

Floristic Composition in Chronosequence in Atlantic Rainforest Fragments

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Authors' contributions

This work was carried out in collaboration among all authors. Authors AVFP, MAMS, MJHL, GHS, AVLL, LMN, ACBLS and MJNR performed field data collection and statistical design and wrote first draft of the manuscript. Author MJNR assisted in the final approve of the manuscript.

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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. In each forest 30 plots of 10 × 10 m were installed for canopy sampling, and within these 100 m² were installed plots of 5 × 5 m for sampling the woody sub-forest at the lower left corner. The growth habits analyzed were arboreal (diameter at breast height, DBH ≥ 5 cm), shrubs (DBH < 5 cm and stem diameter at ground level > 1 cm), herbs, epiphytes and climbing plants. The results suggest that from 16 young forests tended to converge with the mature forest in terms of the proportion of growth forms.

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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 [1,2,3]. 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 is determined more by the initial floristic composition of an area than by the floristic rotation proposed by [4].

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

Although the literature cites some papers that point to convergence, it is known that there are studies reporting the floristic divergence along the chronosequence [9,10]. The authors argued

that this may be due to less similarity of habitats and/or landscape effects [11]. On the landscape effect, [12] found that in landscapes with less than 10-30% of vegetation covering, there are negative effects on the persistence of the species due to the combined effect of landscape area and geometry, which may lead to convergent or divergent trajectories, according to the degree of vegetative cover.

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

2. MATERIALS AND METHODS

2.1 Local Study and Selection of Areas

The fragments of mature and young forest studied are located at the São José Plant (USJ) (07° 54' 17" - 07° 54' 41"S, 34° 54' 17" - 35° 05' 07"), located in the Zona da Mata Norte de Pernambuco, in the domain of the Dense Ombrophylous Forest [13]. The property occupies 270 km², where it has forest remnants that cover 24% of the landscape, being the average size of the fragments of 61 ha, occupying the less useful areas for planting [14].

The local climate is As' (hot and humid), with an annual average temperature of 24.9°C, average rainfall of 1687 mm (Laboratory of Meteorology of Pernambuco - LAMEPE/ITEP). The geological formation is of the Grupo Barreiras type, of plio-pleistocene age, with predominantly sandy soils and strongly undulating relief [15].

2.2 Data Collect

Young forests with 5, 16, 24 and 30 years of regeneration were selected from aerial photographs (1:30,000) of the 1960s, 1970s, 1980s (CONDEPE/FIDEM), IKONOS satellite images acquired in 2005 (1:50,000) and narrative interviews with former residents. Through the captured images it is possible to perform visual

interpretation taking into account the color, tone and texture aspects to distinguish the different successional stages. The narrative interviews were carried out with the residents of the surrounding area to help in obtaining information about the history of land use. As comparison, an area of mature forest (over 60 years old) studied by [16] was selected. It is important to point out that mature forest is the one in which we can guarantee, based on cartographic material and interviews, that there was no intervention in the last 60 years (Fig. 1).

Were installed 30 plots of 10 × 10 m in each forest of the chronosequence, for sampling all woody individuals (trees, bindweed and palm

trees) with stem diameter at 1.30 m of soil (DAP) > 5 cm. In the interior of these plots, were installed in the lower left corner a 5 × 5 m plot for sub-forest sampling (plants with stem diameter at ground level (DAS) ≥ 1 and DAP < 5 cm. Each sample was identified with a sequential numbered aluminum plate, measured on the circumference using a tape measure and estimated the total height (with a ruler marked every 50 cm).

The collection was carried out by the walking method [17], according to the usual collection techniques for plants [18]. The studied habits were: 1) arboreal; 2) shrub; 3) grass; 4) bindweed (woody) and 5) epiphyte.

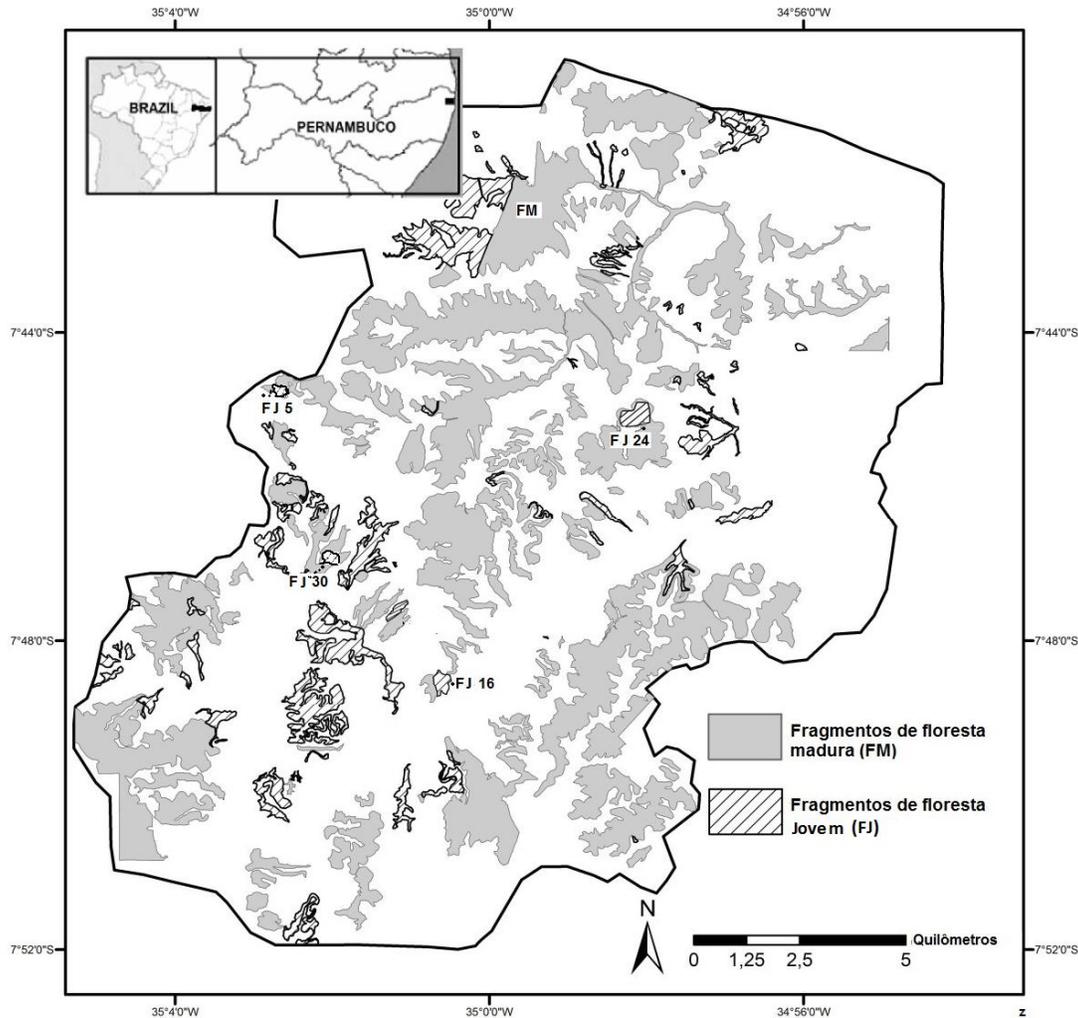


Fig. 1. Location of young forests (FJ 5 = 5 years, FJ = 16 years, FJ = 24 years and FJ 30 = 30 years) and mature forest (FM = over 60 years old) of the São José, Igarassu, Pernambuco, Brazil

2.3 Analysis and Processing of Data

The species sampled were identified with the help of experts and comparisons with collections deposited at the Herbarium Sergio Tavares (HST) and Dárdano de Andrade Lima (IPA). The exsiccates were placed in the Herbarium Professor Vasconcelos Sobrinho (PEUFR). The classification of angiosperm families followed the recommendations of [19].

To test the possible convergence or divergence of habits between the different dropout ages and the proportion between the different habits during the chronosequence, one-way ANOVA was applied, followed by the post-hoc Tukey test through the PAST 2.01 software [20].

In order to verify if there is floristic convergence between the young forests and the mature forest the degree of floristic similarity between the tree species in the chronosequence was evaluated. To do this, we performed: 1) a clustering analysis using the Jaccard similarity index and the mean linkage method per group (UPGMA) [21]; 2) Principal component analysis (PCA), Multidimensional linear analysis technique [22], and 3) non-metric multidimensional scaling (NMDS) [23]. Based on the tree species present

in the five ages, a presence/absence matrix was elaborated to analyze if there would be indicator species for each age, using TWINSpan (Two Way Indicator Species Analysis) analysis [24] using PC-ORD version 4.0 [25]. The option to analyze only trees occurred because it is the best registered habit in the five areas.

3. RESULTS

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

Table 1. Species recorded in four fragments of young forests (5, 16, 24 and 30) and a mature forest

Family	Specie	Habit	FJ5	FJ16	FS24	FS30	FM
Anacardiaceae	<i>Anacardium occidentale</i> L.	ARO				X	
	<i>Mangifera indica</i> L.	ARO		X			
	<i>Tapiriraguianensis</i> Aubl.	ARO	X	X	X	X	X
	<i>Thyrsodium spruceanum</i> Benth.	ARO		X	X	X	X
Annonaceae	<i>Anaxagore adolichocarpa</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>Xylopi a frutescens</i> Aubl. •	ARO	X	X	X	X	
Apocynaceae	<i>Condyllocarpon</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
Araliaceae	<i>Schefflera morototoni</i> (Aubl.) Maguire, Steyer. & Frodin	ARO	X	X	X	X	X

Family	Specie	Habit	FJ5	FJ16	FS24	FS30	FM
Arecaceae	<i>Acrocomiasclerocarpa</i> Mart.*	ARO	X	X	X	X	
	<i>Bactrisferruginea</i> Burret*	ARO					X
	<i>Desmoncus</i> sp.	TRE					X
	<i>Elaeaisguineensis</i> Jaquim *	ARO	X		X	X	
Asteraceae	<i>Conocliniopsisprassifolia</i> (DC.) R.M. King &H.Rob.	ARB					X
	<i>Conyzasumatrensis</i> (Retz.) E. Walker.	ARB	X				
	<i>Pterocaulonalopecuroides</i> (Lam.) DC.	ERV	X				
	<i>Sphagneticolatrilibata</i> (L.) Pruski	ERV	X				
	<i>Tilesiabaccata</i> (L.) Pruski	ARB		X	X		
Boraginaceae	<i>Tournefortiacandidula</i> (Miers) I.M. Johnst.	ARB		X			
Burseraceae	<i>Protium heptaphyllum</i> (Aubl.) Marchand	ARO	X	X	X	X	X
Cecropiaceae	<i>Cecropia pachystachya</i> Trécul.	ARO	X	X	X	X	X
Celastraceae	<i>Maytenusdistichophylla</i> Mart. Ex Reissek ♦	ARO		X	X		X
	<i>Maytenusobtusifolia</i> Mart.	ARO	X				X
Chrysobalanaceae	<i>Hirtellaracemosa</i> Lam.	ARB	X		X	X	X
	<i>Licaniatomentosa</i> (Benth.) Fritsch	ARO	X				
Clusiaceae	<i>Clusianemorosa</i> G.Mey	ARO	X				X
	<i>Rheediagardneriana</i> Tlanch. &Triana	ARO					X
	<i>Symphonia globulifera</i> L. f.	ARO		X			
	<i>Vismiaguianensis</i> (Aubl.) Pers.*	ARO	X	X	X	X	
Cochlospermaceae	<i>Cochlospermumvitifolium</i> (Willd.) Spreng.	ARO		X	X		
Combretaceae	<i>Buchenaviatetraphylla</i> (Aubl.) R.A. Howard	ARO				X	X
Convolvulaceae	<i>Jacquemontiaglaucescens</i> Chois y.	TRE	X				
Dilleniaceae	<i>Davilla aspera</i> (Aubl.) Benoist	TRE		X			
	<i>Davillasp.</i>	TRE					X
	<i>Tetracerabreyniana</i> Schtdl.	TRE		X	X		
	<i>Tetracerasp.</i>	TRE	X				
Ehretiaceae	<i>Cordia multispicata</i> Cham.	ARB				X	
	<i>Cordia nodosa</i> Lam.	ARB				X	X
	<i>Cordia sellowiana</i> Cham.	ARO				X	
	<i>Cordia superba</i> Cham.	ARO					X
Erythroxylaceae	<i>Erythroxylumcitrifolium</i> A. St.-Hil.	ARB		X	X	X	X
	<i>Erythroxylummucronatum</i> Sw.	ARB			X		
Euphorbiaceae	<i>Croton floribundus</i> Spreng.	ARO			X		
	<i>Croton</i> sp.	ARO				X	
	<i>Euphorbia hyssopifolia</i> L.	ERV	X				
	<i>Microstachyscorniculata</i> (Vahl) Griseb.	ERV	X				
Fabaceae	<i>Abarema cochliacarpos</i> (Gomez) Barneby & Grimes	ARO	X				X
	<i>Albiziapolycephala</i> (Benth.) Killip.*	ARO		X	X	X	
	<i>Albiziasaman</i> (Jacq.) F. Muell.	ARO			X	X	

Family	Specie	Habit	FJ5	FJ16	FS24	FS30	FM
	<i>Andirafraxinifolia</i> Benth.	ARO		X			
	<i>Andira nítida</i> Mart. Ex Benth.	ARO					X
	<i>Apuleia leiocarpa</i> (Vogel) J.F. Macbr.	ARO	X	X		X	
	<i>Bauhinia</i> sp.	ARO				X	
	<i>Bowdichiavirgilioides</i> Kunth	ARO	X	X	X	X	X
	<i>Desmodiumaxillare</i> (Sw.) DC.	ERV			X		
	<i>Desmodiumbarbatum</i> (L.) Benth.	ERV	X				
	<i>Dialiumguianense</i> (Aubl.) Sandwith ♦	ARO					X
	<i>Dioclea virgata</i> (L.C.Rich.) Amshoff	TRE	X				
	<i>Inga cayennensis</i> SagotexBenth.	ARO	X	X			X
	<i>Inga flagelliformes</i> (Vell.) Mart.	ARO		X			
	<i>Inga ingoides</i> (Rich.) Willd.	ARO			X	X	
	<i>Inga</i> sp.	ARO					X
	<i>Inga thibaudiana</i> DC.	ARO		X	X	X	X
	<i>Machaeriumhirtum</i> (Vell.) Stellfeld	ARO			X	X	X
	<i>Machaeriumsalzmannii</i> Benth.	ARO		X			
	<i>Plathymeniafoliolosa</i> Benth.	ARO		X		X	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>Stryphnodendronpulcherrimum</i> (Willd.) Hochr.	ARO				X	
	<i>Stylosanthescabra</i> J. Vogel	ARB	X				
	<i>Swartziapickelii</i> Killip ex Ducke	ARO	X	X		X	
Heliconiaceae	<i>Heliconia psittacorum</i> L.	ERV				X	
	<i>Heliconia</i> sp.	ERV				X	
Hernandiaceae	<i>Sparattantheliumbotocudorum</i> M art.	ARB			X	X	X
Humiriaceae	<i>Sacoglottismattogrossensis</i> Bent h.	ARO					X
Lamiaceae	<i>Marsypiantheschamaedrys</i> (Vahl) Kuntze	ERV	X				
Lauraceae	<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
Lecythidaceae	<i>Eschweilera ovata</i> (Cambess.) Miers.	ARO	X	X	X	X	X
	<i>Gustaviaaugusta</i> L.	ARO			X	X	
	<i>Lecythispisonis</i> (Cambess.) Miers. ♦	ARO					X
Loganiaceae	<i>Strychnosbahiensis</i> Krukoff&Barn eby	ARB		X			
	<i>Strychnos</i> sp.	ARB				X	X
Loranthaceae	<i>Psittacanthusdichrous</i> (Mart.) Mart.	EPI	X				
Malpighiaceae	<i>Byrsonima sericea</i> A.DC.	ARO	X	X	X	X	X
	<i>Stigmaphyllonblanchetii</i> C.E. Anderson	ERV				X	

Family	Specie	Habit	FJ5	FJ16	FS24	FS30	FM
Malvaceae	<i>Apeibatibourbou</i> Aubl. •	ARO		X	X	X	
	<i>Guazumaulmifolia</i> Pers.	ARO			X		
	<i>Lueheapaniculata</i> Mart.	ARO			X		X
	<i>Sidarhombifolia</i> L.	ERV	X				
Melastomataceae	<i>Clidemia capitellata</i> (Bonpl.) D. Don.	ARB	X	X	X	X	
	<i>Clidemiahirta</i> Cong.	ARB	X				
	<i>Henrietteasuccosa</i> (Aubl.) DC.	ARO	X	X			X
	<i>Miconia albicans</i> (Benth.) Triana	ARB	X	X	X	X	X
	<i>Miconiaciliata</i> (Rich.) DC.	ARB	X	X	X		X
	<i>Miconiaminultiflora</i> (Bonpl.) DC.	ARO	X	X	X	X	
	<i>Miconiaprasiina</i> (Sw.) DC.	ARO			X	X	
	<i>Miconiasp.</i>	ARB			X	X	
Meliaceae	<i>Guareaguidonia</i> (L.) Sleumer	ARO			X		
	<i>Trichiliaepidota</i> Mart.	ARO					X
Menispermaceae	<i>Cissampelosp.</i>	ERV					X
Monimiaceae	<i>Siparunaguianensis</i> Aubl.	ARO		X	X	X	
Moraceae	<i>Artocarpusheterophyllus</i> Lam. •	ARO		X	X	X	
	<i>Brosimumguianense</i> (Aubl.) Huber	ARO	X	X	X	X	X
	<i>Soroceahilarii</i> Gaudich.	ARO		X	X	X	X
Myristicaceae	<i>Virola gardneri</i> (A. DC.) Warb.	ARO		X			
Myrsinaceae	<i>Rapaneaguianensis</i> Aubl.	ARO		X	X	X	X
Myrtaceae	<i>Calyptranthesbrasiliensis</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 sp.</i>	ARO	X		X		X
	<i>Myrciafallax</i> (Rich.) DC.	ARO		X			X
	<i>Myrciaguianensis</i> (Aubl.) DC.	ARO	X	X	X	X	X
	<i>Myrciaracemosa</i> Barb. Rodr.	ARO	X	X	X	X	X
	<i>Myrcia sylvatica</i> (G. Mey.) DC.	ARO	X	X	X		X
	<i>Myrciatomentosa</i> (Aubl.) DC.	ARO		X	X	X	
	<i>Myrciasp.</i>	ARO	X			X	
	<i>Myrciariaferrugínea</i> O.Berg	ARO					X
	<i>Psidium guajava</i> L.	ARO			X		
<i>Psidium guineense</i> Sw.	ARO	X	X	X	X		
Nyctaginaceae	<i>Guapiralaxa</i> (Netto) Furlan	ARO		X			
	<i>Guapiranítida</i> (Schmidt) Lundell	ARO				X	X
	<i>Guapiraopposita</i> (Vell.) Reitz	ARO					X
	<i>Neeasp.</i>	ARO					X
Ochnaceae	<i>Ourateacastaneifolia</i> (DC.) Engl.	ARO					X
Olacaceae	<i>Schoepfiabrasiliensis</i> A. DC.	ARB		X			X
	<i>Ximeniaamericana</i> L.	ARO	X				
Passifloraceae	<i>Turneraulmifolia</i> L.	ERV	X				
Peraceae	<i>Peraferrugínea</i> (Schott) Müll. Arg.	ARO	X	X	X	X	X
	<i>Pogonophoraschomburgkiana</i> Miers & Benth. ♦	ARO		X			X
Piperaceae	<i>Piper arboreum</i> Aublet	ARB			X		X
	<i>Piper marginatum</i> Jacq.	ARB			X		
Poaceae	<i>Urochloafusca</i> (Sw.) B.F. Hansen & Wunderlin	ERV			X		

Family	Specie	Habit	FJ5	FJ16	FS24	FS30	FM
Polygonaceae	<i>Coccolobamollis</i> Casar.	ARO			X	X	X
Ranunculaceae	<i>Clematis dioica</i> L.	TRE			X		X
Rhamnaceae	<i>Colubrina glandulosa</i> Perkins.	ARO			X		
	<i>Gouaniasp.</i>	TRE					X
Rubiaceae	<i>Alseispickelii</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>Diodiasp.</i>	ERV					X
	<i>Genipaamericana</i> L.	ARO	X				
	<i>Palicoureaacrocea</i> (Sw.) Roem. &Schult.	ARB		X		X	X
	<i>Posoquerialongiflora</i> Aubl.	ARO					X
	<i>Posoqueriasp.</i>	ARO	X				
	<i>Psychotriabarbiflora</i> DC.	ARB		X	X	X	X
	<i>Psychotria bracteocardia</i> (DC.) Müll. Arg.	ARB		X		X	
	<i>Psychotriacapitata</i> Ruiz & Pav.	ARB			X		
	<i>Psychotriacarthagenensis</i> Jacq.	ARO			X		X
	<i>Psychotria cf. deflexa</i> DC.	ARB					X
	<i>Psychotriahoffmannseggiana</i> (Wil Id. ex Roem. &Schult.)	ARB		X			
	<i>Psychotriasp.</i>	ARB				X	
	<i>Richardia grandiflora</i> (Cham. &Schltdl.) Steud	ERV	X				
	<i>Sabiceagrisea</i> Cham. &Schltdl.	TRE	X		X	X	
	<i>Salzmannianitida</i> DC.	ARB					X
	Rubiaceae	ARB		X			
Rutaceae	<i>Ertelatrifolia</i> (L.) Kuntze	ERV	X				
	<i>Zanthoxylumrhoifolium</i> Lam.	ARO			X		
Salicaceae	<i>Banarabraziliensis</i> (Schott) Benth.	ARO			X		
	<i>Banaraguianensis</i> Aubl.	ARO			X		
	<i>Caseariajavitensis</i> Humb., Bonpl. &Kunth	ARO			X	X	X
	<i>Caseariasylvestris</i> Sw.	ARO	X		X	X	X
	<i>Caseariasp.</i>	ARO				X	
Sapindaceae	<i>Allophylus edulis</i> (A.St.-Hil., Cambess. & A. Juss.) Radlk.	ARO	X	X	X	X	X
	<i>Cupaniaoblongifolia</i> Mart.	ARO			X	X	X
	<i>Cupaniapaniculata</i> Cambess.	ARO			X		
	<i>Cupaniaracemosa</i> (Vell.) Radlk.	ARO	X	X	X	X	X
	<i>Cupaniarevoluta</i> Radlk.	ARO			X	X	
	<i>Cupaniasp.</i>	ARO					X
	<i>Paulliniapinnata</i> L.	TRE			X		X
	<i>Paullinia trigona</i> Vell.	TRE		X		X	
	<i>Serjantiasalzmanniana</i> Seem.	TRE			X		X
	<i>Talisia esculenta</i> (A. St.-Hil) Radlk.	ARO	X		X	X	
	<i>Talisiasp.</i>	ARO					X
	Sapindaceae	TRE		X	X		
Sapotaceae	<i>Pouteria grandiflora</i> (A.DC.) Baehni	ARO					X
	<i>Pouteriapeduncularis</i> (Mart. &Eic hlerexMiq.) Baehni	ARO					X

Family	Specie	Habit	FJ5	FJ16	FS24	FS30	FM
	<i>Pouteriasp.</i>	ARO					X
	Sapotaceae	ARO			X		
Simaroubaceae	<i>Simaroubaamara</i> Aubl. ♦	ARO		X	X		X
Solanaceae	<i>Solanumasperum</i> Rich.	ARB			X		
	<i>Solanum paludosum</i> Moric.	ARB	X			X	X
	<i>Solanum sp.</i>	ARB	X				
Verbenaceae	<i>Aegiphilapernambucensis</i> Molde nke.	ARB			X		
	<i>Aegiphilavitelliniflora</i> Walpers.	ARB			X		
	<i>Aegiphilasp.</i>	ARB	X				
	<i>Lantana radula</i> Sw.	ARB	X			X	
Violaceae	<i>Amphirrhoxlongifolia</i> (A.St.-Hil.) Spreng.	ARO			X		
	<i>Paypayrolablanchetiana</i> Tul.	ARO		X			X
	Unknown 1	ERV		X			
	Unknown 2	ERV		X			

ARO - Arboreal, TRE - Bindweed, ARB - Bush, ERV - Herb, EPI - Epiphyte. Young forests (FJ5 = 5 years = 16 years FJ16, FJ24 = 24, FJ30 = 30 years) and mature forest (FM). * - arborescent plant with similar size to tree. Through the analysis of indicator species TWINSpan: ♦ mature forest; • young forests. "X" inside the table represents the presence of the specie in the fragments

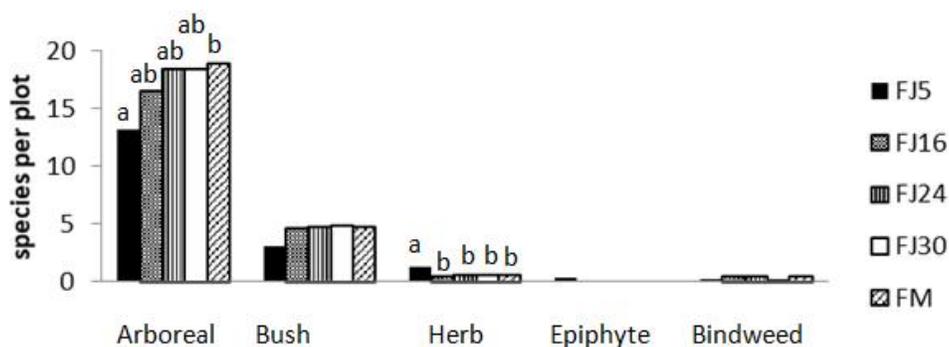


Fig. 2. Average number of species per plot with different growth habits in four young forests (5, 16, 24 and 30) and a mature forest

Equal letters within each habit do not differ by Tukey test ($P < .05$). Young forests (FJ5 = 5 years old, FJ16 = 16 years old, FJ24 = 24 years old, FJ30 = 30 years old, and mature forest FM = over 60 years old)

Tree habit showed the highest number of families, with 43 families and 124 species. From these 124 species 51 occurred in the young forests and 72 in the mature forest, and the two groups shared 43 species. The families that presented the greatest wealth of trees were Myrtaceae and Fabaceae (Mimosoideae), with 15 and 10 species, respectively. There was an increase in the number of species in the families Sapindaceae, Annonaceae, Myrtaceae and Fabaceae throughout the chronosequence; from these 124 tree species recorded in young forests

and mature forest, 15 species (12.9%) were common at all ages (Table 1).

The shrub habitat presented 13 families and 39 species. In the herbs group, 12 families and 19 species were recorded (Table 1). Among the bindweed, nine families and 16 species were recorded (Table 1). The epiphyte of the hemiparasite type *Psittacanthus dichrous* (Loranthaceae) was found only in the young forest of 5 years.

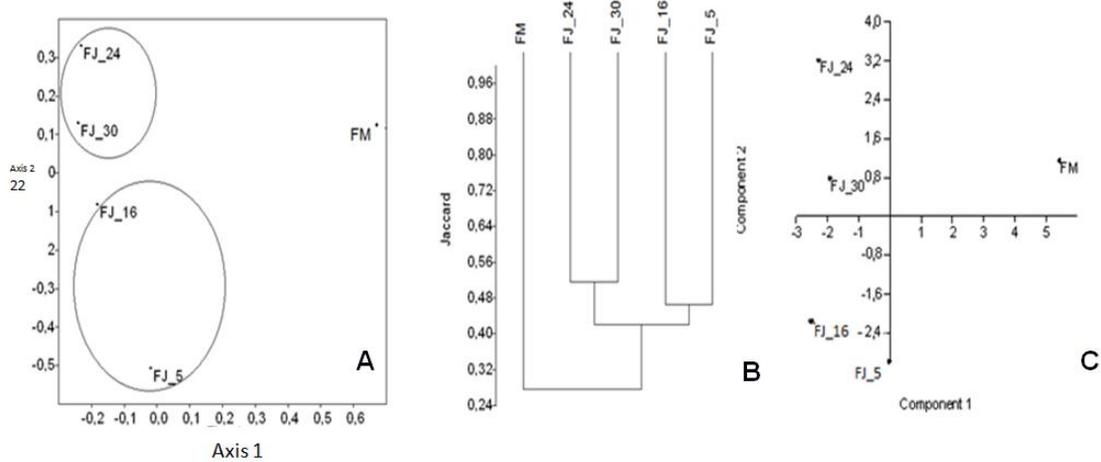


Fig. 3. Multivariate analysis based on the presence and absence of tree species sampled in young and mature forest forests. Ordination by the not metric multidimensional scaling method (NMDS) (A), cluster analysis generated by the Jaccard indices and average link method group (B) and principal component analysis (C). Young forests (FJ_5 = 5 years, FJ_16 = 16, FJ_24 = 24, FJ_30 = 30 years) and mature forest (FM = over 60 years)

Significant differences were observed in terms of number of species in tree and herbaceous habits among the different ages studied (Fig. 2). 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).

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*, *Gutteria schomburgkiana*, *Maytenus distichophylla*, *Dialium guianense* and *Lecythis pisonis* (Table 1).

NMDS analysis applied to the tree species in the chronosequence revealed the formation of two groups, isolating the mature forest (FM) (Fig. 3A). The grouping analysis individualized the mature forest (FM) and two groups, one formed by the young forests of 5 (FJ 5) and 16 years (FJ 16) of regeneration, with 46% similarity and a second formed by the young forests of 24 (FJ 24) and 30 years (FJ 30), with 50% similarity (Fig.

3B). The two groups composed of young forests (FJ 5 - FJ 16 and FJ 24 - FJ 30) differed from mature forest in floristic composition with 28% similarity. This same pattern was also evident in the principal component analyzes (PCA) (Fig. 3C).

4. DISCUSSION

The trends observed during the chronosequence in the fragments revealed that in the youngest forest (5 years) there were several herbs with a short life cycle; also was an increase in the number of tree species and decrease of the herbs in the more advanced stages (16, 24, 30 and mature), what was pattern observed in other chronosequence studies [26,27,28].

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

The small trees that occurred in all the young forests are typical species of edges and clearings of forests [29,30], being present in the young forests in sunny areas [31].

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. 2); this could be attributed to the canopy gaps in the 5 years forest as compared to the mature forest where the canopy is highly dense without allowing enough penetration of sunlight to the forest floor. 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.

The species considered as indicators of mature forest are in agreement with several authors [29,30], since they are species with similar habitat characteristics, being common in the inner of forests and shaded areas.

The results of all multivariate analyzes indicate the formation of two groups of young forests (5 and 16 years old and another 24 and 30 years old), individualizing the mature forests. The literature also points out that the recovery of floristic young forests occurs slowly [32,2]. Regarding this slowness, the fact that young forests and mature forest share 43 tree species, 15 in all forests, suggests that the floristic composition of young forests tends to converge with mature forest, as well as recorded in several researches in tropical forests [2,33,34,35,31].

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

5. CONCLUSIONS

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.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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