

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. 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.

13
14
15
16
17
18
19
20
21
22
23
24
25

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 [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.

26
27
28
29
30
31
32
33
34

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].

35
36

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

37 unpredictable events that results from interactions between individuals and the abiotic
38 environment, involving different patterns (convergence or divergence), mechanisms and
39 causes that lead to complex paths that will determine the processes of recovery of the local
40 vegetation. The results of chronosequences found in tropical forests by several authors [2,8]
41 have reported floristic convergence with mature vegetation.

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

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

56 2. MATERIAL AND METHODS

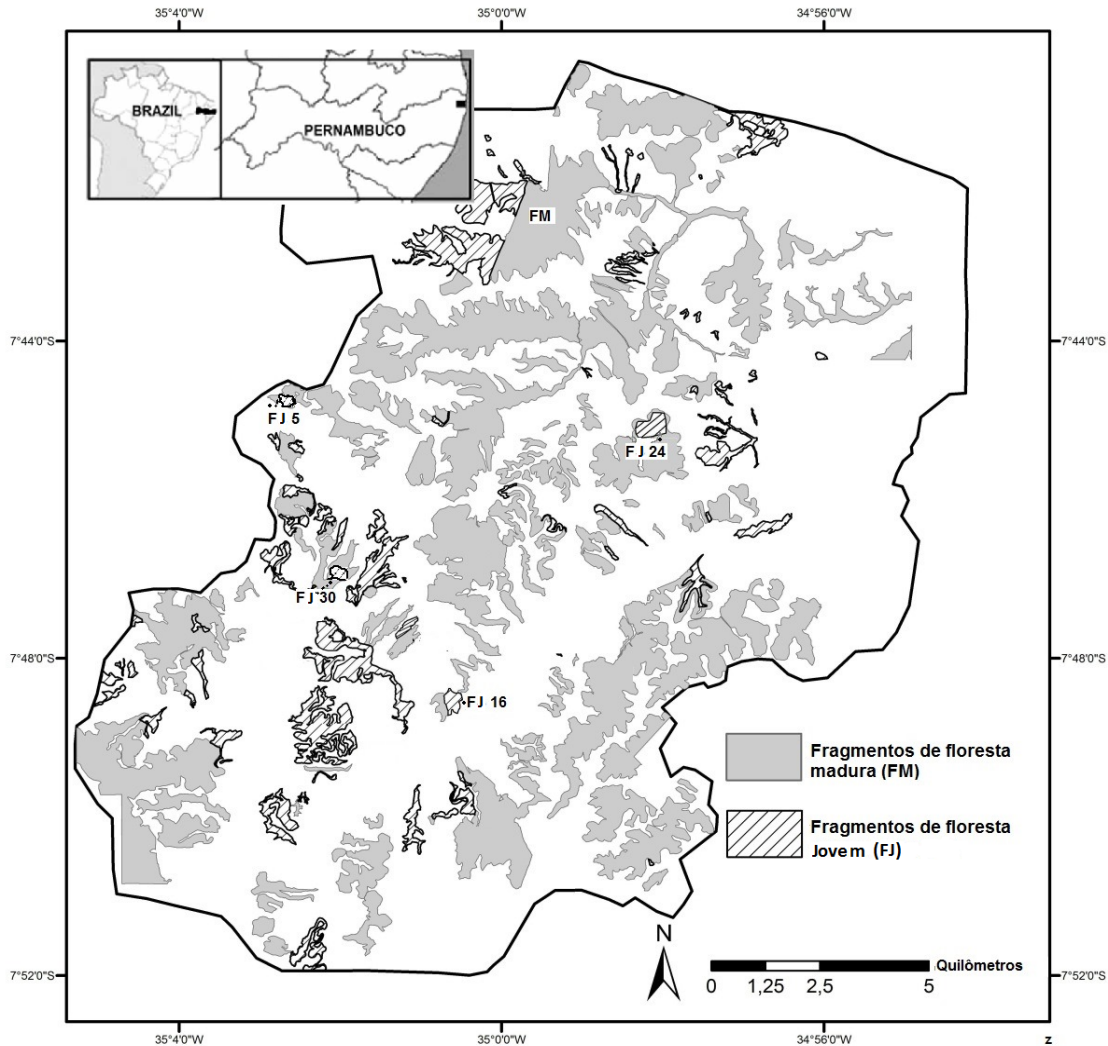
58 2.1. Local study and selection of areas

59 The fragments of mature and young forest studied are located at the São José Plant (USJ)
60 (07° 54' 17" - 07° 54' 41"S, 34° 54' 17" - 35° 05' 07"), located in the Zona da Mata Norte de
61 Pernambuco, in the domain of the Dense Ombrophylous Forest [13]. The property occupies
62 270 km², where it has forest remnants that cover 24% of the landscape, being the average
63 size of the fragments of 61 ha, occupying the less useful areas for planting [14].

64 The local climate is As' (hot and humid), with an annual average temperature of 24.9 °C,
65 average rainfall of 1687 mm (Laboratory of Meteorology of Pernambuco - LAMEPE/ITEP).
66 The geological formation is of the Grupo Barreiras type, of plio-pleistocene age, with
67 predominantly sandy soils and strongly undulating relief [35].

68 2.2. Data collect

69 Young forests with 5, 16, 24 and 30 years of regeneration were selected from aerial
70 photographs (1:30,000) of the 1960s, 1970s, 1980s (CONDEPE/FIDEM), IKONOS satellite
71 images acquired in 2005 (1:50,000) and narrative interviews with former residents. Through
72 the captured images it is possible to perform visual interpretation taking into account the
73 color, tone and texture aspects to distinguish the different successional stages. The narrative
74 interviews were carried out with the residents of the surrounding area to help in obtaining
75 information about the history of land use. As comparison, an area of mature forest (over 60
76 years old) studied by [15] was selected. It is important to point out that mature forest is the
77 one in which we can guarantee, based on cartographic material and interviews, that there
78 was no intervention in the last 60 years (Fig. 1).



79

80 Fig. 1 - Location of young forests (FJ 5 = 5 years, FJ = 16 years, FJ = 24 years and FJ 30 =
 81 30 years) and mature forest (FM = over 60 years old) of the São José, Igarassu,
 82 Pernambuco, Brazil.

83

84 Were installed 30 plots of 10 × 10 m in each forest of the chronosequence, for sampling all
 85 woody individuals (trees, bindweed and palm trees) with stem diameter at 1.30 m of soil
 86 (DAP) > 5 cm. In the interior of these plots, were installed in the lower left corner a 5 × 5 m
 87 plot for sub-forest sampling (plants with stem diameter at ground level (DAS) ≥ 1 and DAP
 88 <5 cm. Each sample was identified with a sequential numbered aluminum plate, measured
 89 on the circumference using a tape measure and estimated the total height (with a ruler
 90 marked every 50 cm).

91

The collection was carried out by the walking method [16], according to the usual collection
 92 techniques for plants [17]. The studied habits were: 1) arboreal; 2) shrub; 3) grass; 4)
 93 bindweed (woody) and 5) epiphyte.

94

95

2.3. Analysis and processing of data

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

100 To test the possible convergence or divergence of habits between the different dropout ages
 101 and the proportion between the different habits during the chronosequence, one-way
 102 ANOVA was applied, followed by the post-hoc Tukey test through the PAST 2.01 software
 103 [19].

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

114

115 3. RESULTS

116

117 In the five fragments sampled, 198 taxa were recorded, distributed by 131 genera and 59
 118 families (Table 1). In the area of 5 years, 66 species and 42 families, being the most
 119 representative: Myrtaceae and Melastomataceae. In the forest of 16 years of abandonment,
 120 we found 75 species and 44 families, with greater representation of Fabaceae, especially the
 121 subfamilies Papilionoideae and Mimosoideae. In the area of 24 years, 88 species and 51
 122 families occurred, Myrtaceae being the one with the greatest number of species. In the 30
 123 years, with 75 species and 41 families, with highlight to Myrtaceae and Fabaceae
 124 (Mimosoideae) families, due to the greater species richness. In the mature forest, there were
 125 95 species and 52 families, with Myrtaceae, Sapindaceae and Rubiaceae with the largest
 126 number of species (Table 1).

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

134 The shrub habitat presented 13 families and 39 species. In the herbs group, 12 families and
 135 19 species were recorded (Table 1). Among the bindweed, nine families and 16 species
 136 were recorded (Table 1). The epiphyte of the hemiparasite type *Psittacanthus dichrous*
 137 (Loranthaceae) was found only in the young forest of 5 years.

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

140

Family	Specie	Habit	FJ 5	FJ1 6	FS2 4	FS 30	F M
Anacardiaceae	<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	X
Annonaceae	<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	
Apocynaceae	<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
Araliaceae	<i>Schefflera morototoni</i> (Aubl.) Maguire, Steyerm. & Frodin	ARO	X	X	X	X	X
Arecaceae	<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	<i>Conocliniopsis prassifolia</i> (DC.) R.M. King & H. Rob.	ARB					X
	<i>Conyzas umatrensis</i> (Retz.) E. Walker.	ARB	X				
	<i>Pterocaulonalo pecuroides</i> (Lam.) DC.	ERV	X				
	<i>Sphagnetico latrilobata</i> (L.) Pruski	ERV	X				
	<i>Tilesia baccata</i> (L.) Pruski	ARB		X	X		
Boraginaceae	<i>Tournefortia candidula</i> (Miers) I.M. Johnst.	ARB		X			
Burseraeae	<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>Maytenus distichophylla</i> Mart. Ex Reissek ♦	ARO		X	X		X
	<i>Maytenus obtusifolia</i> Mart.	ARO	X				X
Chrysobalanaceae	<i>Hirtella racemosa</i> Lam.	ARB	X		X	X	X
	<i>Licania tomentosa</i> (Benth.) Fritsch	ARO	X				
Clusiaceae	<i>Clusia nemorosa</i> G.Mey	ARO	X				X
	<i>Rheedia gardneriana</i> Tlanch. & Triana	ARO					X
	<i>Symphonia globulifera</i> L. f.	ARO		X			
	<i>Vismia guianensis</i> (Aubl.) Pers. •	ARO	X	X	X	X	
Cochlospermaceae	<i>Cochlospermum vitifolium</i> (Willd.) Spreng.	ARO		X	X		
Combretaceae	<i>Buchenavia tetraphylla</i> (Aubl.) R.A. Howard	ARO				X	X
Convolvulaceae	<i>Jacquemontia glaucescens</i> Choisy.	TRE	X				

Dilleniaceae	<i>Davilla aspera</i> (Aubl.) Benoist	TRE	X				
	<i>Davilla</i> sp.	TRE					X
	<i>Tetracera breyniana</i> Schltld.	TRE	X	X			
	<i>Tetracera</i> sp.	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>Erythroxylum citrifolium</i> A. St.-Hil.	ARB	X	X	X	X	X
	<i>Erythroxylum mucronatum</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>Microstachys corniculata</i> (Vahl) Griseb.	ERV	X				
Fabaceae	<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>Andira fraxinifolia</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>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>Dialium guianense</i> (Aubl.) Sandwith ♦	ARO					X
	<i>Dioclea virgata</i> (L.C.Rich.) Amshoff	TRE	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</i> sp.	ARO					X
	<i>Inga thibaudiana</i> DC.	ARO	X	X	X	X	X
	<i>Machaerium hirtum</i> (Vell.) Stellfeld	ARO		X	X	X	X
	<i>Machaerium salzmannii</i> Benth.	ARO	X				
	<i>Plathyenia foliolosa</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>Stryphnodendron pulcherrimum</i> (Willd.) Hochr.	ARO				X		
<i>Stylosanthes scabra</i> J. Vogel	ARB	X					
<i>Swartzia pickelii</i> Killip ex Ducke	ARO	X	X		X		
Heliconiaceae	<i>Heliconia psittacorum</i> L.	ERV				X	

	<i>Heliconia</i> sp.	ERV		X			
Hernandiaceae	<i>Sparattanthelium botocudorum</i> Mart.	ARB		X	X	X	
Humiriaceae	<i>Sacoglottis mattogrossensis</i> Benth.	ARO					X
Lamiaceae	<i>Marsypianthes chamaedrys</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>Gustavia augusta</i> L.	ARO			X	X	
	<i>Lecythis pisonis</i> (Cambess.) Miers. ♦	ARO					X
Loganiaceae	<i>Strychnos bahiensis</i> Krukoff & Barneby	ARB		X			
	<i>Strychnos</i> sp.	ARB				X	X
Loranthaceae	<i>Psittacanthus dichrous</i> (Mart.) Mart.	EPI	X				
Malpighiaceae	<i>Byrsonima sericea</i> A.DC.	ARO	X	X	X	X	X
	<i>Stigmaphyllon blanchetii</i> C.E. Anderson	ERV					X
Malvaceae	<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				
Melastomataceae	<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	
Meliaceae	<i>Guarea guidonia</i> (L.) Sleumer	ARO			X		
	<i>Trichilia lepidota</i> Mart.	ARO					X
Menispermaceae	<i>Cissampelos</i> sp.	ERV					X
Monimiaceae	<i>Siparuna guianensis</i> Aubl.	ARO		X	X	X	
Moraceae	<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
Myristicaceae	<i>Virola gardneri</i> (A. DC.) Warb.	ARO		X			
Myrsinaceae	<i>Rapanea guianensis</i> Aubl.	ARO		X	X	X	X
Myrtaceae	<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	
Nyctaginaceae	<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
Ochnaceae	<i>Ouratea castaneifolia</i> (DC.) Engl.	ARO					X
Olacaceae	<i>Schoepfia brasiliensis</i> A. DC.	ARB		X			X
	<i>Ximenia americana</i> L.	ARO	X				
Passifloraceae	<i>Turnera ulmifolia</i> L.	ERV	X				
Peraceae	<i>Pera ferruginea</i> (Schott) Müll. Arg.	ARO	X	X	X	X	X
	<i>Pogonophora schomburgkiana</i> Miersex 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		
Polygonaceae	<i>Coccoloba mollis</i> Casar.	ARO			X	X	X
Ranunculaceae	<i>Clematis dioica</i> L.	TRE			X		X
Rhamnaceae	<i>Colubrina glandulosa</i> Perkins.	ARO			X		
	<i>Gouania</i> sp.	TRE					X
Rubiaceae	<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		

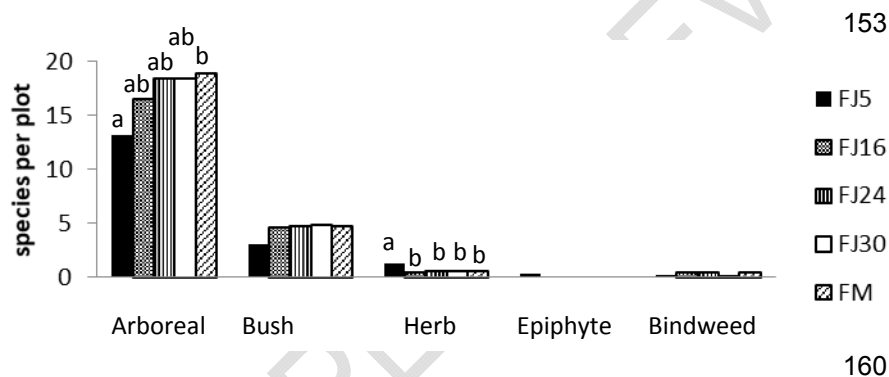
	<i>Psychotria carthagenensis</i> Jacq.	ARO			X			X
	<i>Psychotria cf. deflexa</i> DC.	ARB						X
	<i>Psychotria hoffmannseggiana</i> (Willd. ex Roem. & Schult.)	ARB		X				
	<i>Psychotria</i> sp.	ARB					X	
	<i>Richardia grandiflora</i> (Cham. & Schltld.) Steud	ERV	X					
	<i>Sabicea grisea</i> Cham. & Schltld.	TRE	X		X	X		
	<i>Salzmannia nitida</i> DC.	ARB						X
	Rubiaceae	ARB		X				
Rutaceae	<i>Ertela trifolia</i> (L.) Kuntze	ERV	X					
	<i>Zanthoxylum rhoifolium</i> Lam.	ARO			X			
Salicaceae	<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	X
	<i>Casearia sylvestris</i> Sw.	ARO	X		X	X	X	X
	<i>Casearia</i> sp.	ARO					X	
Sapindaceae	<i>Allophylus edulis</i> (A.St.-Hil., Cambess. & A. Juss.) Radlk.	ARO	X	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			
Sapotaceae	<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			
Simaroubaceae	<i>Simarouba amara</i> Aubl. ♦	ARO		X	X			X
Solanaceae	<i>Solanum asperum</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	
	Unknown 2	ERV	X	

141
142
143
144
145
146
147
148

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.

149 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
150 highest number of species ($p < .02$) in relation to the young (5 years).
151
152



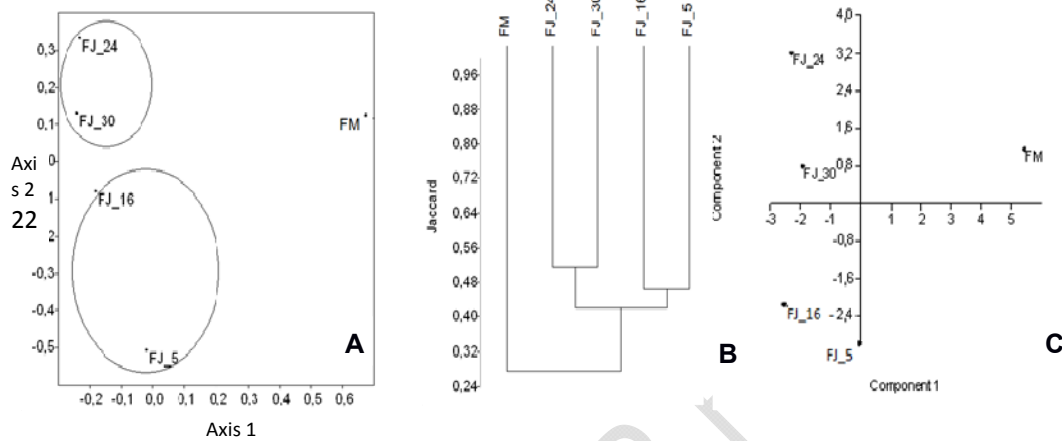
161
162
163
164
165
166
167

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).

168 However, the analysis of TWINSpan (Table 1) identified in division 1 (eigenvalue 0.911) the
169 mature forest area of the young forests. *Albizia polycephala*, *Artocarpus heterophyllus*,
170 *Xylopia frutescens*, *Apeiba tibourbou* and *Vismia guianensis* were arboreal species
171 indicative of young forests, as well as the *Acrocomia sclerocarpa* palm, which was also
172 common in young forests. In the mature forest, only species with more advanced stages
173 were found, such as *Pogonophora schomburgkiana*, *Simarouba amara*, *Gutteria*
174 *schomburgkiana*, *Maytenus distichophyla*, *Dialium guianense* and *Lecythis pisonis* (Table 1).

175 NMDS analysis applied to the tree species in the chronosequence revealed the formation of
 176 two groups, isolating the mature forest (FM) (Fig. 3A). 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. 3B). 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. 3C).

183
 184 **Fig. 3. 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 = over 60 years).**

190
 191 **4. DISCUSSION**

192
 193 The trends observed during the chronosequence in the fragments revealed that in the
 194 youngest forest (5 years) there were several herbs with a short life cycle; also was an
 195 increase in the number of tree species and decrease of the herbs in the more advanced
 196 stages (16, 24, 30 and mature), what was pattern observed in other chronosequence studies
 197 [25,26,27].

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

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

203
 204 In the chronosequence, another trend was observed, in which the richness of the
 205 herbaceous growth form decreased towards the mature forest, where the forest of the initial
 206 stage (5 years) presented the highest proportion, differing from the other forests studied ($p <$
 207 $.01$) (Fig. 2); this could be attributed to the canopy gaps in the 5 years forest as compared to

208 the mature forest where the canopy is highly dense without allowing enough penetration of
209 sunlight to the forest floor. In this way, it was observed that from 16 years after the
210 abandonment the proportion of the growth forms were closer to the mature forest.

211 The species considered as indicators of mature forest are in agreement with several authors
212 [28,29], since they are species with similar habitat characteristics, being common in the inner
213 of forests and shaded areas.

214 The results of all multivariate analyzes indicate the formation of two groups of young forests
215 (5 and 16 years old and another 24 and 30 years old), individualizing the mature forests. The
216 literature also points out that the recovery of floristic young forests occurs slowly [31,2].
217 Regarding this slowness, the fact that young forests and mature forest share 43 tree
218 species, 15 in all forests, suggests that the floristic composition of young forests tends to
219 converge with mature forest, as well as recorded in several researches in tropical forests
220 [2,32,33,34,30].

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

227

228 **5. CONCLUSIONS**

229

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

235

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

242

243 **COMPETING INTERESTS**

244

245 Authors have declared that no competing interests exist.

246

247 **REFERENCES**

248

249 1. Denich M. Estudo da importância de uma vegetação secundária nova para o incremento
250 da produtividade do sistema de produção na Amazônia Oriental Brasileira. Belém: Embrapa
251 - CPATU/ GTZ; 1991.

252

253 2. Chazdon RL, Peres CA, Dent D, Sheil D, Lugo AE, Lamb D et al. The potential for species
254 conservation in tropical secondary forests. *Conservation Biology*. 2009;23(6): 1406-1417.
255 Doi: <https://doi.org/10.1111/j.1523-1739.2009.01338.x>

256

- 257 3. Chazdon, RL. Regeneração de florestas tropicais. Boletim do Museu Paraense Emílio
258 Goeldi. Ciências Naturais. 2012;7(3): 195-218.
259
- 260 4. Clements FE. Plant succession: analysis of the development of vegetation. Washington,
261 D.C.: Carnegie Institute of Washington Publication; 1916.
262
- 263 5. Gleason HA. The individualistic concept of the plant association. Bulletin of the Torrey
264 Botanical Club. 1926;53(1): 7-26.
265
- 266 6. Egler FE. Vegetation science concepts I. Initial floristic composition, a factor in old-field
267 vegetation development. Plant Ecology. 1954;4(10): 412-417.
268
- 269 7. Pickett STA, Collins SL, Armeto JJ. A hierarchical consideration of causes and
270 mechanisms of succession. Vegetatio. 1987;69(1): 109-114.
271
- 272 8. Piotto D, Montagnini F, Thomas W, Ashton M, Oliver C. Forest recovery after swidden
273 cultivation across a 40-year chronosequence in the Atlantic forest of southern Bahia, Brazil.
274 Plant Ecology. 2009;205(2): 261-272. Doi: doi: 10.1007/s11258-009-9615-2.
275
- 276 9. Toledo M, Poorter L, Pena-Claros M, Alarcon A, Balcazar J, Chuvina J et al. Patterns and
277 determinants of floristic variation across lowland forests of Bolivia. Biotropica. 2011;43(4):
278 405-413. Doi: 10.1111/j.1744-7429.2010.00711.x.
279
- 280 10. Harvey BJ, Holzman BA. Divergent successional pathways of stand development
281 following fire in a California closed-cone pine forest. Journal of Vegetation Science. 2014;25
282 (1): 88-99. Doi: <https://doi.org/10.1111/jvs.12073>.
283
- 284 11. Del Moral R, Saura JM, Emenegger JN. Primary succession trajectories on a barren
285 plain, Mount St. Helens, Washington. Journal of Vegetation Science. 2010;21(5): 857-867.
286 Doi: <https://doi.org/10.1111/j.1654-1103.2010.01189.x>.
287
- 288 12. Andrén H. Effects of habitat fragmentation on birds and mammals in landscapes with
289 different proportions of suitable habitat: a review. Oikos. 1994
290
- 291 13. IBGE – (Instituto Brasileiro de Geografia e Estatística). Manual técnico da vegetação
292 brasileira. Manuais técnicos em Geociências, 1. Rio de Janeiro: IBGE; 2012.
293
- 294 14. Trindade MB, Lins-e-Silva ACB, Silva HP, Filgueira, SB, Schessl M. Fragmentation of
295 the Atlantic Rainforest in the northern coastal region of Pernambuco, Brazil: recent changes
296 and implications for conservation. Bioremediation, Biodiversity and Bioavailability. 2008;2(1):
297 5-13.
298
- 299 15. Silva MAM. Efeito de borda na estrutura e na dinâmica espaço-temporal de um
300 fragmento de Mata Atlântica no nordeste do Brasil. Recife: Universidade Federal Rural de
301 Pernambuco; 2010.
302
- 303 16. Filgueiras TS, Brochado AL, Nogueira PE, Guala II GF. Caminhamento: um método
304 expedito para levantamentos florísticos qualitativos. Cadernos de Geociências. 1994;12(1):
305 39-43.
306
- 307 17. Mori AS, Silva LAM, Lisboa G, Coradin L. Manual de manejo do herbário fanerogâmico.
308 Ilhéus: Centro de Pesquisas do Cacau; 1989.
309

- 310 18. APG III. An update of the Angiosperm Phylogeny Group classification for the orders and
311 families of flowering plants: APG III. *Botanical Journal of the Linnean Society*. 2009;161(2):
312 105-121. Doi: <https://doi.org/10.1111/j.1095-8339.2009.00996.x>.
313
- 314 19. Hammer Ø, Harper DAT, Ryan PD. PAST: Paleontological statistics software package
315 for education and data analysis. *Paleont Electronica* 4: 9p.
316 http://www.paleoelectronica.org/2001_1/past/issue1_01.htm.
317
- 318 20. Brower JE, Zar JH. *Field and laboratory methods for general ecology*. 2^aed. Iowa, W.C.
319 Brown Company Publishes; 1984.
320
- 321 21. Jongman RHG, Ter Braak CJF, Van Tongeren OFR. editors. *Data analysis in community
322 and landscape ecology*, 2nd Edition. New York: Cambridge University Press. 1995; 71(3):
323 355-366.
324
- 325 22. Clarke KR, Warwick RM. *Change in marine communities: an approach to statistical
326 analysis and interpretation*. Plymouth: Plymouth Marine Laboratory; 1994.
327
- 328 23. Valentim JA. *Ecologia numérica: uma introdução a análise multivariada de dados
329 ecológicos*. Rio de Janeiro: Interciência; 2000.
330
- 331 24. Mccune B, Mefford MJ. *PC-ORD version 4.0: Multivariate analysis of ecological data –
332 users guide*. MjM Software Design. Glaneden Beach; 1999.
333
- 334 25. Gómez-Pompa A, Vázquez-Yanes C. Successional studies of a rain forest in México. In:
335 West DC, Shugart HH, Botkin DB. (Eds.), *Forest succession: concepts and application*. New
336 York: Springer-Verlag; 1981.
337
- 338 26. Finegan B. Pattern and process in Neotropical secondary rain forests: the first 100 years
339 of succession. *Trends in Ecology and Evolution*. 1996;11(3): 119-124.
340
- 341 27. Spyreas G, Meiners SJ, Matthews JW, Molano-Flores B. Successional trends in floristic
342 quality. *Journal of Applied Ecology*. 2012;49(2): 339-348. Doi: [doi: 10.1111/j.1365-
343 2664.2011.02100.x](https://doi.org/10.1111/j.1365-2664.2011.02100.x).
344
- 345 28. Alves Júnior FT, Brandão CFL, Rocha KD, Marangon LC, Ferreira RLC. Efeito de borda
346 na estrutura de espécies arbóreas em um fragmento de Floresta Ombrófila Densa, Recife,
347 PE. *Revista Brasileira de Ciências Agrárias*. 2006;1(1): 49-56.
348
- 349 29. Gomes JS, Lins-e-Silva ACB, Rodal MJN, Silva HCH. Estrutura do sub-bosque lenhoso
350 em ambientes de borda e interior de dois fragmentos de floresta atlântica em Igarassu,
351 Pernambuco, Brasil. *Rodriguésia*. 2009;60(2): 295-310.
352
- 353 30. Nascimento LM, Sampaio EVSB, Rodal MJN, Lins-e-Silva ACB. Natural forest
354 regeneration in abandoned sugarcane fields in northeastern Brazil: floristic changes. *Biota
355 Neotropica*. 2012;(12): 1-14. Doi: <http://dx.doi.org/10.1590/S1676-06032012000400009>.
356
- 357 31. Guariguata MR, Ostertag R. Neotropical secondary forest succession: changes in
358 structural and functional characteristics. *Forest Ecology and Management*. 2001;148(9):
359 185-206.
360

- 361 32. Letcher SG, Chazdon RL. Rapid recovery of biomass, species richness, and species
362 composition in a forest chronosequence in Northeastern Costa Rica. *Biotropica*. 2009;41(5):
363 608-617. Doi: <https://doi.org/10.1111/j.1744-7429.2009.00517.x>.
364
- 365 33. Norden N, Chazdon RL, Chao A, Jiang YH, Vilchez-Alvarado B. Resilience of tropical
366 rain forests: tree community reassembly in secondary forests. *Ecology Letters*. 2009;12(4):
367 385-394. Doi: <https://doi.org/10.1111/j.1461-0248.2009.01292.x>.
368
- 369 34. Nascimento LM, Sampaio EVSB, Rodal MJN, Lins-e-Silva ACB. Secondary succession
370 in a fragmented Atlantic Forest landscape: evidence of structural and diversity convergence
371 along a chronosequence. *Journal of Forest Research*. 2014;19(6):1-13. Doi:
372 <https://doi.org/10.1007/s10310-014-0441-6>.
373
- 374 35. Companhia Pernambucana de Recursos Hídricos, CPRH. Diagnóstico socioambiental
375 do litoral norte de Pernambuco. Companhia Pernambucana do Meio Ambiente, Recife;
376 2003.
377
378
379

UNDER PEER REVIEW