

## Original Research Article

# Floristic composition in chronosequence in Atlantic Rainforest fragments

### ABSTRACT

Secondary forests play an important role in tropical landscapes and have important ecological functions such as the ability to accumulate biomass. Although the literature points to the convergence between primary and secondary forests, however there are few studies in Atlantic Rainforest in a chronosequence to show it. This study aimed to characterize the changes of floristic composition in a chronosequence (5, 16, 24, 30 years of regeneration and mature forest) in the Atlantic Rainforest. He sought to answer the following questions: Young forests tend to converge resembling floristically with mature forest? In case of this floristic convergence from what age these young forests present rate of growth closer forms of mature forest? The fact that about 35% of the tree species are present in young and mature forests suggests that the floristic composition of young forests tends to resemble the mature forest. The results suggest that from 16 young forests tended to converge with the mature forest in terms of the proportion of growth forms.

*Keywords: Floristic convergence, Young forests, Growth forms, Secondary rainforest.*

### 1. INTRODUCTION

Secondary forests play an important role in tropical landscapes. These ecosystems are sources of timber and non-timber forest products and generally perform important ecological functions, such as the ability to accumulate biomass and nutrients at high rates, maintain biogeochemical cycles and water conservation at levels comparable to primary forests [1,2]. Current research on succession in secondary forests in the tropical regions occurs especially in studies in chronosequences [3].

Regarding succession [4] proposed that it is a highly ordered and predictable process, emphasizing the sequential substitution of herbaceous species by shrubs and finally arboreal species. Differently, [5] suggested that the sequence does not have this fixed and regular sequence, being influenced by the composition of the community, which is determined by stochastic factors.

In relation to floristic composition throughout the succession, [6] described two alternative scenarios. The floristic rotation, with a broadly clementsian view, in which each group of species colonizes the place at certain stage of development, thus making conditions unsuitable for itself and more appropriate for colonization of the next group, at the final stage of succession convergence with the region's mature vegetation. Other scenario is the hypothesis of initial floristic composition, which proposes that after the abandonment of a site, development unfolds from the initial flora; [6] concluded that the secondary succession

**Comment [a1]:** Too personal. Rather say the study sought to...

**Comment [a2]:** Rephrase statement of suit a question.

**Comment [a3]:** Entire abstract needs some adjustment; clearly state the objective of the study, briefly state methods used, summarize results and maybe main recommendation if any. The chronology of this builds a strong abstract

36 is determined more by the initial floristic composition of an area than by the floristic rotation  
37 proposed by [4].

38 At present, it is known that natural landscapes, in general, have a historical complex of land  
39 use disturbances [7]. These authors argued that succession represents a series of  
40 unpredictable events that results from interactions between individuals and the abiotic  
41 environment, involving different patterns (convergence or divergence), mechanisms and  
42 causes that lead to complex paths that will determine the processes of recovery of the local  
43 vegetation. The trajectory followed by the sequence depends on the initial conditions and  
44 stochastic events. The results of chronosequences found in tropical forests by several  
45 authors [2,8] have reported floristic convergence with mature vegetation.

46 Although the literature cites some papers that point to convergence, it is known that there  
47 are studies reporting the floristic divergence along the chronosequence [9,10]. The authors  
48 argued that this may be due to less similarity of habitats and/or landscape effects [11]. On  
49 the landscape effect, [12] found that in landscapes with less than 10-30% of vegetation  
50 covering, there are negative effects on the persistence of the species due to the combined  
51 effect of landscape area and geometry, which may lead to convergent or divergent  
52 trajectories, according to the degree of vegetative cover.

53 From the perspective of the current literature, there is still a great deal of research to be  
54 done. The present research aims to characterize the changes in floristic composition in a  
55 chronosequence (5, 16, 24, 30 years of regeneration and mature forest). Thus, we sought to  
56 answer the following questions: From what age do young forests present a proportion of  
57 growth forms closer to the mature forest? Do young forests tend to diverge or converge  
58 floristically with mature forest?  
59

## 60 2. MATERIAL AND METHODS

### 61 2.1. Local study and selection of areas

63 The fragments of mature and young forest studied are located at the São José Plant (USJ)  
64 (07° 54' 17" - 07° 54' 41"S, 34° 54' 17" - 35° 05' 07"), located in the Zona da Mata Norte de  
65 Pernambuco, in the domain of the Dense Ombrophylous Forest [13]. The property occupies  
66 270 km<sup>2</sup>, where it has forest remnants that cover 24% of the landscape, being the average  
67 size of the fragments of 61 ha, occupying the less useful areas for planting [14].

68 The local climate is As' (hot and humid), with an annual average temperature of 24.9 °C,  
69 average rainfall of 1687 mm (Laboratory of Meteorology of Pernambuco - LAMEPE/ITEP).

70 Young forests with 5, 16, 24 and 30 years of regeneration were selected from aerial  
71 photographs of the 1960s, 1970s, 1980s, 2005 satellite images and interviews with former  
72 residents. As a comparison, an area of mature forest (over 60 years old) studied by [15] was  
73 selected. It is important to point out that mature forest is the one in which we can guarantee,  
74 based on cartographic material and interviews, that there was no intervention in the last 60  
75 years.

### 76 2.2. Data collect

77 Thirty plots of 10 × 10 m were sampled in each forest of the chronosequence, as well as the  
78 floristic survey near the plots. The collection was carried out by the walking method [16],  
79 according to the usual collection techniques for plants [17]. The studied habits were: 1)  
80 arboreal; 2) shrub; 3) grass; 4) bindweed (woody) and 5) epiphyte.

**Comment [a4]:** Material and methods. First part is Location of study area, second part is methodology. Secondly, a map of the study area is very vital.

**Comment [a5]:** Since forest grow on soils, it is also important to mention the soil type in the study area

**Comment [a6]:** I think this section is part of method used. It should be taken to methods. Clearly state how your images were taken and their differently resolutions and how the images help to differentiate the young from old forest. Also tell us in method how interviews help in the research and how the interview was conducted

**Comment [a7]:** Methods are not very clear. Clearly state the methods, how the plots were laid, tools and materials used. How identification of species was done. Did you measure the circumference of the tree species (dbh)? If you used any textbook to help in the identification process, You have to state it here.

### 81 2.3. Analysis and processing of data

82 The species sampled were identified with the help of experts and comparisons with  
83 collections deposited at the Herbarium Sergio Tavares (HST) and Dárdano de Andrade Lima  
84 (IPA). The exsiccates were placed in the Herbarium Professor Vasconcelos Sobrinho  
85 (PEUFR). The classification of angiosperm families followed the recommendations of [18].

86 To test the possible convergence or divergence of habits between the different dropout ages  
87 and the proportion between the different habits during the chronosequence, one-way  
88 ANOVA was applied, followed by the post-hoc Tukey test through the PAST 2.01 software  
89 [19].

90 In order to verify if there is floristic convergence between the young forests and the mature  
91 forest the degree of floristic similarity between the tree species in the chronosequence was  
92 evaluated. To do this, we performed: 1) a clustering analysis using the Jaccard similarity  
93 index and the mean linkage method per group (UPGMA) [20]; 2) Principal component  
94 analysis (PCA), Multidimensional linear analysis technique [21], and 3) non-metric  
95 multidimensional scaling (NMDS) [22]. Based on the tree species present in the five ages, a  
96 presence/absence matrix was elaborated to analyze if there would be indicator species for  
97 each age, using TWINSPLAN (Two Way Indicator Species Analysis) analysis [23] using PC-  
98 ORD version 4.0 [24]. The option to analyze only trees occurred because it is the best  
99 registered habit in the five areas.

100

### 101 3. RESULTS AND DISCUSSION

102

103 In the five fragments sampled, 198 taxa were recorded, distributed by 131 genera and 59  
104 families (Table 1). In the area of 5 years, 66 species and 42 families occurred, being  
105 Myrtaceae and Melastomataceae the most representative. In the forest of 16 years of  
106 abandonment, we found 75 species and 44 families, with greater representation of  
107 Fabaceae, especially the subfamilies Papilionoideae and Mimosoideae. In the area of 24  
108 years, 88 species and 51 families occurred, Myrtaceae being the one with the greatest  
109 number of species. In the 30 years, with 75 species and 41 families, with highlight to  
110 Myrtaceae and Fabaceae (Mimosoideae) families, due to the greater species richness. In  
111 the mature forest, there were 95 species and 52 families, with Myrtaceae, Sapindaceae and  
112 Rubiaceae with the largest number of species (Table 1).

113 The trends observed during the chronosequence in the fragments at the São José Plant  
114 revealed that in the youngest forest (5 years) there were several herbs with a short life cycle  
115 and an increase in the number of tree species and decrease of the herbs in the more  
116 advanced stages (16, 24, 30 and mature), what was pattern observed in other  
117 chronosequence studies [25,26,27].

118 Tree habit showed the highest number of families (43) and species (124), from these 124  
119 species, 51 occurred in the young forests and 72 in the mature forest, and the two groups  
120 shared 43 species. The families that presented the greatest wealth of trees were Myrtaceae  
121 and Fabaceae (Mimosoideae), with 15 and 10 species, respectively. There was an increase  
122 in the number of species in the families Sapindaceae, Annonaceae, Myrtaceae and  
123 Fabaceae throughout the chronosequence; from these 124 tree species recorded in young  
124 forests and mature forest, 15 species (12.9%) were common at all ages (Table 1).

125 The shrub habitat presented 13 families and 39 species. In the herbs group, 12 families and  
126 19 species were recorded (Table 1). Among the bindweed, nine families and 16 species

**Comment [a8]:** I prefer you use with to being.  
State as with .....being the most representative

**Comment [a9]:** Use short and precise sentences  
to discuss your work. Long sentences are confusing

**Comment [a10]:** Punctuation problem here.  
State your opening sentence very well and put a  
fullstop. Then continue a new sentence; From these  
124 species.....

**Comment [a11]:** You could also give the  
percentages of species represented in other ages.  
This gives chronology of your work and makes it  
more scientific

127 were recorded (Table 1). The epiphyte of the hemiparasite type *Psittacanthus dichrous*  
 128 (Loranthaceae) was found only in the young forest of 5 years.

129 It can be noticed an advance to a more typical pattern of mature forests from 16 years after  
 130 the abandonment, due to the increase of the trees and decrease of the herbaceous ones,  
 131 showing the directional substitution of forms of growth.

132 The small trees that occurred in all the young forests are typical species of edges and  
 133 clearings of forests [28,29], being present in the young forests in sunny areas [30].

Comment [a12]: Be explicit with your discussion so that readers can understand clearly

135 **Table 1. Species recorded in four fragments of young forests (5, 16, 24 and 30) and**  
 136 **a mature forest. ARO - Arboreal, TRE - Bindweed, ARB - Bush, ERV - Herb, EPI -**  
 137 **Epiphyte. Young forests (FJ5 = 5 years = 16 years FJ16, FJ24 = 24, FJ30 = 30 years)**  
 138 **and mature forest (FM). \* arborescent plant with similar size to tree. Through the**  
 139 **analysis of indicator species TWINSPAN: ♦ mature forest; • young forests.**

Specie	Habit	FJ5	FJ16	FS24	FS30	FM
<b>Anacardiaceae</b>						
<i>Anacardium occidentale</i> L.	ARO				X	
<i>Mangifera indica</i> L.	ARO		X			
<i>Tapirira guianensis</i> Aubl.	ARO	X	X	X	X	X
<i>Thyrsodium spruceanum</i> Benth.	ARO		X	X	X	X
<b>Annonaceae</b>						
<i>Anaxagorea dolichocarpa</i> Sprague & Sandwith	ARO		X			
<i>Annona salzmannii</i> A.DC.	ARO					X
<i>Guatteria cf. australis</i> A. St.-Hil.	ARO					X
<i>Guatteria pogonopus</i> Mart.	ARO					X
<i>Guatteria schomburgkiana</i> Mart. ♦	ARO	X	X			X
<i>Xylopia frutescens</i> Aubl. •	ARO	X	X	X	X	
<b>Apocynaceae</b>						
<i>Condylocarpon</i> sp.	TRE		X			
<i>Himathanthus phagedaenicus</i> (Mart.) Woodson	ARO	X	X	X	X	X
<i>Rauvolfia grandiflora</i> Mart. ex A.DC.	ARB		X	X		
<i>Tabernaemontana flavicans</i> Willd. ex Roem. & Schult.	ARO					X
<b>Araliaceae</b>						
<i>Schefflera morototoni</i> (Aubl.) Maguire, Steyerl. & Frodin	ARO	X	X	X	X	X
<b>Areceaceae</b>						
<i>Acrocomia sclerocarpa</i> Mart. *•	ARO	X	X	X	X	
<i>Bactris ferruginea</i> Burret *	ARO					X
<i>Desmoncus</i> sp.	TRE					X
<i>Elaeais guineensis</i> Jaquim *	ARO	X		X	X	

**Asteraceae**

*Conocliniopsis prassifolia* (DC.) R.M. King & H.Rob. ARB X

*Conyzas umatrensis* (Retz.) E. Walker. ARB X

*Pterocaulonalo pecuroides* (Lam.) DC. ERV X

*Sphagnetico latrilobata* (L.) Pruski ERV X

*Tilesiabaccata* (L.) Pruski ARB X X

**Boraginaceae** ARB X

*Tournefortia candidula* (Miers) I.M. Johnst.

**Burseraceae**

*Protium heptaphyllum* (Aubl.) Marchand ARO X X X X X

**Cecropiaceae**

*Cecropia pachystachya* Trécul. ARO X X X X X

**Celastraceae**

*Maytenus distichophylla* Mart. Ex Reissek ♦ ARO X X X X

*Maytenus obtusifolia* Mart. ARO X X X X

**Chrysobalanaceae**

*Hirtella racemosa* Lam. ARB X X X X

*Licania tomentosa* (Benth.) Fritsch ARO X

**Clusiaceae**

*Clusia nemorosa* G.Mey ARO X X X

*Rheedia gardneriana* Blanch. & Triana ARO X X

*Symphonia globulifera* L. f. ARO X X X

*Vismia guianensis* (Aubl.) Pers. • ARO X X X X

**Cochlospermaceae**

*Cochlospermum vitifolium* (Willd.) Spreng. ARO X X

**Combretaceae**

*Buchenavia tetraphylla* (Aubl.) R.A. Howard ARO X X

**Convolvulaceae**

*Jacquemontia glaucescens* Choisy. TRE X

**Dilleniaceae**

*Davilla aspera* (Aubl.) Benoist TRE X

*Davilla* sp. TRE X X

*Tetracera breyniana* Schltld. TRE X X

*Tetracera* sp. TRE X

**Ehretiaceae**

*Cordia multispicata* Cham. ARB X

*Cordia nodosa* Lam. ARB X X

*Cordia sellowiana* Cham. ARO X

<i>Cordia superba</i> Cham.	ARO					X
<b>Erythroxylaceae</b>						
<i>Erythroxylum citrifolium</i> A. St.-Hil.	ARB	X	X	X	X	X
<i>Erythroxylum mucronatum</i> Sw.	ARB		X			
<b>Euphorbiaceae</b>						
<i>Croton floribundus</i> Spreng.	ARO		X			
<i>Croton</i> sp.	ARO				X	
<i>Euphorbia hyssopifolia</i> L.	ERV	X				
<i>Microstachys corniculata</i> (Vahl) Griseb.	ERV	X				
<b>Fabaceae – Caesalpinoideae</b>						
<i>Apuleia leiocarpa</i> (Vogel) J.F. Macbr.	ARO	X	X		X	
<i>Bauhinia</i> sp.	ARO				X	
<i>Dialium guianense</i> (Aubl.) Sandwith ♦	ARO					X
<i>Senna georgica</i> H.S. Irwin & Barneby	ARB		X		X	
<i>Senna quinquangulata</i> (L.C. Rich.) H.S. Irwin & Barneby	ERV		X			
<i>Swartzia pickelii</i> Killip ex Ducke	ARO	X	X		X	
<b>Fabaceae – Mimosoideae</b>						
<i>Abarema cochliacarpus</i> (Gomez) Barneby & Grimes	ARO	X				X
<i>Albizia polycephala</i> (Benth.) Killip. •	ARO		X	X	X	
<i>Albizia saman</i> (Jacq.) F. Muell.	ARO			X	X	
<i>Inga cayennensis</i> Sagotex Benth.	ARO	X	X			X
<i>Inga flagelliformes</i> (Vell.) Mart.	ARO		X			
<i>Inga ingoides</i> (Rich.) Willd.	ARO			X	X	
<i>Inga thibaudiana</i> DC.	ARO		X	X	X	X
<i>Inga</i> sp.	ARO					X
<i>Plathymenia foliolosa</i> Benth.	ARO		X		X	X
<i>Stryphnodendron pulcherrimum</i> (Willd.) Hochr.	ARO				X	
<b>Fabaceae – Papilionoideae</b>						
<i>Andira fraxinifolia</i> Benth.	ARO		X			
<i>Andira nitida</i> Mart. Ex Benth.	ARO					X
<i>Bowdichia virgilioides</i> Kunth	ARO	X	X	X	X	X
<i>Desmodium axillare</i> (Sw.) DC.	ERV			X		
<i>Desmodium barbatum</i> (L.) Benth.	ERV	X				
<i>Dioclea virgata</i> (L.C. Rich.) Amshoff	TRE	X				
<i>Machaerium hirtum</i> (Vell.) Stellfeld	ARO			X	X	X
<i>Machaerium salzmannii</i> Benth.	ARO		X			
<i>Stylosanthes scabra</i> J. Vogel	ARB	X				

<b>Heliconiaceae</b>						
<i>Heliconia psittacorum</i> L.	ERV				X	
<i>Heliconia</i> sp.	ERV		X			
<b>Hernandiaceae</b>						
<i>Sparattanthelium botocudorum</i> Mart.	ARB		X	X	X	
<b>Humiriaceae</b>						
<i>Sacoglottis mattogrossensis</i> Benth.	ARO					X
<b>Lamiaceae</b>						
<i>Marsipianthes chamaedrys</i> (Vahl) Kuntze	ERV	X				
<b>Lauraceae</b>						
<i>Ocotea gardneri</i> (Meissn.) Mez	ARO					X
<i>Ocotea glomerata</i> (Nees) Mez	ARO		X	X	X	
<i>Ocotea indecora</i> (Schott) Mez	ARO					X
<i>Ocotea limae</i> Vattimo	ARO					X
<b>Lecythydaceae</b>						
<i>Eschweilera ovata</i> (Cambess.) Miers.	ARO	X	X	X	X	X
<i>Gustavia augusta</i> L.	ARO			X	X	
<i>Lecythis pisonis</i> (Cambess.) Miers. ♦	ARO					X
<b>Loganiaceae</b>						
<i>Strychnos bahiensis</i> Krukoff & Barneby	ARB		X			
<i>Strychnos</i> sp.	ARB				X	X
<b>Loranthaceae</b>						
<i>Psittacanthus dichrous</i> (Mart.) Mart.	EPI	X				
<b>Malpighiaceae</b>						
<i>Byrsonima sericea</i> A.DC.	ARO	X	X	X	X	X
<i>Stigmaphyllon blanchetii</i> C.E. Anderson	ERV				X	
<b>Malvaceae</b>						
<i>Apeiba tibourbou</i> Aubl. •	ARO		X	X	X	
<i>Guazuma ulmifolia</i> Pers.	ARO			X		
<i>Luehea paniculata</i> Mart.	ARO			X		X
<i>Sida rhombifolia</i> L.	ERV	X				
<b>Melastomataceae</b>						
<i>Clidemia capitellata</i> (Bonpl.) D. Don.	ARB	X	X	X	X	
<i>Clidemia hirta</i> Cong.	ARB	X				
<i>Henriettea succosa</i> (Aubl.) DC.	ARO	X	X			X
<i>Miconia albicans</i> (Benth.) Triana	ARB	X	X	X	X	X
<i>Miconia ciliata</i> (Rich.) DC.	ARB	X	X	X		X
<i>Miconia multiniflora</i> (Bonpl.) DC.	ARO	X	X	X	X	
<i>Miconia prasina</i> (Sw.) DC.	ARO			X	X	

<i>Miconia</i> sp.	ARB		X	X		
<b>Meliaceae</b>						
<i>Guarea guidonia</i> (L.) Sleumer	ARO		X			
<i>Trichilia lepidota</i> Mart.	ARO					X
<b>Menispermaceae</b>						
<i>Cissampelos</i> sp.	ERV					X
<b>Monimiaceae</b>						
<i>Siparuna guianensis</i> Aubl.	ARO		X	X	X	
<b>Moraceae</b>						
<i>Artocarpus heterophyllus</i> Lam. •	ARO		X	X	X	
<i>Brosimum guianense</i> (Aubl.) Huber	ARO	X	X	X	X	X
<i>Sorocea hilarii</i> Gaudich.	ARO		X	X	X	X
<b>Myristicaceae</b>						
<i>Virola gardneri</i> (A. DC.) Warb.	ARO		X			
<b>Myrsinaceae</b>						
<i>Rapanea guianensis</i> Aubl.	ARO		X	X	X	X
<b>Myrtaceae</b>						
<i>Calyptanthes brasiliensis</i> Spreng.	ARO			X		X
<i>Campomanesia dichotoma</i> (O.Berg) Mattos	ARO	X	X	X	X	X
<i>Eugenia florida</i> DC.	ARO			X		
<i>Eugenia puniceifolia</i> (Kunth) DC.	ARO	X			X	X
<i>Eugenia umbrosa</i> O. Berg	ARO					X
<i>Eugenia</i> sp.	ARO	X		X		X
<i>Myrcia fallax</i> (Rich.) DC.	ARO		X			X
<i>Myrcia guianensis</i> (Aubl.) DC.	ARO	X	X	X	X	X
<i>Myrcia racemosa</i> Barb. Rodr.	ARO	X	X	X	X	X
<i>Myrcia sylvatica</i> (G. Mey.) DC.	ARO	X	X	X		X
<i>Myrcia tomentosa</i> (Aubl.) DC.	ARO		X	X	X	
<i>Myrcia</i> sp.	ARO	X			X	
<i>Myrciaria ferruginea</i> O.Berg	ARO					X
<i>Psidium guajava</i> L.	ARO			X		
<i>Psidium guineense</i> Sw.	ARO	X	X	X	X	
<b>Nyctaginaceae</b>						
<i>Guapira laxa</i> (Netto) Furlan	ARO		X			
<i>Guapira nítida</i> (Schmidt) Lundell	ARO				X	X
<i>Guapira opposita</i> (Vell.) Reitz	ARO					X
<i>Neea</i> sp.	ARO					X
<b>Ochnaceae</b>						
<i>Ouratea castaneifolia</i> (DC.) Engl.	ARO					X



<b>Olacaceae</b>						
<i>Schoepfia brasiliensis</i> A. DC.	ARB		X			X
<i>Ximenia americana</i> L.	ARO	X				
<b>Passifloraceae</b>						
<i>Turnera ulmifolia</i> L.	ERV	X				
<b>Peraceae</b>						
<i>Pera ferruginea</i> (Schott) Müll. Arg.	ARO	X	X	X	X	X
<i>Pogonophora schomburgkiana</i> Miersex Benth.♦	ARO		X			X
<b>Piperaceae</b>						
<i>Piper arboreum</i> Aublet	ARB			X		X
<i>Piper marginatum</i> Jacq.	ARB			X		
<b>Poaceae</b>						
<i>Urochloa fusca</i> (Sw.) B.F. Hansen & Wunderlin	ERV			X		
<b>Polygonaceae</b>						
<i>Coccoloba mollis</i> Casar.	ARO			X	X	X
<b>Ranunculaceae</b>						
<i>Clematis dioica</i> L.	TRE			X		X
<b>Rhamnaceae</b>						
<i>Colubrina glandulosa</i> Perkins.	ARO			X		
<i>Gouania</i> sp.	TRE					X
<b>Rubiaceae</b>						
<i>Alseis pickelii</i> Pilg. & Schmale	ARO					X
<i>Borreria verticillata</i> (L.) G. Mey	ERV	X				
<i>Diodia apiculata</i> (Roem. & Schult.) K. Schum.	ERV			X		
<i>Diodia</i> sp.	ERV					X
<i>Genipa americana</i> L.	ARO	X				
<i>Palicourea crocea</i> (Sw.) Roem. & Schult.	ARB		X		X	X
<i>Posoqueria longiflora</i> Aubl.	ARO					X
<i>Posoqueria</i> sp.	ARO	X				
<i>Psychotria barbiflora</i> DC.	ARB		X	X	X	X
<i>Psychotria bracteocardia</i> (DC.) Müll. Arg.	ARB		X		X	
<i>Psychotria capitata</i> Ruiz & Pav.	ARB			X		
<i>Psychotria carthagenensis</i> Jacq.	ARO			X		X
<i>Psychotria cf. deflexa</i> DC.	ARB					X
<i>Psychotria hoffmannseggiana</i> (Willd. ex Roem. & Schult.)	ARB		X			
<i>Psychotria</i> sp.	ARB				X	
<i>Richardia grandiflora</i> (Cham. & Schtdl.)	ERV	X				

Steud						
<i>Sabicea grisea</i> Cham. & Schtdl.	TRE	X		X	X	
<i>Salzmannia nitida</i> DC.	ARB					X
Rubiaceae	ARB		X			
<b>Rutaceae</b>						
<i>Ertela trifolia</i> (L.) Kuntze	ERV	X				
<i>Zanthoxylum rhoifolium</i> Lam.	ARO			X		
<b>Salicaceae</b>						
<i>Banara brasiliensis</i> (Schott) Benth.	ARO			X		
<i>Banara guianensis</i> Aubl.	ARO			X		
<i>Casearia javitensis</i> Humb., Bonpl. & Kunth	ARO			X	X	X
<i>Casearia sylvestris</i> Sw.	ARO	X		X	X	X
<i>Casearia</i> sp.	ARO				X	
<b>Sapindaceae</b>						
<i>Allophylus edulis</i> (A.St.-Hil., Cambess. & A. Juss.) Radlk.	ARO	X	X	X	X	X
<i>Cupania oblongifolia</i> Mart.	ARO			X	X	X
<i>Cupania paniculata</i> Cambess.	ARO			X		
<i>Cupania racemosa</i> (Vell.) Radlk.	ARO	X	X	X	X	X
<i>Cupania revoluta</i> Radlk.	ARO			X	X	
<i>Cupania</i> sp.	ARO					X
<i>Paullinia pinnata</i> L.	TRE			X		X
<i>Paullinia trigona</i> Vell.	TRE		X		X	
<i>Serjania salzmanniana</i> Seem.	TRE			X		X
<i>Talisia esculenta</i> (A. St.-Hil) Radlk.	ARO	X		X	X	
<i>Talisia</i> sp.	ARO					X
Sapindaceae	TRE		X	X		
<b>Sapotaceae</b>						
<i>Pouteria grandiflora</i> (A.DC.) Baehni	ARO					X
<i>Pouteria peduncularis</i> (Mart. & Eichlerex Miq.) Baehni	ARO					X
<i>Pouteria</i> sp.	ARO					X
Sapotaceae	ARO			X		
<b>Simaroubaceae</b>						
<i>Simarouba amara</i> Aubl. ♦	ARO		X	X		X
<b>Solanaceae</b>						
<i>Solanum perum</i> Rich.	ARB			X		
<i>Solanum paludosum</i> Moric.	ARB	X			X	X
<i>Solanum</i> sp.	ARB	X				

**Verbenaceae**

<i>Aegiphila pernambucensis</i> Moldenke.	ARB		X
<i>Aegiphila vitelliniflora</i> Walpers.	ARB		X
<i>Aegiphila</i> sp.	ARB	X	
<i>Lantana radula</i> Sw.	ARB	X	X

**Violaceae**

<i>Amphirrhox longifolia</i> (A.St.-Hil.) Spreng.	ARO		X
<i>Paypayrola blanchetiana</i> Tul.	ARO	X	X

**Unknown 1**

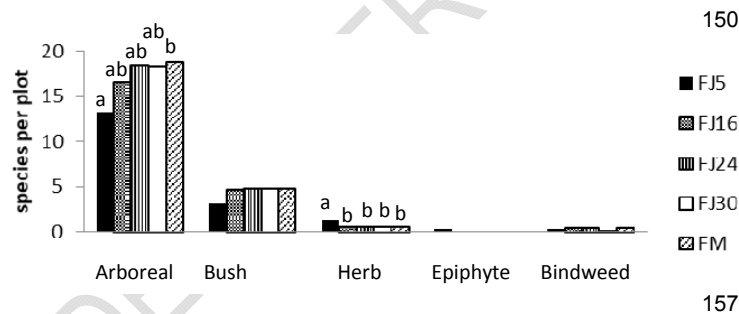
ERV	X
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**Unknown 2**

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Significant differences were observed in terms of number of species in tree and herbaceous habits among the different ages studied (Fig. 1). There was a trend of increasing tree species and decreasing of herbs along the chronosequence, where mature forest had the highest number of species ( $p < .02$ ) in relation to the young (5 years). In the chronosequence, another trend was observed, in which the richness of the herbaceous growth form decreased towards the mature forest, where the forest of the initial stage (5 years) presented the highest proportion, differing from the other forests studied ( $p < .01$ ) (Fig. 1). In this way, it was observed that from 16 years after the abandonment the proportion of the growth forms were closer to the mature forest.



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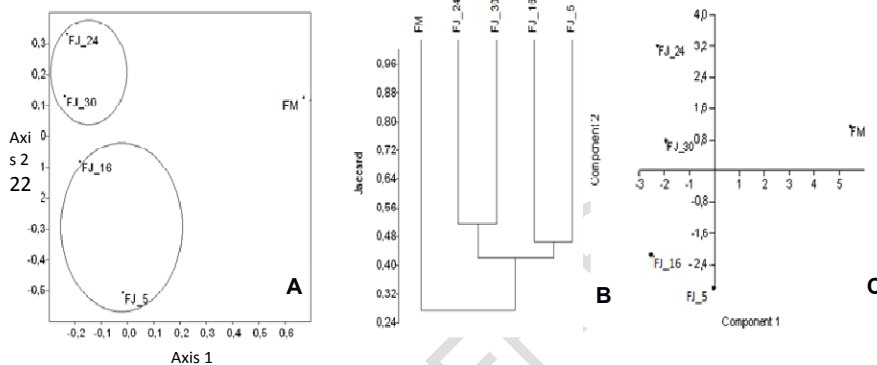
**Fig. 1. Average number of species per plot with different growth habits in four young forests (5, 16, 24 and 30) and a mature forest.** Letters indicate that the average within each habit do not differ by Tukey test ( $P < 0.05$ ) and the same letter are not statistically different from each other. Young forests (FJ5 = 5 years = 16 years FJ16, FJ24 = 24, FJ30 = 30 years) and mature forest (FM).

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However, the analysis of TWINSpan (Table 1) identified in division 1 (eigenvalue 0.911) the mature forest area of the young forests. *Albizia polycephala*, *Artocarpus heterophyllus*, *Xylopia frutescens*, *Apeiba tibourbou* and *Vismia guianensis* were arboreal species indicative of young forests, as well as the *Acrocomia sclerocarpa* palm, which was also common in young forests. In the mature forest, only species with more advanced stages were found, such as *Pogonophora schomburgkiana*, *Simarouba amara*, *Guatteria schomburgkiana*, *Maytenus distichophylla*, *Dialium guianense* and *Lecythis pisonis* (Table 1). The species considered as indicators of mature forest are in agreement with several authors

173 [28,29], since they are species with similar habitat characteristics, being common in the inner  
174 of forests and shaded areas.

175 NMDS analysis applied to the tree species in the chronosequence revealed the formation of  
176 two groups, isolating the mature forest (FM) (Fig. 2A). The grouping analysis individualized  
177 the mature forest (FM) and two groups, one formed by the young forests of 5 (FJ 5) and 16  
178 years (FJ 16) of regeneration, with 46% similarity and a second formed by the young forests  
179 of 24 (FJ 24) and 30 years (FJ 30), with 50% similarity (Fig. 2B). The two groups composed  
180 of young forests (FJ 5 - FJ 16 and FJ 24 - FJ 30) differed from mature forest in floristic  
181 composition with 28% similarity. This same pattern was also evident in the principal



182 component analyzes (PCA) (Fig. 2C).

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184 **Fig. 2. Multivariate analysis based on the presence and absence of tree species**  
185 **sampled in young and mature forest forests. Ordination by the not metric**  
186 **multidimensional scaling method (NMDS) (A), cluster analysis generated by the**  
187 **Jaccard similarity indices and average link method group (B) and principal**  
188 **component analysis (C). Young forests (FJ\_5 = 5 years FJ\_16 = 16, FJ\_24 = 24, FJ\_30**  
189 **= 30 years) and mature forest (FM).**

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191 The results of all multivariate analyzes indicate the formation of two groups of young forests  
192 (5 and 16 years old and another 24 and 30 years old), individualizing the mature forests. The  
193 literature also points out that the recovery of floristic young forests occurs slowly [31,2].  
194 Regarding this slowness, the fact that young forests and mature forest share 43 tree  
195 species, 15 in all forests, suggests that the floristic composition of young forests tends to  
196 converge with mature forest, as well as recorded in several researches in tropical forests  
197 [2,32,33,34,30].

198 It can be hypothesized that the floristic convergence and the strong influence of the initial  
199 floristic composition on the chronosequence flora in the fragments may be related to the fact  
200 that this area presents more than 24% vegetation cover, since, according to [12], landscapes  
201 above the threshold of 10-30% of covering tend to have positive effects on the persistence of  
202 species, leading to different trajectories according to the size and connectivity of the  
203 patches.

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205 **4. CONCLUSIONS**

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In the chronosequence studied at the São José Plant, it can be seen that from 16 years, young forests tended to converge with mature forest in proportion of tree and herbaceous species. The distribution of 43 tree species among young and mature forests suggests that the floristic composition of young forests tends to resemble that of mature forest, confirming the hypotheses of floristic convergence.

Floristic convergence may have been influenced by the São José Plant landscape, which has a 24% vegetation cover, facilitating the persistence of the species in the studied fragments. In addition to sharing 43 species, there were 15 species that were present at all ages, supporting the hypothesis of initial floristic composition, in which the species that participate in the succession over time are established from the beginning in the abandoned area.

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**COMPETING INTERESTS**

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Authors have declared that no competing interests exist.

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