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Original Article

Conservation of Nature

Floristic and Structural Composition of Natural Regeneration in a Subtropical Atlantic Forest

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ABSTRACT

Understanding the regeneration process in an old growth forest is essential for restoration projects. The present research sought to characterize the floristic and structural composition of shrub-tree species in São Francisco de Assis Municipal Park in Blumenau-SC. We sampled 50 permanent plots divided into three height classes. We estimated the total natural regeneration index for each species, the Shannon-Wiener diversity index and Pielou equability, and classified the species according to life-form and ecological group. A total of 1048 individuals were found, distributed in 112 species, 69 genera and 37 families. The species with the highest values of total natural regeneration index were *Rudgea recurva*, *R. jasminoides*, *Ouratea parviflora*, *Psychotria nuda* and *Virola bicuhyba*. The Shannon and Pielou indices demonstrated high diversity and equability for the natural regeneration area sampled. The results indicate species possibly capable of reaching the tree strata, and also indicate high forest conservation.

Keywords: diversity, phytosociology, shrubs.

1. INTRODUCTION AND OBJECTIVES

The Atlantic Rainforest originally occupied an area of approximately 150 million ha, representing one of the largest tropical forests in the Americas, with high biological diversity and endemism, reflecting the high heterogeneity of habitats related to the significant altitudinal, latitudinal and longitudinal range of the region (Ribeiro et al., 2009). However, the forest cover that was previously continuous is now fragmented into small forest remnants, consisting of only 11.7% of the original vegetation cover, and with about 83% of these remnants being smaller than 50 ha (Metzger, 2000; Ribeiro et al., 2009).

The subtropical Atlantic Rainforest has a low percentage of conservation units (about 3% of the total area), and a high degree of degradation. Therefore, there is an urgent need to preserve forest remnants that present significant native species variety (MMA, 2007), many of them still unknown to science. Therefore, for the implementation of strategies and management plans, it is necessary to acquire information about the ecology of native species, considered essential to aid in public decision making and conservation measures (Hanazaki, 2003; Pinto et al., 2006).

In this sense, an important forest ecosystem process is the natural regeneration of plant species. Natural regeneration is mainly represented by three mechanisms: seed rain, dormant seed bank, and seedling bank on the forest floor. These mechanisms are responsible for the reconstruction and establishment of plant populations and determine, in part, the course of forest succession, structure and physiognomy (Garwood, 1989; Narvaes et al., 2008). Natural regeneration itself refers to the seedling bank in the forest understory (Araújo et al., 2004), and consists of a recruitment mechanism for adult individuals from the development of the bank of regenerating individuals in the understory. Additionally, the environmental conditions of the forest, such as light, water and nutrient availability, competition, pathogens and herbivores are determining factors in this process (Fenner & Thompson, 2005). The way that each species responds to such factors, reflects on the success of recruitment (Melo, 2004).

Understanding natural regeneration is fundamental for silvicultural planning with maximum yield, elaboration of degraded area recovery programs and management plans in Conservation Units, as well as to provide indicative information on the current state of the forest in question and forecasts on their behavior and development (Amador & Viana, 2000; IBAMA, 2002; Schorn & Galvão, 2006).

This study was developed in order to provide scientific knowledge for the conservation and management of biodiversity threatened by anthropic action, especially the Atlantic Forest. The objective was to research the floristic and structural composition of the natural regeneration component in the São Francisco de Assis Municipal Natural Park, located in Blumenau, Santa Catarina.

2. MATERIAL AND METHODS

2.1. Study area

The study area comprises the São Francisco de Assis Municipal Natural Park (SFAMNP), located in the center of Blumenau, Santa Catarina (26º 55’ 18.9” S and 49º 04’ 18.9” W). The PNMSFA covers 23 ha, with an altitude varying from 35 to 135 m, and surrounded by an environmental protection area of 43 ha. The climate is Cfa, humid temperate with hot summers (mesothermic), with an average temperature of 18 °C in the coldest month and above 22 °C in the hottest month, without a dry season (Koeppen, 1948).

The forest type is lowland subtropical rainforest, and the area is a region of rugged relief valley with steep slopes and a stream running through it. The land use history includes clear and selective logging of the forest and soil use for agriculture. With more than 50 years without exploitation, there is predominance of forest in advanced secondary stage and small patches of secondary vegetation in intermediate stage (Sevegnani, 2003).

2.2. Data collection

To characterize the natural regeneration, we established 50 permanent plots of 5 x 5 m, equivalent to 1,250 m^2. The sub-bush, shrub, treelet, palm and tree individuals with height ≥ 30 cm and DHB ≤ 5 cm located within the plots were marked and counted. The individuals sampled were classified into three height classes: C1 (from 30 cm to 60 cm in height); C2 (from 61 cm to 1.50 m in height) and C3 (from 1.51 m in height to 5 cm of DHB). Data collection occurred between November 2015 and February 2016.

Within each 5 x 5 m plot, a 3 x 3 m subplot was demarcated, totaling 50 subplots, to adjust the size of the sampling area according to the proposed height classes. Thus, in the 3 x 3 m subplots, individuals of class 1 (C1) and 2 (C2) were sampled, while individuals of class 3 (C3) were sampled in the 5 x 5 m plots. With the subplots of 3 x 3 m, there was a total of 1,700 m^2 of sample area of the regeneration component. The effective sample plots were: 46 (C1), 47 (C2) and 50 (C3), since there was no individual in a few sample plots in C1 and C2.

We identified the plants in the field whenever possible, collecting those unidentified to undertake the identification process in the Roberto Miguel Klein Herbarium (FURB), located at Universidade Regional de Blumenau (FURB).

2.3. Statistical analyses

A rarefaction curve, with 1000 permutations, was constructed for each class in R, version 2.15.3 (R Development Core Team, 2017), using the vegan package. For the estimation of natural regeneration index (NRI), we calculated the distribution (frequency) and abundance (density) for each height class of each species sampled in the plots, using these indexes proposed by Finol (1971) and modified by Volpato (1994).

Shannon-Wiener (H') and Pielou (J') diversity indexes were calculated based on Magurran (1988), relating the proportional abundance of the species to the specific diversity. These calculations were performed in R.

We classified the species into ecological groups applying the classification used by the Floristic and Forest Inventory of Santa Catarina (IFFSC) (Lingner et al., 2013): pioneer (P), secondary (SE) and climax (C). Similarly, the species life-forms were classified according to the classification used by IFFSC (Lingner et al., 2013). A species was considered threatened when listed in the Red Book of Brazilian Flora (Martinelli & Moraes, 2013).

3. RESULTS

3.1. Floristic composition

We sampled 1048 individuals (13 of these dead), distributed in 112 species, 69 genera and 37 families (Table 1). The families with greatest species richness were Myrtaceae (22 spp.), Rubiaceae (15), Lauraceae (10), Melastomataceae (7), and Fabaceae (7), representing 58.93% of the total sampled species (Figure 1). The genera with the highest number of species were *Psychotria* L. (8 spp.), *Eugenia* L. (6) and *Miconia* Ruiz & Pav., *Ocotea* Aubl. and *Piper* L. (5).

Table 1. Natural Regeneration Index (NRI) of species for each class in natural regeneration component at SFAMNP, Blumenau/SC.

Species	Class 1			Class 2			Class 3			NRI
	RD1	RF1	NRI1	RD2	RF2	NRI2	RD3	RF3	NRI3	
Rudgea recurva	15.81	10.80	13.30	9.71	7.44	8.58	16.25	7.67	11.96	11.28
Rudgea jasminoides	7.26	5.68	6.47	8.99	8.37	8.68	8.03	6.82	7.42	7.53
Psychotria nuda	4.27	3.98	4.13	5.04	6.05	5.54	7.46	6.25	6.85	5.51
Ouratea parviflora	2.56	3.41	2.99	5.04	5.58	5.31	6.88	5.68	6.28	4.86
Marlierea tomentosa	1.28	1.70	1.49	6.83	5.12	5.98	4.97	4.55	4.76	4.08
Virola bicuhyba	5.56	5.68	5.62	3.24	3.72	3.48	2.29	2.84	2.57	3.89
Mollinedia schottiana	2.99	3.41	3.20	3.24	3.26	3.25	3.63	4.26	3.95	3.46
Sorocea bonplandii	2.14	2.27	2.20	5.76	5.58	5.67	1.91	2.27	2.09	3.32
Dendropanax australis	2.99	3.41	3.20	3.24	2.79	3.01	3.44	3.98	3.71	3.31
Margaritopsis astrellantha	4.70	4.55	4.62	3.96	3.26	3.61	0.00	0.00	0.00	2.74
Actinostemon concolor	1.28	1.70	1.49	3.60	3.26	3.43	2.68	2.84	2.76	2.56
Garcinia gardneriana	1.28	1.14	1.21	1.80	1.86	1.83	3.44	2.84	3.14	2.06

RD1 = relative density for Class 1; RF1 = relative frequency for Class 1; NRI1 = Natural Regeneration Index for Class 1; RD2 = relative density for Class 2; RF2 = relative frequency for Class 2; NRI2 = Natural Regeneration Index for Class 2; RD3 = relative density for Class 3; RF3 = relative frequency for Class 3; NRI3 = Natural Regeneration Index for Class 3; NRI = total Natural Regeneration Index.*threatened species according to Martinelli & Moraes (2013); **exotic species.

Table 1. Continued...

Species	Class 1			Class 2			Class 3			NRI
	RD1	RF1	NRI1	RD2	RF2	NRI2	RD3	RF3	NRI3	
Sloanea guianensis	2.56	3.41	2.99	0.72	0.93	0.82	1.53	1.99	1.76	1.86
Psychotria brachypoda	1.71	1.14	1.42	3.60	1.86	2.73	1.15	1.14	1.14	1.76
Guapira opposita	1.71	2.27	1.99	1.44	1.86	1.65	1.15	1.70	1.43	1.69
Justicia brasiliana	5.98	3.41	4.70	0.00	0.00	0.00	0.00	0.00	0.00	1.57
Pausandra morisiana	0.43	0.57	0.50	0.72	0.93	0.82	3.63	2.84	3.24	1.52
Trichilia casaretti	0.00	0.00	0.00	1.08	1.40	1.24	3.06	3.41	3.23	1.49
Ocotea teleiandra	0.43	0.57	0.50	1.08	1.40	1.24	1.72	1.99	1.85	1.20
Marlierea obscura	0.43	0.57	0.50	2.16	2.33	2.24	0.57	0.85	0.71	1.15
Guarea macrophylla	0.00	0.00	0.00	1.44	1.86	1.65	1.72	1.70	1.71	1.12
Hirtella hebeclada	1.28	1.70	1.49	1.08	0.93	1.00	0.38	0.57	0.48	0.99
Psychotria suterella	0.43	0.57	0.50	0.36	0.47	0.41	1.53	1.99	1.76	0.89
Myrcia pubipetala	0.43	0.57	0.50	1.44	1.86	1.65	0.38	0.57	0.48	0.87
Sebastiania argutidens	0.43	0.57	0.50	0.36	0.47	0.41	1.34	1.99	1.66	0.86
Protium kleinii	2.14	1.70	1.92	0.36	0.47	0.41	0.19	0.28	0.24	0.86
Euterpe edulis	1.28	1.70	1.49	0.72	0.93	0.82	0.19	0.28	0.24	0.85
Myrcia spectabilis	0.43	0.57	0.50	0.36	0.47	0.41	1.53	1.70	1.62	0.84
Eugenia cerasiflora	0.43	0.57	0.50	1.44	1.40	1.42	0.38	0.57	0.48	0.80
Leandra dubia	1.71	0.57	1.14	1.44	0.47	0.95	0.19	0.28	0.24	0.78
Neomitranthes glomerata	0.43	0.57	0.50	0.72	0.93	0.82	0.76	1.14	0.95	0.76
Calyptranthes strigipes	0.43	0.57	0.50	1.08	0.93	1.00	0.57	0.85	0.71	0.74
Heisteria silvianii	0.43	0.57	0.50	1.44	1.40	1.42	0.19	0.28	0.24	0.72
Pera glabrata	0.00	0.00	0.00	0.36	0.47	0.41	1.34	1.99	1.66	0.69
*Eugenia cereja**	1.28	1.70	1.49	0.36	0.47	0.41	0.00	0.00	0.00	0.64
Quiina glaziovii	0.85	1.14	1.00	0.36	0.47	0.41	0.38	0.57	0.48	0.63
Stylogyne pauciflora	1.28	1.70	1.49	0.00	0.00	0.00	0.19	0.28	0.24	0.58
Nectandra oppositifolia	1.28	1.70	1.49	0.00	0.00	0.00	0.19	0.28	0.24	0.58
Pourouma guianensis	0.85	1.14	1.00	0.36	0.47	0.41	0.19	0.28	0.24	0.55
Mollinedia triflora	0.43	0.57	0.50	0.36	0.47	0.41	0.57	0.85	0.71	0.54
*Brosimum lactescens**	0.43	0.57	0.50	0.36	0.47	0.41	0.57	0.85	0.71	0.54
*Bunchosia marítima**	0.85	1.14	1.00	0.72	0.47	0.59	0.00	0.00	0.00	0.53
Ocotea dispersa	0.43	0.57	0.50	0.72	0.93	0.82	0.19	0.28	0.24	0.52
Inga striata	0.00	0.00	0.00	0.72	0.93	0.82	0.57	0.85	0.71	0.51
Myrceugenia myrcioides	0.00	0.00	0.00	1.08	0.93	1.00	0.38	0.57	0.48	0.49
Piper solmsianum	0.85	1.14	1.00	0.00	0.00	0.00	0.38	0.57	0.48	0.49
*Plinia cordifolia**	0.00	0.00	0.00	0.36	0.47	0.41	0.96	1.14	1.05	0.49
*Eugenia burkartiana**	1.28	1.14	1.21	0.00	0.00	0.00	0.19	0.28	0.24	0.48
Miconia cabucu	0.00	0.00	0.00	0.36	0.47	0.41	0.76	1.14	0.95	0.45
Sebastiania brasiliensis	0.00	0.00	0.00	0.72	0.93	0.82	0.38	0.57	0.48	0.43
Aiouea saligna	0.00	0.00	0.00	0.36	0.47	0.41	0.57	0.85	0.71	0.38
*Ocotea catharinensis**	0.00	0.00	0.00	0.36	0.47	0.41	0.57	0.85	0.71	0.38
Piper cernuum	0.43	0.57	0.50	0.00	0.00	0.00	0.57	0.57	0.57	0.36
Trichilia silvatica	0.00	0.00	0.00	0.72	0.93	0.82	0.19	0.28	0.24	0.35
*Magnolia ovata**	0.00	0.00	0.00	0.72	0.93	0.82	0.19	0.28	0.24	0.35

RD1 = relative density for Class 1; RF1 = relative frequency for Class 1; NRI1 = Natural Regeneration Index for Class 1; RD2 = relative density for Class 2; RF2 = relative frequency for Class 2; NRI2 = Natural Regeneration Index for Class 2; RD3 = relative density for Class 3; RF3 = relative frequency for Class 3; NRI3 = Natural Regeneration Index for Class 3; NRI = total Natural Regeneration Index.*threatened species according to Martinelli & Moraes (2013); **exotic species.

Table 1. Continued...

Species	Class 1			Class 2			Class 3			NRI
	RD1	RF1	NRI1	RD2	RF2	NRI2	RD3	RF3	NRI3	
*Seguieria langsdorffii**	0.85	1.14	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33
Piper ulei	0.85	1.14	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33
*Ocotea odorifera**	0.43	0.57	0.50	0.36	0.47	0.41	0.00	0.00	0.00	0.30
Piper caldense	0.00	0.00	0.00	0.72	0.93	0.82	0.00	0.00	0.00	0.27
Trichilia pseudostipularis	0.43	0.57	0.50	0.00	0.00	0.00	0.19	0.28	0.24	0.25
Psychotria officinalis	0.43	0.57	0.50	0.00	0.00	0.00	0.19	0.28	0.24	0.25
Aphelandra chamissoniana	0.85	0.57	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.24
Piper miquelianum	0.85	0.57	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.24
Xylopia brasiliensis	0.00	0.00	0.00	0.36	0.47	0.41	0.19	0.28	0.24	0.22
Hieronyma alchorneoides	0.00	0.00	0.00	0.36	0.47	0.41	0.19	0.28	0.24	0.22
Inga marginata	0.43	0.57	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Dahlstedtia cf. *pentaphylla*	0.43	0.57	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Eugenia melanogyna	0.43	0.57	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Myrcia selloi	0.43	0.57	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Eugenia beaurepairiana	0.43	0.57	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.17
*Eugenia brevistyla**	0.43	0.57	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Matayba intermedia	0.43	0.57	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Dahlstedtia cf. *pinnata*	0.43	0.57	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Miconia tristis	0.43	0.57	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Pseuderanthemum riedelianum	0.43	0.57	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.17
*Campomanesia reitziana**	0.43	0.57	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Psychotria deflexa	0.43	0.57	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Justicia carnea	0.43	0.57	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.17
Miconia cinerascens var. *robusta*	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.28	0.43	0.14
Cariniana estrellensis	0.00	0.00	0.00	0.36	0.47	0.41	0.00	0.00	0.00	0.14
Inga sp.	0.00	0.00	0.00	0.36	0.47	0.41	0.00	0.00	0.00	0.14
Inga vera subsp. *affinis*	0.00	0.00	0.00	0.36	0.47	0.41	0.00	0.00	0.00	0.14
Casearia sylvestris	0.00	0.00	0.00	0.36	0.47	0.41	0.00	0.00	0.00	0.14
*Syzygium jambos***	0.00	0.00	0.00	0.36	0.47	0.41	0.00	0.00	0.00	0.14
*Myrciaria floribunda**	0.00	0.00	0.00	0.36	0.47	0.41	0.00	0.00	0.00	0.14
Campomanesia xanthocarpa	0.00	0.00	0.00	0.36	0.47	0.41	0.00	0.00	0.00	0.14
*Brosimum glaziovii**	0.00	0.00	0.00	0.36	0.47	0.41	0.00	0.00	0.00	0.14
Calyptranthes lucida	0.00	0.00	0.00	0.36	0.47	0.41	0.00	0.00	0.00	0.14
Copaifera trapezifolia	0.00	0.00	0.00	0.36	0.47	0.41	0.00	0.00	0.00	0.14
Erythroxylum cuspidifolium	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08
Marlierea eugeniopsoides	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08
Cordiera concolor	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08
Cryptocarya aschersoniana	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08
Bactris setosa	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08
*Geonoma gamiova**	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08
Psychotria carthagenensis	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08
*Ocotea nectandrifolia**	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08

RD1 = relative density for Class 1; RF1 = relative frequency for Class 1; NRI1 = Natural Regeneration Index for Class 1; RD2 = relative density for Class 2; RF2 = relative frequency for Class 2; NRI2 = Natural Regeneration Index for Class 2; RD3 = relative density for Class 3; RF3 = relative frequency for Class 3; NRI3 = Natural Regeneration Index for Class 3; NRI = total Natural Regeneration Index.*threatened species according to Martinelli & Moraes (2013); **exotic species.

Table 1. Continued...

Species	Class 1			Class 2			Class 3			NRI
	RD1	RF1	NRI1	RD2	RF2	NRI2	RD3	RF3	NRI3	
Jacaranda puberula	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08
Aniba firmula	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08
Tapirira guianensis	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08
*Coffea arabica***	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08
Amaioua guianensis	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08
Psychotria vellosiana	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08
Endlicheria paniculata	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08
Aparisthmium cordatum	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08
Miconia budlejoides	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.28	0.24	0.08
Total			**100.00**				**100.00**		**100.00**	**100.00**

RD1 = relative density for Class 1; RF1 = relative frequency for Class 1; NRI1 = Natural Regeneration Index for Class 1; RD2 = relative density for Class 2; RF2 = relative frequency for Class 2; NRI2 = Natural Regeneration Index for Class 2; RD3 = relative density for Class 3; RF3 = relative frequency for Class 3; NRI3 = Natural Regeneration Index for Class 3; NRI = total Natural Regeneration Index.*threatened species according to Martinelli & Moraes (2013); **exotic species.

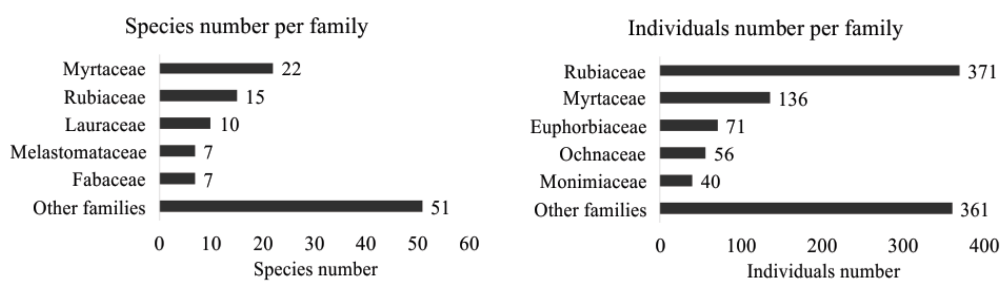

Figure 1. Species and individual numbers per family sampled in natural regeneration component at SFAMNP, Blumenau/SC.

The most abundant species were *Rudgea recurva* (149 ind.), *R. jasminoides* (84 ind.), *Psychotria nuda* (63 ind.), *Ouratea parviflora* (56 ind.), and *Marlierea tomentosa* (48 ind.), corresponding to 38.65% of the total individuals sampled. We sampled 18 threatened species, and we also found two exotic species in the sample, the coffee tree (*Coffea arabica*) and pink jambo (*Syzygium jambos*, Table 1).

The species that obtained the highest values in the Natural Regeneration Index (NRI) were: *Rudgea recurva* (11.28%), *Rudgea jasminoides* (7.53%), *Psychotria nuda* (5.51%), *Ouratea parviflora* (4.86%), *Marlierea tomentosa* (4.08%), *Virola bicuhyba* (3.89%), *Mollinedia schottiana* (3.46%), *Sorocea bonplandii* (3.32%), *Dendropanax australis* (3.31%) and *Margaritopsis astrellantha* (2.74%). These species represented 52.53% of the NRI sampled (Table 1).

Regarding the species ecological groups, 16.07% corresponded to pioneer (with 5.7% of individuals), 48.21% as secondary (39.81% of individuals) and 28.57% as climax (52.85% of individuals), with 7.14% being unable to be classified (1.64% of individuals) (Table 2). The tree life-form was comprised of 45.54% of species and 21.64% of individuals, treelets with 31.25% of species and 51.5% of individuals, shrubs with 16.96% of species and 24.35% of individuals, sub-bushes 3.57% of species and 1.74% of individuals, and palm with 2.68% of species and 0.77% of individuals.

The species accumulation curve tended to be stable (Figure 2). The Shannon diversity and Pielou equability indices for each size class are shown in Table 3, in which Classes 1 and 2 presented the highest H’ value, while Class 2 presented the highest J value.

Table 2. Species and individuals by ecological group and life-form for each class in natural regeneration component at SFAMNP, Blumenau/SC.

		Class 1		Class 2		Class 3		Total	
		Species	Ind.	Species	Ind.	Species	Ind.	Species	Ind.
Ecological groups	Climax	24	112	23	141	26	294	32	547
	Secondary	31	90	33	119	38	203	54	412
	Pioneer	9	24	7	12	11	23	18	59
	Non-classified	4	8	4	7	2	2	8	17
Life-forms	Tree	28	66	34	64	32	94	51	224
	Treelet	19	89	21	145	28	299	35	533
	Shrub	16	58	10	68	14	126	19	252
	Sub-bush	4	18	0	0	0	0	4	18
	Palm	1	3	1	2	3	3	3	8

Legend: Ind. = individuals.

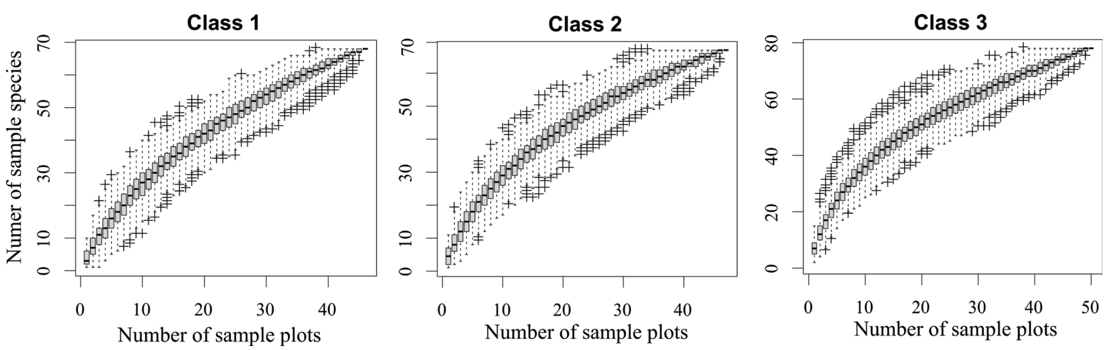

Figure 2. Species accumulation curve for each class in natural regeneration component at SFAMNP, Blumenau/SC.

Table 3. Species, genera, families, Shannon and Pielou indexes, individuals per hectare and effective sample plots for each class in natural regeneration component at SFAMNP, Blumenau/SC.

	Class 1	Class 2	Class 3
Species	68	67	77
Genera	43	49	54
Families	28	29	29
Shannon Index	3.61	3.61	3.47
Pielou Index	0.855	0.858	0.797
Ind/ha	5,200.00	6,177.78	4,184.00
Effective sample plots	46	47	50

4. DISCUSSION

4.1. Floristic composition

The first five richest families in this study were the same for all Subtropical Rain Forest in Santa Catarina (Meyer et al., 2013). These five families, in addition to Euphorbiaceae, are the most important for the Subtropical Rain Forest in Brazil (Oliveira-Filho & Fontes, 2000).

Myrtaceae, which presented the greatest richness in this study, is considered the fourth richest botanical family in Brazil, standing out as one of the dominant families in several vegetation formations (Landrum & Kawasaki, 1997; Giulietti et al., 2005). The species of this family are ecologically important for the Atlantic Rainforest, presenting diverse relationships to the local fauna, such as pollinator insects like bees and fruit dispersers such as birds, rodents and monkeys (Barroso et al., 1999).

The genera *Piper*, *Psychotria* and *Miconia* are predominantly understory species, whereas *Eugenia* and *Ocotea* are present in both understory and canopy (Meyer et al., 2013). Oliveira-Filho & Fontes (2000) pointed out that *Eugenia*, *Ocotea*, *Myrcia* and *Miconia* represent the genera with the highest species richness for the Atlantic Forest of Southeastern Brazil. The same pattern was found (except for *Myrcia*) in the regeneration sample in this study.

Regarding the exotic species found, Carvalho (2005) studied the pink jambo's potential for invasion in a forest fragment in the state of Rio de Janeiro. He found that the species have all the characteristics of a successful invasive plant such as short intervals of phenological events, rapid germination and seedling growth. The coffee tree, in turn, is considered invasive, being found in the understories of forests in several regions of Brazil, mainly in the Southeast (Martins et al., 2008).

The predominance of climax and secondary individuals in natural regeneration areas indicates that the forest is in the advanced stages of secondary succession and in a good state of conservation, with an abundant presence of characteristic species from primary forest understories, such as *Rudgea* spp. and *Psychotria* spp. (Delprete et al., 2004). The high number of secondary species sampled may indicate old wood exploitation activities and land use in the area, reflecting the current process of regeneration.

The presence of species of different ecological groups in the natural regeneration allows the response of different environmental conditions in the forest, which represent an important colonization mechanism of the area (Sccoti et al., 2011). Pioneer individuals in forests are related to the opening of natural clearings by the falling of trees (Colonetti et al., 2009), which is also considered a mechanism to maintain the diversity of species in tropical forests (Hartshorn, 1980). In the study area, this opening could also be generated by the landslides from 2008, or the severe winter with frost during 2013. Pioneering plants tend to have their regeneration niche associated with' disturbance and are determined by luminosity, acting directly on the recruitment of these species (Goodale et al., 2012). This may be the case of pioneer species sampled in this study, such as *Jacaranda puberula*, *Miconia cabucu* and *M. cinerascens* var. *robusta.*

Species dwelling in the sub-canopy and understory, in conditions of the interior of the forest, do not determine the physiognomy of the community canopy, but rather the internal vertical strata of the community, with trees and emergent individuals composing the physiognomy of the canopy (Sevegnani, 2003). Thus, natural regeneration is effectively represented by trees and palms, corresponding to young individuals of canopy species (Meyer et al., 2013). Rubiaceae, Melastomataceae and Piperaceae represent species of other life-forms, which are presented mainly by treelets and shrubs that have their ecological niche only in the understory (Meyer et al., 2013).

These natural regeneration sinusia, in the Atlantic Forest, are composed of a relatively small number of species, but with a large number of individuals (Veloso & Klein, 1957). In this study, the tree group consisted of 45.54% of the species and 21.64% of the individuals in the natural regeneration, while the shrubs contributed only 16.96% of the species, and therefore 24.35% of the individuals, represented mainly by *Psychotria nuda* (6.09% of individuals), *Ouratea parviflora* (5.41% of individuals), and *Dendropanax australis* (3.28% of individuals).

The Shannon diversity and Pielou equability indices for each size class indicate high biological diversity of natural regeneration, as well as high equability among species. Meyer et al. (2013) warns that high diversity indexes do not necessarily suggest that the forest presents well-preserved vegetation, depending on the action of degradation factors such as brushing in the understories and selective cutting of tree species, influencing the composition and richness of natural regeneration. The park underwent selective logging with some areas subjected to clear cutting of the forest and land use for cultivation. However, the area has since gone more than 50 years without exploitation (Sevegnani, 2003).

4.2. Natural regeneration structure

R. recurva and *R. jasminoides* had the highest NRI in all size classes. Both species are typical of sub-forests of primary forests in the Subtropical Rain Forest (Delprete et al., 2004). Tabarelli & Mantovani (1997) cite that many understory species may occur in secondary forests of different ages, as well as, in old forests with different structures. This pattern indicates a broad niche of regeneration, observed by the authors in *R. jasminoides*. This phenomenon may explain its high regeneration in this study, suggesting that these species have the potential to regenerate in several environments.

Rubiaceae represented 32.05% of the NRI obtained in this study, highlighting the family importance of the understory structure in sub-tropical forests, and establishing important ecological relationships. This family provides resources such as pollen, nectar and fruits to birds, mammals, and insects (Citadini-Zanette et al., 2009; Paiva et al., 2016). On the other hand, Myrtaceae, which presented the highest richness value in this study, corresponded to 14.03% of the NRI sampled.

Species that have NRI indexes below 1.0% may, from a given time, demonstrate a higher degree of difficulty in regenerating, or suggest that late species are establishing themselves in the ecosystem (Silva et al., 2010). In the present study, 89 species obtained values lower than 1.0% for NRI, of which 44 are secondary species and 17 are pioneers. Therefore, low regeneration of these species may be associated with environmental conditions, where canopy closure provides microclimatic conditions favorable to shade tolerant species (Higuchi et al., 2006), thereby limiting the establishment of pioneer and secondary species.

With respect to the density of individuals by size class, Class 2 grouped the highest value (Table 3). The result obtained did not correspond to the distribution pattern of the individuals in inverted 'J', characterized by the greater number of individuals concentrated in the smaller size classes. Low adult densities and regenerants of a given species suggest that they may be substituted, during forest succession, and *in situ* conservation will depend on the establishment of all stages of the species growth in the environment (Silva et al., 2004). Likewise, considering the natural regeneration component, species occurring in all size classes in the community will probably form the future structural composition of the forest (Citadini-Zanette, 1995).

Thus, according to the results of this study (and not considering the seed bank), species such as *Cryptocarya aschersoniana*, *Plinia cordifolia*, *Ocotea catharinensis*, and *Copaifera trapezifolia*, among others, presented low NRI values and no individuals were reported in the smallest size class, indicating the possible absence of these species in the future forest composition. However, Schaaf et al. (2006) postulates that if even a species has few individuals in the smaller classes, but is subjected to a low probability of dying due to competition, the chance of these species remaining in the environment is high.

5. CONCLUSION

The families Myrtaceae, Rubiaceae, Lauraceae and Melastomataceae, as well as the genera *Eugenia*, *Psychotria, Miconia* and *Ocotea* constitute the richest taxa. The most abundant species were *Rudgea recurva* and *R. jasminoides*, typical of understory and very frequent in the Santa Catarina Subtropical Rain Forest, demonstrating their importance in structuring the forest. The results indicated a natural regeneration component with high diversity, equability and characteristic elements of the primary forests in the Atlantic Forest.

The secondary species presented a greater number of species, followed by the climax ones and finally the pioneers. However, the climax species were more abundant, followed by the secondary ones and pioneers. The treelet life-form was predominant among the individuals, whereas the arboreal life-form comprised the largest number of species.

The natural regeneration represented mainly by the species *Rudgea recurva*, *R. jasminoides*, *Ouratea parviflora*, *Psychotria nuda* and *Virola bicuhyba*, evidenced their regeneration potential. However, 89 of the 112 species sampled presented low regeneration, half of which were secondary. The understory microclimatic conditions may limit the regeneration of these species, and simultaneously favor species from more advanced succession stages.

We observed species with low regeneration, with few or no individuals present in the smaller size classes, indicating a tendency to be substituted in future forest composition. We suggest continuous monitoring of these species in the Park area and the elaboration of an adequate management plan that allows these measures.

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