diversity indices ( $F_{ric}$  and  $F_{dis}$ ) in plots closer to the reservoir while plots distant showed a decrease tendency ( $\Delta < 0$ ). However, structural and taxonomic diversity did not showed significant relationships. Forests with high soil water availability are usually related with high turnover rates (PHILLIPS et al., 2010). It reflects in high growth and recruitment, but also in high mortality rates. A high water availability also can increase weathering and leach of soil nutrients and reducing productivity (SWAINE, 1996). Besides, in dry forests some large-diameter drought adapted trees, may not survive at high levels of water availability due to anoxic soil conditions (GLENZ et al., 2006; KOLB; JOLY, 2009). This factors can reduces net changes in basal area and tree density, and could explain non-significant results in structural parameters. Similarly, these factors can affects taxonomy diversity parameters because despite new species can take advantage of more water availability and establish in the system, others can do not survive in high-water conditions, also reflecting in non-significant net changes over time. Thus, further studies that evaluate demographic process (i.e. recruitment, growth and mortality) are needed to disentangle how reservoirs can affect structural and floristic parameters.

High functional richness ( $F_{ric}$ ) is related with a fully niche occupation (MASON et al., 2013). In dry forests, most species need to have adaptations to drought stress and it could limit species with different strategies of resource use (LOHBECK et al., 2013; LOHBECK et al., 2012). After damming, an increase in water availability mainly in plots closer to the reservoir, increased environmental heterogeneity, allowing the growth of species that do not tolerate drought stressful conditions and increasing the occupation of most part of the niche amplitude. A high functional dispersion ( $F_{dis}$ ) reflects in a high uniformity in distribution of tree abundance in the niche spectrum (LALIBERTÉ, ETIENNE; LEGENDRE, 2010). More water availability, besides increase the amplitude of the niche occupation, can allow a community with less traits dominance, suggesting that more individuals are using different resources. The results suggest that functional diversity is a good predictor of changes in dry forests affected by reservoirs, because changes in functional diversity was not a consequence of an increase in species diversity, but a consequence of new conditions caused by the input of a limiting resource in dry forests, that can change the way that species interact with environmental factors.

*The reservoir reduces the importance of drought-adapted traits and increase importance of high-light traits*

We predicted that the abundance of species with functional traits related to drought avoidance and/or resistance (lower specific leaf area, higher wood density, deciduous and compoundness) will have a higher decrease in plots closer to the reservoir. We partially found decreases in drought-adapted strategies. Wood density had a higher decrease in plots closer to reservoir, while increasing in plots distance lead to an increase tendency ( $\Delta > 0$ ). Wood density are related with adaptations to low water availability (CHAVE, JÉRÔME et al., 2006; POORTER; MARKESTEIJN, 2008). It provides a protection to drought-adapted species against process as xylem cavitation, considered the main cause of tree mortality in dry habitats (CAVENDER-BARES; KITAJIMA; BAZZAZ, 2004). Hence, dry forest species allocate more biomass in roots to increase water capture and show a low growth rates than wet forest species (POORTER; MARKESTEIJN, 2008). The high decrease in wood density in plots closer to the reservoir suggest that the need of dry forest species to invest in high wood density is buffered. The reservoir increase soil water availability and allow a better performance of species that need to invest in less structures to resist to drought conditions.

We do not found significant relationships between plots distance of the reservoir and deciduousness. Deciduous species can shed their leaves in dry season and have a taproot to

avoid desiccation (POORTER; MARKESTEIJN, 2008). Although, with an increase in water availability in the system, deciduous species also can change their phenology, decreasing the percentage of shedding leaves during the dry season and increase their performance in comparison to evergreen species (REICH; BORCHERT, 1984). It could maintain the relative importance of deciduous species and could explain non-significant results.

Surprisingly, SLA had a higher decrease and compound leaves had a higher increase in plots closer to reservoir, while increasing in plots distance lead to an increase tendency in SLA ( $\Delta > 0$ ) and a decrease tendency in compoundness ( $\Delta < 0$ ). Low SLA values reflects in thicker leaves associated with leaves longevity, drought resistance and excessive light exposure resistance such as investments in trichomes and secondary compounds (i.e. tannins, lignin and cuticular waxes) (PEARCY, 2007; PÉREZ-HARGUINDEGUY et al., 2013). Species with compound leaves can shed a low percentage of leaves during the dry season, once they can drop individual leaflets instead whole leaves. They can also reduce loss of water by transpiration, folding leaflets in most hot period of the day (POORTER; MARKESTEIJN, 2008). Besides compound leaves are related with heat losses, once the space between leaflets allow the passage of wind, cooling better the leaves than species with entire leaves (NIINEMETS, 1998).

The increasing of drought-adapted leaf traits even with increase in water availability could be explained by the light incidence in plots closer to the reservoir. Light intensity is the main driver of functional responses in tree communities (CARREÑO-ROCA BADO et al., 2012; FINEGAN; CAMACHO, 1999). Before to be in reservoir shorelines, plots were located in core areas of the forest continuum, with less light incidence due to shading of surrounding trees. With dam construction, a large quantity of vegetation was flooding and these plots become edge areas (with intense light incidence), increasing strategies to resist the new environmental conditions. Therefore, besides the effect of increase in water availability, the results suggests that light incidence could play an important role in dry forests affected by reservoirs, mainly related to leaf traits.

### **Concluding remarks**

Our study can be summarized in two main results. First, reservoirs increased functional diversity of dry forests, but did not influence taxonomy diversity. Secondly, reservoirs affected functional composition of tropical dry forests, decreasing the importance of drought-adapted traits (WD) and increasing the importance of traits adapted to high light exposure (lower SLA and higher Com), indicating that different factors (i.e. water availability

and light intensity) could drive changes in these areas. Our results highlight the importance of evaluating reservoirs impacts in tree communities and give basis to predict for changes in tree communities caused by reservoirs and to create better plans to reduce their effects in tree communities.

### References:

ALMEIDA, R. M. et al. Emissions from Amazonian dams. **Nature Climate Change**, v. 3, n. 12, p. 1005-1005, 2013.

BAKKER, M. A.; CARREÑO-ROCABADO, G.; POORTER, L. Leaf economics traits predict litter decomposition of tropical plants and differ among land use types. **Functional Ecology**, v. 25, n. 3, p. 473-483, 2011.

BATES, D.; MAECHLER, M.; BOLKER, B. lme4: Linear mixed-effects models using Eigen and syntax classes. R package version 0.999375-42; 2011. **Reference Source**, 2012.

CARREÑO-ROCABADO, G. et al. Effects of disturbance intensity on species and functional diversity in a tropical forest. **Journal of Ecology**, v. 100, n. 6, p. 1453-1463, 2012.

CAVENDER-BARES, J.; KITAJIMA, K.; BAZZAZ, F. Multiple trait associations in relation to habitat differentiation among 17 Floridian oak species. **Ecological Monographs**, v. 74, n. 4, p. 635-662, 2004.

CHAVE, J. et al. Towards a worldwide wood economics spectrum. **Ecology Letters**, v. 12, n. 4, p. 351-366, 2009.

CHAVE, J. et al. Regional and phylogenetic variation of wood density across 2456 neotropical tree species. **Ecological applications**, v. 16, n. 6, p. 2356-2367, 2006.

FINEGAN, B.; CAMACHO, M. Stand dynamics in a logged and silviculturally treated Costa Rican rain forest, 1988–1996. **Forest ecology and management**, v. 121, n. 3, p. 177-189, 1999.

FINER, M.; JENKINS, C. N. Proliferation of hydroelectric dams in the Andean Amazon and implications for Andes-Amazon connectivity. **Plos one**, v. 7, n. 4, p. e35126, 2012.

FITZHUGH, T. W.; RICHTER, B. D. Quenching urban thirst: growing cities and their impacts on freshwater ecosystems. **BioScience**, v. 54, n. 8, p. 741-754, 2004.

GLENZ, C. et al. Flooding tolerance of Central European tree and shrub species. **Forest Ecology and Management**, v. 235, n. 1, p. 1-13, 2006.

GRAF, W. L. Dam nation: A geographic census of American dams and their large-scale hydrologic impacts. **Water resources research**, v. 35, n. 4, p. 1305-1311, 1999.

GREATHOUSE, E. A. et al. Indirect upstream effects of dams: consequences of migratory consumer extirpation in Puerto Rico. **Ecological Applications**, v. 16, n. 1, p. 339-352, 2006.

GRUMBINE, R. E.; PANDIT, M. K. Threats from India's Himalaya dams. **Science**, v. 339, n. 6115, p. 36-37, 2013.

GUO, Z. et al. Hydroelectricity production and forest conservation in watersheds. **Ecological Applications**, v. 17, n. 6, p. 1557-1562, 2007.

JANSSON, R. et al. EFFECTS OF RIVER REGULATION ON RIVER-MARGIN VEGETATION: A COMPARISON OF EIGHT BOREAL RIVERS. **Ecological applications**, v. 10, n. 1, p. 203-224, 2000.

KILCA, R. V. et al. Edaphic and structural differences between two seasonal forests in the Cerrado biome. **Neotropical Biology and Conservation**, v. 4, n. 3, p. 150-163, 2009.

KOLB, R. M.; JOLY, C. A. Flooding tolerance of *Tabebuia cassinoides*: Metabolic, morphological and growth responses. **Flora-Morphology, Distribution, Functional Ecology of Plants**, v. 204, n. 7, p. 528-535, 2009.

LALIBERTÉ, E.; LEGENDRE, P. A distance-based framework for measuring functional diversity from multiple traits. **Ecology**, v. 91, n. 1, p. 299-305, 2010.

LALIBERTÉ, E.; SHIPLEY, B. FD: measuring functional diversity from multiple traits, and other tools for functional ecology. R package version 1.0-11. URL <http://CRAN.R-project.org/package=FD> [accessed 9 January 2012], 2011.

LAURANCE, W. F.; GOOSEM, M.; LAURANCE, S. G. Impacts of roads and linear clearings on tropical forests. **Trends in Ecology & Evolution**, v. 24, n. 12, p. 659-669, 2009.

LOHBECK, M. et al. Successional changes in functional composition contrast for dry and wet tropical forest. **Ecology**, v. 94, n. 6, p. 1211-1216, 2013.

LOHBECK, M. et al. Functional diversity changes during tropical forest succession. **Perspectives in Plant Ecology, Evolution and Systematics**, v. 14, n. 2, p. 89-96, 2012.

LÓPEZ, R. R.; VINCENT, L.; RAP, E. Re-engineering closing watersheds: The negotiated expansion of a dam-based irrigation system in Bolivia. **International Journal of Water Resources Development**, v. 31, n. 1, p. 50-63, 2015.

MALLIK, A. U.; RICHARDSON, J. S. Riparian vegetation change in upstream and downstream reaches of three temperate rivers dammed for hydroelectric generation in British Columbia, Canada. **Ecological Engineering**, v. 35, n. 5, p. 810-819, 2009.

MASON, N. W. et al. A guide for using functional diversity indices to reveal changes in assembly processes along ecological gradients. **Journal of Vegetation Science**, v. 24, n. 5, p. 794-806, 2013.

NIINEMETS, Ü. Are compound-leaved woody species inherently shade-intolerant? An analysis of species ecological requirements and foliar support costs. **Plant Ecology**, v. 134, n. 1, p. 1-11, 1998.

NILSSON, C.; JANSSON, R.; ZINKO, U. Long-term responses of river-margin vegetation to water-level regulation. **Science**, v. 276, n. 5313, p. 798-800, 1997.

NILSSON, C. et al. Fragmentation and flow regulation of the world's large river systems. **Science**, v. 308, n. 5720, p. 405-408, 2005.

NILSSON, C.; SVEDMARK, M. Basic principles and ecological consequences of changing water regimes: riparian plant communities. **Environmental Management**, v. 30, n. 4, p. 468-480, 2002.

NORRIS, D. E. Mosquito-borne diseases as a consequence of land use change. **EcoHealth**, v. 1, n. 1, p. 19-24, 2004.

PEARCY, R. W. Responses of plants to heterogeneous light environments. In: (Ed.). **Functional Plant Ecology, Second Edition**: CRC press, 2007.

PÉREZ-HARGUINDEGUY, N. et al. New handbook for standardised measurement of plant functional traits worldwide. **Australian Journal of botany**, v. 61, n. 3, p. 167-234, 2013.



PHILLIPS, O. L. et al. Drought–mortality relationships for tropical forests. **New Phytologist**, v. 187, n. 3, p. 631-646, 2010.

POORTER, L.; MARKESTEIJN, L. Seedling traits determine drought tolerance of tropical tree species. **Biotropica**, v. 40, n. 3, p. 321-331, 2008.

PRADO-JUNIOR, J. A. et al. Conservative species drive biomass productivity in tropical dry forests. **Journal of Ecology**, 2016.

REICH, P. B.; BORCHERT, R. Water stress and tree phenology in a tropical dry forest in the lowlands of Costa Rica. **The Journal of Ecology**, p. 61-74, 1984.

SANTIAGO, L. S. et al. Leaf photosynthetic traits scale with hydraulic conductivity and wood density in Panamanian forest canopy trees. **Oecologia**, v. 140, n. 4, p. 543-550, 2004/08/01 2004.

SWAINE, M. Rainfall and soil fertility as factors limiting forest species distributions in Ghana. **Journal of Ecology**, p. 419-428, 1996.

TEAM, R. D. C. R Development Core Team. **RA Lang Environ Stat Comput**, v. 55, p. 275-286, 2013.

TRANVIK, L. J. et al. Lakes and reservoirs as regulators of carbon cycling and climate. **Limnology and Oceanography**, v. 54, n. 6part2, p. 2298-2314, 2009.

VALE, V. S. D. et al. Fast changes in seasonal forest communities due to soil moisture increase after damming. **Revista de Biología Tropical**, v. 61, n. 4, p. 1901-1917, 2013.

VAN DER SANDE, M. T. et al. Old-growth Neotropical forests are shifting in species and trait composition. **Ecological Monographs**, v. 86, n. 2, p. 228-243, 2016.

VILLÉGER, S.; MASON, N. W.; MOUILLOT, D. New multidimensional functional diversity indices for a multifaceted framework in functional ecology. **Ecology**, v. 89, n. 8, p. 2290-2301, 2008.

ZANNE, A. E. et al. Global wood density database. 2009.

### Appendix 1.

Plots distance of the reservoir (m), tree density (TD), basal area (BA, m<sup>2</sup>), Shannon index (H'), rarefied species richness (S'), specific leaf area (SLA, cm<sup>2</sup>/g), wood density (WD, g/cm<sup>3</sup>), deciduosness (%), compoundness (%), functional richness (F<sub>ric</sub>) and functional dispersion (F<sub>dis</sub>) per plot (P) in both sampling (T<sub>0</sub> and T<sub>10</sub>) of two patches of seasonal dry forest studied.

Area	Pl	Dist	TD		BA		H'		S'		SLA		WD		Dec		Com		F <sub>ric</sub>		F <sub>dis</sub>	
			T <sub>0</sub>	T <sub>10</sub>	T <sub>0</sub>	T <sub>10</sub>	T <sub>0</sub>	T <sub>10</sub>	T <sub>0</sub>	T <sub>10</sub>	T <sub>0</sub>	T <sub>10</sub>	T <sub>0</sub>	T <sub>10</sub>	T <sub>0</sub>	T <sub>10</sub>	T <sub>0</sub>	T <sub>10</sub>	T <sub>0</sub>	T <sub>10</sub>	T <sub>0</sub>	T <sub>10</sub>
1	1	0	31	35	0.20	0.34	1.60	2.08	24.0	27.0	13.2	13.2	0.667	0.614	0.39	0.35	0.61	0.68	0.16	0.25	0.13	0.12
1	2	10	33	33	0.30	0.43	1.70	1.76	9.5	11.0	13.2	13.1	0.656	0.660	0.39	0.42	0.48	0.45	0.18	0.18	0.12	0.12
1	3	20	30	33	0.23	0.36	2.02	1.90	16.0	15.0	13.8	13.6	0.717	0.698	0.60	0.61	0.63	0.58	0.44	0.38	0.16	0.15
1	4	30	39	36	0.36	0.43	1.87	1.96	15.0	18.5	14.1	13.5	0.700	0.684	0.51	0.39	0.62	0.53	0.20	0.21	0.15	0.14
1	5	40	29	17	0.28	0.26	1.24	1.56	6.0	6.5	14.7	13.3	0.671	0.669	0.59	0.41	0.83	0.59	0.28	0.28	0.13	0.13
1	6	50	31	26	0.32	0.45	1.58	1.58	11.0	11.0	14.0	13.4	0.604	0.605	0.35	0.35	0.81	0.77	0.40	0.40	0.10	0.11
1	7	0	39	42	0.31	0.42	1.74	1.95	21.5	17.0	12.9	12.0	0.760	0.739	0.67	0.62	0.49	0.47	0.42	0.46	0.18	0.20
1	8	10	29	27	0.23	0.30	1.94	1.79	21.5	9.8	13.8	14.6	0.674	0.647	0.52	0.46	0.76	0.75	0.33	0.25	0.14	0.13
1	9	20	43	39	0.31	0.42	2.13	2.11	19.5	33.0	14.0	13.9	0.697	0.689	0.67	0.67	0.49	0.41	0.46	0.44	0.14	0.13
1	10	30	27	28	0.29	0.35	2.05	1.84	20.0	12.0	13.6	13.4	0.725	0.705	0.67	0.50	0.48	0.36	0.17	0.19	0.16	0.15
1	11	40	27	21	0.20	0.24	1.50	2.15	6.5	11.5	13.5	14.2	0.742	0.737	0.67	0.67	0.56	0.48	0.19	0.26	0.17	0.16
1	12	50	18	17	0.22	0.34	1.99	2.15	38.0	15.0	14.0	14.6	0.704	0.665	0.56	0.47	0.56	0.47	0.42	0.53	0.19	0.16
1	13	0	36	36	0.25	0.34	1.65	1.94	15.0	13.7	13.3	12.9	0.632	0.600	0.33	0.31	0.69	0.69	0.53	0.63	0.15	0.16
1	14	10	39	35	0.24	0.32	1.65	1.83	9.8	11.5	13.8	14.2	0.601	0.623	0.28	0.31	0.64	0.47	0.27	0.32	0.10	0.12
1	15	20	30	22	0.24	0.22	1.62	1.57	10.0	13.0	13.7	13.4	0.685	0.631	0.50	0.32	0.60	0.45	0.35	0.35	0.15	0.11

1	16	30	20	26	0.22	0.33	1.59	2.00	8.0	9.0	13.9	14.8	0.646	0.659	0.35	0.42	0.65	0.54	0.27	0.34	0.14	0.17
1	17	40	18	18	0.34	0.42	1.38	1.59	6.3	6.5	13.1	13.7	0.635	0.648	0.28	0.39	0.61	0.56	0.20	0.15	0.14	0.15
1	18	50	20	19	0.22	0.20	0.98	0.69	4.0	2.0	13.7	13.0	0.583	0.559	0.15	0.00	0.75	0.47	0.14	NA	0.06	0.03
1	19	0	30	21	0.41	0.43	1.74	1.62	9.0	7.0	11.5	10.0	0.692	0.768	0.37	0.68	0.37	0.27	0.42	0.38	0.18	0.22
1	20	10	40	33	0.31	0.38	1.81	1.96	10.0	10.5	12.7	12.7	0.728	0.726	0.48	0.48	0.50	0.36	0.31	0.33	0.19	0.19
1	21	20	37	29	0.28	0.31	2.00	2.27	11.5	14.5	13.2	13.4	0.784	0.750	0.65	0.59	0.38	0.34	0.47	0.46	0.17	0.16
1	22	30	28	24	0.35	0.41	1.71	2.04	20.5	57.0	14.2	14.5	0.700	0.728	0.43	0.63	0.68	0.58	0.37	0.36	0.18	0.19
1	23	40	27	26	0.32	0.40	1.87	1.90	31.0	31.0	13.3	13.6	0.682	0.708	0.41	0.50	0.48	0.31	0.30	0.24	0.14	0.15
1	24	50	28	19	0.34	0.33	1.87	1.77	8.3	7.3	14.4	14.7	0.682	0.645	0.57	0.47	0.57	0.63	0.33	0.33	0.15	0.14
1	25	0	24	29	0.40	0.51	1.96	2.33	17.5	26.0	13.4	12.5	0.775	0.712	0.75	0.77	0.54	0.40	0.33	0.42	0.19	0.16
1	26	10	25	14	0.27	0.12	1.64	2.14	8.5	24.0	14.4	13.8	0.737	0.716	0.72	0.71	0.68	0.64	0.27	0.26	0.16	0.15
1	27	20	16	11	0.18	0.19	1.34	1.85	5.5	9.0	14.0	14.5	0.817	0.694	1.00	0.73	0.56	0.64	0.12	0.27	0.20	0.10
1	28	30	16	10	0.47	0.10	2.08	1.83	10.2	12.0	14.4	14.4	0.745	0.738	0.75	0.70	0.50	0.40	0.37	0.28	0.22	0.23
1	29	40	16	21	0.13	0.22	1.39	1.46	6.0	10.0	10.3	9.8	0.699	0.738	0.69	0.81	0.56	0.38	0.15	0.24	0.20	0.21
1	30	50	19	14	0.46	0.57	1.99	1.73	10.5	10.0	13.3	12.5	0.696	0.751	0.63	0.79	0.68	0.57	0.30	0.26	0.18	0.23
1	31	0	37	28	0.25	0.27	2.10	2.43	17.0	18.2	15.1	15.1	0.751	0.749	0.73	0.81	0.59	0.42	0.45	0.47	0.18	0.19
1	32	10	33	31	0.42	0.61	2.04	2.58	16.0	30.8	14.6	13.9	0.686	0.700	0.67	0.69	0.64	0.53	0.41	0.46	0.16	0.17
1	33	20	14	10	0.37	0.13	2.14	2.16	24.0	23.0	15.1	15.9	0.770	0.685	0.79	0.80	0.50	0.60	0.20	0.27	0.18	0.14
1	34	30	22	22	0.35	0.50	2.21	2.48	18.5	36.5	13.1	13.9	0.711	0.707	0.77	0.78	0.50	0.43	0.33	0.40	0.17	0.17
1	35	40	28	22	0.26	0.31	2.27	2.26	14.0	17.3	13.3	10.9	0.666	0.704	0.71	0.82	0.57	0.32	0.32	0.32	0.14	0.17
1	36	50	18	17	0.27	0.29	1.78	2.34	30.0	24.0	13.8	15.3	0.619	0.656	0.39	0.58	0.61	0.58	0.42	0.47	0.10	0.12
1	37	0	35	33	0.24	0.28	2.11	2.30	27.0	23.3	12.8	13.6	0.789	0.741	0.77	0.76	0.43	0.45	0.34	0.34	0.17	0.16
1	38	10	42	30	0.31	0.34	2.11	2.16	16.8	22.3	14.9	15.1	0.697	0.691	0.69	0.72	0.50	0.34	0.41	0.36	0.11	0.11

1	39	20	23	18	0.30	0.36	2.04	2.21	14.0	16.3	13.6	13.4	0.622	0.604	0.43	0.53	0.39	0.32	0.32	0.49	0.10	0.13
1	40	0	29	28	0.42	0.22	2.41	2.43	13.9	18.2	14.4	14.7	0.687	0.586	0.62	0.46	0.62	0.64	0.34	0.43	0.12	0.15
1	41	10	26	20	0.29	0.28	2.01	2.16	21.3	18.0	13.7	13.9	0.628	0.648	0.38	0.48	0.77	0.67	0.32	0.29	0.12	0.12
1	42	20	22	14	0.20	0.15	2.35	2.44	25.0	27.0	15.0	16.3	0.696	0.716	0.73	0.73	0.64	0.67	0.24	0.33	0.14	0.16
1	43	30	17	19	0.25	0.33	2.23	2.48	11.0	18.6	13.8	13.2	0.719	0.747	0.71	0.84	0.53	0.47	0.24	0.26	0.16	0.18
1	44	40	30	20	0.28	0.24	2.05	2.36	14.3	35.5	14.6	15.3	0.645	0.701	0.47	0.65	0.67	0.60	0.26	0.30	0.15	0.16
1	45	50	18	17	0.21	0.12	2.03	2.04	10.5	14.0	14.8	14.8	0.679	0.620	0.72	0.59	0.67	0.35	0.28	0.24	0.14	0.15
1	46	0	28	31	0.49	0.41	2.38	2.13	16.8	14.3	13.8	12.3	0.716	0.642	0.71	0.61	0.50	0.52	0.42	0.38	0.14	0.19
1	47	10	18	12	0.15	0.15	2.25	2.10	18.0	19.5	13.0	12.5	0.657	0.669	0.67	0.58	0.67	0.50	0.41	0.37	0.12	0.14
1	48	20	21	23	0.43	0.53	2.38	2.49	25.0	28.8	16.0	16.0	0.641	0.626	0.57	0.42	0.48	0.42	0.33	0.35	0.12	0.14
1	49	30	24	23	0.55	0.78	2.55	2.63	21.0	38.0	14.4	15.1	0.719	0.731	0.75	0.75	0.63	0.58	0.54	0.56	0.17	0.17
1	50	40	22	8	0.22	0.10	1.96	1.73	11.0	8.0	13.6	14.3	0.662	0.709	0.59	0.50	0.68	0.75	0.33	0.26	0.13	0.14
1	51	50	25	13	0.36	0.27	1.83	1.67	8.3	6.3	12.0	11.3	0.638	0.651	0.52	0.46	0.48	0.31	0.39	0.38	0.16	0.19
1	52	0	22	17	0.25	0.26	2.21	1.95	28.0	24.0	14.7	14.0	0.684	0.635	0.50	0.45	0.59	0.65	0.52	0.47	0.15	0.13
1	53	10	15	22	0.38	0.53	1.93	2.39	10.0	20.0	14.7	14.4	0.677	0.716	0.53	0.68	0.53	0.45	0.38	0.49	0.18	0.20
1	54	20	20	14	0.28	0.34	1.87	1.91	17.0	13.0	13.2	12.3	0.614	0.725	0.40	0.64	0.65	0.36	0.34	0.32	0.13	0.19
1	55	0	40	40	0.38	0.38	2.18	2.59	18.0	36.3	13.3	12.9	0.674	0.656	0.50	0.50	0.43	0.40	0.51	0.67	0.15	0.18
1	56	10	38	27	0.35	0.34	2.19	1.86	20.6	11.2	15.8	15.1	0.649	0.630	0.47	0.44	0.71	0.67	0.27	0.19	0.12	0.10
1	57	20	26	20	0.29	0.26	1.55	1.37	8.5	7.5	12.9	12.8	0.665	0.631	0.23	0.29	0.42	0.24	0.27	0.19	0.12	0.08
1	58	0	45	39	0.34	0.33	2.46	2.69	22.6	27.9	14.5	14.4	0.676	0.702	0.49	0.60	0.58	0.45	0.37	0.39	0.12	0.14
1	59	10	20	16	0.26	0.21	2.55	2.60	21.2	36.0	14.4	14.1	0.713	0.708	0.65	0.69	0.60	0.38	0.47	0.39	0.13	0.13
1	60	20	21	16	0.14	0.17	2.20	2.31	19.0	16.3	12.9	13.3	0.700	0.741	0.57	0.69	0.48	0.44	0.42	0.34	0.15	0.15
2	1	0	29	33	0.76	0.60	2.68	2.96	26.0	43.0	13.0	13.5	0.679	0.708	0.59	0.47	0.86	0.79	0.48	0.55	0.17	0.18

2	2	10	27	32	0.28	0.41	2.97	3.09	45.0	54.6	12.7	13.1	0.723	0.723	0.52	0.50	0.67	0.69	0.41	0.43	0.14	0.14
2	3	0	26	29	0.58	0.58	2.61	2.48	25.0	17.0	12.4	12.5	0.747	0.698	0.31	0.21	0.77	0.86	0.41	0.46	0.14	0.16
2	4	10	22	29	0.37	0.41	2.54	2.53	61.5	22.0	12.4	13.7	0.743	0.718	0.36	0.43	0.86	0.90	0.43	0.41	0.13	0.15
2	5	20	25	25	0.76	0.87	2.73	2.73	87.0	40.8	12.2	12.6	0.769	0.745	0.24	0.24	0.60	0.64	0.35	0.52	0.14	0.15
2	6	0	21	23	0.37	0.28	2.20	2.43	30.0	18.3	12.0	12.6	0.742	0.701	0.33	0.35	0.90	0.74	0.29	0.43	0.09	0.13
2	7	10	28	30	0.83	0.92	2.25	2.48	14.0	22.0	12.2	13.2	0.753	0.741	0.39	0.40	0.93	0.93	0.29	0.33	0.12	0.12
2	8	20	24	29	0.51	0.70	2.22	2.35	35.5	21.0	12.3	12.5	0.771	0.762	0.17	0.24	0.83	0.83	0.33	0.34	0.11	0.12
2	9	30	19	25	0.44	0.48	2.33	2.35	21.3	14.5	13.1	13.0	0.657	0.665	0.26	0.31	0.58	0.54	0.39	0.42	0.16	0.17
2	10	0	26	33	0.46	0.63	2.79	3.06	31.2	33.1	12.5	13.2	0.729	0.714	0.42	0.47	0.69	0.65	0.44	0.48	0.13	0.14
2	11	10	26	22	0.58	0.72	2.76	2.75	37.5	36.5	12.4	13.2	0.765	0.761	0.50	0.57	0.77	0.65	0.34	0.37	0.14	0.16
2	12	0	24	15	0.46	0.12	2.53	2.40	26.3	34.5	13.0	11.8	0.724	0.689	0.33	0.33	0.88	0.67	0.36	0.51	0.11	0.15
2	13	10	40	20	0.69	0.42	2.91	2.39	37.6	15.0	12.7	12.2	0.720	0.730	0.50	0.52	0.70	0.71	0.50	0.40	0.13	0.14
2	14	20	24	23	0.62	0.51	2.33	2.22	17.0	13.5	12.5	11.7	0.739	0.737	0.58	0.70	0.83	0.91	0.21	0.23	0.14	0.12
2	15	30	32	30	0.31	0.36	2.73	2.75	38.5	49.3	12.0	11.8	0.693	0.687	0.34	0.37	0.75	0.73	0.42	0.43	0.12	0.12
2	16	40	42	40	0.71	0.68	2.26	2.32	21.6	21.6	12.2	12.6	0.718	0.710	0.14	0.12	0.81	0.80	0.44	0.44	0.12	0.13
2	17	0	23	19	0.51	0.64	2.34	2.16	31.0	25.0	12.8	13.1	0.672	0.663	0.57	0.47	0.87	0.84	0.39	0.36	0.10	0.10
2	18	10	28	26	1.10	1.38	1.89	2.08	10.0	21.3	12.4	12.8	0.683	0.681	0.68	0.69	0.89	0.88	0.21	0.29	0.10	0.11
2	19	20	24	19	0.33	0.20	2.32	2.31	13.7	13.0	14.7	15.5	0.763	0.749	0.50	0.65	0.75	0.80	0.25	0.20	0.13	0.13
2	20	30	19	22	0.48	0.54	2.33	2.52	21.3	26.0	12.9	13.3	0.745	0.734	0.68	0.68	0.79	0.82	0.26	0.40	0.11	0.13
2	21	0	29	29	0.55	0.60	2.21	2.48	10.5	17.0	13.4	12.9	0.696	0.702	0.38	0.45	0.72	0.76	0.29	0.49	0.16	0.16
2	22	10	26	27	0.43	0.66	2.39	2.51	20.0	37.5	12.3	13.0	0.724	0.717	0.35	0.33	0.85	0.89	0.23	0.32	0.11	0.12
2	23	20	26	21	0.45	0.51	2.55	2.56	15.3	18.7	12.6	12.7	0.758	0.757	0.46	0.52	0.69	0.67	0.23	0.23	0.13	0.12
2	24	30	22	19	0.42	0.50	2.39	2.29	14.0	12.7	14.2	14.2	0.727	0.725	0.59	0.63	0.73	0.68	0.36	0.31	0.15	0.15

2	25	0	22	25	0.61	0.79	2.26	2.43	12.0	14.4	12.4	12.3	0.761	0.733	0.68	0.62	0.77	0.77	0.24	0.39	0.14	0.14
2	26	10	22	25	0.83	0.97	2.16	2.27	12.0	13.0	12.5	12.4	0.689	0.699	0.45	0.48	0.77	0.68	0.24	0.30	0.14	0.14
2	27	20	33	39	0.59	0.77	2.46	2.41	15.7	16.0	12.4	12.3	0.721	0.732	0.55	0.64	0.73	0.74	0.28	0.31	0.12	0.12
2	28	30	23	26	0.61	0.76	2.17	2.31	10.6	14.0	13.8	13.6	0.723	0.726	0.52	0.50	0.78	0.69	0.35	0.36	0.15	0.16
2	29	0	24	22	0.33	0.36	2.15	2.24	13.0	26.0	12.9	12.8	0.702	0.720	0.33	0.45	0.75	0.68	0.27	0.40	0.12	0.13
2	30	10	26	26	0.37	0.40	1.97	2.10	13.3	13.0	13.6	13.5	0.739	0.745	0.46	0.46	0.77	0.65	0.26	0.40	0.10	0.13
2	31	20	18	21	0.39	0.46	2.06	2.08	20.5	25.0	12.8	13.4	0.763	0.759	0.67	0.62	0.44	0.62	0.25	0.22	0.13	0.13
2	32	30	12	21	0.19	0.28	2.37	2.38	33.5	80.0	12.6	12.6	0.721	0.762	0.50	0.62	0.67	0.48	0.36	0.42	0.14	0.12
2	33	0	26	28	0.57	0.53	2.45	2.41	21.0	50.0	12.9	12.1	0.734	0.717	0.58	0.68	0.85	0.82	0.34	0.30	0.12	0.11
2	34	10	24	25	0.62	0.78	2.73	2.78	33.5	33.6	12.4	12.7	0.769	0.732	0.46	0.52	0.63	0.68	0.28	0.33	0.11	0.13
2	35	20	21	24	0.25	0.32	2.24	2.45	21.3	26.0	11.9	12.3	0.768	0.774	0.43	0.50	0.81	0.75	0.28	0.33	0.11	0.11
2	36	30	24	19	0.22	0.25	2.33	2.35	17.0	26.0	12.5	12.4	0.739	0.735	0.46	0.58	0.63	0.47	0.31	0.38	0.12	0.14
2	37	40	23	18	0.39	0.40	2.32	2.51	31.0	17.7	12.5	13.2	0.776	0.756	0.48	0.56	0.83	0.78	0.29	0.35	0.11	0.12
2	38	50	21	20	0.31	0.42	2.52	2.58	14.1	18.0	12.7	12.6	0.703	0.697	0.57	0.60	0.76	0.75	0.33	0.37	0.13	0.14
2	39	0	24	24	0.25	0.29	2.30	2.32	14.0	17.0	12.9	12.9	0.742	0.715	0.67	0.75	0.83	0.79	0.24	0.25	0.10	0.12
2	40	10	30	34	0.54	0.72	2.20	2.35	13.0	15.5	12.8	12.7	0.761	0.759	0.60	0.56	0.70	0.74	0.25	0.38	0.12	0.11
2	41	20	21	23	0.30	0.39	2.32	2.39	17.3	22.3	13.3	13.8	0.739	0.727	0.48	0.61	0.81	0.74	0.34	0.36	0.14	0.15
2	42	0	26	30	0.43	0.56	2.49	2.58	18.2	17.5	12.0	12.6	0.657	0.626	0.42	0.37	0.85	0.91	0.39	0.39	0.13	0.14
2	43	10	27	28	0.29	0.35	2.52	2.52	24.0	17.8	13.2	13.9	0.744	0.732	0.63	0.50	0.81	0.75	0.39	0.42	0.15	0.15
2	44	20	23	24	0.54	0.58	2.49	2.42	26.0	20.0	13.8	13.5	0.734	0.729	0.22	0.32	0.91	0.92	0.39	0.42	0.13	0.13
2	45	30	24	24	0.48	0.48	2.29	2.19	22.5	18.5	12.9	12.7	0.741	0.737	0.46	0.44	0.71	0.72	0.36	0.34	0.12	0.13
2	46	0	24	35	0.29	0.46	2.19	2.47	18.5	38.5	11.8	13.1	0.735	0.712	0.67	0.51	0.63	0.69	0.21	0.37	0.10	0.13
2	47	10	28	28	0.26	0.29	2.44	2.48	18.2	21.0	11.4	11.9	0.769	0.750	0.39	0.32	0.71	0.86	0.20	0.21	0.09	0.09

2	48	20	35	35	0.36	0.46	2.28	2.24	34.0	23.5	12.9	12.9	0.737	0.739	0.43	0.37	0.83	0.83	0.26	0.26	0.08	0.08
2	49	30	20	24	0.31	0.42	2.29	2.36	21.3	22.3	13.2	13.4	0.767	0.754	0.45	0.46	0.65	0.63	0.32	0.33	0.12	0.12
2	50	0	25	30	0.33	0.51	2.60	2.67	62.5	54.0	13.0	13.2	0.715	0.717	0.40	0.40	0.92	0.93	0.40	0.41	0.13	0.12
2	51	10	33	37	0.50	0.58	2.79	2.76	33.0	56.0	13.0	13.1	0.761	0.741	0.39	0.43	0.73	0.78	0.40	0.41	0.14	0.13
2	52	20	24	22	0.31	0.37	2.36	2.15	22.3	32.0	12.8	13.2	0.725	0.709	0.58	0.61	0.79	0.83	0.32	0.33	0.13	0.14
2	53	30	24	26	0.52	0.51	2.64	2.54	29.8	24.0	14.0	13.6	0.708	0.724	0.42	0.46	0.79	0.81	0.45	0.34	0.13	0.12
2	54	20	24	26	0.22	0.26	2.26	2.44	19.0	32.0	12.6	12.5	0.794	0.777	0.58	0.71	0.71	0.50	0.23	0.35	0.15	0.12
2	55	30	29	30	0.64	0.88	2.13	2.16	29.0	23.0	11.8	11.7	0.798	0.795	0.45	0.43	0.83	0.83	0.38	0.38	0.12	0.12
2	56	40	32	26	0.38	0.45	2.58	2.49	21.6	18.2	12.6	13.1	0.738	0.728	0.63	0.58	0.72	0.69	0.36	0.37	0.14	0.14
2	57	50	18	22	0.36	0.38	2.29	2.13	14.8	11.5	12.5	12.5	0.752	0.745	0.72	0.73	0.94	0.95	0.23	0.19	0.10	0.09
2	58	60	26	31	0.61	0.64	2.37	2.55	26.0	30.8	12.8	13.3	0.727	0.711	0.62	0.68	0.81	0.81	0.36	0.46	0.14	0.13
2	59	40	21	26	0.41	0.43	2.43	2.49	20.0	18.2	12.0	12.2	0.744	0.720	0.67	0.58	0.62	0.65	0.39	0.26	0.15	0.12
2	60	40	12	13	0.37	0.31	2.10	2.14	19.5	46.0	12.0	14.4	0.764	0.772	0.75	0.85	0.75	0.54	0.20	0.23	0.16	0.17

---

**Appendix 2.**

Species scientific names, tree density (TD), specific leaf area (SLA), wood density (WD), deciduousness (Dec, Deciduous D and Evergreen E) and compoundness (Com, compound leaves C and entire leaves E) registered in studied dry forests.

<b>Species</b>		<b>SLA</b>	<b>WD</b>	<b>Dec</b>	<b>Com</b>
<i>Aegiphila integrifolia</i>	1	NA	0.66	D	E
<i>Agonandra brasiliensis</i>	3	NA	0.82	D	E
<i>Albizia niopoides</i>	9	NA	0.54	D	C
<i>Allophylus sericeus</i>	23	19	0.47	E	C
<i>Aloysia virgata</i>	44	NA	0.62	D	E
<i>Anadenanthera colubrina</i>	106	7.4	0.87	D	C
<i>Apeiba tibourbou</i>	5	NA	0.25	E	E
<i>Apuleia leiocarpa</i>	34	17.9	0.88	D	C
<i>Aspidosperma cuspa</i>	1	16.9	0.75	E	E
<i>Aspidosperma cylindrocarpon</i>	4	13.5	0.75	D	E
<i>Aspidosperma discolor</i>	142	10.4	0.75	D	E
<i>Aspidosperma parvifolium</i>	24	15.5	0.75	D	E
<i>Aspidosperma subincanum</i>	9	20.8	0.75	D	E
<i>Astronium fraxinifolium</i>	25	11.3	0.87	D	C
<i>Astronium nelson-rosae</i>	130	11.3	0.87	D	C
<i>Attalea phareolata</i>	3	NA	0.33	E	C
<i>Bauhinia rufa</i>	1	NA	0.64	E	C
<i>Bauhinia unguolata</i>	1	NA	0.64	E	C
<i>Byrsonima laxiflora</i>	1	15.9	0.65	E	E
<i>Callisthene major</i>	63	10	0.75	D	E
<i>Campomanesia guazumaefolia</i>	1	NA	0.82	E	E
<i>Campomanesia vellutina</i>	50	22.6	0.82	D	E
<i>Cardiopetalum calophyllum</i>	11	NA	0.59	E	E
<i>Cariniana estrellensis</i>	2	9.2	0.56	D	E
<i>Casearia gossypiosperma</i>	62	18.4	0.68	D	E
<i>Casearia grandiflora</i>	172	12.8	0.68	D	E
<i>Casearia rupestris</i>	175	17.06	0.68	D	E



<i>Casearia sylvestris</i>	14	20	0.68	E	E
<i>Cecropia pachystachia</i>	39	NA	0.34	E	E
<i>Cedrela fissilis</i>	9	12	0.41	D	C
<i>Ceiba speciosa</i>	2	21.1	0.35	D	C
<i>Celtis iguanae</i>	36	NA	0.65	D	E
<i>Cheiloclinium cognatum</i>	122	12.8	0.77	E	E
<i>Chomelia pohliana</i>	1	NA	0.57	E	E
<i>Chrysophyllum gonocarpum</i>	1	13.9	0.75	E	E
<i>Coccoloba mollis</i>	49	NA	0.60	D	E
<i>Copaifera langsdorffii</i>	82	11.1	0.61	E	C
<i>Cordia alliodora</i>	7	NA	0.53	D	E
<i>Cordia trichotoma</i>	1	NA	0.53	D	E
<i>Cordia sessilis</i>	155	12	0.88	E	E
<i>Coussarea hydrangeaefolia</i>	24	19.8	0.62	E	E
<i>Coutarea hexandra</i>	4	NA	0.60	E	E
<i>Cupania vernalis</i>	8	10.5	0.64	E	C
<i>Dilodendron bipinnatum</i>	54	15.6	0.71	D	C
<i>Diospyros hispida</i>	26	12.5	0.63	D	E
<i>Dipterix alata</i>	4	NA	NA	E	C
<i>Duguetia lanceolata</i>	69	12.6	0.75	E	E
<i>Enterolobium contortisiliquum</i>	16	NA	0.51	D	C
<i>Erioteca condolleana</i>	7	NA	NA	E	C
<i>Erythroxylum daphnites</i>	10	NA	0.79	E	E
<i>Erythroxylum deciduum</i>	1	NA	0.79	E	E
<i>Eugenia florida</i>	7	16.2	0.76	E	E
<i>Eugenia ligustrina</i>	11	14.8	0.76	E	E
<i>Faramea hyacinthina</i>	1	12.8	0.58	E	E
<i>Ficus cf. enormis</i>	1	NA	0.42	E	E
<i>Garcinia gardneriana</i>	1	10.7	0.69	E	E
<i>Genipa americana</i>	2	NA	0.75	E	E
<i>Guapira venosa</i>	1	NA	0.66	E	E
<i>Guarea guidonia</i>	2	9.1	0.64	E	C
<i>Guazuma ulmifolia</i>	503	13.8	0.54	E	E

<i>Guettarda viburnoides</i>	2	16.6	0.71	E	E
<i>Handroanthus impetiginosus</i>	7	NA	0.92	D	C
<i>Handroanthus chrysotrichus</i>	3	NA	0.92	D	C
<i>Handroanthus serratifolius</i>	22	NA	0.92	D	C
<i>Handroanthus vellosi</i>	23	NA	0.92	D	C
<i>Heisteria ovata</i>	37	9.7	0.70	E	E
<i>Heteropterys byrsonimifolia</i>	3	NA	NA	E	E
<i>Hymenaea courbaril</i>	8	10.5	0.81	D	C
<i>Inga laurina</i>	6	NA	0.58	E	C
<i>Inga sessilis</i>	239	12.3	0.58	E	C
<i>Ixora brevifolia</i>	10	12.2	0.88	E	E
<i>Jacaranda cuspidifolia</i>	4	NA	0.48	D	C
<i>Lonchocarpus cultratus</i>	57	NA	0.74	D	C
<i>Luehea divaricata</i>	17	NA	0.52	D	E
<i>Luehea grandiflora</i>	52	19.3	0.52	D	E
<i>Mabea fistulifera</i>	47	NA	0.61	D	E
<i>Machaerium aculeatum</i>	1	NA	0.73	D	C
<i>Machaerium acutifolium</i>	1	NA	0.73	D	C
<i>Machaerium brasiliense</i>	29	15	0.73	D	C
<i>Machaerium hirtum</i>	1	11.8	0.73	D	C
<i>Machaerium nyctitans</i>	1	NA	0.73	D	C
<i>Machaerium stipitatum</i>	20	NA	0.73	D	C
<i>Machaerium villosum</i>	13	18.9	0.73	E	C
<i>Maclura tinctoria</i>	10	22	0.79	D	E
<i>Maprounea guianensis</i>	3	NA	0.59	E	E
<i>Margaritaria nobilis</i>	2	NA	0.48	D	E
<i>Matayba elaeagnoides</i>	1	12	0.77	E	C
<i>Matayba guianensis</i>	6	11.9	0.77	E	C
<i>Maytenus floribunda</i>	1	10.6	0.73	E	E
<i>Metrdorea stipularis</i>	10	NA	NA	E	E
<i>Micropholis velunosa</i>	38	14.3	0.66	E	E
<i>Myracrodruon urundeuva</i>	234	10.6	1.00	D	C
<i>Myrcia splendens</i>	17	NA	0.82	E	E

<i>Myrcia tomentosa</i>	7	NA	0.82	D	E
<i>Myrciaria glanduliflora</i>	121	15.21	0.70	E	E
<i>Myrsine umbellata</i>	2	11.3	0.71	E	E
<i>Nectandra cissiflora</i>	1	9.5	0.58	E	E
<i>Ocotea corymbosa</i>	5	10.2	0.55	E	E
<i>Piper arboreum</i>	8	NA	0.39	E	E
<i>Piptadenia gonoacantha</i>	15	NA	0.81	D	C
<i>Platypodium elegans</i>	9	12.3	0.81	D	C
<i>Pouteria gardneri</i>	24	12.8	0.76	E	E
<i>Pouteria torta</i>	4	12.8	0.76	E	E
<i>Protium heptaphyllum</i>	54	11.5	0.56	E	C
<i>Psidium guajava</i>	19	NA	0.93	E	E
<i>Psidium rufum</i>	1	NA	0.93	E	E
<i>Psidium sartorianum</i>	5	15.3	0.93	E	E
<i>Qualea dichotoma</i>	4	NA	0.65	D	E
<i>Qualea multiflora</i>	12	12.9	0.65	E	E
<i>Rhamnidium elaeocarpum</i>	42	22.9	0.80	D	E
<i>Rudgea viburnoides</i>	6	NA	0.57	E	E
<i>Schefflera morototoni</i>	16	NA	0.44	E	C
<i>Senegalia polyphylla</i>	29	7.4	0.63	D	C
<i>Simira viridifolia</i>	7	NA	0.68	D	E
<i>Siparuna guianensis</i>	48	18.3	0.66	E	E
<i>Siphoneugena densiflora</i>	23	9.3	0.91	E	E
<i>Sorocea bomplandii</i>	1	NA	0.61	E	E
<i>Sweetia fruticosa</i>	19	12.5	0.78	D	C
<i>Tabebuia roseoalba</i>	4	NA	0.75	D	C
<i>Tapirira guianensis</i>	1	9.8	0.37	E	C
<i>Tapirira obtusa</i>	3	11.9	0.37	E	C
<i>Terminalia glabrescens</i>	100	11.4	0.73	D	E
<i>Terminalia phaeocarpa</i>	4	12.9	0.73	D	E
<i>Trema micrantha</i>	1	NA	0.28	E	E
<i>Trichilia catigua</i>	7	14.1	0.67	E	C
<i>Trichilia elegans</i>	1	16.9	0.67	E	C

<i>Trichilia pallida</i>	13	21.4	0.67	E	C
<i>Unonopsis guatterioides</i>	4	16	0.56	E	E
<i>Vatairea macrocarpa</i>	1	NA	0.68	E	C
<i>Virola sebifera</i>	8	9.5	0.48	E	E
<i>Xylopia aromatica</i>	15	9.3	0.59	E	E
<i>Zanthoxylum rhoifolium</i>	2	NA	0.62	D	C
<i>Zanthoxylum riedelianum</i>	4	NA	0.62	D	C

---