ATLANTIC FOREST REGENERATION IN ABANDONED PLANTATIONS OF EUCALYPT (*Corymbia citriodora* (Hook.) K.D.Hill and L.A.S.Johnson) IN RIO DE JANEIRO, BRAZIL

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SUMMARY

*This study evaluated the floristic and phytosociological structure of the native tree community of the Atlantic Forest in five plantations of eucalypt (*Corymbia citriodora*) abandoned since 1996 in the União Biological Reserve, Rio de Janeiro, Brazil. Eleven years after abandonment, plots of 20×10m were established totaling 0.1ha, in five different stands. A total of 219 individuals with DBH ≥5cm were sampled and distributed in 18 families and 36 species. The most important species were* Xylopia sericea*,* Eugenia supraaxillaris*,* Cupania oblongifolia *and* Annona dolabripetala*. Fabaceae was the richest family in species, followed by Myrtaceae and Bignoniaceae. Annonaceae was the family that had the greatest number of individuals, followed by Myrtaceae and Sapindaceae. The density and basal area per ha, by stands, ranged from 0 to 1010 individuals and 0 to 9.9$m^2 \cdot ha^{-1}$, respectively. Species richness ranged from 0 (stand 4) to 22 (stand 2). The results indicate a low natural regeneration in the understory of the eucalypt stands 11 years after abandonment. The possible inhibitory role of* Corymbia citriodora *in the establishment and growth of native tree species is discussed.*

Introduction

The Atlantic forest is suffering a continual process of fragmentation of its original forest cover, resulting in loss of biodiversity (Scariot *et al*., 2005). It is believed that this biome has been reduced to about 7% of its original area (Myers *et al*., 2000). Human pressure in the Atlantic forest has generally been related to the expansion of agro-forestry, which entails the replacement of native forests by plantations of sugar cane, pastures and eucalypt plantations for industrial use (Lima, 1996).

In Brazil it is estimated that the plantation of different species of eucalypt occupy an area >3×10^{6}ha (Mora and García, 2000), with the highest concentration in the states of Paraná, São Paulo and Minas Gerais. These species have great economic importance, being widely used in the production of paper and charcoal, in the pharmaceutical, cosmetic and perfumery industries, in the manufacture of cleaning supplies, and in construction, among others. Their rapid growth, high resistance to drought, high re-growth capacity, low cost of establishment of plantations and low requirements of soil quality and rainfall make many species of eucalypt ideal for reforestation (Schneider, 2003). Pires *et al*. (2006) stressed the importance of the percentage of ground cover provided by eucalypt litter in plantations. According to these authors, this is a key factor in reducing soil loss by erosion; they conclude that among the studied forest systems, the eucalypt plantation was the closest to the native forest in terms of soil loss. However, studies of impact on the soil by eucalypt plantations are still incipient.

The use of forest plantations for land reclamation and as a catalyst for restoration of native forests has been considered an important strategy since, in general, they present a rapid growth and provide favorable conditions for germination and establishment of native species (Parrota *et al*., 1997; Feyera *et al*., 2002). Some studies have shown that eucalypt plantations can be successfully used in the recovery of degraded areas, serving as a facilitator for the regeneration of native species (Silva Júnior *et al*., 1995; Geldenhuys, 1997; Feyera *et al*., 2002; Sartori *et al*., 2002; Souza *et al*., 2007; Nóbrega *et al*., 2008). However, some species of eucalypt, such as *Corymbia citriodora* (Hook.) K. D. Hill & L. A. S. Johnson (≡ *Eucalyptus citriodora* Hook.) have been considered harmful because of allelopathy (Nishimura *et al*., 1984) and their slow decomposition (Rezende *et al*., 2001), which could complicate or even prevent the germination and growth of other species (Clark and Clark, 1991; Schneider, 2003, Ostertag *et al*., 2008). Other concerns common to the eucalypt species are related to the reduction of groundwater due to overuse, growth suppression of other species that may cause an increase in soil erosion and, finally, the low capacity of eucalypt forests to support fauna (Schneider, 2003).

In this context, the objective of the present work was to evaluate the structure and flo-

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REGENERACIÓN DE LA SELVA ATLÁNTICA EN PLANTACIONES ABANDONADAS DE EUCALIPTO (*Corymbia citriodora* (Hook.) K. D. Hill and L. A. S. Johnson) EN RIO DE JANEIRO, BRASIL

Vinicios Troncone Evaristo, João Marcelo Alvarenga Braga y Marcelo Trindade Nascimento

RESUMEN

*Se evaluó la estructura florística y fitosociológica de la comunidad de árboles nativos de la Selva Atlántica en cinco plantaciones de eucalipto (*Corymbia citriodora*) abandonadas desde 1996 en la Reserva Biológica União, Río de Janeiro, Brasil. Once años después de ser abandonadas se establecieron lotes de 20×10m, totalizando 0,1ha, en cinco parcelas diferentes. El muestreo incluyó un total de 219 individuos con DAP ≥5cm, distribuidos en 18 familias y 36 especies. Las especies más importantes fueron* Xylopia sericea*,* Eugenia supraaxillaris*,* Cupania oblongifolia *y* Annona dolabripetala*. La familia más abundante fue Fabaceae, seguida por Myrtaceae y Bignoniaceae. La familia con el mayor número de individuos fue Annonaceae, seguida por Myrtaceae y Sapindaceae. La densidad y área basal por ha, por parcela, fue de 0 a 1010 individuos y de 9,9$m^2 \cdot ha^{-1}$, respectivamente. La riqueza de especies osciló entre 0 (parcela 4) y 22 (parcela 2). Los resultados indican una regeneración natural baja en el sotobosque de las parcelas de eucalipto tras 11 años de abandono. Se discute el posible papel inhibitorio de* Corymbia citriodora *en el establecimiento y crecimiento de especies nativas.*

REGENERAÇÃO DA SELVA ATLÂNTICA EM PLANTAÇÕES ABANDONADAS DE EUCALIPTO (*Corymbia citriodora* (Hook.) K.D.Hill E L.A.S.Johnson) NO RIO DE JANEIRO, BRASIL

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RESUMO

*Avaliou-se a estrutura florística e fitosociológica da comunidade de árvores nativas da Selva Atlântica em cinco plantações de eucalipto (*Corymbia citriodora*) abandonadas desde 1996 na Reserva Biológica União, Rio de Janeiro, Brasil. Onze anos depois de ser abandonadas se estabeleceram lotes de 20×10m, totalizando 0.1ha, em cinco parcelas diferentes. A amostragem incluiu um total de 219 indivíduos com DAP ≥5cm, distribuídos em 18 famílias e 36 espécies. As espécies mais importantes foram* Xylopia sericea*,* Eugenia supraaxillaris*,* Cupania oblongifolia *e* Annona dolabripetala*. A família mais abundante foi Fabaceae, seguida por Myrtaceae e Bignoniaceae. A família com o maior número de indivíduos foi Annonaceae, seguida por Myrtaceae e Sapindaceae. A densidade e área basal por ha, por parcela, foram de 0 a 1.010 indivíduos e de 9,9$m^2 \cdot ha^{-1}$, respectivamente. A riqueza de espécies oscilou entre 0 (parcela 4) e 22 (parcela 2). Os resultados indicam uma regeneração natural baixa no sotobosque das parcelas de eucalipto após 11 anos de abandono. Discute-se o possível papel inibitório de* Corymbia citriodora *no estabelecimento e crescimento de espécies nativas.*

ristic composition of eucalypt (*Corymbia citriodora*) plantations abandoned since 1996, aiming to identify whether the establishment of native Atlantic forest tree species is occurring in the understory of these plantations and what are the main species and ecological groups to which these species belong.

Materials and Methods

Study Area

The União Biological Reserve (REBIO União) was officially created in 1998 and is located in the municipality of Rio das Ostras, Rio de Janeiro, Brazil, at 22º27'30''S and 42º02'15"W. It occupies an area of 2550ha, with ~2200ha of Atlantic Forest and 220ha of eucalypt plantations (IBAMA, 2007). The rest is occupied by areas of former industrial use, roads, power and communication towers, railway, gas pipelines and abandoned pastures. The REBIO União, formerly known as *Fazenda União*, has had part of its original forest cover removed and transformed into fuel for steam powered locomotives since the 1930s. In the 1960s this area became the property of the Federal Railways enterprise (RFFSA), which initiated the eucalypt plantations. The first species introduced was *Eucalyptus grandis* W. Hill ex Maiden, for the production of firewood and charcoal. In the 1970s, with the replacement of steam powered locomotives by electric trains, the species *Corymbia citriodora* was planted for the production of sleepers used in the construction of railways. In 1992 the process of privatization of RFFSA was initiated, and the farm was placed for sale. RFFSA was privatized in 1996, but with the influence of the scientific community and civil society in favor of conserving the habitat of the rare primate *Leontopithecus rosalia* (Golden Lion Tamarin), the Brazilian Institute of Environment and Natural Resources (IBAMA) created the REBIO União in 1998.

The climate in the region of the biological reserve is tropical humid (Nimer, 1979), with an average annual temperature of 25.6ºC and rainfall ~2100 mm/year, with 80% of the rainfall concentrated between October and April (unpublished data of the Translocation Program of the Golden Lion Tamarin Association). According to the IBGE (1992) classification, the vegetation of the REBIO União has lowland and submontane formations and is classified as Dense Tropical Rainforest. The soil of the plantations, according to Miranda *et al*. (2007) is distrophic red-yellow podzolic.

Eucalypt stands

There are 47 stands of eucalypt (*Corymbia citriodora*) in the REBIO União, ranging from 0.21 to 16.36ha, with a total area of ~220ha (IBAMA, 2007). From these, five stands were selected based on age, spacing between individuals and land use. These stands have a number of eucalypt trees ranging from 750 to 980 individuals/ha and a total basal area of 20.2-25.7$m^2 \cdot ha^{-1}$. As common characteristics, all stands had a fragment of the Atlantic forest within 400m and had been treated with the same silvicultural techniques, receiving liming and NPK fertilization during the establishment of the stand and pruning, and cleaning every three-years

with a cutting cycle of 7, 14 and 21 years. It is emphasized that the stands were abandoned in 1996 and since then have not received any type of silvicultural intervention.

Floristic and structural characterization

In each of the five chosen stands five plots of 10×20m were located randomly, for a total of 0.1ha in each stand. In each plot all living individuals with DBH ≥5cm were marked and measured. Data collection was conducted between February and March 2007.

The material collected for botanical identification and vouchers were deposited in the Herbarium UENF, in the Center for Bioscience and Biotechnology, Universidade Estadual do Norte Fluminense Darcy Ribeiro. The families were listed in alphabetical order and classified according to APG II (2003). The spelling of the binomials and the abbreviations of the authors of the species were checked and updated based on the websites of the International Plant Names Index (www.ipni.org/index.html) and Missouri Botanical Garden (http://mobot. mobot.org/W3T/Search/vast.html).

For analysis of phytosociological parameters the program FITOPAC1 (Shepherd, 1995) was used and values of relative density, relative dominance index, cover value index (CVI) and basal area (BA) were calculated according to Mueller-Dombois and Ellenberg (1974).

The species were classified within the guilds or ecological groups proposed by Gandolfi *et al*. (1995), being pioneers, early or late secondary species. The term 'unclassified' is used when, due to the lack of ecological information, the species could not be placed in any of the above categories. This classification was based mainly on the work of Carvalho *et al*. (2006) and Carvalho and Nascimento (2009). Besides these features, the dispersal syndromes of diaspores according to Van der Pijl (1982) was also used, and the species were classified as anemochoric, autochoric and zoochoric.

TABLE I
RESULTS OBTAINED IN FIVE STANDS IN EUCALYPT PLANTATIONS (*Corymbia citriodora*) IN THE UNIÃO BIOLOGICAL RESERVE, RIO DE JANEIRO, BRAZIL

Stand	N	D	AB	S	fam	H'	J'
1	101	1010	9.9	17	12	2.1	0.73
2	80	800	5.7	22	10	2.7	0.9
3	1	10	0.03	1	1	0	0
4	0	0	0	0	0	0	0
5	37	370	4.0	20	12	2.7	0.92
Total	219	2190	19.63	36	18	-	-

N: number of individuals, D: density (ha^{-1}), AB: basal area ($m^2 \cdot ha^{-1}$), S: and richness, fam: number of families, H': Shannon diversity index, and J': evenness.

Results

Structure

A total of 219 individuals of native trees were collected, with density ranging from zero (stand 4) to 1010 individuals/ha (stand 1) and basal area from zero (stand 4) to $9.9 m^2 \cdot ha^{-1}$ (stand 1). Stand 3 had only one individual, *Myrsine coriacea*, in the plots sampled (Table I). Only two standing dead individuals were found in the 25 plots (0.5ha), one in stand 1 and another in stand 5, accounting for only 0.9% of the total density.

Floristic composition and diversity

The 219 individuals sampled, considering the five stands, were distributed in 18 families and 36 species (Tables II and III). All species were identified (Table III), 60% had up to 3

TABLE II
LIST OF SPECIES (DBH ≥5cm) OBSERVED IN STANDS 1-5 OF EUCALYPT IN THE UNIÃO BIOLOGICAL RESERVE, RIO DE JANEIRO, BRAZIL*

Family	Species	1	2	3	5	UC	DS
Annonaceae	*Guatteria campestris* R.E.Fr.	X	X			Si	Zoo
Annonaceae	*Annona dolabripetala* Raddi		X		X	Si	Zoo
Annonaceae	*Xylopia sericea* A.St.-Hill.	X	X		X	Pi	Zoo
Asteraceae	*Piptocarpha macropoda* (DC.) Baker	X			X	Pi	Ane
Asteraceae	*Vernonanthura discolor* (Spreng.) H.Rob.		X			Pi	Ane
Bignoniaceae	*Cybistax antisyphilitica* (Mart.) Mart.	X			X	Si	Ane
Bignoniaceae	*Jacaranda bracteata* Bureau & K.Schum		X			Si	Ane
Bignoniaceae	*Jacaranda puberula* Cham.	X	X			Si	Ane
Bignoniaceae	*Sparattosperma leucanthum* (Vell.) K.Schum.	X	X			Pi	Ane
Erythroxylaceae	*Erythroxylum pulchrum* A.St.-Hil.	X				St	Zoo
Euphorbiaceae	*Pera glabrata* (Schott) Poepp. ex Baill.		X			Si	Zoo
Fabaceae	*Apuleia leiocarpa* (Vogel) J.F.Macbr.		X			Si	Ane
Fabaceae	*Dalbergia frutescens* (Vell.) Britton		X		X	St	Ane
Fabaceae	*Dalbergia nigra* (Vell.) Allemão ex Benth.		X		X	St	Ane
Fabaceae	*Exostyles venusta* Schott ex Spreng.				X	St	Zoo
Fabaceae	*Peltogyne angustiflora* Ducke				X	St	Ane
Fabaceae	*Piptadenia gonoacantha* (Mart.) J.F.Macbr.		X		X	Pi	Ane
Fabaceae	*Swartzia oblata* R.S.Cowan		X			St	Zoo
Lacistemataceae	*Lacistema pubescens* Mart.	X	X			Si	Zoo
Lauraceae	*Licaria bahiana* H.W.Kurtz	X				St	Zoo
Lecythidaceae	*Lecythis lanceolata* Poir.				X	St	Zoo
Malpighiaceae	*Byrsonima sericea* DC.	X				Pi	Zoo
Melastomataceae	*Miconia cinnamomifolia* (DC.) Naudin	X	X		X	Pi	Zoo
Meliaceae	*Guarea guidonia* (L.) Sleumer		X		X	Si	Zoo
Meliaceae	*Guarea macrophylla* Vahl	X	X			St	Zoo
Myrsinaceae	*Myrsine coriacea* (Sw.) R.Br. ex Roem. and Schult.			X		Si	Zoo
Myrtaceae	*Eugenia dodonaeifolia* Cambess.		X			Sc	Zoo
Myrtaceae	*Eugenia supraaxillaris* Spring	X			X	Sc	Zoo
Myrtaceae	*Myrcia anceps* (Spreng.) O.Berg	X	X		X	Sc	Zoo
Myrtaceae	*Myrcia splendens* (Sw.) DC.		X		X	Sc	Zoo
Salicaceae	*Casearia arborea* (Rich.) Urb.				X	Si	Zoo
Salicaceae	*Casearia sylvestris* Sw.				X	Si	Zoo
Sapindaceae	*Cupania oblongifolia* Mart.	X	X		X	Si	Zoo
Sapindaceae	*Cupania racemosa* (Vell.) Radlk.	X	X			St	Zoo
Sapotaceae	*Pradosia lactescens* (Vell.) Radlk.				X	St	Zoo
Siparunaceae	*Siparuna guianensis* Aubl.	X			X	Si	Zoo

* Stand 4 did not have native individuals with DBH ≥5cm.
Pi: pioneer, Si: early secondary, St: late secondary, UC: unclassified, DS: dispersal syndrome, Ane: anemochoric, and Zoo: zoochoric.

individuals and 11 species (30.5%) had only one individual (Table III).

Fabaceae was the richest family in terms of number of species (7), followed by Myrtaceae and Bignoniaceae with four species each. Annonaceae was the family with the greatest number of individuals (68), followed by Myrtaceae, Bignoniaceae and Sapindaceae with 36, 24 and 23 individuals, respectively. Of the seven species of Fabaceae, four had only one individual (Table III).

The five most important species in the stands (Table III) were *Xylopia sericea, Eugenia supraaxillaris, Cupania oblongifolia, Annona dolabripetala* and *Sparattosperma leucanthum*. These species accounted for ~50% of the total CVI.

Of the 36 species sampled in plots, 19% were pioneers, 39% were early secondary and 32% were late secondary, and 11% were unclassified (Table II). However, in relation to the number of individuals sampled, 39.4% were pioneers, 33.5% were early secondary, 10.5% were late secondary and 16.5% were unclassified. Regarding the dispersal syndrome, about 70% of the species were zoochoric (Table II), ranging from 64% (stand 2) to 76.5% (stand 1). Considering the number of individuals, the percentage of animal-dispersed individuals in the total sample was 81%.

At stand 1, 17 species divided into 12 families were observed (Tables I and II). At this stand the species that showed the highest value of IVC was *X. sericea* (84.39), representing 41.6% of native tree individuals at this stand. Other important species were *E. supraaxillaris* and *C. oblongifolia*. These three species represent 66.3% of individuals. Due to the higher density of *X. sericea*, the most important family was Annonaceae, followed by Myrtaceae and Sapindaceae. The occurrence at this stand of a single individual of *Licaria bahiana*, which is the first citation of this species of Lauraceae for the flora of the State of Rio de Janeiro, is emphasized.

TABLE III
PHYTOSOCIOLOGICAL PARAMETERS OF THE SPECIES IN EUCALYPT PLANTATIONS OF THE UNIÃO BIOLOGICAL RESERVE, RIO DE JANEIRO, BRAZIL, TOTALING 0.5ha*

Species	n	DR	DoR	AB	CVI
Xylopia sericea	50	22.83	23.67	0.464	46.50
Eugenia supraaxillaris	15	6.85	9.55	0.187	16.40
Cupania oblongifolia	18	8.22	6.93	0.136	15.15
Annona dolabripetala	15	6.85	8.23	0.161	15.08
Sparattosperma leucanthum	15	6.85	5.90	0.116	12.75
Piptadenia gonoacantha	6	2.74	8.31	0.163	11.05
Myrcia anceps	11	5.02	5.16	0.101	10.18
Lacistema pubescens	11	5.02	4.30	0.084	9.32
Miconia cinnamomifolia	8	3.65	2.64	0.052	6.30
Myrcia splendens	9	4.11	1.44	0.028	5.54
Cupania racemosa	6	2.74	2.21	0.043	4.95
Piptocarpa macropoda	3	1.37	3.50	0.069	4.87
Casearia sylvestris	4	1.83	2.31	0.045	4.14
Siparuna guianensis	6	2.74	1.40	0.027	4.14
Casearia arborea	3	1.37	1.90	0.037	3.27
Dalbergia frutescens	4	1.83	1.24	0.024	3.06
Dalbergia nigra	3	1.37	1.59	0.031	2.96
Guatteria campestris	3	1.37	1.43	0.028	2.80
Byrsonima sericea	3	1.37	1.28	0.025	2.65
Pradosia lactecens	3	1.37	1.00	0.020	2.37
Cybistax antasyphiletica	3	1.37	0.63	0.012	2.00
Jacaranda puberula	3	1.37	0.53	0.011	1.90
Guarea macrophylla	2	0.91	0.59	0.012	1.50
Guarea guidonia	2	0.91	0.51	0.010	1.43
Jacaranda bracteata	2	0.91	0.32	0.006	1.23
Exostyles venusta	1	0.46	0.50	0.010	0.95
Lecythis lanceolata	1	0.46	0.49	0.010	0.95
Pera glabrata	1	0.46	0.43	0.009	0.89
Peltogyne angustiflora	1	0.46	0.40	0.008	0.86
Eugenia dodonaeifolia	1	0.46	0.35	0.007	0.81
Licaria bahiana	1	0.46	0.31	0.006	0.77
Vernonanthura discolor	1	0.46	0.30	0.006	0.75
Erythroxylum pulchrum	1	0.46	0.25	0.005	0.71
Myrsine coriacea	1	0.46	0.14	0.003	0.60
Swartzia oblata	1	0.46	0.13	0.003	0.58
Apuleia leiocarpa	1	0.46	0.12	0.002	0.58

* Species are ranked by decreasing value of CVI. n: number of individuals, dr: relative density, DoR: relative dominance, BA: basal area (m^2), CVI: cover value index.

Stand 2 showed the highest richness among the stands, 22 species belonging to 10 families (Tables I and II). At this stand the most important family was also Annonaceae, followed by Bignoniaceae and Myrtaceae. The most important species was *A. dolabripetala* with a CVI of 42.9. However, this species was not the most abundant (16.25%), with *S. leucanthum* showing the highest values of relative density (17.5%) and the second most important CVI (37.39).

Stands 3 and 4 were differentiated by the absence (stand 4) or the occurrence of only one native individual (stand 3) (Tables I and II).

Stand 5 was the second richest (20 species divided into 12 families), in which 13 species occurred with only one single individual (Tables I and II). The most important families were Fabaceae, Salicaceae and Annonaceae (Table II). *Piptadenia gonoacantha* was the most important species, with four individuals (10.8% of the total density) and the highest CVI (45.49) in this stand. This high value of CVI was due to the value of the basal area, which, if converted to relative dominance, represented 34.7% of the total basal area of the stand.

Discussion

The occurrence of Annonaceae as the most important family in the understory of the eucalypt plantations studied, especially in abundance, has not been observed in areas of mature forest in the region (Kurtz and Araujo, 2000; Moreno *et al*., 2003; Rodrigues, 2004). However, other authors such as Borém and Oliveira-Filho (2002), Pessoa and Oliveira (2006), Carvalho *et al*. (2007) and Christo *et al*. (2009) reported Annonaceae as the most representative family in species richness and/or abundance in secondary forests in this region. It should be noted that the importance of this family, both in plantations and in secondary forests, results from the high density and dominance of the pioneer species *Xylopia sericea* and *Annona dolabripetala*.

The most species rich families in the understory of the plantations, Fabaceae and Myrtaceae, are among those with greater richness in the region and are well represented along the Brazilian coast (Peixoto and Gentry, 1990).

The absence of native individuals with DBH ≥5.0cm at stand 4 and the presence of only one individual at stand 3 seems to result from a fire in 2001, which probably destroyed the regeneration layer and allowed an increase in the abundance of the Capim-sapê (*Imperata brasiliensis* Trin.) and also from the location of this stand at the top of a hillock, which may limit the arrival of propagules dispersed from the adjacent forest, and may inhibit the development of seedlings of native tree species.

Among the species that prominently appeared in the plantations (Table III), only *Cupania oblongifolia* appeared among the most important in other studies in the State of Rio de Janeiro (Guedes-Bruni *et al*., 1997; Pessoa *et al*., 1997; Carvalho *et al*., 2007). Considering that the most important native species within the eucalypt plantations of RE-

BIO União were considered pioneers or early secondary (Rolim *et al*., 1999; Carvalho *et al*., 2006) these would not be expected to appear as the most important species in studies that were carried out in areas covered by mature forest or in advanced stages of ecological succession.

Comparing basal area and density values of natural regeneration in the understory of eucalypt plantations obtained in this study with those found at other locations (Table IV) a discrepancy may be noticed among the results, even if considered the minimum threshold for inclusion (DBH ≥5cm). This fact increases the uncertainty regarding the use of eucalypt plantations in the recovery of degraded areas, although several studies have shown that eucalypt plantations can act as facilitators in the process of natural regeneration (Tabarelli *et al*., 1993; Silva Júnior *et al*., 1995; Durigan *et al*., 1997; Geldenhuys, 1997; Parrota *et al*., 1997; Feyera *et al*., 2002; Sartori *et al*., 2002; Souza *et al*. 2007; Nóbrega *et al*., 2008).

Data on richness and diversity of native tree species (~20 species in 1000m^2), when compared with those obtained in native forests of Rio de Janeiro, showed that the understory of eucalypt plantations in the biological reserve are much lower in diversity and number of species than secondary forests of the region (over 100 species; Table IV). As expected, these differences are even more evident when compared to Rodrigues (2004), who found over 200 species of trees with DBH ≥10cm in 1.2ha of a well preserved natural forest in the REBIO Union. However, this pattern is maintained even when compared with a similar study by Silva-Júnior *et al*. (1995), who found 123 species of trees regenerating in a *Eucalyptus grandis* W. Hill ex Maiden plantation 10 years after abandonment, in the state of Minas Gerais. In this sense, it can be considered that the low number of species (20) found in 0.1ha and of 37 species in all stands sampled (0.5ha; Table IV) agrees with Bone *et al*. (1999), Saporetti Júnior *et al*. (2003), Neri *et al*. (2005) and Ostertag *et al*. (2008), who observed a negative effect of eucalypt plantations on the regeneration of native species.

TABLE IV
DENSITY (ind/ha), BASAL AREA (BA), RICHNESS (S) AND SHANNON DIVERSITY (H') IN EUCALYPT PLANTATIONS IN THE UNIÃO BIOLOGICAL RESERVE, RIO DE JANEIRO, BRAZIL, IN AREAS OF SECONDARY FOREST IN THE REGION AND OTHER STANDS

Place	Inclusion *	n (ind/ha)	BA $m^2 \cdot ha^{-1}$	S	H'	Reference
Stand 1	DAP ≥5cm	1010	9.9	17	2.1	This study
Stand 2	DAP ≥5cm	800	5.7	22	2.7	This study
Stand 3	DAP ≥5cm	10	0.03	1	-	This study
Stand 4	DAP ≥5cm	0	0	0	0	This study
Stand 5	DAP ≥5cm	370	4.0	20	2.7	This study
Macaé de Cima -disturbed sector	DAP ≥5cm	2217	28	157	3.6	Pessoa *et al.,* 1997
Mata Rio Vermelho - RJ	DAP ≥5cm	1745	29.1	106	3.9	Carvalho *et al.,* 2007
Ilha Grande - 5 years of abandonment	DAP ≥2.5cm	1915	5.6	26	2.5	Oliveira, 2002
Ilha Grande - 25 years of abandonment	DAP ≥2.5cm	2784	26.3	70	3.3	Oliveira, 2002
Ilha Grande - 50 years of abandonment	DAP ≥2.5cm	2273	32.4	63	3.1	Oliveira, 2002
Fazenda Biovert - Silva Jardim	DAP ≥3.2cm	1608	18.4	129	4.1	Borém e Oliveira Filho, 2002
Plantation of *E. grandis* - 30 years Cerrado	DAP ≥3.2cm	3760	8.3	39	2.6	Neri *et al*., 2005
Plantation of *E. saligna* - SP stand LVA	h ≥150cm	184	0.8	24	2.5	Sartori *et al*., 2002
Plantation of *E. saligna* - SP stand LV	h ≥150cm	1982	1.4	90	3.8	Sartori *et al*., 2002
Plantation of *E. grandis* - MG	DAP ≥5cm	634.5	17.9	123	-	Silva Júnior *et al*., 1995
Plantation of *C. citriodora* - cerrado SP	DAP ≥5cm	1375	6.02	25	2.14	Durigan *et al*., 1997
Plantation of *Eucalyptus* sp. - SP	CAP ≥10cm	960	-	63	-	Tabarelli *et al*., 1993
Plantation of *E. camaldulensis* Malásia	h ≥200cm	453	0.8	18	2.8	Bone *et al*., 1999

Inclusion: minimum threshold for inclusion in the sample.

The low number of native species sampled in the understory of these stands corroborates the hypothesis that *Corymbia citriodora* is not a species that facilitates the regeneration of native tree species within the plantations, but rather may be acting as an inhibitor. The mechanism of inhibition can be explained by the presence of allelopathy as a negative effect on the germination and/or growth of several species (Nishimura *et al*., 1984; Singh *et al*. 1991), due to the liberation of essential oils from their leaves and that 'repel' the faunal dispersers, by the small and hard fruits of *Corymbia citriodora* that are not used as food by birds and mammals, and by the near absence of refuges for fauna (Schneider, 2003). However, a more detailed assessment of the dispersers in these plantations is necessary because about 70% of the species (n= 25) and 81% of the individuals in the understory of the plantations studied are dispersed by animals.

The results indicate that despite being abandoned for more than 11 years, the process of regeneration of native species in eucalypt plantations of the REBIO União seems to be slow, with dominance of pioneer tree species. Thus, the data obtained in the eucalypt stands of the REBIO União do not support the hypothesis of the use of eucalypt as a facilitator for the recovery of an original community of Atlantic Forest. In this particular case, the eucalypt *Corymbia citriodora* seems to be inhibiting or even preventing the growth and establishment of some native species.

Finally, we believe that generalizations about the use of eucalypt as a facilitator for re-establishment of a native tree community in reforested areas should be avoided, since there are over 600 species (Lima, 1996) of eucalypt (*Corymbia* spp. and *Eucalyptus* spp.) and the answers may differ depending on the species of eucalypt used and the different environmental conditions.

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