



Diversity, composition and biomass of native vascular plants regenerating under *Acacia mangium* Will. plantations in northern Amazonia

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Received: 13 June 2018 / Revised: 26 March 2019 / Accepted: 5 July 2019 / Published online: 29 July 2019
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Abstract

It is imperative that studies can be developed to assess the role of homogeneous tree plantations in biodiversity conservation and the ability to store atmospheric carbon. This study aimed to evaluate the effects of *Acacia mangium* Will. plantations established in areas originally occupied by savanna (locally termed “lavrado”) on the establishment success of vascular plants, by analyzing three attributes of the community—diversity, composition and biomass. All plants with base diameter ≥ 1 cm were measured in 28 0.05-ha plots (11 plots allocated in natural areas of “lavrado” and 17 under *A. mangium* plantations). Species diversity was much higher in *A. mangium* plantation than in the natural areas of “lavrado”. There was a clear floristic differentiation between *A. mangium* and “lavrado”, with high density of forest species and low density of “lavrado” species growing under *A. mangium* plantations. “Lavrado” plots presented high floristic similarity, but plots under *A. mangium* plantations were far less similar, indicating a more heterogeneous vegetation. Biomass of vascular plants in *A. mangium* plantations was about one-fifth of that found in natural “lavrado” sites, but in “lavrado” 92.6% of the total biomass was allocated in only two species, whereas in *A. mangium* plantation two species comprised only 43% of the total biomass. In *A. mangium* plantation, species classified as forest species and typical “lavrado” species accounted for 72.8% and 27.2% of total biomass, respectively. Our results showed that *A. mangium* plantations resulted in high alpha and beta plant diversity due to the invasion of alien forest species. Also, biomass of “lavrado” species in plantations was smaller and species relative abundances completely different from natural “lavrados”. Therefore, we conclude that forest plantations established in savannas cannot be used to meet conservationist purposes.

Keywords Afforestation · Ecological restoration · Roraima · Savanna

1 Introduction

It is consensus among conservationists that protected natural areas will be insufficient to ensure the conservation status of global biodiversity (Myers et al. 2000; Butchart et al. 2010). In this scenario, among other strategies, forest plantations may have an important role in retaining the biodiversity of the original ecosystem (Chapman and Chapman 1996; Loumeto and Huttel 1997; Barlow et al. 2007; Gardner et al. 2009; Peltzer and MacLeod 2014; Luck et al. 2014). Although afforestation has been increasing worldwide, information on biodiversity and ecosystem processes is still incipient in such land use (Gardner et al. 2009; Luck et al. 2014). Incentives for carbon stock and sequestration by plantations with appropriate management techniques can represent a breakthrough on the sustainability of large areas outside legally protected reserves. Therefore, it is

Electronic supplementary material The online version of this article (<https://doi.org/10.1007/s40415-019-00539-w>) contains supplementary material, which is available to authorized users.

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imperative that investigations in forest plantations are developed to assess their ability to store and sequester carbon and their roles for biodiversity conservation. In Brazil, the area occupied by homogenous forest plantations of *Eucalyptus*, *Pinus* and *Acacia* species amounted 6,813,123 ha by the year 2012, with *Eucalyptus* plantations representing around 75% of the total, followed by *Pinus* (23%) and *Acacia*, which represented only 2.2% (148,311 ha). Less than 10% of the Brazilian forest plantation area (623,420 ha) is in the Amazon, predominantly with species of the genus *Eucalyptus* (ABRAF 2013).

Forest plantations have been recognized under the Clean Development Mechanism. There is an incentive for reforestation and afforestation projects to sequester carbon because of growing concern about the highly probable impacts of anthropogenic emissions on the planet's climate (Kanowski and Catterall 2010). In addition, it is argued that both planted and naturally regenerating forests can provide significant benefits in terms of other ecosystem services when compared to other more intensive land uses. The premise of such activities is that the potential for carbon storage in forests is greater than in agricultural crops and pastures, due to the accumulation of biomass in the wood and the incorporation of higher levels of carbon in the soil (Kanowski and Catterall 2010). Moreover, forest plantations can increase the chance of germination and establishment of vascular native vegetation in the understory in comparison with highly degraded areas, where erosive processes and fires negatively impact soil fertility and the seed bank (Senbeta et al. 2002; Yirdaw and Lukkanen 2003). However, allelopathy, in which allelopathic chemicals are released into environment through volatilization, leaching, foliage root decomposition and root exudation, is widely recognized to be one of the causes of biodiversity reduction in homogeneous forest plantations, such as *Eucalyptus* spp. (Zhang and Shenglei 2009; Chu et al. 2014) and *Pinus* spp. (Guerrero and Bustamente 2007; Alrababah et al. 2009) plantations. Therefore, the negative allelopathic effects on germination and growth of native plants can select the establishment of few species, which, in turn, will result in a lower local and regional diversity of tree species regenerating under the plantations.

Misinterpretation of savannas as degraded ecosystems which must be restored may lead to wrong strategies to manage and conserve such ecosystems (Veldman et al. 2015a, b). The Brazilian savanna (termed "cerrado") as it is today, with high plant species diversity and plant functional traits, is a result of 1000 years of evolution. The "cerrado" dates back to more than 30,000 years, and its persistence is due to an increase in seasonality and temperature, and adaptation to fire appeared well before human colonization of the continent (Ledru 2002). Fire is an important factor to maintain biodiversity, and its exclusion has a deleterious effect on savanna species diversity (Roitman et al. 2008; Abreu et al.

2017). Afforestation appears to be an alternative to usual land uses (such as crop plantation) with recorded increase in plant diversity and carbon stocks. However, species composition in the forest plantations can be different from a natural savanna and carbon stocks may vary according to climate (Berthrong et al. 2012). Therefore, forest plantations established in savannas must be analyzed in order to identify the value of this type of land use for conservation and maintenance of ecosystem services.

The Brazilian savanna, considered as a global biodiversity hot spot (*sensus* Myers et al. 2000), covers approximately 2 million km² and is located mainly in the central part of Brazil. Currently, half the area of native "cerrado" vegetation has been severely modified or eradicated and has been replaced by various types of land use, including forest plantations. Sano et al. (2009) estimated that forest plantations in "cerrado" areas are around approximately 3 million ha. At the northern Amazon biome, in the state of Roraima (Brazil) and extending to Venezuela, Guyana and Suriname, a continuous block of savanna (locally called "lavrado") is 61,664 km² in size, in which 43,358 km² (70%) is established in Brazil (Barbosa et al. 2007). In the central part of the Roraima state occurs the contact between the "lavrado" and the forest ecosystem (terra firme forest) that dominates the Amazon Basin.

There is still a lack of studies on natural regeneration under commercial plantations in the Brazilian Amazon (but see Barlow et al. 2007; Lima and Vieira 2013), and to our knowledge, no study has evaluated natural regeneration under homogeneous plantations established in areas of savanna in this region. This study collected important information about the establishment of vascular plants in "lavrado" areas that were converted to *A. mangium* Will. plantations in "lavrado"/forest boundary in Roraima. In this region, about 30,000 ha of "lavrado" was converted into *A. mangium* plantations in the early 2000s. Fire has been controlled in these areas since the establishment of the plantations. In areas originally occupied by savannas, there is evidence that shows diffuse effects such as increased diversity due to occupation by exotic species and colonization by native forest species (Loumeto and Huttel 1997; Peltzer and MacLeod 2014). Forest plantations can serve as catalysts for the regeneration of tree species, which could alter the savanna ecosystem allowing the advance of forest species.

The objectives of this study were to: (i) determine the magnitude of the differences in diversity, biomass and composition of native vascular plants established under *A. mangium* plantations and adjacent "lavrados" and (ii) determine the biomass allocated regarding successional groups (pioneer versus non-pioneer species) and the origin of the species (forest species and savanna species). Considering that fire has been controlled in the *A. mangium* plantations since the beginning of the plantation, the hypotheses of this

study were: (i) the diversity and biomass of tree species will be higher in *A. mangium* plantations than in “lavrados”; (ii) there will be a high differentiation in terms of floristic composition between the two situations, with the composition of species under plantations encompassing both savanna and forest species, resulting in an greater divergence of floristic composition among plots in *A. mangium* plantations; and (iii) it is expected that there will be a differentiation in terms of biomass between forest species on the one hand, and savanna species on the other hand, as well as with respect to successional groups in *A. mangium* plantations.

2 Materials and methods

Study site – The study was carried out in the Serra da Lua region, located within the municipality of Bonfim, Roraima State, Brazil (2°46'0"N and 60°24'0"W). The study site is approximately 40 km east from the capital Boa Vista, which is accessed through the RR-207 highway. The average annual temperature is 26 °C, and precipitation ranges 1700–2000 mm year⁻¹ (Barbosa 1997). The relief is quite flat with altitude varying from 90 to 130 m. Soils are poor in nutrients, and the predominant types are Argisol, Yellow Latosol, Red Latosol and Hydromorphic Quartzene Neosols (Vale-Júnior and Schaefer 2010). The study area comprises six farms (Acácia Magnífica, Nova Cintra III, Garimpeira, T.D. Araçá, Castelão and Castelão Norte) belonging to the company FIT Forest Management of Brazil LTDA, totaling an area of 14,868 ha. The company, through a partnership with local scientific institutions (Universidade Federal de Roraima—UFRR and Empresa Brasileira de Pesquisa Agropecuária—EMBRAPA/Roraima) granted the area of the six farms to carry out researches. The six farms encompass a mosaic of planted forests of *A. mangium*, remnants of “lavrado”, semideciduous seasonal and gallery forests. In the end 1980s and early 1990s, the natural “lavrado” areas were clear-cut and converted to pastures for cattle ranch. After 8–10 years of prescribed fires for management of grasses, productivity declined in the pastures, so they were abandoned and monocultures of *A. mangium* began, aged between 10 and 16 years at the time of data collection for this study.

Experimental design – Data for this study were obtained from the permanent plots established in four blocks, each block comprising two 5-km parallel trails separated by 1 km (Electronic Supplementary Material: Fig. A1). In each 5 km trail, five long and narrow permanent plots of 2 × 250 m size (0.05 ha) were installed, totaling ten plots per block, according to the RAPELD standard (Rapid Assessment Protocol for Long-term Ecological Studies; Magnusson et al. 2005) established in the long-term ecological researches of the Biodiversity Research Program (PPBio). The plots follow the topographic contour in order to maintain a constant elevation and to minimize internal variations in soil type and depth to the water table within each plot (Magnusson et al. 2005). Out of the total of 40 permanent plots established in the four blocks, 17 plots are allocated under *A. mangium* plantations, 11 in natural areas of “lavrado”, eight in semideciduous seasonal forest and four plots in gallery forest. For this study, we used the 28 plots in *A. mangium* and “lavrado”. Based on the inventory of the 17 plots allocated to the plantations, the basal area of *A. mangium* individuals ranged from 8.18 to 31.59 m² ha⁻¹ (mean ± standard deviation = 19.88 ± 6.15 m² ha⁻¹) and the density of 340 to 1140 individuals ha⁻¹ (804.7 ± 229.62 individuals ha⁻¹). In each plot, all native vascular plants with basal diameter (D_b) ≥ 1 cm, measured at 10 cm height from the ground, were measured for D_b , DBH (diameter at breast height – diameter measured at 1.30 cm from the ground), crown diameter (D_c) and total height (H_t). The stem diameters (D_b and DBH) were measured with caliper and diametric tape when the diameters were lower and higher than 5 cm, respectively. Individuals with $H_t > 2$ m were measured using a clinometer, and two perpendicular measurements of the canopy were obtained using a metric tape. All individuals measured in the plots were mapped, marked with aluminum tags, and botanical samples were collected for taxonomic identification by comparison with the herbarium material of the Universidade Federal de Roraima and Instituto Nacional de Pesquisas da Amazônia (INPA).

Data analysis – We used different allometric equations to estimate aboveground biomass of the native vascular plants sampled in the 28 plots according to the species origin and successional group (Table 1).

Table 1 Allometric formulas used to estimate aboveground biomass of different plant groups

Plant group	Equation formula	Source
“Lavrado” species	$\text{Log}_{10}(B) = 4.501 + 0.459 * \text{log}_{10}(H_t) + 1.589 * \text{log}_{10}(D_b) + 1.025 * \text{log}_{10}(D_c)$	Barbosa and Fearnside (2005)
Pioneer species	$B = \exp(1.7972 + 2.4206 * \ln(\text{DAP}))$	Nelson et al. (1999)
<i>Cecropia</i> species	$B = \exp(2.5118 + 2.4257 * \ln(\text{DAP}))$	Nelson et al. (1999)
Non-pioneer species	$0.0673 * (\rho * H_t * \text{DAP}^2)^{0.976}$	Chave et al. (2014)

ρ is the wood density in g cm⁻³

The rarefaction method (Gotelli and Colwell 2001) was used to generate the expected number of species in order to compare the two habitats, *A. mangium* plantations and “lavrado”, in terms of floristic diversity for the $1 \leq D_b < 4.9$ cm size class and the entire dataset (i.e., when all size classes are included in the analysis). We used rarefaction based on individuals and plots to minimize the confounding effect of the variation in the number of individuals and the sampling area on the number of species (Gotelli and Colwell 2001).

Multidimensional non-metric scaling (NMDS) was used to reduce the dimensionality of the original matrices of floristic composition for both $1 \leq D_b < 4.9$ cm class and the entire dataset. The Sørensen index (Bray–Curtis) was used as a measure of distance in the association matrix using species relative abundance data (percentage of species within each plot). Randomization tests ($n = 50$ runs) confirmed that two axes explain significantly more variation than expected at random ($P < 0.02$ in both cases). The final value of the stress (standardized residual sum of squares) was less than < 0.23 , which indicates that the distances obtained in the ordering matrix reflect the distances of the original matrix. We used Pearson’s r parametric correlation coefficient to assess the relationships between the abundance of each species and the scores of each axis of the NMDS in order to determine which were the most important species that defined the floristic gradient. Pearson correlations are calculated for sample units against ordination axes (McCune and Mefford 2011).

The rarefaction curves and ordination analyses were both performed using PAST v3.13 software (Hammer et al. 2001).

3 Results

Diversity and composition in *A. mangium* and “lavrado” – A total of 1180 individuals with $D_b \geq 1$ cm, which covered 68 vascular plant species belonging to 32 families, were sampled in the 28 plots allocated in both habitats. Thirteen individuals could not be identified at the specific level, and one individual of an exotic tree species (*Mangifera indica*) L. was sampled (Electronic Supplementary Material: Table A1).

For the $1 \leq D_b < 4.9$ cm size class, even though the number of individuals sampled in the 11 “lavrado” plots (332 individuals) was higher than the number of individuals sampled in the 17 plots of the *A. mangium* (273) plots, the absolute number of species found in the *A. mangium* plantations was almost double the number of species in the “lavrado”, with 47 and 25 species, respectively. When the entire database is considered, only two new species are added in the “lavrado”, with a total of 27 species distributed in 786 individuals, whereas for *A. mangium* plantations the number of species

increases from 47 to 55 species distributed in 381 individuals, which corresponds to approximately half the number of individuals sampled in the “lavrado”. In fact, the rarefaction curves as a function of the cumulative number of plots and accumulated numbers of individuals showed that *A. mangium* plantations sustained relatively more species than areas of “lavrado” for the $1 \leq D_b < 4.9$ cm class (Fig. 1a, b) and the entire dataset (Fig. 1c, d).

Only 12 (20% of the total) and 15 species (22% of the total) for the $1 \leq D_b < 4.9$ cm class and the entire dataset, respectively, were common in both habitats. Such low sharing of species between habitats for both size classes is reflected in the NMDS ordinations. The two-dimensional NMDS diagram, explaining most of the variation among plots in floristic composition, showed clearly a separation between *A. mangium* plantations and “lavrado” for the $1 \leq D_b < 4.9$ cm class, mainly along axis 2 (Fig. 2a) (axis 1: $t = 0.4$, $p = 0.69$; axis 2: $t = 2.69$, $p = 0.013$). This axis, which explained 31.8% of the total variation of the original matrix, was positively correlated with *Curatella americana* L. ($r = 0.65$) and *Byrsonima crassifolia* (L.) Kunth (0.4), the two most abundant species in “lavrado” sites, and negatively correlated with *Siparuna guianensis* Aubl. (-0.75), *Tapirira guianensis* Aubl (0.6), *Trattinnickia rhoifolia* Willd. (-0.57) and *Virola sebifera* Aubl. (-0.57), all typically forest species, indicating, as expected, that “lavrado” plots showed higher density of *C. americana* and *B. crassifolia* and lower density of the other species. The differentiation between habitats became more evident when considering the entire dataset (Fig. 2b). The floristic separation occurred mainly along axis 1, which explained 49.4% of the total variation (axis 1: $t = 3.65$, $p = 0.001$; axis 2: $t = 1.49$, $p = 0.15$). This axis was positively correlated with *T. guianensis* ($r = 0.65$), *Parinari campestris* Aubl. (0.63), *Xylopia aromatica* (Lam.) Mart. (0.58), *S. guianensis* (0.54), *V. sebifera* (0.53), *Himatanthus articulatus* Vahl (Woodson) (0.52), *Calophyllum brasiliense* Cambess. (0.50) and *T. rhoifolia* (0.50), all forest species with the exception of *H. articulatus*, and negatively correlated with *C. americana* (0.85). This gradient demonstrated that plots established in *A. mangium* plantations presented high density of forest species and lower density of “lavrado” species. It is worth noting that, in both size classes, plots under *A. mangium* plantations presented less floristic similarity, as they are much more scattered throughout the ordination diagrams, indicating a more heterogeneous vegetation, whereas a greater floristic similarity was found among “lavrado” plots.

Biomass allocated to species origin and successional group in *A. mangium* plantations – Biomass estimate of vascular plants ≥ 1 cm D_b in *A. mangium* plantations was, on average, about one-fifth that found in natural “lavrado” sites, with 2.2 ± 0.9 Mg ha⁻¹ and 12.2 ± 3.6 Mg ha⁻¹, respectively.

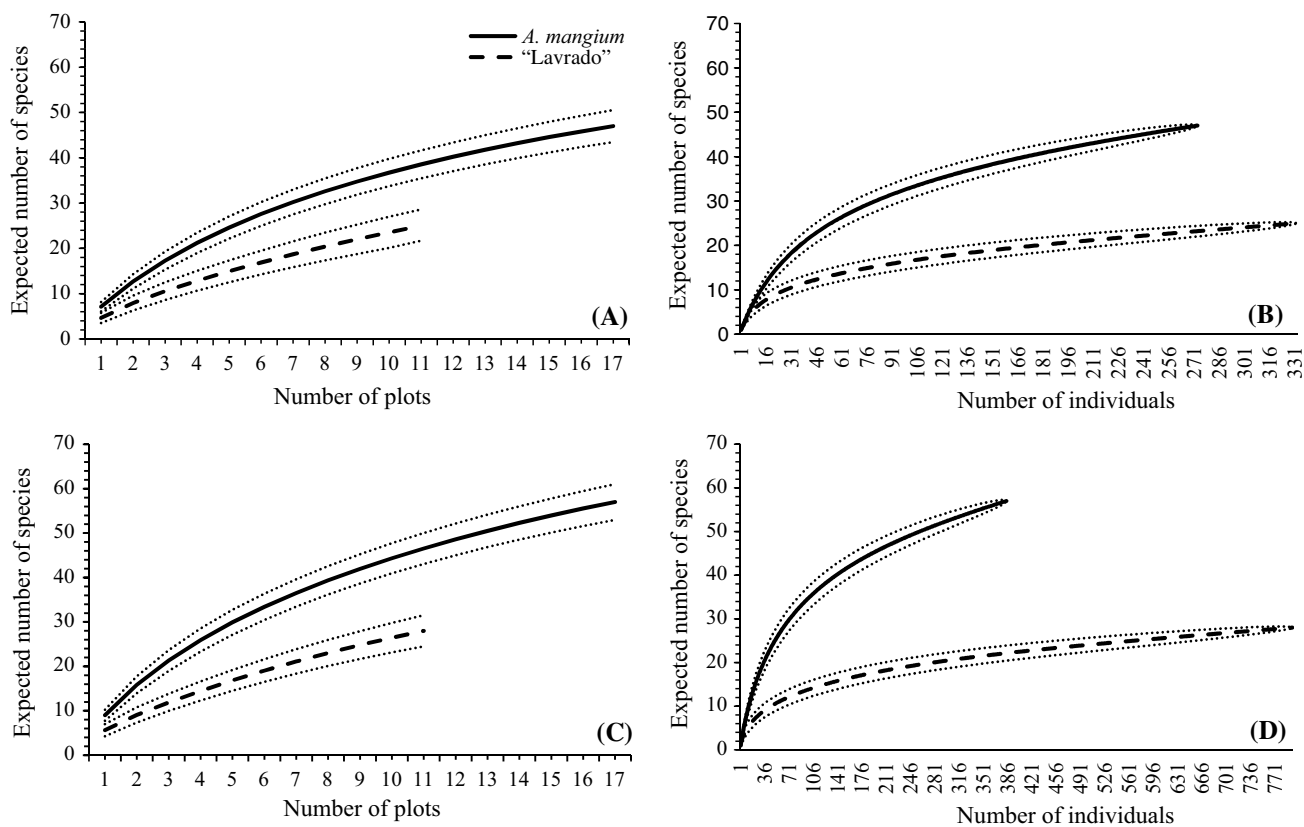


Fig. 1 Species-area and species-individual accumulation curves (mean ± 95% confidence interval) for the *A. mangium* plantations and “lavrado” areas in the $1 \leq D_b < 4.9$ class (a and b) and the entire dataset (c and d)

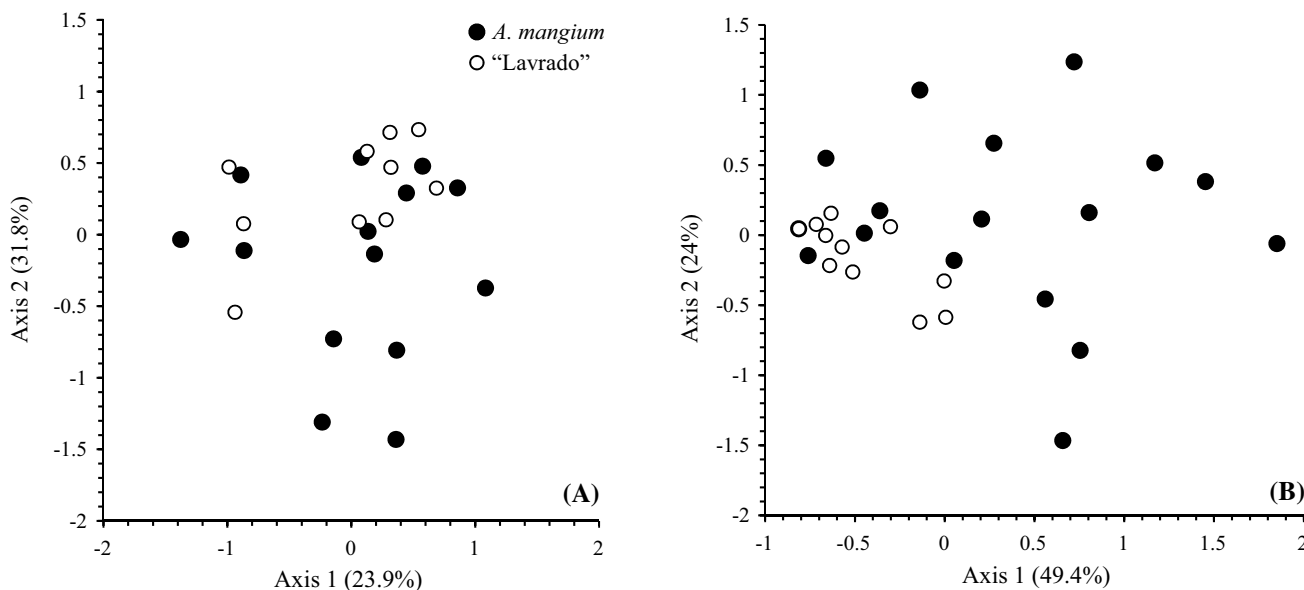


Fig. 2 Non-metric multidimensional scaling (NMDS) ordinations based on the species abundance for the *A. mangium* plantations and “lavrado” areas in the $1 \leq D_b < 4.9$ class (a) and the entire dataset (b)

However, 92.6% of the total biomass in the “lavrado” was allocated to only two species—*C. americana* with 81%

and *B. crassifolia* with 11.6%, the two most abundant species, while in *A. mangium* plantations, the two species that

represented the highest proportion of biomass, *Posoqueria latifolia* (Rudge) Schult. and *B. crassifolia*, comprised 43% of the total biomass.

In the *A. mangium* plantations, 48 and only seven species were classified as forest species and “lavrado” species, respectively, with 72.8% and 27.2% of the total biomass allocated to forest species (1.6 Mg ha⁻¹) and “lavrado” species (0.6 Mg ha⁻¹). For the forest species that established in the *A. mangium* plantations, the biomass allocated to the group of 26 non-pioneer species was 0.72 Mg ha⁻¹ and 0.86 Mg ha⁻¹ for the 22 pioneer species which represented, in percentage terms, 45.7% and 54.3% of the total biomass of forest species, respectively (Fig. 3). *P. latifolia* was the non-pioneer species that made up the largest proportion of total biomass in this group, with 81.4% of the total biomass, and *Alchornea discolor* was the most representative species in terms of biomass for the group of pioneer species, comprising 33.1% of the total biomass in this group.

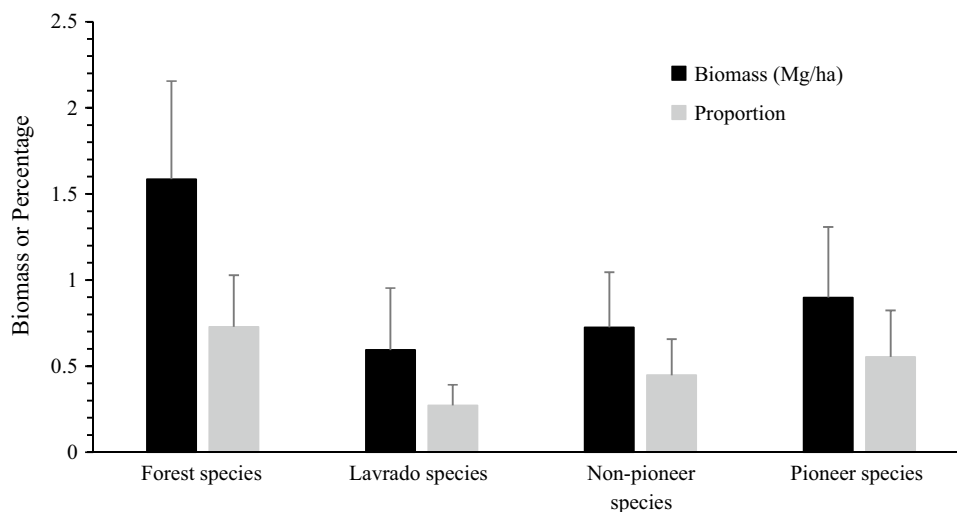
4 Discussion

The main objective of this study was to evaluate how three plant community attributes—diversity, composition, and biomass of native vascular plants—change when natural areas of savannas in northern Brazilian Amazonia are converted into homogenous plantations of *A. mangium*. Although arbitrary, the division into size classes allowed us to glimpse in greater detail the dynamics of regeneration in different stages after 8–14 years of plantation.

The most striking finding of our study is that the effects of plantation and/or fire exclusion resulted not only in an increase in local diversity, but also an increase in the species turnover as revealed by the greater floristic dissimilarity among *A. mangium* plots. Several studies have shown

that homogeneous forest plantations result in an increase in floristic diversity, which depends on several factors, such as the species, soil type and intensity of land use prior to plantation (Loumeto and Huttel 1997; Yirdaw and Lukkanen 2003; Lemenih and Teketay 2005; Duan et al. 2010; Lima and Vieira 2013). This increase in diversity is a result of plantations’ ability to accelerate the colonization of plant species, as they positively influence microclimatic conditions in terms of soil humidity and light quality reaching the understory (Lemenih et al. 2004; Duan et al. 2010), improving soil structure and fertility (Parrota 1992; Duan et al. 2010), reducing competition through grass suppression (Parrota et al. 1997) and favoring seed dispersal by attracting dispersers due to increased availability of food resources and shelter (Wunderle 1997). *Acacia mangium* plantations may have attracted some dispersers, facilitating the arrival of propagules of zoocoric shade-tolerant forest species, such as *Buchenavia tetraphylla* (Aubl.) R.A.Howard, *C. brasiliense*, *Chrysophyllum argenteum* Jacq., *Peltogyne paniculata* Benth., *Protium sagotianum* Marchand, and *T. rhoifolia*. Dominant plant species of savanna are mainly dispersed by birds (Mourão et al. 2010), which also are the most important disperser of *A. mangium* seeds into the savannas (Aguar et al. 2014). Bernard and Fenton (2002) showed that among 11 most abundant frugivorous bats found in a mosaic of forest fragments and savannas, six species were predominant in the savanna and three were more abundant in forest fragments and only were shared equally between habitats. Therefore, the replacement of savannas by tree plantations may influence the composition and abundance of seeds dispersers. However, the plots allocated to *A. mangium* plantations are quite close to the forest and this may have facilitated the dispersal and establishment of this group of plants. The distance to the source of propagules is a key factor that positively influences the regeneration of vascular plants in degraded sites. Mesquita et al. (2001) showed that

Fig. 3 Absolute and proportional biomass (mean ± standard deviation) of forest and “lavrado” species, forest pioneer and non-pioneer forest species for *A. mangium* plantations



the diversity of vascular plants regenerating in secondary forests increases with decrease in the distance of the nearest primary forest.

The success of establishment of forest species in savanna areas subject to recurrent fires is limited due to the high mortality of the aerial biomass as a result of their thinner bark relative to savanna species (Hoffmann et al. 2009). When savanna areas are protected from fire, both tolerant and intolerant fire species may experience increased density and size (Fensham and Butler 2003). However, there are differences in growth between these two types of fire-tolerant plants. Forest species that colonize savannas present a greater capacity of establishment due to their fast growth when compared to the typical savanna species (Rossatto et al. 2009). Moreover, the “lavrado” dominant species *C. americana* presents low rates of germination (27% in laboratory; Oliveira et al. 2012), but *Cecropia* species showed higher rates (> 60%) of germination under milder temperature (25 °C), but an abrupt decrease (~ 20%) with increase of 5 °C (Godoi and Takaki 2004). Therefore, “lavrado” species may present low ability to compete with forest pioneer species under fire exclusion, as a result of changes in the microclimate toward a less hot and dry conditions under *A. mangium* shade compared to the open natural “lavrados”. In addition, fast-growing pioneer forest species are early colonizers in open habitats, which facilitate the establishment of other species (Hennenberg et al. 2006). Tree plantations play an important role for establishment of forest species, by providing humid and cooler conditions, but fire exclusion itself promotes changes in the ecosystem, such as increase in organic matter and humidity in the soil. In Savanna–Amazon transition zone, plots subjected to fire exclusion showed lower rates of mortality followed by a significant increase in the abundance of a forest fast-growing species (*Tachigali vulgaris* L.F. Gomes da Silva & H.C. Lima) (Reis et al. 2015). In summary, these forest species contribute to eliminate, through competition, savanna species and grasses, which, in turn, can reduce the frequency and intensity of fires resulting in the expansion of forests in areas originally occupied by savanna. In fact, our study showed high dominance of forest species after 8–14 years of the *A. mangium* plantations and, in addition, both light-demanding forest species for germination and growth and shade-tolerant forest species presented high potential of regeneration. Thus, we predict that over the years there will be a further decrease in the representativeness of savanna species in the plantations.

An important aspect of our study is that information on the three attributes could be known in natural areas of “lavrado” and, therefore, it was possible to compare the effects of *A. mangium* plantations on the establishment of native plants. However, the experimental design did not allow us to disentangle the effects of the fire exclusion and the effects of the plantations themselves. Thus, the inclusion

of a further treatment, a deforested “lavrado” with exclusion of fire, could elucidate the mechanisms involved in establishment of plants in *A. mangium* plantations. If plant diversity and floristic composition were similar to those found in the *A. mangium* plantations, one could conclude that the plantations have no effect on the success of plant establishment; on the other hand, if these two attributes had totally different patterns between deforested “lavrado” and plantations, it could be inferred that plantations exert influence.

In this study, increase in species richness was due mainly to the generalist forest plant species, which benefit from the new microclimate created in the understory of the forest plantations and concomitant fire suppression. Savannas are grassy ecosystems with a pool of species that evolved as a result of a combination of factors such as climate, soil and fire regime (Ledru 2002). However, increasing diversity and biomass in forest plantations do not imply gain in conservation or maintenance of ecosystem services. In addition, forest plantations are cut periodically, reducing carbon stock in the aboveground biomass and species richness at very low levels. After 30 years of fire suppression in the southeastern Brazilian “Cerrado”, Abreu et al. (2017) showed that biomass increased 140%, followed by an increase in the number of tree species, but savanna plant species decreased by 67%. The herbaceous and shrub species of the savanna represented the major part of the species loss, demonstrating that changes in the light availability were one of the main factors to diminish the diversity of savanna plants. In the present study, savanna tree species that recruited in the *A. mangium* plantations were represented by a few individuals with thin trunks and small crowns. In fact, afforestation can have a deleterious effect on savanna species as the effects of fire suppression and changes in temperature, humidity and light availability prevent the maintenance of most savanna species. The misinterpretation of the degraded savanna landscapes has contributed to the misconception that savannas should be recovered by suppressing fires and planting trees to restore a forest that has occupied this ecosystem in the past (Veldman et al. 2015a, b). Forest plantations cannot be used to serve conservation purposes or to justify the insufficiently protected area in savannas. Savannas should be recognized as old growth ecosystems (sensu Veldman et al. 2015b), having more value than could be achieved by carbon storage. Biodiversity as a source of new products (such as medicines, natural foods, fibers), groundwater recharge, headwaters and rivers conservation, pollinator conservation, natural beauty and ecotourism are ecosystem services that should be valued to contribute to the conservation of savannas.

Acknowledgements We are grateful to F.I.T. Manejo Florestal do Brasil LTDA for allowing us to conduct this research in its farms. Financial support was provided by F.I.T., National Council for Scientific and

Technological Development (CNPq/Universal 459735/2014-4) and Federal University of Amapá (PAPESQ/UNIFAP Edital N° 015/2015). We thank Paulo Apóstolo and Ricardo Perdiz for plant identification, Eder Oliveira, Wesley Souza, Aginaldo de Souza, Wicles Batista and Marcelo Cruz for field work organization and assistance.

Author's contribution JJT designed the research and collected the data. JJT and HEMM analyzed the data. HEMN wrote the paper.

Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

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