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Artigos

Dynamics of natural regeneration in a fragment of a Mixed Ombrophilous Forest in the upland region of Santa Catarina, Brazil

Dinâmica da regeneração natural em um fragmento de Floresta Ombrófila Mista na região do planalto de Santa Catarina, Brasil

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ABSTRACT

This study aimed to analyze the temporal changes in the floristic composition and regeneration structure in a remnant of Mixed Ombrophilous Forest that has been without interventions for decades. Two surveys were undertaken for the study; the first survey was conducted in 2012, and the second in 2017. The experimental area comprised 20 circular plots of 2.5 m radius, where was it performed the quantification of the regenerants, measurement of individual tree heights, and identification of the ecological group that each surveyed species belonged. All individuals with a minimum height of 0.50 m and a circumference at breast height of less than 15 cm were measured. Approximately 12,382 ind ha^{-1} were found in 2012 and 11,185 ind ha^{-1} in 2017. Only the following species increased their abundance per hectare in 2017 compared to the previous survey: *Dalbergia frutescens* (280.3 ind ha^{-1}), *Myrsine coriacea* (178.3 ind ha^{-1}), *Allophylus guaraniticus* (76.4 ind ha^{-1}), *Bernadia pulchella* (51.0 ind ha^{-1}), *Casearia obliqua* (50.9 ind ha^{-1}), *Casearia decandra* (25.5 ind ha^{-1}), and *Luehea divaricata* (25.5 ind ha^{-1}). The remaining species had a negative balance or disappeared from the study. Ecological group analysis indicated the gradual replacement of shadow-tolerant climax species by pioneer and light-demanding climax species. The most representative species identified on both occasions did not undergo major changes, indicating that they are more likely to remain in the studied area. The results indicated that the studied remnant forest is in an advanced phase of succession; however, it presents punctual alterations that reflect its floristic and ecological dynamics.

Keywords: Ecological group; Species diversity; Temporal changes in forest

RESUMO

Este estudo teve como objetivo analisar as alterações temporais na composição florística e estrutura da regeneração em um remanescente de Floresta Ombrófila Mista sem intervenções há décadas, nos anos de 2012 e 2017. A área experimental foi composta por 20 parcelas circulares de 2,5 m de raio, onde foi realizada a quantificação dos regenerantes; a medição das alturas individuais das árvores e a identificação do grupo ecológico ao qual cada espécie pesquisada pertencia. Todos os indivíduos com altura mínima de 0,50 m e circunferência a altura do peito menor do que 15 cm foram medidos. Aproximadamente 12.382 ind ha^{-1} foram encontrados em 2012 e 11.185 ind ha^{-1} em 2017. Somente as seguintes espécies tiveram aumento de densidade em 2017 em comparação com o ano 2012: *Dalbergia frutescens* (280,3 ind ha^{-1}), *Myrsine coriacea* (178,3 ind ha^{-1}), *Allophylus guaraniticus* (76,4 ind ha^{-1}), *Bernadia pulchella* (51,0 ind ha^{-1}), *Casearia obliqua* (50,9 ind ha^{-1}), *Casearia decandra* (25,5 ind ha^{-1}) e *Luehea divaricata* (25,5 ind ha^{-1}). As demais espécies tiveram um saldo negativo ou desapareceram da área. A análise dos grupos ecológicos indicou gradual substituição de espécies clímax tolerantes à sombra por espécies pioneiras e clímax exigentes de luz. As espécies mais representativas identificadas em ambas ocasiões não sofreram grandes alterações, indicando que são mais propensas a permanecer na área estudada. Os resultados indicaram que o remanescente estudado se encontra em fase avançada de sucessão; no entanto, apresenta alterações pontuais que refletem sua dinâmica florística e ecológica.

Palavras-chave: Grupos ecológicos; Diversidade de espécies; Mudanças temporais na floresta

1 INTRODUCTION

Mixed Ombrophilous Forest, also called Araucaria forest, is a floristic community resulting from the mixture of floras of Austral-Andean and Afro-Brazilian origin (VELOSO; RANGEL-FILHO; LIMA, 1991), characterized by the presence of *Araucaria angustifolia* (Bertol.) Kuntze (VELOSO, 1991).

In southern Brazil, the Araucaria forest is one of the most degraded forest formations owing to deforestation. In the State of Santa Catarina accelerated exploitation has transformed large areas of native vegetation into sparse and greatly altered fragments, leaving only 24.4% of the original coverage (VIBRANS *et al*., 2013).

With the recurrent loss of forest areas and, consequently, biodiversity, the study of the floristic and phytosociological compositions of forests is of great importance; it offers subsidies that help in understanding the dynamic structure through successional, climatic, edaphic, and anthropogenic parameters in a forest, which are essential for the management and regeneration of different plant communities (MARTINS *et al*., 2017).

Knowledge about the productive and regenerative capacity of forests disturbed by anthropic or natural actions generates greater subsidies for their preservation and correct management (SANQUETTA; CORTE; EISFELD, 2003). Studies on natural regeneration in forests are of great importance for understanding the ecological functioning of these ecosystems, as they allow inferences on the dynamics of communities and populations of tree species, which represent fundamental information for forest management (SANTOS *et al*., 2015).

Thus, given the impacts caused by anthropic action or natural events, monitoring the dynamics of communities and populations of regenerating tree species in fragmented landscapes is essential because it increases our knowledge of the floristic and structural changes that occur over time (NUNES *et al*., 2016). So, the study of floristic dynamics provides important information that can be implemented in the sustainable management of natural forests, in addition to furthering our understanding of the possible consequences of recent anthropogenic and natural changes, such as deforestation, forest fragmentation, among others (SHEIL; JENNINGS; SAVILL, 2000).

Given the above, this study aimed to evaluate the temporal changes in the floristic composition and phytosociological structure of the regenerative stratum in a remnant of Mixed Ombrophilous Forest without interventions for more than 40 years located in Santa Catarina, Brazil, in 2012 and 2017.

2 MATERIAL AND METHOD

2.1 Study area characterization

The study was carried out in a forest fragment of the Private Natural Heritage Reserve (PNHR) "Emílio Einsfeld Filho," located in Campo Belo do Sul, Santa Catarina (SC), Brazil (28°02'55.00"S, 50°45'59.56"W). The study area has 3,367 ha, with approximately 71% canopy cover, characterized by different succession stages.

The vegetation that constitutes the PNHR is basically formed by Mixed Ombrophilous Forest. Much of the vegetation in the study area has suffered anthropogenic action through selective logging in the past, mainly of high commercial value woods such as *Araucaria* and *Ocotea*. However, these interventions have been suspended for more than 40 years (ZELLER, 2010).

In the remainder evaluated, there are two dominant geomorphic units: the Planalto dos Campos Gerais and the Planalto Dissecado of the Iguaçu River / Rio Uruguai. The main soils identified at the site are the Litossal Neossols, the Cambisols and the Nitosols most present in the vicinity of the Pelotas and Canoas / Caveiras rivers (EMBRAPA, 2006).

2.2 Data collection

In 2012, Schorn *et al*. initiated a forest inventory in the study area, which involved randomly selecting and creating 20 circular sample units with 2.5 m radius, totaling a sample area of 392.5 m².

All individuals with a minimum height of 0.50 m and a circumference at breast height of less than 15 cm were measured. The collected data corresponded quantification of the regenerants, measurement of heights and identification of the ecological group that each surveyed species belonged. The same sample units were measured again in March 2017 for the second data collection of the study.

2.3 Data analysis

With the data collected from the sampling carried out in the 2012 and 2017 surveys, the floristic and phytosociological parameters of natural regeneration were estimated. The dynamics of regeneration were evaluated by changes in the structural values of the species between the two surveyed periods.

The parameters used to estimate the structure of regeneration was density, based on Mueller-Dombois and Ellenberg (1974). Species identification was carried out through expert opinions and specialized literature. The species were classified at family level according to the APG IV system (ANGIOSPERM PHYLOGENY GROUP, 2016). For the classification of species in regeneration guilds, the following classes were used: pioneer (P), climax demanding light (CL), and climax tolerant to shadow (CS) (classifications are based on those described by Oliveira-Filho (1994)). The regeneration value expresses the importance of species in the community by averaging the relative parameters of density, frequency and size category of regeneration (FINOL, 1971).

In order to determine the similarity from regenerative component between of surveys the Jaccard index was calculated. To calculate the diversity of the floristic composition, the Shannon (*H'*) and Pielou (*J*) indices were used (BROWER; ZARR, 1984; MAGURRAN, 1988). All analyzes were held through in the PAST® statistical software version 2.17c, according to the methodology described by Felfili and Rezende (2003) and Magurran (2004).

All the calculations covered all species sampled in the survey area with density greater than 10 individuals per hectare. Changes in species density were analyzed using the paired t-test (alpha was set at = 0.05) and also in regeneration guilds (ecological groups) using the Mann Whitney's nonparametric test (alpha was set at = 0.05).

3 RESULTS AND DISCUSSION

3.1 Floristic composition and species diversity

Approximately 12,382 ind ha^{-1} were found in 2012 and 11,185 ind ha^{-1} in 2017 (Table 1). Results showed there was no significant difference (paired t-test; $p < 0.05$) in the density distribution of regenerating individuals between survey years 2012 and 2017. The reduction of density of individuals may be linked a natural disturbance (storm) between the two surveys, which led to the fall of some mature trees, which consequently ends up suppressing natural regeneration, at the same time that it opens clearings and resumes the succession. Therefore, the forest dynamics do not cease in advanced stages as it deviates towards localized disturbances such as falls from trees or others that characterize the heterogeneity of the forest (CHAZDON *et al*., 2012).

Table 1 – Floristic and structural descriptors evaluated for the regenerative component of a tree community in 2012 and 2017 in a fragment of a Mixed Ombrophilous Forest in Santa Catarina, Brazil

Evaluated Descriptors	2012	2017
Number of Species	49	66
Number of Gender	43	39
Number of Families	30	27
Jaccard Index	0.31	0.31
Shannon Diversity Index (*H'*)	3.15	3.18
Pielou Equity (*J*)	0.81	0.80
Number of individuals sampled	486	439
Number of individuals per hectare	12,382	11,185

Source: Authors (2019)

Overall, in both surveys, 88 species and 35 botanical families were identified. Among the species, 49 were identified in 2012 and 66 in 2017, with only 27 found in both surveys. Regarding families, eight were found only in the first survey and six exclusively in the second.

The families with higher species richness in both periods were Myrtaceae, Fabaceae, Lauraceae, Sapindaceae, and Euphorbiaceae. Together, these families comprised about 48% and 52% of the total species in 2012 and 2017, respectively.

In the same forest typology, the Myrtaceae family also stood out in terms of species richness in studies by Higuchi *et al*. (2012, 2015, 2016), Ribeiro *et al*. (2013), Santos *et al*. (2015), Dalla Rosa *et al*. (2016), Silva *et al*. (2017), Santana *et al*. (2018), Santos *et al*. (2018) and Vefago *et al*. (2019). According to Seguer *et al*. (2005), the presence of a larger number of species of the Myrtaceae family practically follows the floristic pattern for this forest formation. In this context, the Mixed Ombrophilous Forest constitutes an important dispersal center of the Myrtaceae family, being observed from large trees to undergrowth trees and shrubs (NASCIMENTO; LONGHI; BRENA, 2001).

The Jaccard index indicated low floristic similarity (0.31) between the two survey periods (2012 and 2017), this probably happened due to the high number of rare species, that is, species that have few individuals. Gonzaga *et al*. (2013) also considered low rates below 0.5. The range of this index ranges from 0 when there are no shared species to 1 when the same species are shared. This index measures differences in the presence of the absence of species (ÁLVAREZ *et al*., 2004). The estimated *J* values were considered high for both surveys, indicating that few species stand out in relation to the number of individuals. In contrast, Watzlawick *et al*. (2011) found a relatively low *J* value (0.68) in a Mixed Ombrophilous Forest fragment, indicating average uniformity. In the same forest typology, Cordeiro and Rodrigues (2007) found a *J* value of 0.90, noting high uniformity in the vegetation.

The survey conducted in 2012 found *H’* and *J* values of 3.15 and 0.81, while the survey in 2017 found *H’* and *J* values of 3.18 and 0.80, respectively (Table 1). The H' value was lower to that found in an experiment by Aguiar *et al*. (2017) (3.34) in an MOF in Lages, SC, Brazil and by Santos *et al*. (2018) (3.42) in the same city and forest type. In contrast, H' value was higher to that found in an experiment by Santos *et al*. (2015) in an MOF fragment in Lages, SC, Brazil (2,73) and Dalla Rosa *et al*. (2016) in a remnant of the same forest typology in Urubici, SC, Brazil (2,51). According to Felfili and Rezende (2003), *H’* values are generally between 1.3 and 3.5 and may exceed 4.0 and reach around 4.5 in tropical forest environments.

3.2 Structural dynamics of natural regeneration

According to the data collected, only the following species increased their abundance per hectare in 2017 compared to the previous survey: *Dalbergia frutescens* (280.3 ind ha^{-1}), *Myrsine coriacea* (178.3 ind ha^{-1}), *Allophylus guaraniticus* (76.4 ind ha^{-1}), *Bernadia pulchella* (51.0 ind ha^{-1}), *Casearia obliqua* (50.9 ind ha^{-1}), *Casearia decandra*

(25.5 ind ha^{-1}), and *Luehea divaricata* (25.5 ind ha^{-1}) (Table 2). The remaining species had a negative balance from in the study, and the largest losses in terms of the number of individuals per hectare were observed in *Sebastiana brasiliensis* (-484.1 ind ha^{-1}), *Ocotea pulchella* (-458.6 ind ha^{-1}), *Matayba elaeagnoides* (-382.2 ind ha^{-1}), *Myrcia multiflora* (-356.7 ind ha^{-1}), *Rudgea parquioides* (-331.2 ind ha^{-1}), *A. angustifolia* (331.2 ind ha^{-1}), and *Eugenia rostrifolia* (-280.3 ind ha^{-1}).

Table 2 – Percentage of change in density of individuals per species in a fragment of a Mixed Ombrophilous Forest in Santa Catarina, Brazil

Species	Absolute density		Changes	
	2012	2017	ind ha^{-1}	(%)
Allophylus edulis (A.St.-Hil., Cambess. & A. Juss.) Radlk.	0.0	280.3		
Allophylus guaraniticus (A.St.-Hil.) Radlk	1248.4	1324.8	76.4	6.0
Allophylus sp.	0.0	280.3		
Annona emarginata (Schltdl.) H.Rainer	382.2	203.8	-178.3	-47.0
Araucaria angustifolia (Bertol.) Kuntze	535.0	203.8	-331.2	-62.0
Bernardia pulchella (Baill.) Müll. Arg	25.5	76.4	51.0	200.0
Brunfelsia cuneifolia J.A.Schmidt	0.0	25.5		
Brunfelsia pilosa Plowman	51.0	25.5	-25.5	-50.0
Cabralea canjerana (Vell.) Mart. subsp.	0.0	76.4		
Calyptranthes concinna DC.	254.8	51.0	-203.8	-80.0
Campomanesia guaviroba (DC.) Kiaersk.	25.5	25.5	0.0	0.0
Capsicum sp.	25.5	0.0	-25.5	-100.0
Casearia decandra Jacq.	1095.5	1121.0	25.5	2.0
Casearia obliqua Spreng.	51.0	101.9	50.9	100.0
Celtis iguanaea (Jacq.) Sarg.	0.0	25.5		
Cinnamodendron dinisii Schwacke	229.3	178.3	-51.0	-22.0
Citronella gongonha (Mart.) R.A.Howard	25.5	0.0	-25.5	-100.0
Clethra scabra Pers.	0.0	25.5		
Critoniopsis quinqueflora (Less.) H. Rob.	0.0	101.9		
Cupania vernalis Cambess.	458.6	305.7	-152.9	-33.0
Dalbergia frutescens (Vell.) Britton	51.0	331.2	280.3	550.0
Daphnopsis racemosa Griseb.	25.5	25.5	0.0	0.0

To be continued ...

Table 2 – Continuation

Species	Absolute density		Changes	
	2012	2017	ind ha^{-1}	(%)
Drimys brasiliensis Miers	25.5	0.0	-25.5	-100.0
Erythroxylum deciduum A.St.-Hil.	0.0	25.5		
Eugenia pyriformis Cambess.	25.5	0.0	-25.5	-100.0
Eugenia rostrifolia D.Legrand	280.3	0.0	-280.3	-100.0
Eugenia uniflora L.	203.8	76.4	-127.4	-63.0
Eugenia sp.	0.0	509.6		
Gymnanthes klotzschiana Müll.Arg.	0.0	76.4		
Ilex brevicuspis Reissek	0.0	51.0		
Ilex paraguariensis A.St.-Hil.	0.0	25.5		
Ilex theezans Mart. ex Reissek	152.9	0.0	-152.9	-100.0
Ilex sp.	0.0	25.5		
Lamanonia ternata Vell.	25.5	0.0	-25.5	-100.0
Luehea divaricata Mart. & Zucc.	25.5	51.0	25.5	100.0
Machaerium paraguariense Hassl.	0.0	51.0		
Machaerium stipitatum (DC.) Vogel	0.0	51.0		
Matayba elaeagnoides Radlk.	993.6	611.5	-382.2	-38.0
Miconia cinerascens Miq.	101.9	76.4	-25.5	-25.0
Miconia cubatanensis Hoehne	0.0	509.6		
Mimosa scabrella Benth.	25.5	0.0	-25.5	-100.0
Monteverdia aquifolia (Mart.) Biral	25.5	0.0	-25.5	-100.0
Muellera campestris (Mart. ex Benth.) M.J. Silva & A.M.G. Azevedo	51.0	25.5	-25.5	-50.0
Myrceugenia sp.	51.0	0.0	-51.0	-100.0
Myrcia brasiliensis Kiaersk.	0.0	25.5		
Myrcia hartwegiana (O.Berg) Kiaersk.	0.0	76.4		
Myrcia multiflora (Lam.) DC.	1579.6	1222.9	-356.7	-23.0
Myrcia oblongata DC.	0.0	25.5		
Myrcianthes pungens (O.Berg) D. Legrand	51.0	0.0	-51.0	-100.0
Myrocarpus frondosus Allemão	152.9	0.0	-152.9	-100.0
Myrsine coriacea (Sw.) R.Br.	866.2	1044.6	178.3	21.0
Myrsine umbellata Mart.	0.0	25.5		
Myrsine sp.	25.5	0.0	-25.5	-100.0

To be continued ...

Table 2 – Continuation

Species	Absolute density		Changes	
	2012	2017	ind ha^{-1}	(%)
Nectandra lanceolata Nees	25.5	0.0	-25.5	-100.0
Nectandra megapotamica (Spreng.) Mez	331.2	229.3	-101.9	-31.0
Ocotea puberula (Rich.) Nees.	152.9	25.5	-127.4	-83.0
Ocotea pulchella (Nees & Mart.) Mez	535.0	76.4	-458.6	-86.0
Ocotea sp.	0.0	51.0		
Pera glabrata (Schott) Poepp. ex Baill.	25.5	0.0	-25.5	-100.0
Piptocarpha angustifolia Dusén ex Malme	25.5	0.0	-25.5	-100.0
Podocarpus lambertii Klotzsch ex Endl.	178.3	101.9	-76.4	-43.0
Prunus myrtifolia (L.) Urb.	101.9	0.0	-101.9	-100.0
US-1	0.0	25.5		
US-10	25.5	0.0	-25.5	-100.0
US-2	0.0	25.5		
US-3	0.0	25.5		
US-4	0.0	25.5		
US-5	0.0	25.5		
US-6	0.0	25.5		
US-7	0.0	25.5		
US-8	0.0	101.9		
US-9	0.0	25.5		
Roupala montana Aubl.	152.9	25.5	-127.4	-83.0
Rudgea parquioides (Cham.) Müll.Arg	433.1	101.9	-331.2	-76.0
Schaefferia argentinensis Speg.	0.0	25.5		
Sebastiania brasiliensis Spreng.	687.9	203.8	-484.1	-70.0
Seguieria aculeata Jacq.	25.5	0.0	-25.5	-100.0
Solanum mauritianum Scop.	0.0	76.4		
Solanum pabstii L.B.Sm. & Downs	0.0	25.5		
Solanum sanctae-catharinae Dunal	0.0	51.0		
Solanum sp.	0.0	25.5		
Sorocea bonplandii (Baill.) W.C.Burger *et al*.	0.0	51.0		
Strychnos cf. *brasiliensis* Mart.	25.5	0.0	-25.5	-100.0
Styrax leprosus Hook. & Arn.	433.1	152.9	-280.3	-65.0
Symplocos tetrandra Mart.	0.0	127.4		

To be continued ...

Table 2 – Conclusion

Species	Absolute density		Changes	
	2012	2017	ind ha^{-1}	(%)
Symplocos sp.	0.0	101.9		
Vernonanthura discolor (Spreng.) H.Rob.	0.0	51.0		
Xylosma ciliatifolia (Clos) Eichler	51.0	0.0	-51.0	-100.0
Zanthoxylum kleinii (R.S.Cowan) P.G.Waterman	25.5	0.0	-25.5	-100.0

Source: Authors (2019)

In where: US = unidentified species.

Vefago *et al*. (2019), evaluating the dynamics of the natural regeneration of remnants of Mixed Ombrophilous Forest in the Planalto Sul Catarinense, observed that the natural regeneration was characterized by structural instability, as well as richness stability. According to Higuchi *et al*. (2015), the variation of the most abundant species can be explained due to their different life strategies and respective capacities to develop in the forest understory. Some species may produce more propagules, however, they are inefficient competitors. Other species may produce few propagules, but with good competitive capacity (HIGUCHI *et al*., 2015).

In 2012, *Myrcia multiflora* was the most important species in the community; however, it was reduced in density by 23% in 2017. With this decrease, *Allophylus guaraniticus* became the species with the highest density in the community. In a study by Callegaro *et al*. (2015), *A. guaraniticus* it was described as one of the species with the highest regeneration potential in the studied community. In a study by Vefago *et al*. (2019), this specie also was among the most representative. These results demonstrate the importance of this species in the Mixed Ombrophilous Forest.

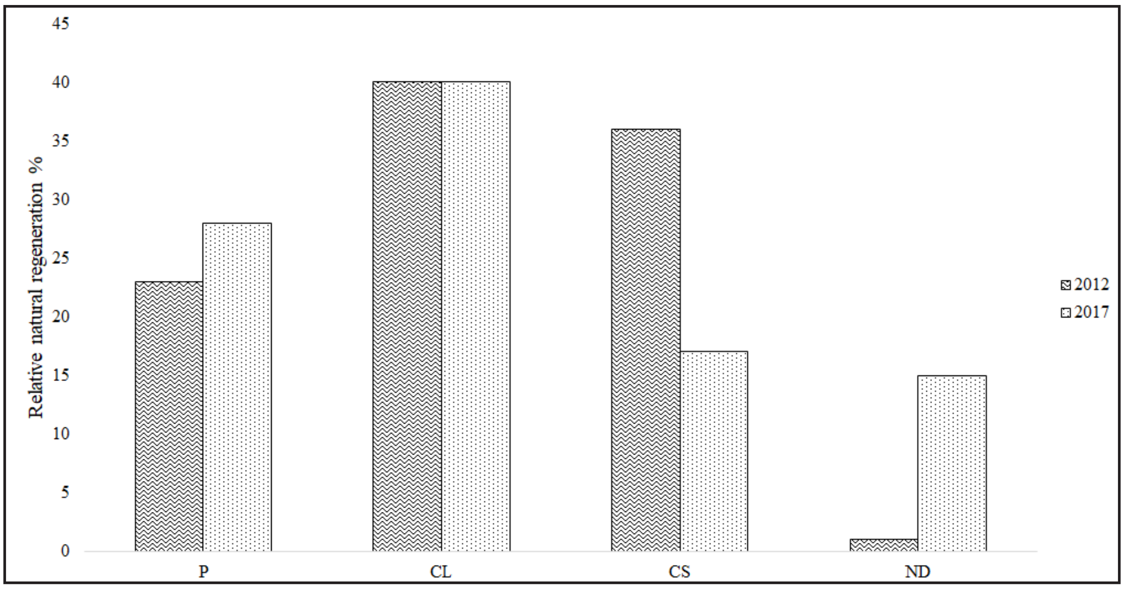
It should be noted that 22 species that occurred in 2012 presented a negative balance in the study, presenting changes of -100%. In contrast, 39 new species were added to the experimental area. It is observed that the exclusive species had few individuals per hectare in 2012, which may have facilitated their disappearance.

Thus, the species with the largest number of individuals in the 2012 survey and which kept their population contingent stable in the community in 2017 were *Allophylus guaraniticus*, *Casearia decandra*, *Myrsine coriacea*, and *Matayba elaeagnoides*. In contrast, others that had low abundance, most with 25 ind ha^{-1}, had a negative balance in the study and were replaced by others in 2017. Hence, it is believed that species with lower densities are more likely to be replaced than others that physiognomically dominate the community.

3.3 Dynamics of ecological groups

In 2012, there was a higher representativeness of light-demanding climax species and shadow-tolerant climax species, and a lower representativeness of pioneer species. In 2017, there was a large reduction in the representativeness of shadow-tolerant climax species and a increase in pioneer species, while light-demanding climax species remained stable (Figure 1). The rate of change that occurred between the survey years, 2012 and 2017, was significant just for shade tolerant species (Mann Whitney test; p <0.05).

Figure 1 – Relative natural regeneration by ecological group between 2012 and 2017



Source: Authors (2019)

In where: P = Pioneers; CL = climax demanding light; CS = climax tolerant to shadow; ND = Ecological group not defined.

However, in the second survey, there was a reduction in shade-tolerant species and an increase in the representativeness of pioneer species. This can be verified, for example, with the increases in representativity of *Myrsine coriacea* (pioneer) and *Sebastiana brasiliensis* (climax tolerant to shadow) in 2017.

It should be noted that among the various factors that may have triggered this change, canopy change because of tree falls and weather events are notable. In the studied forest fragment, there was a natural disturbance (storm) between the two surveys, which led to the fall of some mature trees and consequent opening of clearings. The change in the microclimate caused by these clearings may have led to an increase in the representativeness of pioneer species and a large reduction in shade-tolerant individuals. In disturbed open areas forming large clearings (>50 m^2), colonization occurs most intensely by pioneering species and light-demanding climax species, which in many cases had not been established in the degraded area prior to the disturbance (WHITMORE, 1990; CHAZDON, 2016). The occurrence of these clearings allows more species to coexist and foster a high local diversity of species (BURSLEM; SWAINE, 2002; CHAZDON, 2016). These facts could help to explain the changes that occurred in the forest in this study, both in the structural composition and in the distribution of ecological groups, between the two surveys.

4 CONCLUSION

The floristic composition has undergone major changes, demonstrating that constant dynamism of the natural forest. The most representative species in both surveys did not undergo major changes, indicating that they are more likely to remain in the study area. In contrast, the less representative species disappeared or did not change their position in the forest community in the 2017 survey. Ecological group analysis indicated the gradual replacement of shadow-tolerant climax species by pioneer. However, this situation is influenced by natural disturbances, restarting the succession until again establishing a favorable environment for other ecological groups.

The analysis of the dynamics between the periods identified possible alterations in the forest fragment, which were reflected reduction significant of shadow-tolerant climax species in 2017.

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REFERENCES

AGUIAR, M. D. *et al*. Similaridade entre adultos e regenerantes do componente arbóreo em floresta com araucária. **Floresta e Ambiente**, Seropédica, v. 24, e0008321, 2017.

ÁLVAREZ, M. *et al*. **Manual de métodos para el desarrollo de inventarios de biodiversidad.** Bogotá: Ramos López Editorial, 2004. 236 p.

ANGIOSPERM PHYLOGENY GROUP IV. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants. **Botanical Journal of the Linnean Society**, v. 181, p. 1-20, 2016.

BROWER J. E.; ZAR, J. H. **Field and laboratory methods for general ecology.** Dubuque: W. M. C. Brow, 1984. 226 p.

BURSLEM, D. F. R.; SWAINE, M. D. Forest Dynamics and Regeneration. *In*: CHAZDON, R. L.; WHITMORE, T. C. **Fundations of Tropical Forest biology**. Chicago: University of Chicago Press, 2002. p. 577-583.

CALLEGARO, M. R. *et al*. Regeneração natural de espécies arbóreas em diferentes comunidades de um remanescente de floresta ombrófila mista. **Ciência Rural**, Santa Maria, v. 45, n. 10, p. 1795-1801, 2015.

Regeneração de florestas tropicais. Boletim do Muse**u Paraense Emílio Goeldi de Ciências Naturais, [s. l.], v. 7**, n.*3, p*. 195-218, 2012.

CHAZDON, R. L. **Renascimento de Florestas**: regeneração na era do desmatamento. São Paulo: Oficina de Textos, 2016. 432 p.

CORDEIRO, J.; RODRIGUES, W. A. Caracterização fitossociológica de um remanescente de Floresta Ombrófila Mista em Guarapuava, PR. **Revista Árvore**, Viçosa, v. 31, n. 3, p. 545-554, 2007.

DALLA ROSA, A. *et al*. Natural regeneration of tree species in a cloud forest in Santa Catarina, Brazil. **Revista Árvore**, Viçosa, v. 40, n. 6, p. 1073-1082, 2016.

EMBRAPA. **Sistema brasileiro de classificação de solos**. Rio de Janeiro: EMBRAPA-SPI, 2006. 360 p.

FELFILI, J. M.; REZENDE, R. P. **Conceitos e métodos em fitossociologia**. Brasília: Universidade de Brasília, 2003. 68 p.

FINOL, U. H. Nuevos parametros a considerarse em el analisis estructural de las selvas virgines tropicales. **Revista Florestal Venezuelana**, [*s. l.*], v. 14, n. 21, p. 29-42, 1971.

GONZAGA, A. P. D. *et al*. Similaridade florística entre estratos da vegetação em quatro Florestas Estacionais Deciduais na bacia do Rio São Francisco. **Rodriguésia**, Rio de Janeiro, v. 64, n. 1, p. 11-19, 2013.

HIGUCHI, P. *et al*. Fatores determinantes da regeneração natural em um fragmento de floresta com araucária no Planalto Catarinense. **Scientia Forestalis**, Piracicaba, v. 43, n. 106, p. 251-259, 2015.

HIGUCHI, P. *et al*. Floristic composition and phytogeography of the tree component of Araucaria Forest fragments in southern Brazil. **Brazilian Journal of Botany**, São Paulo, v. 35, n. 2, p. 145-157, 2012.

HIGUCHI, P. *et al*. Florística e estrutura do componente arbóreo e relação com variáveis ambientais em um remanescente florestal em Campos Novos - SC. **Ciência Florestal**, Santa Maria, v. 26, n. 1, p. 35-46, 2016.

MAGURRAN, A. E. **Ecological diversity and its measurement**. New Jersey: Princeton University Press, 1988. 179 p.

MAGURRAN, A. E. **Measuring biological diversity**. Oxford: Blackwell Science, 2004. 256 p.

MARTINS, P. J. *et al*. Dinâmica da vegetação arbórea em Floresta Ombrófila Mista Montana antropizada. **Floresta e Ambiente**, Seropédica, v. 24, e00097014, 2017.

MUELLER, D.; ELLENBERG, H. **Aims and methods of vegetation ecology**. New York: John Wiley & Sons, 1974. 547 p.

NASCIMENTO, A. R. T.; LONGHI, S. J.; BRENA, D. A. Estrutura e padrões de distribuição espacial de espécies arbóreas em uma amostra de Floresta Ombrófila Mista em Nova Prata, RS. **Ciência Florestal**, Santa Maria, v. 11, n. 1, p. 105-119, 2001.

NUNES M. H. *et al*. Dinâmica de populações de espécies arbóreas em fragmentos de floresta aluvial no sul de Minas Gerais, Brasil. **Floresta**, Curitiba, v. 46, n. 1, p. 57-66, 2016.

OLIVEIRA-FILHO, A. T. Estudos ecológicos da vegetação como subsídios para programas de revegetação com espécies nativas: uma proposta metodológica. **Cerne**, Lavras, v. 1, n. 1, p. 64-72, 1994.

RIBEIRO, T. M. *et al*. Mixed rain forest in southeastern Brazil: tree species regeneration and floristic relationships in a remaining stretch of forest near the city of Itaberá, Brazil. **Acta Botânica Brasilica**, Brasília, v. 27, n. 1, p. 71-86, 2013.

SANQUETTA, C. R.; CORTE, D. A. P.; EISFELD, R. L. Crescimento, mortalidade e recrutamento em duas florestas de araucária (*Araucaria angustifolia* (Bertol.) Kuntze) no Estado do Paraná, Brasil.

Revista Ciências Exatas e Naturais, Guarapuava, v. 5, n. 1, p. 101-112, 2003.

SANTANA, L. D. *et al*. Estrutura, diversidade e heterogeneidade de uma floresta ombrófila mista altomontana em seu extremo norte de distribuição (Minas Gerais). **Ciência Florestal**, Santa Maria, v. 28, n. 2, p. 567-579, 2018.

SANTOS, G. N. *et al*. Regeneração natural em uma floresta com araucária: inferências sobre o processo de construção da comunidade de espécies arbóreas. **Ciência Florestal**, Santa Maria, v. 28, n. 2, p. 483-494, 2018.

SANTOS, K. F. *et al*. Regeneração natural do componente arbóreo após a mortalidade de um maciço de taquara em um fragmento de Floresta Ombrófila Mista em Lages – SC. **Ciência Florestal**, Santa Maria, v. 25, n. 1, p. 107-117, 2015.

SCHORN, L. A. *et al*. **Relatório Fitossociológico da RPPN Emílio Einsfield Filho - Campo Belo do Sul (SC)**. Blumenau: FURB, 2012. 300 p.

SEGER, C. D. *et al*. Levantamento florístico e análise fitossociológica de um remanescente de Floresta Ombrófila Mista localizado no município de Pinhais, Paraná-Brasil. **Revista Floresta**, Curitiba, v. 35, n. 2, p. 291-302, 2005.

SHEIL, D.; JENNINGS, S.; SAVILL, P. Long-term permanent plot observations of vegetation dynamics in Bundongo, a Ugandan rain forest. **Journal of Tropical Ecology**, Australia, v. 16, n. 6, p. 675-800, 2000.

SILVA, J. O. *et al*. Floristic composition and phytogeography contextualization of the natural regeneration of an alluvial forest located in the “Planalto Sul Catarinense” Region, SC, Brazil. **Revista Árvore**, Viçosa, v. 41, n. 2, e410203, 2017.

VEFAGO, M. B. *et al*. What explains the variation on the regenerative component dynamics of Araucaria Forests in southern Brazil? **Scientia agrícola**, Piracicaba, v. 76, n. 5, p. 405-414, 2019.

VELOSO, H. Sistema Fitogeográfico. *In*: MANUAL Técnico da Vegetação Brasileira. Rio de Janeiro: IBGE, 1991. p. 9-38.

VELOSO, H. P.; RANGEL-FILHO, A. L.; LIMA, L. C. A. **Classificação da vegetação brasileira, adaptada a um sistema universal***.* Rio de Janeiro: IBGE, 1991. 124 p.

VIBRANS, A. C. *et al*. Extensão original e remanescentes da Floresta Ombrófila Mista em Santa Catatina. *In*: VIBRANS, A. C. *et al*. **Inventário Florístico Florestal de Santa Catarina**: Floresta Ombrófila Mista. Blumenau: EDIFURB, 2013. p. 191-222.

WATZLAWICK, L. F. *et al*. Estrutura, diversidade e distribuição espacial da vegetação arbórea na Floresta Ombrófila Mista em Sistema Faxinal, Rebouças (PR). **Ambiência**, Guarapuava, v. 7, n. 3, p. 415-427, 2011.

WHITMORE, T. C. **An introduction to tropical rain forest**. New York: Oxford University Press, 1990. 226 p.

ZELLER, R. H. **Plano de Manejo**: Reserva Particular do Patrimônio Natural Emílio Einsfeld Filho, Santa Catarina. Campo Belo do Sul: Florestal Gateados, 2010. 146 p.

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