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Artigos

Phytosociology of natural regeneration as a subsidy for restoration in post-harvest areas of *Pinus* sp. in the Mixed and Dense Ombrophilous Forest

Fitossociologia da regeneração natural como subsídio para restauração em áreas pós-colheita de *Pinus* sp. na Floresta Ombrófila Mista e Densa em transição

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ABSTRACT

The objective of this study was to evaluate the natural regeneration in permanent preservation areas (PPA) in forest restoration process after *Pinus* sp. harvest through the survey of phytosociological parameters.. The study was carried out in the PPA, associated with springs and rivers in two areas with different post-harvest ages of *Pinus* sp., being inserted in Mixed Ombrophilous Forest (MOF - 7 years old) and Dense Ombrophilous Forest in transition (DOF/MOF - 12 years old) both in the Santa Catarina state. Nineteen rectangular plots with dimensions of 25 m x 4 m (100 m²) were allocated at random in each one of the areas, for the floristic-structural evaluation of the tree-shrub regenerative component. In the DOF in transition, 913 regenerating individuals of tree and shrub species were sampled, belonging to 90 species, 60 genera and 30 botanical families. The species with the highest importance value were *Cupania vernalis* (8.71%), followed by *Bernardia pulchella* (5.93%), *Aureliana wettsteiniana* (5.25%). At MOF, an area undergoing restoration in less time, 782 regenerating individuals of tree and shrub species were sampled, belonging to 62 species, 21 botanical families and 30 genera. The species with the highest importance value were *Myrsine coriacea* (10.06%), *Solanum variabile* (9.79%), *Myrsine lorentziana* (7.08%). Shannon's diversity indexes were H' = 3.76 for DOF in transition and H' = 3.24 for MOF, and showed a high diversity of species, whereas the Pielou equability index obtained J = 0.81 for DOF in transition and J = 0.77 for MOF, showing high uniformity in the distribution of individuals in the species for the two areas. The diametric distribution of the individuals showed an "inverted J" pattern for both phytophysiognomies, behavior expected in native forests. The NMDS (Non-metric multidimensional scaling) presented a stress value of 9.81% indicating suitability of the ordering and allowing inferences to be made with reliability. Through the NMDS ordering, it was observed the formation of two distinct floristic-structural groups, associated with MOF phytophysiognomies and MOF/DOF transition. All plots inserted in MOF areas are grouped to the right in the ordering, while most plots inserted in the MOF/DOF transition area are grouped to the left of the ordering. The tree-shrub regenerative component evaluated in post-harvest areas of Pinus sp. at both phytophysiognomies has a great diversity of species with great importance for forest formation, being a favorable environment for the conservation of species and essential to guarantee the succession of the forest and the restoration resilience.

Keywords: Phytosociology; Regenerative Component; Richness

RESUMO

O objetivo deste estudo foi avaliar a regeneração natural em Áreas de Preservação Permanente em processo de restauração florestal pós-colheita de *Pinus* sp. por meio do levantamento de parâmetros fitossociológicos. O estudo foi realizado nas APPs associadas a nascentes e rios de duas áreas com diferentes idades pós-colheita de *Pinus* sp., sendo inseridas em Floresta Ombrófila Mista (FOM - 7 anos) e Floresta Ombrófila Densa em transição (FOD/FOM - 12 anos) ambas no estado de Santa Catarina. Foram alocadas 19 parcelas retangulares com dimensões de 25 m x 4 m (100 m²) de forma aleatória em cada uma das áreas, para a avaliação florístico-estrutural do componente regenerativo arbóreo-arbustivo. Na FOD em transição foram amostrados 913 indivíduos regenerantes de espécies arbóreas e arbustivas, pertencentes a 90 espécies, 60 gêneros e 30 famílias botânicas. As espécies com maior IVI foram *Cupania vernalis* (8,71%), seguido de *Bernardia pulchella* (5,93%), *Aureliana wettsteiniana* (5,25%). Na FOM, área em processo restauração em menor tempo, foram amostrados 782 indivíduos regenerantes de espécies arbóreas, arbustivas, pertencentes a 62 espécies, 21 famílias botânicas e 30 gêneros. As espécies com maior IVI foram *Myrsine coriacea* (10,06*%), Solanum variabile* (9,79%), *Myrsine lorentziana* (7,08%). Os índices de diversidade de Shannon foram H' = 3,76 para FOD em transição e H' = 3,24 para FOM, e denotaram alta diversidade de espécies, já o índice de equabilidade de Pielou obteve J = 0,81 para FOD em transição e J = 0,77 para FOM, demonstrando alta uniformidade na distribuição dos indivíduos nas espécies para as duas áreas. A distribuição diamétrica dos indivíduos apresentou padrão "J invertido" para ambas as fitofisionomias, comportamento esperado em florestas nativas. A NMDS apresentou um valor de *stress* de 9,81% indicando adequabilidade da ordenação e permitindo a realização de inferências com confiabilidade. Por meio da ordenação NMDS, observou-se a formação de dois grupos florístico-estruturais distintos, associados as fitofisionomias de FOM e transição FOM/FOD. Todas as parcelas inseridas em áreas de FOM encontram-se agrupadas à direita na ordenação, enquanto que a maioria das parcelas inseridas na área de transição FOM/FOD estão agrupadas à esquerda da ordenação. O componente regenerativo arbóreo-arbustivo avaliado em áreas pós-colheita de *Pinus* sp. em ambas as fitofisionomias possui grande diversidade de espécies com grande valor de importância à formação florestal, sendo um ambiente favorável para a conservação de espécies e fundamental para garantir a sucessão da floresta e a resiliência da restauração.

Palavras-chave: Fitossociologia; Componente regenerativo; Riqueza

1 INTRODUCTION

The Atlantic Forest is one of the world's biodiversity hotspots (MYERS *et al*., 2000) for having several species of great importance, this ecosystem is considered one of the most threatened ones in the world, (SCARANO; CEOTTO, 2015) mainly due to the high index of fragmentation that led to the loss of more than 80% of its original coverage (RIBEIRO *et al*., 2011). Among the typologies of the Atlantic Forest Biome present in the Santa Catarina state, the Dense Ombrophilous Forest (DOF) and the Mixed Ombrophilous Forest (MOF) stand out as those most affected by the exploitation of wood and the agricultural activities, resulting in a high rate of fragmentation and even extinction of endemic species (GASPER *et al*., 2013; VIBRANS *et al*., 2013).

The DOF is one of the main typologies of the state, with high diversity. However, due to the exploration, it is currently composed of isolated remnants and of varying sizes and stages of regeneration (VIBRANS *et al*., 2013). The MOF, known as Araucaria Forest, due to the predominant presence of *Araucaria angustifolia* (Bertol.) Kuntze on the canopy (VIBRANS *et al*., 2013) also suffered with the exploration and removal of wood (GASPER *et al*., 2013; VIBRANS *et al*., 2013) of noble species such as *Araucaria angustifolia* (Pinheiro-do-Paraná) and *Ocotea porosa* (Nees) Barroso (Imbuia). This exploration led to the reduction of natural reserves, giving space to agricultural production and forest plantations.

Among the species used in forest stands, the genus *Pinus* stands out in terms of cultivated area, once it is a source of raw material of great importance for the forest sector (BOGNOLA *et al.,* 2018). Many of the areas implanted in past decades encompassed permanent preservation areas, which included the banks of rivers, streams, springs and hilltops, among others (SEUBERT *et al*., 2017). However, areas with forest plantations in inadequate locations are being regularized by forestry companies and, the most common situation that has been occurring, is that companies leave the permanent preservation areas to recover themselves through natural regeneration. This method has been highlighted for being the best cost-benefit in areas with potential for natural regeneration (BRANCALION *et al*., 2010).

However, in order to be successful in conducting natural regeneration, it is necessary to carry out the monitoring of the ecological processes until the restoration of the forest (RODRIGUES; BRANCALION; ISERNHAGEN, 2013). The monitoring of the restoration can be carried out using ecological indicators and, among the indicators used are the floristic and structural survey of natural regeneration, which allows to know the floristic composition of the regenerative layer, being highly influenced by anthropic actions in the initial process of vegetation succession (DARONCO; MELO; DURIGAN, 2013).

In order to verify the evolution of forest restoration in post-harvest areas of

Pinus sp. and to subsidize restoration actions, the objective of this study was to carry out a phytosociological survey of natural regeneration in post-harvest permanent preservation areas of *Pinus* sp. in the Mixed Ombrophilous Forest and in a transition area between Dense Ombrophilous Forest and Mixed Ombrophilous Forest. In this sense, we sought to answer the following questions: 1) Does the floristic-structural composition of natural regeneration in the post-harvest areas of *Pinus* sp. differ between the phytophysiognomies evaluated? 2) Is natural regeneration satisfatory to attest to the passive restoration of these areas? 3) Do richness and the diversity of species guarantee the succession and restoration of the evaluated areas??

2 MATERIAL AND METHODS

2.1 Description of the study area

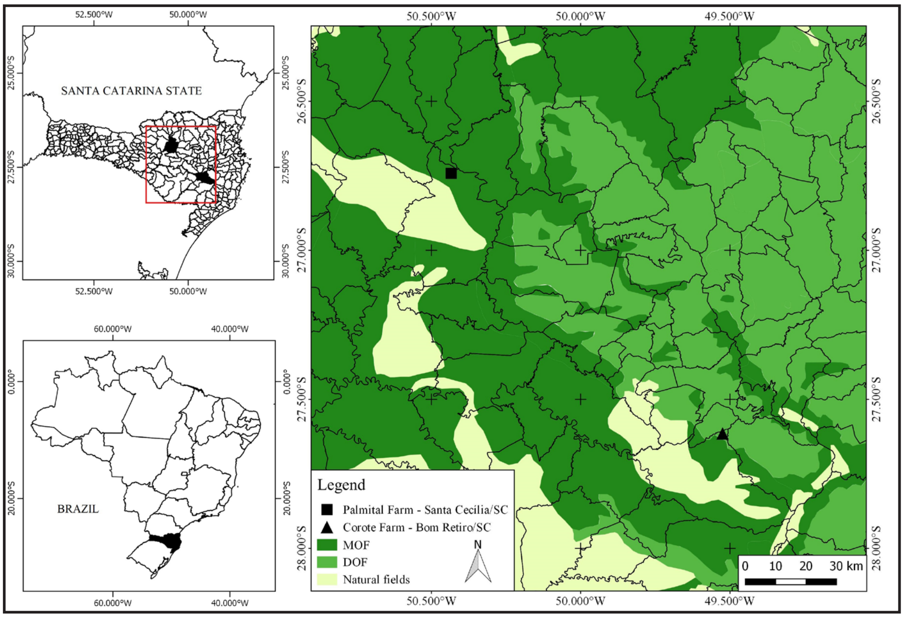
The study was carried out in the permanent preservation areas (PPA) associated with springs and rivers in two areas, one inserted in the Mixed Ombrophilous Forest (MOF) and the other in a transition area between Dense Ombrophilous Forest (DOF) and MOF in the state of Santa Catarina. The areas were previously occupied by stands of *Pinus* sp., and were harvested, following the determination of Law No 12651/2012 (BRAZIL, 2012) and, subsequently, the forest restoration process of the areas began through the conduction of natural regeneration. Both areas evaluated have vegetation in the medium stage of regeneration, with understory present, significant species diversity and indicator species and characteristics of the medium stage of vegetation. In the MOF/DOF transition area, the following stand out: *Inga marginata* Willd.; *Jacaranda puberula* Cham; *Ilex paraguariensis* A. St.-Hil.; *Cupania vernalis* Cambess, among others. In the MOF area, *Baccharis uncinella* DC stands out; *Solanum variabile* Mart., *Solanum mauritianum* Scop.; *Myrsine coriacea* (Sw.) R. Br. ex Roem. & Schult., in addition to species from the Lauraceae and Myrtaceae families (COUNCIL OF NATIONAL ENVIRONMENT, 1994).

The area evaluated in the municipality of Bom Retiro, Santa Catarina state, is inserted in a transition area between MOF and DOF (Figure 1). At an average altitude of

940 m, the climate of the region is characterized as humid mesothermal (Cfb), with cool summer and average temperature of 17.7ºC, with no defined dry season (ALVARES *et al*., 2013). The soil is classified as Cambisol with a prominent A horizon with a clay texture (POTTER *et al*., 2004; BATISTA, 2012). Approximately 12 years ago, after environmental regularization and removal of *Pinus* sp. in approximately 610.5 ha destined for the APP, the restoration process began by conducting natural regeneration.

The area evaluated in the municipality of Santa Cecília, Santa Catarina state, is part of the Mixed Ombrophilous Forest typology (Figure 1), with an average altitude of 1,138 m, and a climate characterized by humid mesothermal (Cfb), with a cool summer and an average temperature of 15.8ºC, without presenting well-defined dry seasons (ALVARES *et al*., 2013). The soil type is classified as Latosol Bruno with a prominent A horizon and very clayey texture (POTTER *et al*., 2004). Approximately seven years after the environmental adaptation and the removal of *Pinus* sp. present in approximately 406 ha destined to the PPA, the restoration process began by conducting local natural regeneration.

Figure 1 – Location of study areas in the municipalities of Bom Retiro (Dense Ombrophilous Forest in transition) and Santa Cecília (Mixed Ombrophilous Forest) both in the state of Santa Catarina, Brazil



Source: Authors (2020)

2.2 Data collection and processing

Nineteen rectangular plots with dimensions of 25 m x 4 m (100 m²) were allocated at random, according to the methodology proposed by CBRN 01/2015 (SÃO PAULO, 2015) which establishes a protocol for monitoring areas under restoration for the state of São Paulo.

In each plot, all tree/shrub individuals taller than 50 cm and circumference at breast height (CBH) of up to 15 cm, measured at 1.30 m, were measured and marked with metal plates. For individuals with a height of less than 1.30 m, the circumference at soil height (CSH) was measured. The identification of the species, whenever possible, was carried out in loco and, when not recognized in the field, these were collected and sent to the Dendrology Laboratory of the University of the State of Santa Catarina for later identification. The material was identified by consulting the Herbarium LUSC of the same institution, specialists and specialized bibliography. The taxonomic classification of the species was performed according to APG IV (ANGIOSPERM PHYLOGENY GROUP, 2016) and Flora do Brasil 2020 (JARDIM BOTÂNICO DO RIO DE JANEIRO, 2020). As they are regenerating individuals, some individuals did not have leaves or reproductive organs, making identification difficult, being thus classified into morphospecies.

In the phytosociological survey and analysis of the horizontal structure, the parameters proposed by Mueller-Dombois and Ellemberg (2002) were considered, these being density, dominance, frequency and the importance value, in addition to Shannon's diversity indexes (H') and Pielou's equability (J). The comparison of the richness between the areas was carried out through the construction of the species accumulation curve, developed by the randomization method, with 1,000 permutations. The distribution of diameters and heights of natural regeneration was carried out for the two studied vegetation types. The classes and their amplitudes were defined according to the statistical method. The species were classified according to the literature as for dispersion syndrome as anemochoric, autochoric and zoochoric, based on a review of studies that used the classification by Budowski (1965). As for the ecological group, the species were classified as pioneer, early secondary, late secondary and climax, based on the review of works that used the classification of Van Der Pijl (1982), being calculated the percentage of species for each functional group.

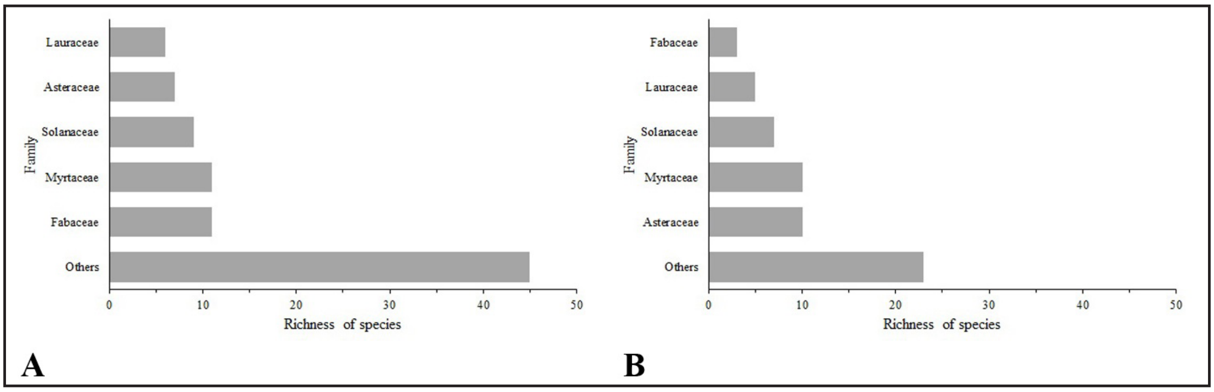
The floristic-structural similarity of natural regeneration between the plots was analyzed using NMDS (Non-metric Multidimensional Scaling) analysis using species abundance data in the plots and as a measure of similarity the Bray-Curtis method. The suitability of the ordering was assessed using the stress value. For this analysis, rare species (with less than 10 individuals) have been removed from the similarity matrix, as they are of little relevance and may hinder your interpretation of the analysis. From the NMDS ordering, it was verified the formation of two floristic-structural groups associated with the different studied physiognomies. The comparison of the community organization between the groups was carried out by means of non-parametric multivariate analysis of variance (PERMANOVA). All analyzes were performed using the R Studio statistical program (R DEVELOPMENT TEAM, 2019). For the diversity indices, NMDS and PERMANOVA, the Vegan package was used (OKSANEN *et al*., 2019).

3 RESULTS AND DISCUSSION

In the transition areas between FOM/FOD, 913 regenerating individuals of tree and shrub species were sampled, belonging to 90 species, 60 genera and 30 botanical families, one species was identified at the family level, six species at the genus level and four non-species were identified due to the absence of leaves and/or reproductive organs. The families with the highest species richness were: Fabaceae (11 species), Myrtaceae (11 species), Solanaceae (9 species), Asteraceae (7 species) and Lauraceae (6 species) (Figure 2 A). The floristic composition, with high richness of the Myrtaceae and Lauraceae families, characterizes a transition area of Mixed Ombrophilous Forest (MOF) and Dense Ombrophilous Forest (DOF) (SILVA *et al*., 2013). Thus, the families sampled in this study are in accordance with the floristic pattern, following the natural composition of the Dense Ombrophylous Forest (BOSA *et al*., 2015).

In the MOF areas, 782 regenerating individuals of tree and shrub species, belonging to 62 species, 21 botanical families and 30 genera, were sampled. In addition, three species were identified at the genus level and four species were not identified due to the absence of leaves and/or reproductive organs. The families with the highest species richness were: Asteraceae (11), Myrtaceae (10), Solanaceae (7), Lauraceae (5), Fabaceae (3) (FIGURE 2 B). The richness of these families follows the floristic pattern of the MOF, since the predominance of Myrtaceae, Asteraceae, Solanaceae and Lauraceae were also found in studies carried out by several authors (e.g. HIGUCHI *et al*., 2012; FERREIRA *et al*., 2013; 2016).

Figure 2 – Species richness by family in post-harvest permanent preservation areas of Pinus sp. in transition areas between Mixed and Dense Ombrophilous Forest (A); and in areas of Mixed Ombrophilous Forest (B)



Source: Authors (2020)

Regarding the phytosociological survey for the regenerative component of the transition areas between MOF/DOF, it was possible to observe that the species with the highest importance value (VI) were *Cupania vernalis* Cambess. (8.71%), followed by *Bernardia pulchella* (5.93%), *Aureliana wettsteiniana* (5.25%), *Clethra scabra* (5.22%), and *Matayba elaeagnoides* (4.51%) (Table 1). The species that obtained the highest VI have zoochoric dispersion syndrome, with the exception of *Clethra scabra*, which is anemochoric. *Cupania vernalis* and *Bernardia pulchella* are early secondary and *Clethra* *scabra* and *Aureliana wettsteiniana* are pioneer species, present at the beginning of the forest succession process. *Matayba elaeagnoides* is late secondary, and is present in more advanced stages of the forest, once it is a species that has higher edaphoclimatic requirements and only establishes itself in degraded areas after the initial colonization by an early pioneer and secondary species (FERREIRA *et al*., 2013).

Table 1 – Phytosociological parameters of the regenerative component in transition areas between Mixed and Dense Ombrophilous Forest, ordered in descending order by the Importance Value (IV)

Species	Ni	AD	RD	ADo	RDo	AF	RF	IV	EG/DS
Cupania vernalis Cambess.	89	468,42	9,75	0,15	12,79	47,37	3,59	8,71	Es/Zoo
Bernardia pulchella (Baill.) Müll. Arg.	85	447,37	9,31	0,06	5,3	42,11	3,19	5,93	Es/Zoo
Aureliana wettsteiniana (Witasek) Hunz. & Barbosa	54	284,21	5,91	0,07	5,46	57,89	4,38	5,25	P/Zoo
Clethra scabra Pers.	42	221,05	4,6	0,11	9,06	26,32	1,99	5,22	P/Ane
Matayba elaeagnoides Radlk.	41	215,79	4,49	0,08	6,65	31,58	2,39	4,51	Ls/Zoo
Piper aduncum L.	60	315,79	6,57	0,03	2,51	57,89	4,38	4,49	P/Zoo
Annona sylvatica A. St.-Hil.	43	226,32	4,71	0,08	6,93	15,79	1,2	4,28	Es/Zoo
Allophylus edulis (A.St.-Hil. et al.) Hieron. ex Niederl.	52	273,68	5,7	0,04	3,36	36,84	2,79	3,95	Es/Zoo
Cabralea canjerana (Vell.) Mart.	23	121,05	2,52	0,04	3,45	47,37	3,59	3,19	Ls/Zoo
Myrsine coriacea (Sw.) R. Br. ex Roem. & Schult.	34	178,95	3,72	0,03	2,08	47,37	3,59	3,13	P/Zoo
Solanum sanctae-catharinae Dunal	32	168,42	3,5	0,03	2,27	36,84	2,79	2,85	P/Zoo
Machaerium paraguariense Hassl.	34	178,95	3,72	0,05	3,79	10,53	0,8	2,77	Ls/Ane
Mollinedia clavigera Tul.	22	115,79	2,41	0,03	2,61	42,11	3,19	2,74	Es/Zoo
Cedrela fissilis Vell.	12	63,16	1,31	0,03	2,82	36,84	2,79	2,31	Ls/Ane
Myrcia splendens (Sw.) DC.	7	36,84	0,77	0,03	2,55	26,32	1,99	1,77	P/Zoo
Casearia sylvestris Sw.	10	52,63	1,1	0,03	2,41	21,05	1,59	1,7	Ls/Zoo
Symplocos tenuifolia Brand	8	42,11	0,88	0,02	1,65	26,32	1,99	1,51	Ls/Zoo
Psychotria vellosiana Benth.	8	42,11	0,88	0,01	1	26,32	1,99	1,29	Es/Zoo
Lithraea brasiliensis Marchand	8	42,11	0,88	0,01	0,93	21,05	1,59	1,13	P/Zoo
Cinnamomum sellowianum (Nees & Mart.) Kosterm.	6	31,58	0,66	0,01	1	21,05	1,59	1,08	Ls/Zoo
Nectandra membranácea (Sw.) Griseb.	7	36,84	0,77	0,01	0,79	21,05	1,59	1,05	Ls/Zoo
Erythrina cristagalli L.	10	52,63	1,1	0,01	0,43	21,05	1,59	1,04	P/Aut
Annona rugulosa (Schltdl.) H. Rainer	9	47,37	0,99	0,01	0,74	15,79	1,2	0,97	Es/Zoo
Myrcia glomerata (Cambess) G. Burton & E. Lucas	7	36,84	0,77	0,02	1,32	10,53	0,8	0,96	Es/Zoo
Ocotea puberula (Rich.) Nees	11	57,89	1,2	0,01	0,77	10,53	0,8	0,92	Es/Zoo

To be continued ...

Table 1 – Continuation

Species	Ni	AD	RD	ADo	RDo	AF	RF	IV	EG/DS
Luehea divaricata Mart. & Zucc.	5	26,32	0,55	0,02	1,32	10,53	0,8	0,89	Es/Ane
Aspidosperma tomentosum Mart. & Zucc.	6	31,58	0,66	0,01	0,78	15,79	1,2	0,88	P/Ane
Campomanesia xanthocarpa (Mart.) O. Berg	7	36,84	0,77	0,01	0,6	15,79	1,2	0,85	Ls/Zoo
Dalbergia frutescens (Vell.) Britton	7	36,84	0,77	0,01	0,89	10,53	0,8	0,82	Ls/Aut
Xylosma ciliatifolia (Clos) Eichler	4	21,05	0,44	0,01	0,78	15,79	1,2	0,81	Es/Zoo
Eugenia pyriformis Cambess.	11	57,89	1,2	0	0,38	10,53	0,8	0,79	Es/Zoo
Solanum mauritianum Scop.	4	21,05	0,44	0,01	0,62	15,79	1,2	0,75	P/Zoo
Solanum pseudocapsicum L.	4	21,05	0,44	0	0,17	21,05	1,59	0,73	P/Zoo
Myrocarpus frondosus Allemão	6	31,58	0,66	0	0,24	15,79	1,2	0,7	Es/Ane
Inga edulis Mart.	3	15,79	0,33	0,01	0,85	10,53	0,8	0,66	Es/Zoo
Myrcia palustres DC.	5	26,32	0,55	0	0,17	15,79	1,2	0,64	P/Zoo
Endlicheria paniculata (Spreng.) J. F. Macbr.	4	21,05	0,44	0	0,27	15,79	1,2	0,63	Ls/Zoo
Styrax leprosus Hook. & Arn.	4	21,05	0,44	0,01	0,61	10,53	0,8	0,61	Es/Zoo
Muellera campestris (Mart. ex Benth.) M. J. Silva & A. M. G. Azevedo	3	15,79	0,33	0,01	0,69	10,53	0,8	0,6	Es/Ane
Casearia decandra Jacq.	6	31,58	0,66	0	0,33	10,53	0,8	0,59	Ls/Zoo
Lantana cf. *camara* L.	4	21,05	0,44	0	0,14	15,79	1,2	0,59	N/Zoo
Psychotria sp.	4	21,05	0,44	0	0,08	15,79	1,2	0,57	N/N
Frangula sphaerosperma (Sw.) Kartesz & Gandhi	3	15,79	0,33	0,01	0,53	10,53	0,8	0,55	P/Zoo
Athenaea fasciculata (Vell.) I.M.C. Rodrigues & Stehmann	6	31,58	0,66	0,01	0,57	5,26	0,4	0,54	P/Zoo
Solanum cassioides L. B. Sm. & Downs	7	36,84	0,77	0,01	0,46	5,26	0,4	0,54	Es/Zoo
Not identified sp. 1	3	15,79	0,33	0	0,09	15,79	1,2	0,54	N/N
Myrsine parvula (Mez) Otegui.	2	10,53	0,22	0,01	0,52	10,53	0,8	0,51	Es/Zoo
Miconia sellowiana Naudin	3	15,79	0,33	0	0,35	10,53	0,8	0,49	P/Zoo
Machaerium cf. *stipitatum* Vogel	3	15,79	0,33	0,01	0,71	5,26	0,4	0,48	Es/Ane
Aiouea glaziovii (Mez) R. Rodhe	4	21,05	0,44	0	0,2	10,53	0,8	0,48	C/Zoo
Vernonanthura tweedieana (Baker) H. Rob.	4	21,05	0,44	0	0,12	10,53	0,8	0,45	P/Ane
Inga lentiscifolia Benth.	4	21,05	0,44	0	0,11	10,53	0,8	0,45	Es/Zoo
Myrcia hatschbachii D. Legrand	6	31,58	0,66	0	0,26	5,26	0,4	0,44	Ls/Zoo
Zanthoxylum rhoifolium Lam.	2	10,53	0,22	0	0,26	10,53	0,8	0,42	Ls/Zoo
Not identified sp. 2	2	10,53	0,22	0	0,24	10,53	0,8	0,42	P/Zoo
*Dahlstedtia pentaphylla (*Taub.) Burkart	3	15,79	0,33	0	0,09	10,53	0,8	0,4	N/Zoo
Blepharocalyx salicifolius (Kunth) O. Berg	3	15,79	0,33	0	0,07	10,53	0,8	0,4	Es/Zoo
Symphyopappus compressus (Gardner) B. L. Rob.	6	31,58	0,66	0	0,12	5,26	0,4	0,39	P/Ane
Nectandra megapotamica (Spreng.) Mez	3	15,79	0,33	0	0,03	10,53	0,8	0,39	Ls/Zoo
Eugenia pluriflora DC.	2	10,53	0,22	0	0,11	10,53	0,8	0,38	Ls/Zoo
Pavonia sp.	5	26,32	0,55	0	0,18	5,26	0,4	0,38	N/N
Piptocarpha regnellii (Sch.Bip.) Cabrera	1	5,26	0,11	0,01	0,6	5,26	0,4	0,37	P/Ane
Vitex megapotamica (Spreng.) Moldenke	4	21,05	0,44	0	0,14	5,26	0,4	0,32	Es/Zoo

To be continued ...

Table 1 – Conclusion

Species	Ni	AD	RD	ADo	RDo	AF	RF	IV	EG/DS
Piptocarpha angustifolia Dusén ex Malme	2	10,53	0,22	0	0,33	5,26	0,4	0,32	P/Ane
Erythroxylum myrsinites Mart.	2	10,53	0,22	0	0,26	5,26	0,4	0,29	Ls/Zoo
Symplocos tetrandra Mart.	3	15,79	0,33	0	0,1	5,26	0,4	0,27	Ls/Zoo
Peltophorum dubium (Spreng.) Taub.	2	10,53	0,22	0	0,2	5,26	0,4	0,27	Es/Zoo
Senna neglecta (Vogel) H. S. Irwin Barneby	2	10,53	0,22	0	0,16	5,26	0,4	0,26	P/Aut
Piper sp.	2	10,53	0,22	0	0,12	5,26	0,4	0,25	N/N
Piptocarpha axillaris (Less.) Baker	1	5,26	0,11	0	0,21	5,26	0,4	0,24	P/Ane
Coccocypselum lanceolatum (Ruiz & Pav.) Pers.	1	5,26	0,11	0	0,21	5,26	0,4	0,24	N/Zoo
Solanum variabile Mart.	2	10,53	0,22	0	0,09	5,26	0,4	0,24	P/Zoo
Baccharis dentata (Vell.) G. M. Barroso	1	5,26	0,11	0	0,14	5,26	0,4	0,22	P/Ane
Prunus myrtifolia (L.) Urb.	1	5,26	0,11	0	0,14	5,26	0,4	0,21	Es/Zoo
Jacaranda puberula Cham.	1	5,26	0,11	0	0,13	5,26	0,4	0,21	P/Ane
Solanum cf. *didymum* Dunal	2	10,53	0,22	0	0,01	5,26	0,4	0,21	N/Zoo
Eugenia neoverrucosa Sobral	1	5,26	0,11	0	0,11	5,26	0,4	0,21	Ls/Zoo
Campomanesia guazumifolia (Cambess.) O. Berg.	1	5,26	0,11	0	0,07	5,26	0,4	0,19	Ls/Zoo
Psychotria suterella Müll.Arg.	1	5,26	0,11	0	0,05	5,26	0,4	0,19	Ls/Zoo
Banara tomentosa Clos	1	5,26	0,11	0	0,05	5,26	0,4	0,19	C/Zoo
Solanum sp.	1	5,26	0,11	0	0,05	5,26	0,4	0,19	N/N
Campovassouria bupleurifolia (DC.) R. M. King & H. Rob.	1	5,26	0,11	0	0,05	5,26	0,4	0,19	P/Ane
Symphyopappus sp.	1	5,26	0,11	0	0,03	5,26	0,4	0,18	N/N
Not identified sp. 3	1	5,26	0,11	0	0,02	5,26	0,4	0,18	N/N
Mollinedia schottiana (Spreng.) Perkins	1	5,26	0,11	0	0,02	5,26	0,4	0,18	C/Zoo
Not identified sp. 4	1	5,26	0,11	0	0,02	5,26	0,4	0,18	N/N
Trichilia cf. *pallens* C. DC.	1	5,26	0,11	0	0,01	5,26	0,4	0,17	C/Zoo
Sorocea bonplandii (Baill.) W.C. Burger *et al*.	1	5,26	0,11	0	0,01	5,26	0,4	0,17	Ls/Zoo
Pleroma sellowianum (Cham.) P.J.F. Guim. & Michelang.	1	5,26	0,11	0	0,01	5,26	0,4	0,17	P/Ane
Alchornea sidifolia Müll.Arg.	1	5,26	0,11	0	0,01	5,26	0,4	0,17	Ls/Zoo

Source: Authors (2020)

In where: Ni = Number of individuals; AD = Absolute density (ind/ha); RD = Relative density (%); ADo = Absolute dominance (m²/ha); RDo = Relative dominance (%); AF = Absolute frequency (%); RF= Relative frequency (%); IV = Importance value index (%); EG = Ecological group; DS = Dispersion syndrome; N = Not identified.

In the MOF areas, the species with the highest importance value (VI) were *Myrsine coriacea* (10.06%), *Solanum variabile* (9.79%), *Myrsine lorentziana* (7.08%), *Baccharis uncinella* (5, 22%), *Clethra scabra* (5.48%) and *Ilex paraguariensis* (3.61%).

Among the species with the highest IV, four have zoochoric dispersion syndrome and two anemochoric. Except *Ilex paraguariensis*, which is a late secondary and *Myrsine lorentziana*, which is an early secondary, the other species are pioneers, characteristic of the initial stage of forest succession.

Myrsine coriacea and *Solanum variabile* had the highest IV, of 10.06% and 9.79%, respectively (Table 2). The high IV of these species is related to the dispersion syndrome and the ecological group, zoochoric and pioneer, respectively. They are species that have a large seed bank on the soil, allowing their establishment in altered areas (SALAMI *et al*., 2015). In addition, in recovery projects with conduction of natural regeneration, the pioneer species are the first to establish themselves, and are called facilitating species, which help in the initial phase of restoration, changing the conditions of the community, so that the next species have an easier time to establish themselves, because the location is already favorable so that the successional plants can introduce themselves.

Among the species sampled, *Araucaria angustifolia* and *Ocotea porosa*, both of great ecological importance for the conservation of MOF and threatened with extinction, presented low IV, 1.27% and 1.65%, respectively. *Araucaria angustifolia* is a characteristic species of this formation, frequently observed in fragments of the region (FERREIRA *et al*., 2016), mainly due to the dominance of the forest canopy. However, the number of individuals found in this study was extremely low, with only one regenerant. Similar results to this study were found by Secco, Accra and Caraiola (2019), in a survey carried out in a regeneration area after clearcut of *Pinus taeda* in the Paraná state, which original forest typology belongs to the MOF.

The low number of individuals of *Araucaria angustifolia* occurs among other factors, due to the low availability of seeds, caused by the absence of nearby native forest remnants (PALUDO *et al*., 2011). Secco, Accra and Caraiola (2019), point out that this result may be a consequence of the limited seed dispersal mechanism, the lack of dispersing animals, among which birds (red-spectacled amazon and blue jackdaw) stand out and especially small mammal ones. *Araucaria angustifolia* represents food for several species of wild fauna, these can act both as predators and as dispersers of these seeds, making it more difficult to find these individuals in the regenerative stratum (SANQUETTA *et al*., 2005).

Table 2 – Phytosociological parameters of the regenerative component in areas of Mixed Ombrophilous Forest, ordered in descending order by the Importance Value

Species	Ni	AD	RD	ADo	RDo	AF	RF	IV	EG/DS
Myrsine coriacea (Sw.) R. Br. ex Roem. & Schult.	149	784,21	0,38	0,28	20,06	94,74	9,73	10,06	P/Zoo
Solanum variabile Mart.	92	484,21	11,76	0,17	12,21	52,63	5,41	9,79	P/Zoo
Myrsine parvula (Mez) Otegui.	14	73,68	19,05	0,02	1,1	10,53	1,08	7,08	Es/Zoo
Baccharis uncinella DC.	45	236,84	0,26	0,14	9,99	52,63	5,41	5,22	P/Ane
Clethra scabra Pers.	39	205,26	1,92	0,08	5,69	57,89	5,95	4,52	P/Ane
Ilex paraguariensis A.St.-Hil.	36	189,47	0,26	0,07	5,17	52,63	5,41	3,61	Ls/Zoo
Grazielia intermedia (DC.) R. M. King & H. Rob.	63	331,58	0,13	0,07	5,36	42,11	4,32	3,27	P/Ane
Grazielia serrata (Spreng.) R. M. King & H. Rob.	2	10,53	8,06	0	0,2	10,53	1,08	3,11	P/Ane
Baccharis intermixta Gardner	35	184,21	0,13	0,06	4,39	42,11	4,32	2,95	P/Ane
Frangula sphaerosperma (Sw.) Kartesz & Gandhi	22	115,79	1,15	0,05	3,47	26,32	2,7	2,44	P/Zoo
Myrcia cruciflora A. R. Lourenço & E. Lucas	5	26,32	5,75	0,01	0,46	10,53	1,08	2,43	Es/Zoo
Inga lentiscifolia Benth.	4	21,05	4,6	0,01	0,79	15,79	1,62	2,34	Es/Zoo
Drimys angustifolia Miers	5	26,32	4,99	0,01	0,39	15,79	1,62	2,33	P/Zoo
Ocotea pulchella (Nees & Mart.) Mez	15	78,95	1,53	0,02	1,45	31,58	3,24	2,08	Ls/Zoo
Schinus terebinthifolia Raddi	15	78,95	1,92	0,01	0,79	31,58	3,24	1,98	P/Zoo
Allophylus edulis (A. St.-Hil. *et al*.) Hieron. ex Niederl.	24	126,32	2,81	0,02	1,43	15,79	1,62	1,96	Ls/Zoo
Baccharis microdonta DC.	2	10,53	4,48	0	0,26	10,53	1,08	1,94	P/Ane
Cinnamomum sellowianum (Nees & Mart.) Kosterm.	15	78,95	1,28	0,05	3,44	10,53	1,08	1,93	N/Zoo
Vernonanthura montevidensis (Spreng.) H. Rob.	22	115,79	2,81	0,02	1,79	10,53	1,08	1,89	P/Ane
Solanum cassioides L.B.Sm. & Downs	25	131,58	3,2	0,02	1,69	5,26	0,54	1,81	N/N
Ocotea porosa (Nees & Mart.) Barroso	12	63,16	1,79	0,02	1,53	15,79	1,62	1,65	Ls/Zoo
Mimosa scabrella Benth.	6	31,58	0,26	0,04	2,78	15,79	1,62	1,55	P/Aut
Prunus myrtifolia (L.) Urb.	9	47,37	1,41	0,02	1,55	15,79	1,62	1,52	Es/Zoo
Podocarpus lambertii Klotzsch ex Endl.	11	57,89	0,51	0,01	0,74	26,32	2,7	1,32	Ls/Zoo
Araucaria angustifolia (Bertol.) Kuntze	1	5,26	3,07	0	0,2	5,26	0,54	1,27	Es/Zoo
Solanum paranense Dusén	8	42,11	1,02	0,02	1,1	15,79	1,62	1,25	Es/Zoo

To be continued ...

Table 2 – Continuation

Species	Ni	AD	RD	ADo	RDo	AF	RF	IV	EG/DS
Cinnamomum amoenum (Nees & Mart.) Kosterm.	10	52,63	0,13	0,03	2,11	10,53	1,08	1,11	Ls/Zoo
Symplocos cf. pentandra (Mattos) Occhioni ex Aranha	7	36,84	0,9	0,01	0,59	15,79	1,62	1,03	Ls/Zoo
Myrceugenia oxysepala (Burret) D. Legrand & Kausel[l]	4	21,05	0,9	0,01	0,79	10,53	1,08	0,92	Ls/Zoo
Myrceugenia myrcioides (Cambess.) O. Berg	7	36,84	0,77	0,02	1,46	5,26	0,54	0,92	Ls/Zoo
Not identified sp. 8	3	15,79	0,38	0,01	0,59	15,79	1,62	0,87	N/N
Ocotea sp.	1	5,26	1,92	0	0,03	5,26	0,54	0,83	N/N
Myrceugenia euosma (O. Berg) D. Legrand	6	31,58	0,77	0,01	0,5	10,53	1,08	0,78	Es/Zoo
Symphyopappus sp.	10	52,63	1,28	0,01	0,52	5,26	0,54	0,78	N/N
Picramnia parvifolia Engl.	4	21,05	0,13	0	0,31	15,79	1,62	0,68	Ls/Zoo
Not identified sp. 7	3	15,79	0,13	0	0,17	15,79	1,62	0,64	N/N
*Solanum mauritianu*m Scop.	3	15,79	0,38	0	0,26	10,53	1,08	0,58	P/Zoo
Myrcia guianensis (Aubl.) DC.	2	10,53	0,51	0	0,13	10,53	1,08	0,57	Es/Zoo
Eugenia pluriflora DC.	3	15,79	0,38	0	0,18	10,53	1,08	0,55	Es/Zoo
Myrciaria delicatula (DC.) O. Berg	5	26,32	0,13	0,01	0,97	5,26	0,54	0,55	Ls/Zoo
Luehea divaricata Mart. & Zucc.	3	15,79	0,13	0	0,33	10,53	1,08	0,51	Es/Ane
Solanum lacerdae Dusén	2	10,53	0,26	0,01	0,71	5,26	0,54	0,5	P/Zoo
Drimys brasiliensis Miers	1	5,26	0,64	0	0,28	5,26	0,54	0,49	Ls/Zoo
Vernonanthura westiniana (Less.) H. Rob.	2	10,53	0,26	0	0,09	10,53	1,08	0,48	P/Ane
Not identified sp. 5	2	10,53	0,13	0	0,21	10,53	1,08	0,47	N/N
Matayba elaeagnoides Radlk.	3	15,79	0,38	0,01	0,38	5,26	0,54	0,43	Ls/Zoo
Myrciaria tenella (DC.) O. Berg	3	15,79	0,64	0	0,11	5,26	0,54	0,43	Ls/Zoo
Campovassouria cruciata (Vell.) R. M. King & H. Rob.	1	5,26	0,64	0	0,01	5,26	0,54	0,4	P/Ane
Schinus polygama (Cav.) Cabrera	3	15,79	0,38	0	0,15	5,26	0,54	0,36	P/Zoo
Inga vera Willd.	1	5,26	0,51	0	0,02	5,26	0,54	0,36	Es/Zoo
Symplocos uniflora (Pohl) Benth.	1	5,26	0,13	0,01	0,4	5,26	0,54	0,36	Ls/Zoo
Eugenia uniflora L.	1	5,26	0,38	0	0,06	5,26	0,54	0,33	Es/Zoo
Solanum sanctae-catharinae Dunal	3	15,79	0,38	0	0,04	5,26	0,54	0,32	P/Zoo
Monteverdia aquifolia (Mart.) Biral	1	5,26	0,38	0	0,01	5,26	0,54	0,31	Es/Zoo
Solanum pseudoquina A. St.-Hil.	1	5,26	0,13	0	0,22	5,26	0,54	0,3	Es/Zoo
Baccharis sp.	2	10,53	0,26	0	0,09	5,26	0,54	0,3	N/N
Myrcia selloi (Spreng.) N. Silveira	1	5,26	0,26	0	0,08	5,26	0,54	0,29	Es/Zoo

To be continued ...

Table 2 – Conclusion

Species	Ni	AD	RD	ADo	RDo	AF	RF	IV	EG/DS
Vernonanthura tweedieana (Baker) H. Rob.	2	10,53	0,26	0	0,05	5,26	0,54	0,28	N/Ane
Not identified sp. 6	1	5,26	0,26	0	0,02	5,26	0,54	0,27	N/N
Monteverdia ilicifolia (Mart. ex Reissek) Biral	2	10,53	0,13	0	0,05	5,26	0,54	0,24	Ls/Zoo
Symplocos tetrandra (Mart.) Miq.	1	5,26	0,13	0	0,04	5,26	0,54	0,24	Ls/Zoo
Escallonia bífida Link & Otto	1	5,26	0,13	0	0,01	5,26	0,54	0,23	P/Ane

Source: Authors (2020)

In where: Ni= Number of individuals; AD = Absolute density (ind/ha); RD = Relative density (%); ADo = Absolute dominance (m^2/ha); RDo = Relative dominance (%); AF = Absolute frequency (%); RF = Relative frequency (%); IV = Importance value index (%); EG = Ecological group; DS = Dispersion syndrome; N = Not identified.

For the MOF/DOF transition areas, the value of the Shannon diversity index (H ‘) obtained was 3.76 and the Pielou index (J) was 0.81. These values confirm the high diversity and low dominance of one or a few species in the regenerative component. Ronchi, Duarte and Schorn (2020) found values close to those verified in this study when evaluating the natural regeneration of an area under restoration nine years ago, after the extraction of *Eucalyptus grandis* in Santa Catarina state, obtaining 3.7 for H ‘and 0.89 for J.

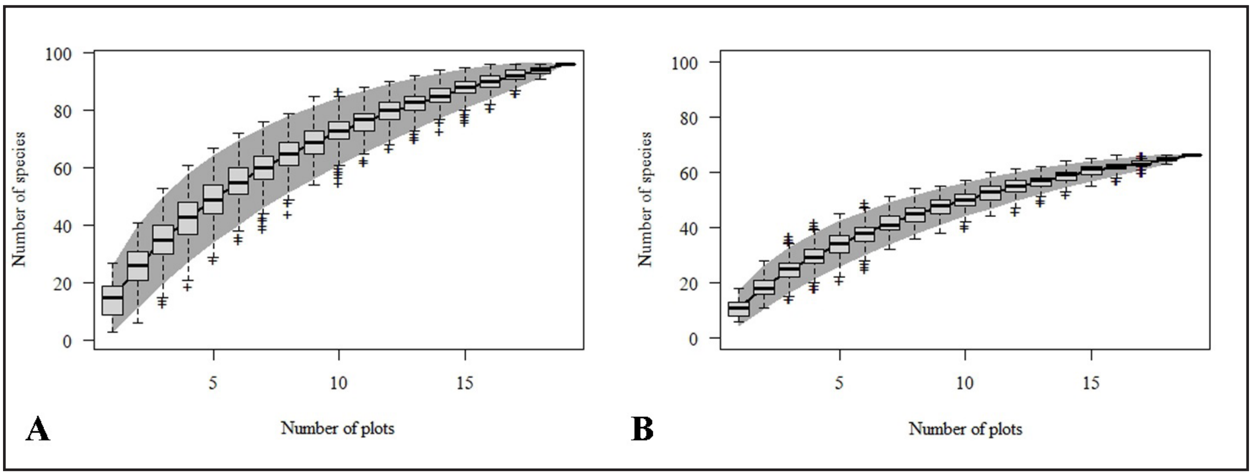
In the MOF area, the Shannon (H‘) diversity was 3.24 and the Pielou index (J) was 0.77, ensuring high species diversity and low dominance of one or a few species in the evaluated area. Ferreira *et al*. (2016), evaluated the natural regeneration in an area inserted in an anthropized matrix of the MOF, used for agricultural purposes with seven years in the process of restoration, and obtained a Shannon diversity (H ‘) of 3.21 and a Pielou index (J) of 0.79, showing low ecological dominance and relatively homogeneous distribution between species.

The species richness found for the MOF/DOF transition areas and MOF areas, were 90 and 62, respectively. The species accumulation curves (Figure 3) demonstrate that the sampling was adequate for the floristic characterization of natural regeneration, since with the inclusion of the last sample unit, a low inclusion of new species was obtained, being 3.75% and 3.57%, respectively.

The species richness verified for the MOF/DOF transition areas (90) was lower than that observed by other authors in assessments of natural regeneration in fragments of DOF in Santa Catarina state, such as Colonetti *et al*. (2009), which s*ample*d 107 species distributed in 80 genera and 42 families, in areas with forest fragments conserved nearby, directly influencing the dispersion and appearance of a greater number of species, when compared with the present study. In the study by Bosa *et al*. (2015) in an area degraded by selective cut, abandoned approximately 30 years ago, 102 regenerating species distributed in 78 genera and 42 families were sampled, that is, the number of regenerating species is variable and is related to the degree of degradation, environmental conditions in the area.

Regarding the species richness in the sampled MOF area (62), the result obtained was internal to other studies, such as the one carried out by Secco, Accra and Caraiola (2019), which also evaluated the restoration process in post-harvest MOF area of *Pinus* sp., in restoration process for approximately two years, where it sampled 64 species, grouped into 42 genera and 27 families.

Figure 3 – Accumulation curve of regeneration species in transition areas between Mixed and Dense Ombrophilous Forest (A); and in areas of Mixed Ombrophilous Forest (B)



Source: Authors (2020)

However, the richness of the natural regeneration sampled in both areas evaluated is in accordance with the expected standards and indicated by Maçaneiro *et al*. (2016), who raised a variation between 39 and 109 species in studies of natural regeneration in MOF, demonstrating the importance value of this fragment for conservation and studies of secondary forests.

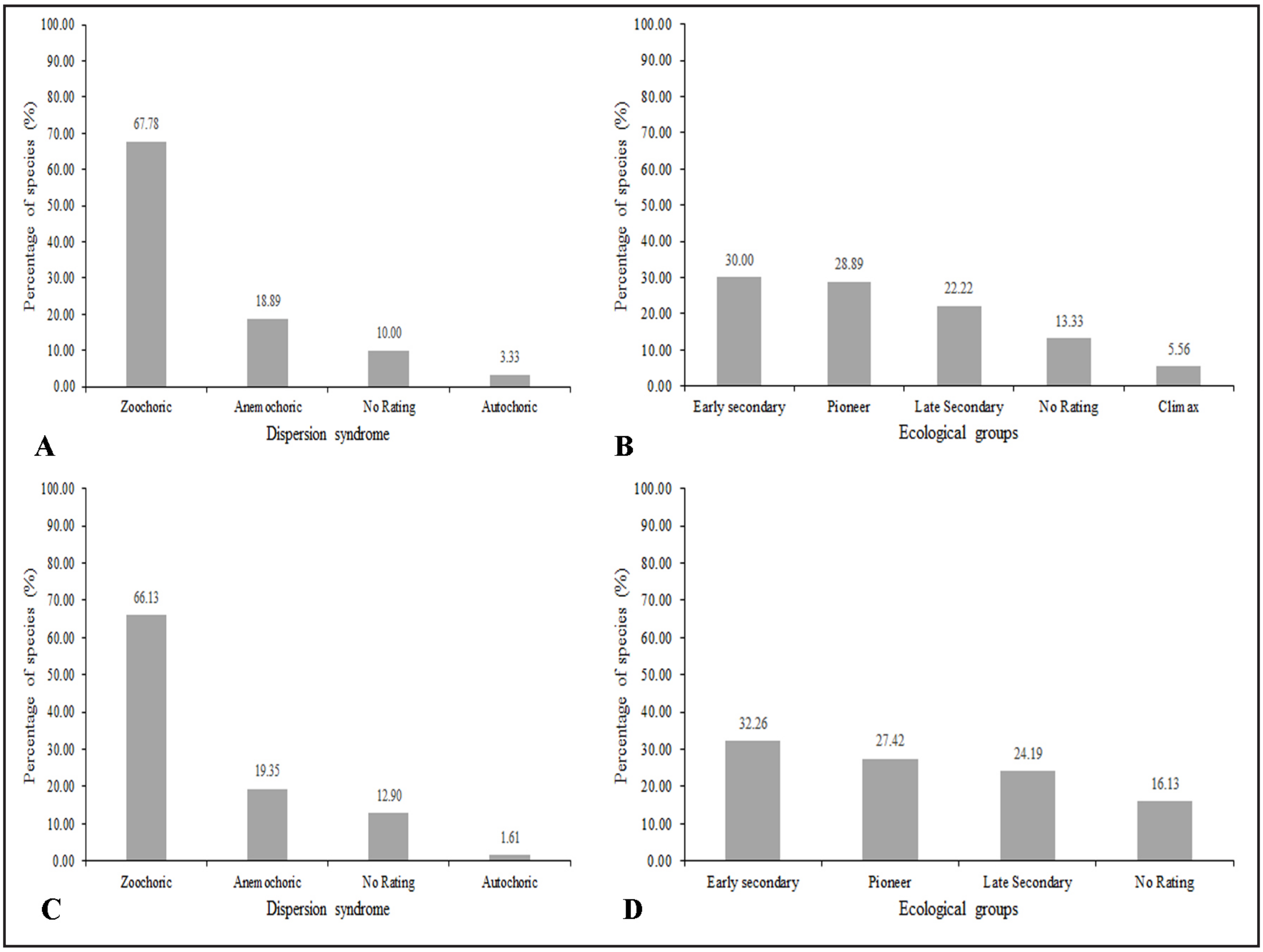
In the MOF/DOF transition areas, most species sampled have zoochoric dispersion syndrome (66.67%), followed by anemochoric (18.89%) and autochoric (4.44%), and without evaluation (10%) (Figure 4). Likewise, in the areas of MOF, most of the sampled species have zoochoric dispersion syndrome (66.13%), followed by anemochoric (19.36%) and autochoric (1.61%) and without evaluation (12.90 %) (Figure 4). The expressive presence of zoochoric species corresponds to what is expected for riparian forests in the domain of the Atlantic Forest, as it presents 50% to 90% of its tree species dispersed by animals, being the main responsible for the revegetation of degraded or disturbed areas, in addition to increasing chances of recolonization and promote the increase of biodiversity in disturbed areas through the entry of new propagules (BOCCHESE *et al*., 2008; PEREIRA *et al*., 2010; SOUZA *et al*., 2012; FERREIRA *et al*., 2013).

Regarding the ecological groups, in the areas in transition from MOF/DOF, 27 early secondary species (30.00%), 26 pioneer species (28.89%), 20 late secondary species (22.22%), five species were sampled climax (5.56%) and 12 species without classification (13.33%) (Figure 4). In the MOF, 20 pioneer species (32.26%), 17 early secondary species (27.42%) and 15 late secondary species (24.19%) were sampled, 10 species without evaluation (16.13%), it is important to highlight that in the MOF area there was no presence of climax species.

The predominance of pioneer species is characteristic in areas that are established after a long period of disturbances (PEREIRA *et al*., 2010). And both pioneer and early secondary species are representative of forest formations in the process of initial restoration and responsible for the colonization of these disturbed forests, these species show rapid growth and development and provide favorable edaphoclimatic conditions for the development of late species (SILVA *et al*., 2013; SECCO; ACRA;

CORAIOLA, 2019). In this way, the importance of obtaining pioneer species in recovery areas is highlighted, as they provide efficient and rapid soil coverage (PEREIRA *et al*., 2010) and facilitate the occurrence of natural regeneration.

Figure 4 – Dispersion syndromes and ecological groups of species sampled in the natural regeneration of the transition area between Mixed and Dense Ombrophylous Forest (A and B); and in the area of Mixed Ombrophylous Forest (C and D)



Source: Authors (2020)

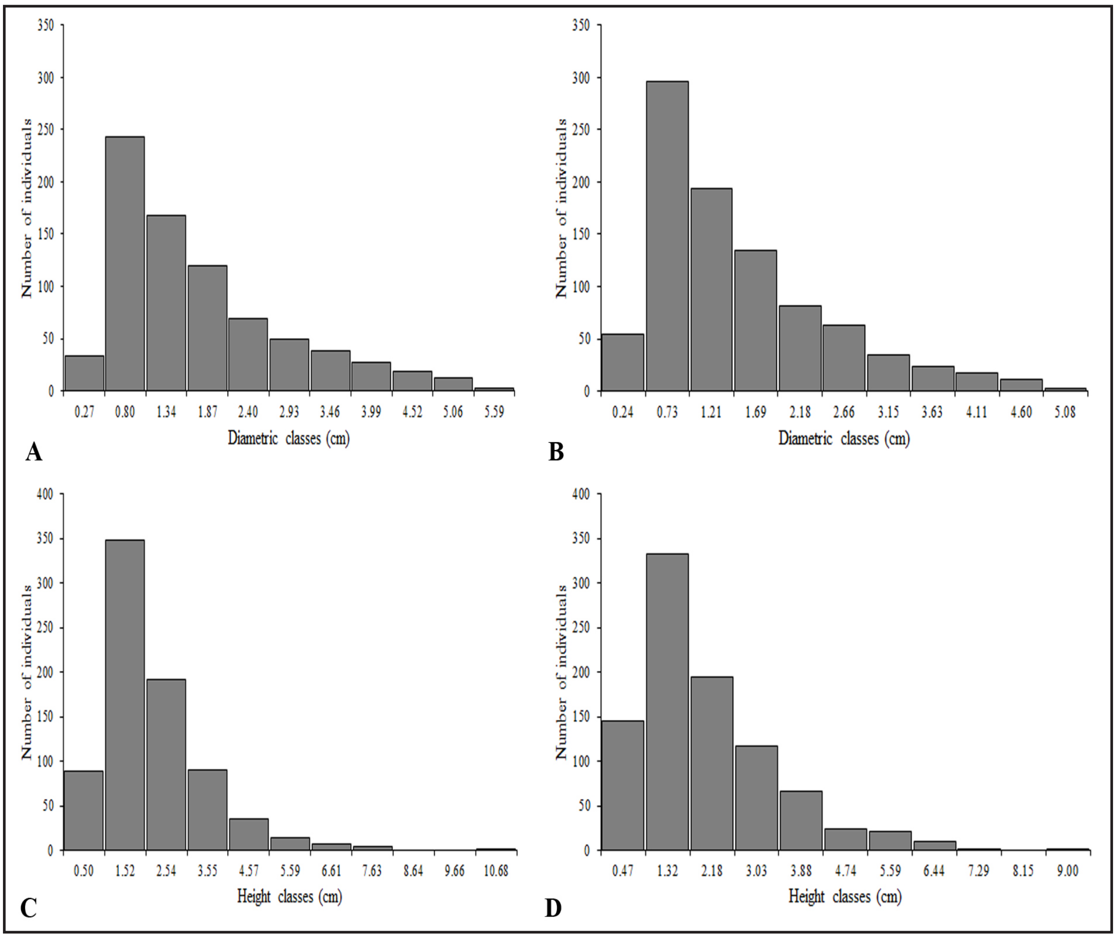
3.1 Height and diameter classes

The diametric distribution of the individuals presented an “inverted J” pattern, for both phytophysiognomies (Figure 5), expected behavior in native forests. In the

MOF areas and in the MOF/DOF transition area, 72.1% and 72.3% of the individuals are included in the four classes of smaller diameter (<2.0 cm), respectively. Regarding height, 92.1% are in the four lowest height classes (<4 m) in the MOF areas, and 86.4% in the MOF/DOF transition area (<3.5 m).

The high occurrence of individuals in the lower classes of diameter denotes that the population is stable in development. Canalez, Corte and Sanquetta (2006) concluded that the "J-inverted" form of distribution indicates that regeneration remains within a continuous flow, with a higher density of individuals in the lower classes in natural regeneration being common, this behavior is expected in natural forests.

Figure 5 – Diametric structure and height of natural regeneration in post-harvest permanent preservation areas of *Pinus* sp. in Mixed Ombrophylous Forest (A and C) and transition area between Mixed and Dense Ombrophylous Forest (B and D)



Source: Authors (2020)

3.2 NMDS Ordering

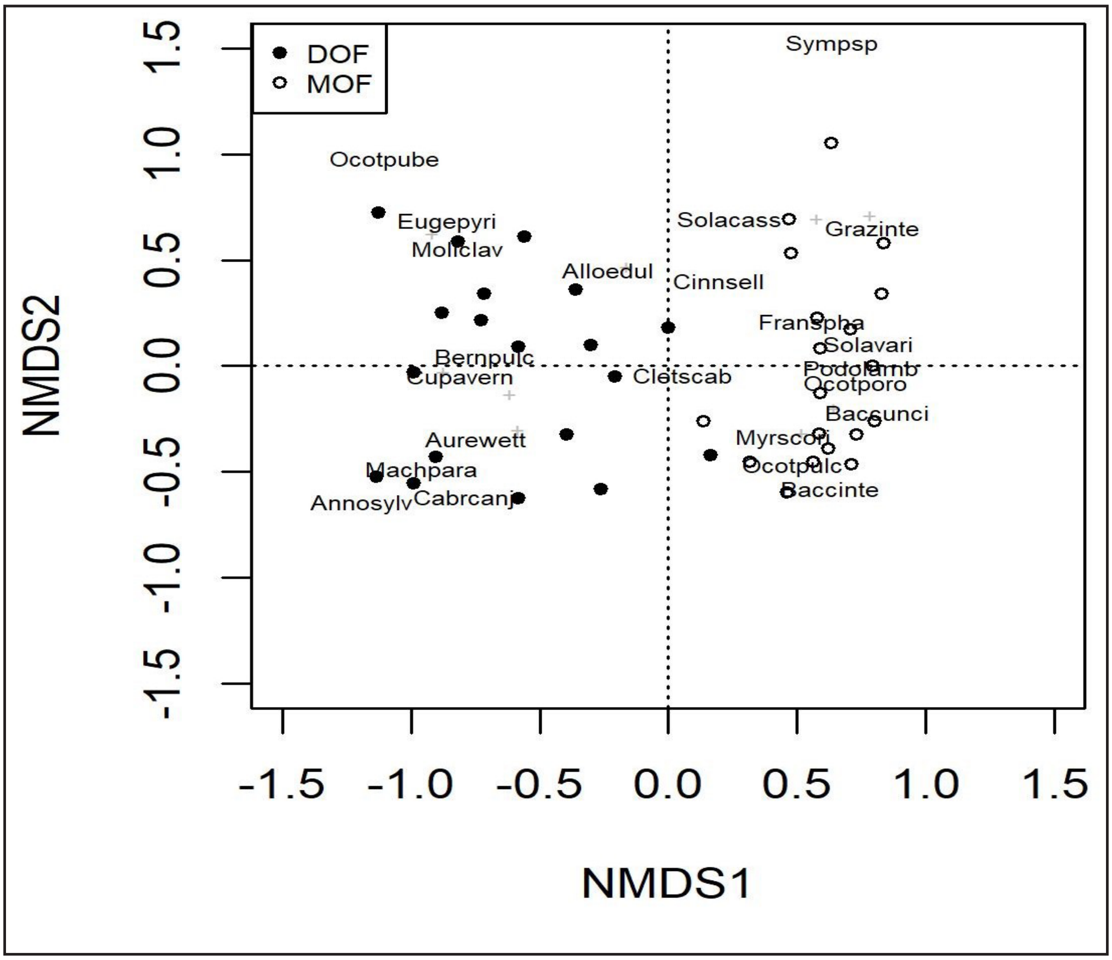
The NMDS presented a stress value of 9.81%, indicating suitability of the ordering and allowing inferences to be made with reliability. Through the NMDS ordering (Figure 6), the formation of two distinct floristic-structural groups was observed, associated with MOF and MOF/DOF transition. All plots inserted in MOF areas are grouped to the right in the ordering, while most plots inserted in the MOF/DOF transition area are grouped to the left of the ordering. There was a difference in the floristic composition between the clusters by means of PERMANOVA ($p < 0.001$), indicating that the natural regeneration in the post-harvest PPA of *Pinus* sp. presentes a low floristic-structural similarity between the studied vegetation types, althought they presente similar characteristics and include transition enviroments.

The low floristic similarity between MOF and DOF phytophysiognomies occurs mainly in response to climatic variables, altitude and the presence of a geographical barrier (HIGUCHI *et al*., 2012). According to these authors, the occurrence of lower temperatures in areas of higher altitude and the presence of a geographical barrier formed by mountain formations “Serra do Mar” and “Serra Geral” prevent the flow of species between DOF and MOF, allowing the establishment of exclusive species in DOF, intolerant to low temperatures, which causes high species substitution among phytophysiognomies.

The heterogeneity between the evaluated areas is associated with several factors, ranging from the topographic profile, availability of nutrients in the soil and the successional stage. Narvaes *et al.* (2014) attributed topography to the main source of vegetation variation in these environments, since the physical and chemical characteristics of soils vary depending on the topographic position.

The occurrence of exclusive species in both phytophysiognomies was verified. It is the case of: *Annona sylvatica, Aureliana wettsteiniana, Piper aduncum, Cabralea canjerana, Cupania vernalis* and *Mollinedia clavigera* in the transition areas MOF/DOF and *Grazielia intermedia, Ocotea porosa, Ocotea pulchella, Ilex paraguariensis* and species of the genus *Baccharis* in the areas of MOF. Species such as *Clethra scabra, Cinnamomum sellowianum and Allophylus edulis*, had a wide distribution in both phytophysiognomies, being located in the center of the diagram (Figure 6).

Figure 6 – Plot distribution and floristic-structural composition of natural regeneration in post-harvest permanent preservation areas of *Pinus* sp. in Mixed Ombrophilous Forest and transition area between Mixed and Dense Ombrophilous Forest, in NMDS analysis (Nonmetric Multidimensional Scaling)



Source: Authors (2020)

In where: Alloedul= *Allophylus edulis*; Annosylv= *Annona sylvatica*, Aurewett= *Aureliana wettsteiniana*; Baccinte: *Baccharis intermixta*; Baccunci: *Baccharis uncinella*; Bernpulc: *Bernardia pulchella*; Cabrcanj: *Cabralea cajerana*; Cedrfiss: *Cedrela fissilis*; Cinnsell= *Cinnamomum sellowianum*; Cletscab= *Clethra scabra*; Eugepyri: *Eugenia pyriformis*; Franspha= *Frangula sphaerosperma*; Grazinte= *Grazielia intermedia*; Ilexpara = *Ilex paraguariensis*; Machpara = *Machaerium paraguariense*; Mataelae= *Matayba elaeagnoides*; Mollclav= *Mollinedia clavigera*; Myrccruc= *Myrcia cruciflora*; Myrscori= *Myrsine coriacea*; Myrsparv= *Myrsine parvula*; Ocotporo= *Ocotea porosa*; Ocotpube= *Ocotea puberula*; Ocotpulc= *Ocotea pulchella*; Pipeadun = *Piper aduncum*; Podolamb= *Podocarpus lambertii*; Schitere = *Schinus terebinthifolia*; Solacass= *Solanum cassioides*; Solasanc= *Solanum sanctae-catharinae*; Solavari= *Solanum variabile*; Sympsp= *Symphyopappus* sp.; Vernmont= *Vernonanthura montevidensis.*

The species sampled in the MOF/DOF transition are of great environmental and ecological importance. *Aureliana wettsteiniana* and *Piper aduncum* are pioneer and zoochoric species. The species *Annona sylvatica*, *Cupania vernalis* and *Mollinedia clavigera* are the early secondary group and zoochoric, representative in the initial phase and responsible for the colonization of these disturbed forests. *Cabralea canjerana*, on the other hand, is late secondary and zoochoric, present in the intermediate phase of the succession. At MOF, the species sampled from the genus *Baccharis*, the others belonging to the Asteraceae family (e.g. *Grazielia intermedia*) are present in the initial stage of the succession, and are responsible for the colonization of open areas, coming to contribute to the process and ensure the beginning of the restoration process. (RECH *et al*., 2017; SECCO; ACRA; CORAIOLA, 2019). It is important to highlight the presence of Ocotea puberula due to its great ecological importance, mainly for areas in recovery of the ecosystem, being zoochoric, with abundant fruiting, guaranteeing the conservation of the local fauna and flora (MARTINS, 2009).

Both areas evaluated had *Pinus* plantation as the main factor of degradation, but after the removal of these individuals and the beginning of the recovery process, they show great potential for perpetuation and reestablishment of the forest ecosystem. The areas presented several similar characteristics in the regenerative extract, when considering attributes such as high richness, diversity and the presence of species with high importance value for the evaluated formations. However, the time of restoration, environmental factors, the presence or absence of the degradation factor and the typology of the region contributes to the results being different, both in diversity and species richness. These results show the different succession trajectories of the forest, and provide relevant information regarding the restoration period and conditions of the evaluated ecosystem, enabling the proper planning of the restoration in the local context, such as the definition of priority species for the introduction and enrichment these areas.

4 CONCLUSIONS

The arboreal-shrubby regenerative component evaluated in post-harvest areas of *Pinus* sp. in MOF areas and MOF/DOF transition areas they have a great diversity of species with great importance for forest formation, being a favorable environment for the conservation of species and essential to guarantee the succession of the forest and the restoration resilience.

The richness and diversity of the arboreal-shrubby regeneration componente was satisfactory, with high richness and species diversity, making the conduction of natural regeneration a viable alternative for the restoration of post-harvest areas of *Pinus* sp. in the MOF areas and MOF/DOF transition areas, capable of providing subsidies that guarantee the restoraion and succession os the of the evaluated areas..

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