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Phytosociology of a fragment of araucaria moist forest, Irani, SC, Brazil

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ABSTRACT: The main purpose of this study is to determine the phytosociological structure of a fragment of Araucaria Forest, located in the municipal district of Irani, Santa Catarina State, Brazil. There were 30 plots of 500 m² installed in systematic sampling process in two stages. The individuals with a circumference at breast height higher than 30 cm were sampled. The index of Odum, Shannon and Weaver, Pielou, and parameters of density, dominance, frequency, and importance value were calculated. It was a sample of 1447 trees, distributed in 61 species, 49 genres, and 34 families. The families with the highest species richness were Lauraceae, Myrtaceae, Aquifoliaceae and Elaeocarpaceae, Fabaceae, Salicaceae, and Sapindaceae. The species with the largest importance values were *Nectandra grandiflora*, *Dicksonia sellowiana*, *Calyptranthes concinna*, *Casearia decandra*, *Jacaranda puberula*, *Prunus myrtifolia* and *Ocotea porosa*. It should be emphasized the occurrence of a few individuals of *Araucaria angustifolia*, which is the characteristic species of this forest type, indicating the exploitation of this species in the past.

Keywords: araucaria forest, floristic analysis, horizontal structure.

Fitossociologia de um fragmento de floresta ombrófila mista, em Irani, SC, Brasil

RESUMO: Este trabalho tem como objetivo principal determinar a estrutura fitossociológica, em fragmento de Floresta Ombrófila Mista, em Irani, SC. Foram instaladas 30 parcelas de 500 m², em processo de amostragem sistemático em dois estágios. Foram amostrados os indivíduos com circunferência à altura do peito maior que 30 cm. Foram calculados os índices de Odum, de Shannon e Weaver, Pielou e os parâmetros de densidade, dominância, frequência e valor de importância. Foram amostrados 1447 indivíduos arbóreos, distribuídos em 61 espécies, 49 gêneros e 34 famílias. As famílias com maior riqueza de espécies foram Lauraceae, Myrtaceae, Aquifoliaceae e Elaeocarpaceae, Fabaceae, Salicaceae e Sapindaceae. As espécies com maiores valores de importância foram *Nectandra grandiflora*, *Dicksonia sellowiana*, *Calyptranthes concinna*, *Casearia decandra*, *Jacaranda puberula*, *Prunus myrtifolia* e *Ocotea porosa*. Foi observada a ocorrência de poucos indivíduos de *Araucaria angustifolia*, espécie característica desta formação florestal, indicando o histórico de exploração desta espécie.

Palavras-chave: floresta com araucária, análise florística, estrutura horizontal.

1. INTRODUCTION

According to Koch; Corrêa (2002), the Araucaria Moist Forest had a total length of approximately 200,000 km² until the early twentieth century, covering about 40% of Paraná, 31% of Santa Catarina, 25% of Rio Grande do Sul. They were also in the areas of higher altitude of Rio de Janeiro, São Paulo, and Minas Gerais, as well as Paraguay and Argentina.

The Araucaria Moist Forest belongs to the Atlantic Forest biome and it is characterized by the presence of *Araucaria angustifolia* (Bertol.) Kuntze as an emerging species, forming clusters in combination with other species, in different stages of succession (IBGE, 2012). The Araucaria Moist Forest is part of a regional ecosystem with high species richness and several cases of endemism (MEDEIROS et al., 2004). According to Leite (2002), approximately 13.3% of the tree species are endemic, 45.7% have a preference for this vegetation formation, and 41% of species are also common to other phytosociological regions.

Physiognomy, structure and floristic differences allow the division of Araucaria Forest in Alluvial formations, forming riparian forests; Submontane, although they are found only in disjoint areas, as in the case of Lauro Müller region, SC, and Escudo Riograndense (IBGE, 2012; Leite, 2002); Montana, between 400 and 1000 m; and Alto Montana.

For Alto Montana formation, some authors differ in altitude, according to IBGE (2012) and Higuchi et al. (2013) it is above 1,000 m and according to Roderjan et al. (2002), it is above 1,200 m of altitude.

With the intense exploitation that endures to this days, the remnants of this forest, as well as all plant formations in southern Brazil, are characterized by small forest fragments and most of the time they are isolated. The most obvious

consequence of fragmentation is the decreasing number of species, both vegetables, and animals, which mainly have the power resources and committed shelter and reproduction. These effects are potentiated in species with low dispersal capacity and restricted distribution, especially endangered (MÄHLER JR; LAROCCA, 2009).

The study of the remaining forest fragments, even small and isolated, allows subsidies for the conservation and recovery plans for degraded areas and the sustainable use of its resources. According to Longhi (1980), knowledge of the floristic composition of a forest fragment in addition to its vertical and horizontal structure allows deductions about the origin, ecological characteristics and effects of possible human actions.

Knowing the phytosociological structure of a forest, it is possible to compare with other similar, seeking explanations for possible differences between them, such as soil conditions, weather conditions, topography and different successional stages of each forest formation.

Given the above, this study aims to determine the vegetation structure and floristic composition of a fragment of Araucaria Moist Forest, located in the municipality of Irani in the state of Santa Catarina.

2. MATERIAL AND METHODS

The study area is located in the municipality of Irani, Santa Catarina. The region is part of the Atlantic Forest biome and is inserted in the phytosociological region of the Araucaria Forest (IBGE, 2010). The climate is Mesothermal super humid no dry (IBGE, 2010 b), with average temperatures between 16 °C and 19 °C, and average rainfall from 2500 to 2700 mm per year (PANDOLFO et al., 2002).

The soils of the region were formed from basaltic rocks, with higher acidity. They have basis saturation less than 50%, being considered as dystrophic soils (CROCE, 2002).

The studied forest fragment has an area of 64.78 ha, an average altitude of 1,100 m and center point at Latitude 27°00'35.16" S and Longitude 51°53'13.75" W. It has a visible human intervention due to the presence of improvements belonging to some farms, glades, and animal tracks, as well as

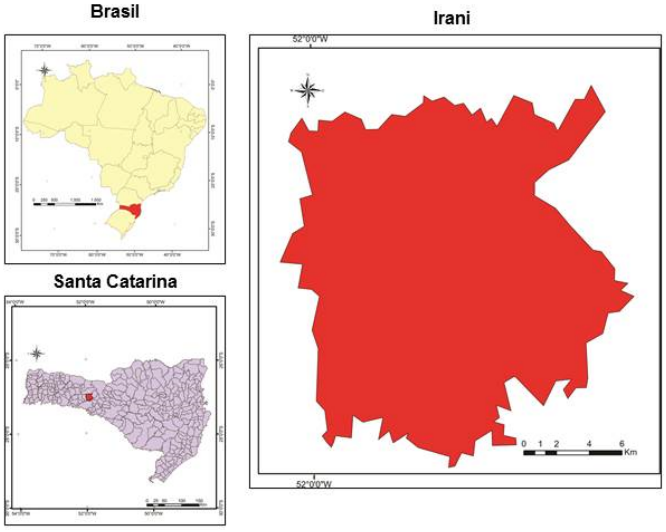

Figure 1. Location of the City of Irani, SC, Brazil.
Figura 1. Localização do Município de Irani, SC, Brasil.

trails to collect pine nuts and yerba mate extract. According to the former owner, in the 1980s, there was selective cutting of timber species, mainly *A. angustifolia* and *Ocotea porosa* (Nees & Mart.) Barroso.

Data were obtained from a systematic sampling in two stages, with plots of 10 x 50 m (500 m²). In this sampling process, the sampling units were selected in two stages, between rows, with a distance of 80 m between plots and in line with an interval of 50 m. There were five lines considered, with a variable number of plots in each line.

A sampling line was installed following the direction North - South, greater variability of the forest. With the first sampling line information, a logarithmic model was fitted, estimating the number of plots to be measured, stabilizing the accumulated number of species (PÉLLICO NETTO E BRENA, 1997). The optimum amount of plots was estimated at 30, corresponding to 15000 m² total sample area (Figure 2). The resulting equation of the logarithmic model setting (1) is mathematically the curve species/area of Figure 2.

$$E = -73.7071 + 14.7028 \times \ln(A)$$

where: E = the accumulated number of species; A = accumulated sampled area.

In each sample unit, information was collected from the trees with Circumference at Breast Height (CBH) greater than 30.0 cm, making up the collection of botanical material, which was later identified in the Herbarium of the Federal University of Paraná in Curitiba, PR, Brazil.

For the demarcation of sample units in the field, the following equipment was used: tape measures 50 m and iron beacons. The circumference at breast height was measured using a tape, and tree pruner to collect botanical material.

Indices were calculated of Species Odum, diversity Shannon-Weaver, and Pielou evenness. As the density parameters, absolute and relative dominance and frequency and importance value of each species in Microsoft Excel were also calculated.

The diameter distribution chart for the set of species was made using the diameters at breast height of trees sampled for grouped data in absolute diametric classes with an amplitude of 5 cm, totaling 16 classes. From the diameter distribution, the ratio "q" De Liocourt in Microsoft Excel was calculated.

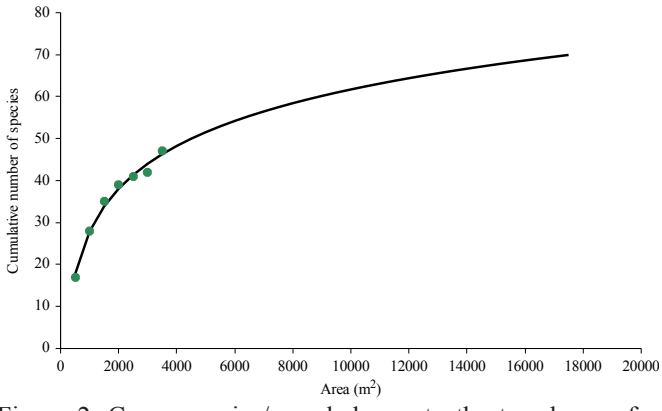

Figure 2. Curve species/sampled area to the tree layer of a fragment of Araucaria Forest, in Irani, SC, Brazil.
Figura 2. Curva espécie/área amostrada para o estrato arbóreo de um fragmento de Floresta Ombrófila Mista, em Irani, SC, Brasil.

3. RESULTS AND DISCUSSION

There were 1447 trees were found, totaling 34.86 m² ha of basal area. They belong to 61 species belonging to 49 genres and 34 families (Table 1). Herrera et al. (2009), Seger et al. (2005), Formento et al. (2004), Kozera et al. (2006) and Lingner et al. (2007) in the work carried out in the Montana Araucaria Moist Forest, they found results ranging from 41 to 71 species, 31 to 54 genre and 21-33 families. In Alto Montana Araucaria Moist Forest, values obtained ranged from 46 to 61 species, 33 to 44 genre, and between 20 and 28 families (MARTINS-RAMOS et al., 2011; HIGUCHI et al., 2013; KLAUBERG et al., 2009).

The families with the highest species were Lauraceae (7), Myrtaceae (7), Aquifoliaceae (4), Elaeocarpaceae, Fabaceae, Salicaceae, and Sapindaceae, with three species each. These families together accounted 49.18% of the total number of species sampled.

Aside from Elaeocarpaceae family, these same families had the highest number of species found by Herrera et al. (2009) in the Montana Araucaria Moist Forest.

According to Seger et al. (2005) and Higuchi et al. (2013), the occurrence of many species of Myrtaceae, Lauraceae, Fabaceae, Sapindaceae, and Salicaceae is quite common for both the Montana and Alto Montana Araucaria Moist Forest.

The Odum index calculated was 8.38, considered average if compared with Rode et al. (2009), which was 11.3 and Schaaf et al. (2006) 7.1, both in Montana Araucaria Moist Forest. For the index of Shannon, which usually takes values from 1.5 to 3.5 (LONGHI, 1997), the calculated value was 3.41, similar to those found by Rode et al. (2009) with 3.55 and Herrera et al. (2009) with 3.58, both held in Montana Araucaria Moist Forest. This study also showed values higher than those found by Klauberg et al. (2010) with 3.05 and Higuchi et al. (2013) with 2.79 in Alto Montana Araucaria Moist Forest and Cordeiro; Rodrigues (2007) with 2.79 in Araucaria Moist Forest with an average altitude of 1070 m. Differences between the values found may be due to several factors, such as different locations, different conditions of soil and climate, different successional stages of vegetation in each area, as well as possible human interventions in the areas (MOGNON et al., 2012).

The evenness "J" index was 0.830, which is related to the Shannon index. The value found for the forest fragment in this study indicates that the fragment has 83% of the maximum diversity considered by Shannon index. It is considered a high value found, with the distribution of individuals within practically uniform species, also indicating the absence of dominant species in the fragment. Rode et al. (2009), Higuchi et al. (2013) and Cordeiro; Rodrigues (2007) found values of 0.81, 0.70 and 0.90, respectively. Floristic Inventory Forest of Santa Catarina for the Araucaria Moist Forest, with altitudes between 1,000 and 1,200 m, Meyer et al. (2013) found values ranging from 1.36 to 3.36 Nats ind^{-1} for the Shannon index, and 0.43 to 0.94 for the evenness index.

The species with the highest density values were *Nectandra grandiflora, Calyptranthes concinna, Jacaranda puberula, Dicksonia sellowiana, Eugenia melanogyna*. These are the species with the highest participation in the floristic composition of the forest fragment, considering the number of individuals (Table 1). The largest dominance values were presented by *Nectandra grandiflora, Dicksonia sellowiana, Ocotea porosa, Matayba elaeagnoides and Lamanonia ternata*. These species stood out because of the number of individuals present in the fragment associated with the presence of individuals with large diameters in the case of *N. grandiflora, M. eleagnoides and L. ternata* (Table 1).

However, for *A. angustifolia,* only nine individuals per hectare were sampled. This further reinforces the history of commercial exploitation of the species in some diameter classes.

On the frequency, which in many cases is related to the density, it is highlighted *C. decandra, J. puberula, N. grandiflora, D. sellowiana* and *L. ternata*. None of the species were found in all sampled plots, with the highest occurrence was 20 installments of 30 sampled in cases of *C. decandra, J. puberula,* and *N. Grandiflora*. This is due to no uniform distribution of species in the community under study. According to Moro; Martins (2011), the smaller frequency value, the higher distribution of species in the forest community (Table 1).

For the importance value (IVI), the highest values were found to *N. grandiflora, D. sellowiana, C. concinna, C. decandra, J. puberula, P. myrtifolia* and *O. porosa*. In general, the species with the highest IVI have the greater geographic reach and a slower dynamic in the plant community (MORO; MARTINS, 2011).

The average CBH calculated for all the forest was 19.5 cm lower than the values reported by Herrera et al. (2009), which was 23.9 cm and Longhi (1997), all in Alto Montana Araucaria Moist Forest. According to Figueiredo Filho et al. (2010), the average diameter of Araucaria Forest in Southern Brazil is 22.9 cm.

Considering all the species, diameter distribution showed a negative exponential distribution, known as inverted "J" (Figure 2). Individuals found in the first diameter class accounted for 32.14% of all sampled individuals. In the second diametric class, there were 25.71% of individuals and 9.05% in the third diametric class, falling to 0.07% in the last diameter class. This is a common behavior in natural forests, with continuous regeneration.

Diametric class 54.0 to 59.0 cm on all classes presented only an individual, except the diameter class between 74.0 to 79.0 cm, which did not have any individual sampled. In the inventory, Floristic Forest of Santa Catarina, Vibrans et al. (2013) also found a negative exponential distribution, both remnants of Araucaria Forest with altitude up to 1,200 m, as in remaining located at 1,200 m altitude.

According to Scolforo (2006) and Schaaf et al. (2006b), this behavior is characteristic of multispecies and multigene forests, occurring in areas of secondary forest, as in the early processes of succession. However, the distribution in inverted "J" does not guarantee that the forest has no regeneration problems, requiring further study. Schaaf et al. (2006b) found that the maintenance of a species in the forest is more linked to its ability to compete with the passage of time, some individuals in the smaller diameter classes.

For the forest fragment studied, the value of "q" of De Liocourt presented is variable, meaning that the forest fragment studied is irregular for diameter distribution.

It is also observed in Figure 2, a decrease in the number of individuals from the third to the fourth diametric class, which may show increased regeneration, caused by clearings openings in the forest fragment as a result of selective logging on the site over the past 30 years. The presence of species such as

Table 1. Phytosociological parameters of the species found in tree layer of Araucaria Moist Forest fragment in the city of Irani, SC, Brazil, ordered by importance value in 2015.
Tabela 1. Parâmetros fitossociológicos das espécies encontradas em estrato arbóreo de fragmento de Floresta Ombrófila Mista no Município de Irani, SC, Brasil, ordenadas pelo valor de importância, no ano de 2015.

Family	Species	RD	RDo	RF	IVI
Lauraceae	*Nectandra grandiflora* Nees	12.51	10.70	4.31	27.52
Dicksoniaceae	*Dicksonia sellowiana* Hook.	6.08	6.31	4.09	16.49
Myrtaceae	*Calyptranthes concinna* DC.	6.91	5.44	3.02	15.37
Salicaceae	*Casearia decandra* Jacq	5.18	4.44	4.31	13.94
Bignoniaceae	*Jacaranda puberula* Cham.	6.43	2.97	4.31	13.71
Rosaceae	*Prunus myrtifolia* (L.) Urb.	3.94	5.36	4.09	13.39
Lauraceae	*Ocotea porosa* (Nees & Mart.) Barroso	3.46	5.88	3.45	12.78
Cunoniaceae	*Lamanonia ternata* Vell.	2.76	5.47	4.09	12.33
Sapindaceae	*Matayba elaeagnoides* Radlk.	2.70	5.70	3.23	11.63
Euphorbiaceae	*Sapium glandulosum* (L.) Morong	3.73	4.11	3.66	11.51
Myrtaceae	*Eugenia melanogyna* (D. Legrand) Sobral	5.67	2.62	3.02	11.30
Lauraceae	*Ocotea pulchella* (Nees) Mez	3.11	3.83	3.66	10.61
Euphorbiaceae	*Sebastiania commersoniana* (Baill.) L.B. Sm. & Downs	3.46	3.49	2.37	9.31
Sapindaceae	*Cupania vernalis* Camb.	2.63	2.28	3.66	8.57
Elaeocarpaceae	*Vernonanthura discolor* (Spreng.) H.Rob.	2.07	3.24	3.02	8.33
Myrtaceae	*Myrcia guianensis* (Aubl.) DC.	2.83	1.90	2.37	7.11
Araucariaceae	*Araucaria angustifolia* (Bertol.) Kuntze	0.97	3.57	2.16	6.69
Canellaceae	*Cinnamodendron dinisii* Schwacke	2.49	1.55	2.37	6.41
Aquifoliaceae	*Ilex theezans* Mart. ex Reissek	2.07	1.66	2.16	5.88
Myrtaceae	*Myrceugenia miersiana* (Gardner) D. Legrand & Kausel	2.14	1.10	2.59	5.83
Clethraceae	*Clethra scabra* Pers.	1.73	1.94	1.94	5.61
Styracaceae	*Styrax leprosus* Hook. & Arn.	1.45	0.90	2.16	4.50
Winteraceae	*Drimys brasiliensis* Miers	1.31	0.83	2.16	4.30
Asteraceae	*Piptocarpha angustifolia* Dusén ex Malme	0.83	1.54	1.72	4.09
Myrtaceae	*Campomanesia xanthocarpa* O.Berg	1.11	0.96	1.94	4.01
Elaeocarpaceae	*Sloanea lasiocoma* K. Schum	0.55	1.86	1.29	3.71
Symplocaceae	*Symplocos* sp.	0.97	0.61	1.72	3.30
Fabaceae	*Mimosa scabrella* Benth.	0.69	1.73	0.86	3.28
Lauraceae	*Ocotea laxa* (Nees) Mez	1.04	0.86	1.29	3.19
Aquifoliaceae	*Ilex paraguariensis* A. St.-Hil.	0.97	0.68	1.51	3.16
Rutaceae	*Zanthoxylum rhoifolium* Lam.	0.62	0.46	1.94	3.02
Primulaceae	*Myrsine umbellata* Mart.	1.04	0.69	1.29	3.02
Lauraceae	*Ocotea puberula* (Rich.) Nees	0.48	1.41	1.08	2.98
Salicaceae	*Casearia sylvestris* Sw.	0.69	0.38	1.51	2.58
Sapindaceae	*Allophylus edulis* (A. St.-Hil. et.al.) Radlk	0.48	0.30	1.08	1.86
Rubiaceae	*Coussarea contracta* (Walp.) Müll.Arg.	0.48	0.16	0.86	1.51
Asteraceae	*Dasyphyllum tormentosum* (Spreng.) Cabrera	0.35	0.31	0.65	1.30
Lauraceae	*Nectandra megapotamica* (Spreng.) Mez	0.28	0.36	0.65	1.28
Loganiaceae	*Strychnos brasiliensis* (Spreng.) Mart.	0.62	0.21	0.43	1.26
Fabaceae	*Lonchocarpus campestres* Mart. ex Benth.	0.28	0.18	0.65	1.11
Myrtaceae	*Eugenia involucrata* DC.	0.21	0.19	0.65	1.04
Aquifoliaceae	*Ilex dumosa* Reissek	0.35	0.25	0.43	1.03
Annonaceae	*Annona neosalicifolia* H.Rainer	0.28	0.08	0.65	1.01
Myrtaceae	*Eugenia pyriformis* Cambess.	0.21	0.06	0.65	0.92
Proteaceae	*Roupala asplenioides* Sleumer	0.21	0.25	0.43	0.89
	Plaqueta 459	0.21	0.21	0.43	0.85
Lamiaceae	*Vitex megapotamica* (Spreng.) Moldenke	0.14	0.18	0.43	0.75
Elaeocarpaceae	*Sloanea monosperma* Vell.	0.21	0.09	0.43	0.73
Cunoniaceae	*Weinmannia paulliniifolia* Pohl ex Ser.	0.14	0.10	0.22	0.46
Lauraceae	*Cryptocarya aschersoniana* Mez	0.07	0.14	0.22	0.43
Meliaceae	*Cedrela fissilis* Vell.	0.07	0.11	0.22	0.39
Apocynaceae	*Aspidosperma australe* Müll.Arg.	0.07	0.07	0.22	0.35
Solanaceae	*Solanum pseudoquina* A. St.-Hill.	0.07	0.05	0.22	0.33
	Plaqueta 453	0.07	0.05	0.22	0.33
Salicaceae	*Xylosma pseudosalzmanii* Sleumer	0.07	0.04	0.22	0.32
Aquifoliaceae	*Ilex brevicuspis* Reissek	0.07	0.02	0.22	0.31
Cyatheaceae	*Cyathea corcovadensis* (Raddi) Domin	0.07	0.02	0.22	0.31
Primulaceae	*Myrsine hermogenesii* (Jung-Mendaçolli & Bernacci) Freitas & Kinoshita	0.07	0.02	0.22	0.30
Cannabaceae	*Trema micrantha* (L.) Blume	0.07	0.02	0.22	0.30
Cardiopteriadaceae	*Citronella paniculata* (Mart.) Howard	0.07	0.01	0.22	0.30
Erytroxylaceae	*Erythroxylum deciduum* A.St.-Hil.	0.07	0.01	0.22	0.30
Fabaceae	*Bauhinia forficata* Link	0.07	0.01	0.22	0.30
Adoxaceae	*Sambucus australis* Cham. & Schltdl.	0.07	0.01	0.22	0.30
	Total	100	100	100	300

RD = relative density in%; RDo = relative dominance in%; RF = relative frequency in%; IVI = Importance Value Index, in%. ΣDA = 964.6700; ΣFA = 1546.6670; ΣDoA = 34.8644

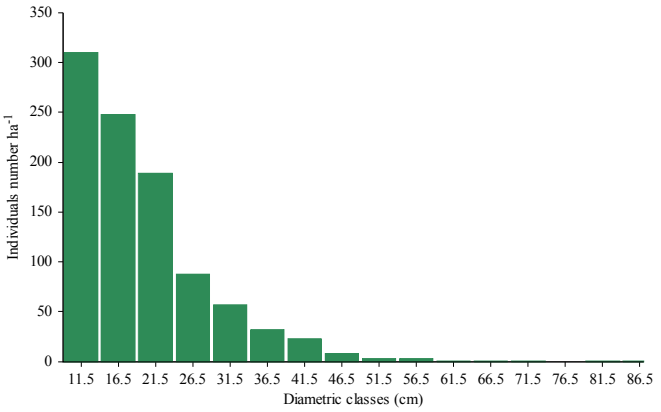

Figure 3. Diametric distribution to the tree layer of a fragment of Araucaria Forest, in Irani, SC, Brazil.
Figura 3. Distribuição diamétrica para o estrato arbóreo de um fragmento de Floresta Ombrófila Mista, em Irani, SC, Brasil.

P. angustifolia, V. discolor, and *M. scabrella* in the first three diameter classes is, according to Carvalho (2008, p. 515), one of the most obvious indicator forests that have already suffered operation. Another evidence of exploitation that occurred in the area is that 49% of species in the three smaller diameter classes are heliophytic, or need light to germinate and establish in the forest community.

According to Souza et al. (2008), a study conducted in the National Forest (FLONA) of São Francisco de Paula - RS, in areas where there were intense exploration or natural disasters, Araucaria presented more intense regeneration.

In some parts of the study area, *taquarais* were found *(Merostachys multiramea* Hack.), with the limited occurrence of trees, not observing young trees in these areas. Further, at a point with more sparse trees, there is the occurrence of some *M. scabrella* with an average of 20 years old. This suggests that, in that place, nearly 20 years ago there was a clear cut vegetation, leaving the soil exposed to sunlight and allowing the germination of this species.

4. CONCLUSIONS

Families with greater quantity were *Lauraceae, Myrtaceae, Aquifoliaceae, Elaeocarpaceae, Fabaceae, Salicaceae and Sapindaceae*, representing 49.18% of total species. The species of greatest importance were *Nectandra grandiflora, Docksonia sellowiana*, *Calyptranthes concinna, Casearia decandra, Jacaranda puberula, Prunus myrtifolia* and *Ocotea porosa.*

The richness of the area is average compared to other forest fragments.

Diversity is considered high. The spatial distribution of species in the community, based on the frequency, was not uniform. The pattern of diameter distribution for all species fragment was negative exponential manner.

It is highlighted the forest fragment studied, the low number of *Araucaria angustifolia* and also the absence of this species in the understory of the fragment. This demonstrates selective explorations performed in the past and the possibility of problems in the regeneration of forest species in the community.

The area studied has great importance for the conservation of fauna and flora species in the region, because of its richness and diversity of forest species.

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