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Allied species with *Dicksonia sellowiana* Hook. in a High Montane Araucaria Forest Remnant, in Southern Brazil

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Abstract
The Araucaria Forest in highlands is an environment characteristic of regions with altitudes greater than 1200 above sea level, in southern Brazil. The species that occur in this place are adapted to conditions of low temperatures and high humidity, where the presence of *Dicksonia sellowiana* Hook., a tree-sized pteridophyte with expressive importance value in many remnants. This research aimed to identify the associations of this species in a remnant of Araucaria Forest in the mountain region of Santa Catarina. The site was inventoried with permanent plots of fixed area of 200 m², which were systematically and contiguously distributed in 3 transects following the slope gradient of the terrain (1411 to 1940 m). The surveys evaluated the scientific name, geographic coordinates and DBH, with an inclusion limit of 5 cm for each individual. Subsequently, 14 individuals of *D. sellowiana* were randomly selected and used as a reference to the center of the sampling units of Prodan method, than the six closest trees were measured, identified and measured the distance from the center of the unit sampling to the sixth tree (R6) to determine its area. As the measurements of the permanent plots contain the geographic coordinates of all trees, the selection of Prodan sampling units and the collection of data (R6, N.ha-1, G.ha^{-1}) were performed using ArcGis Software. The average basal area value was 69.5 m².ha^{-1} and the average density was 1628 ind.ha^{-1}, values compatible with those obtained in the permanent plots (69.4 m².ha^{-1} and 1630 ind.ha^{-1} respectively), obtaining sample sufficiency by the collector curve. *Dicksonia sellowiana* showed association with 14 species, being inserted in characteristic environments with less sun exposure, slopes and presence of watercourses, generating an environment with low floristic diversity, however, with a high degree of endemism in the Atlantic Forest.

Keywords
Tree fern — Forest Invetory — Xaxim — Spatial distribution — Atlantic Forest

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1. Introduction

The Mixed Ombrophilous Forest (MOF) or Araucaria Forest is a phytoecological unit belonging to the forest ecosystem of the Atlantic Forest biome, which originally occupied an area of approximately 175,000 km², mainly in the southern region of Brazil (Castella; Britez, 2004; Passos et al., 2021). In the State of Santa Catarina, MOF is one of the most threatened by human action, where it originally covered 45% of the state area, currently remaining around 22% to 24% (Vibrans et al., 2013; Fockink et al., 2020).

On the Santa Catarina plateau, the remnants of this typology are found in fragments of discontinuous areas with secondary forest formations and few relics of primary formations, many of which have been significantly altered by selective cutting of the noblest woods (Vibrans et al., 2013). In the High montane environments of this region,

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the sources of large rivers of importance to the South of Brazil occur (Wiggers, 2017), in addition to having great hydrological appeal for being a region of recharge and outcrop of the Guarani aquifer (Klauberg et al., 2010), being strategic studies aimed at forest conservation.

The MOF is composed of some forest subdivisions differentiated by the altitude at which they occur. High montane MOF is present in regions where the altitude is equivalent to or exceeds 1200 m above sea level (Roderjan et al., 2002). This phytophysiognomy in Santa Catarina forms discontinuous areas, found mainly on the eastern edge of the South Plateau, or further inland. Due to the presence of Brazilian pine (*Araucaria angustifolia* (Bertol.) Kuntze.), the occurrence of some species is limited to the undergrowth, forming a variable floristic composition. However, it is possible to observe a continuous floristic composition formed by the imbuia (*Ocotea porosa* (Nees & Mart.) Barroso) associated with the sapopema *(Sloanea monosperma* Vell.), oor constituted mainly by *Gomidesia* sp., *Myrcia bombycina* (O. Berg) Kiaersk, *Siphoneugenia reitzii* D. Legrand e *Myrceugenia euosma* (O.Berg) D. Legrand, *Drimys brasiliensis* Miers and genus *Ilex* (Santa Catarina, 1986).

The species belonging to the high montane MOF are adapted to a harsh winter with snow and frost. This phenomenon occurs because the climate of mountainous areas has a strong influence on the floristic composition and structure of the tree component (Koehler et al., 2002). Due to the high altitude, temperatures are lower, favoring the formation of low clouds, forming a nebular environment characterized by low incidence of sunlight and high relative humidity, which leads to a low evapotranspiration capacity that associated with the predominance of shallow soils, reflects in an ecologically selective environment (Higuchi et al., 2013).

Dicksonia sellowiana Hook. is one of the species found in the region, with easy recognition and presents itself as one of the most characteristic of the vegetation in the regions of the Plateau and West of Santa Catarina (Gasper et al., 2011). It has an arboreal-shrubby size (tree ferns); its caudice is thickened by the dense web of adventitious roots and fronds many times larger than one meter in length. It has already been described that massifs of *Dicksonia sellowiana* are found in lowlands or humid slopes, generally forming compact colonies, due to the accumulation of sediments and humidity (Martins et al., 2011), being a species of great ecological importance (Senna, 2011). 1996). This species adds a large amount of organic matter to the soil and harbors many epiphytic species (Fraga et al., 2008), however it was practically removed from the MOF during the last 50 to 60 years for commercial purposes, as its caudices were used to manufacture pots for growing orchids and other ornamental plants (Pillar, 2009). Aiming at its protection and conservation, the Ministry of the Environment has included this species in the Official List of Endangered Species of Brazilian Flora (Brasil, 2008).

The study presented by Mantovani (2004) on *Dicksonia sellowiana* made it possible to understand the phytosociological structure and environments where this species is located, as well as the climatic and edaphic requirements for its occurrence (Gasper et al., 2011). It is noteworthy that studies on this species are rare, especially with regard to methodologies that identify the association of species in native forests, which highlights the importance of carrying out forest inventories in order to obtain essential data for the characterization and knowledge of the species. Given this information, the selection of a sampling system that is sensitive to detecting the association of species in native forests, especially the sampling method (size and shape of sampling units) is fundamental for forest inventories of this type of information.

This activity, which aims to obtain qualitative and quantitative information on forest resources and on many characteristics of the areas in which species are growing (Husch et al., 1993), involves sampling techniques, which can be subdivided into methods (population approach referring to a single sampling unit) and sampling processes (approach to the population referring to the set of sampling units). For Pellico Netto; Brena (1997); Sanquetta et al., (2014) and Machado; Figueiredo Filho (2014), sampling methods can be classified as fixed area (with variations in size and shape) and variable (Bitterlich, Prodan, Strand, among others).

The Prodan method involves sampling units of variable area with a circular shape, selecting the six trees closest to the central point of the sampling unit, and the inclusion of individuals proportionally to their distance from a point of origin (Téo et al., 2014). According to Kleinn; Vilcko (2006) Prodan's (1968) proposal establishing six trees and their distance from the center of the sampling unit is an application of the k-tree sampling technique with k=6, suggested for application in forest management inventories. However, according to these authors, point-to-tree distance techniques are also applied in ecological studies, where the k closest objects (trees or plants) to a sampling point are selected and constitute the set of objects inserted in the sampling unit.

The k-tree sampling methodology, in this case the variation proposed by Prodan (1968), best known in Brazil, is attractive to identify the association of species in a forest community. Since the center of the sampling unit can be considered as an individual or a tree of a species of interest (Péllico Netto et al., 2012) and, with this, the biological distances between this and the other trees in the forest can be evaluated. Other works also used this tool to indicate the association of other species with one of interest. Including the work by Gallo et al., (2019), which aimed to analyze the tree species associated with *Zanthoxylum rhoifolium* Lam. in a fragment of Mixed Alluvial Ombrophilous Forest and the work of Mazon et al., (2019), who adapted it for the sampling of species associated with *Araucaria angustifolia*.

Combining the importance of *Dicksonia sellowiana* for forest typology, the present work aims to use the Prodan sampling method as an alternative for phytosociological assessment and to identify associations of this species in a remnant of high montane MOF in the mountainous region of the state of Santa Catarina in South of Brazil .

2. Material and Methods

The data used to carry out the study were obtained from a survey conducted in a particular area in the municipality of Urupema, located in the mountainous region of the state of Santa Catarina, Brazil. According to Alvares et al., (2013), the climate of the region, according to the Köppen classification, is of the Cfb type, with an average annual temperature of 13ºC, with well-distributed rainfall throughout the year, with an average annual rainfall of 1,789 mm, in addition to the presence of frost in winter.

The study site is situated at an average altitude of 1444 m above sea level, ranging from 1411 to 1490 m. The vegetation is characterized as high montane MOF, according to Roderjan et al., (2002), this denomination is attributed to the ombrophilous forests that are located at altitudes above 1200 m above sea level.

The forest measurement began in 2012, when permanent sampling units were installed, distributed in transects over the forest cover of the property. In each transect, sampling units of fixed area of 10 x 20 m were allocated, in a systematic and contiguous way, following the slope gradient of the site (1411 to 1490 m), as shown in Fig. 1.

The survey sought to collect pertinent information about the local flora, such as scientific name, total height, geographic coordinates and diameter at breast height (DBH), with a minimum inclusion limit of 5 cm. In 2017, the same information was collected again, where it was possible to study the forest dynamics.

In studies developed by Venturini (2019) and Oliveira (2021) in the same area, it was observed that *Dicksonia sellowiana* was the species with the highest Importance Value (IV%) compared to the other species observed in the permanent plots. The species is considered an arborescent fern, with a generally erect stem, reaching up to 10 m in height, with dense trichomes and many adventitious roots that occur from the base to close to the apex (caudice), with up to 130 cm in diameter, where the

Table 1. Estimators of basal area and number of trees per hectare using the Prodan method.

Estimator	Formula
Basal area per hectare	$G=\frac{d_1^2+d_2^2+...+\frac{d_6^2}{2}}{R_6^2}(2500)$
Number of trees per hectare	$N=\frac{55.000}{\pi R_6^2}$

Where: G = Basal area (m².ha^{-1}); N = Number of trees per hectare; di = Diameter at breast height (m); R_6 = Distance from the center of the sample unit to the sixth measured tree (m).

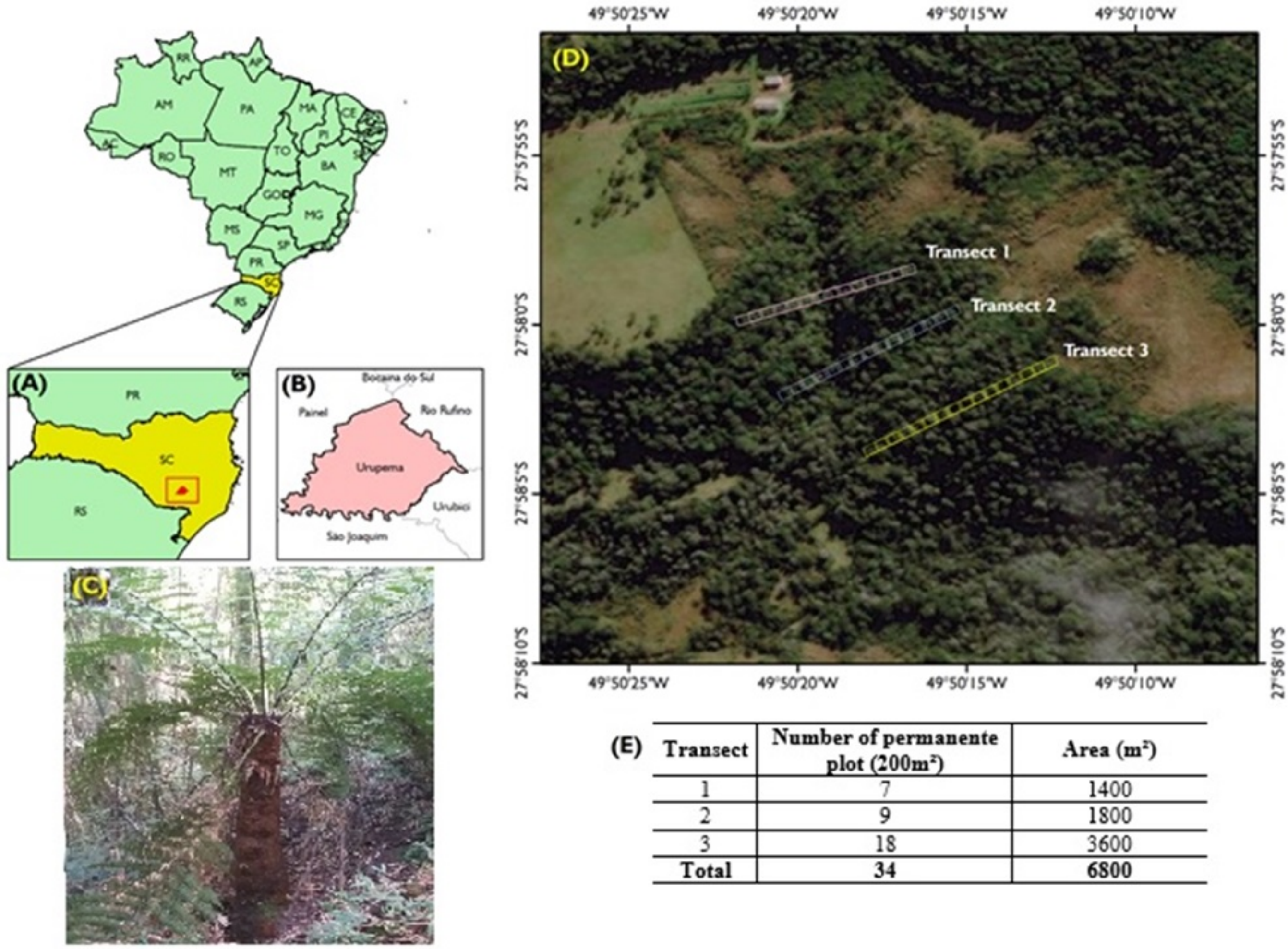
bi-pinnate leaves from 1 m to 5 m (Tryon; Tryon, 1982). Thus, we sought to identify the possible associations of this species with the other species in the remnant.

An adaptation of the method developed by Prodan (1968) was used, which considers the measurement of 6 trees and the distance or radius of the sixth tree as a reference for the sampling unit (Péllico Netto; Brena, 1997; Hall, 1991; Kleinn; Vilcko, 2006), taking an individual of *Dicksonia sellowiana* as the center of the unit, the 6 closest trees (DBHp $\geq$5cm) to it were evaluated, as seen in Fig. 2.

In the updated 2012 measurement database, 14 individuals of *Dicksonia sellowiana* were randomly selected in the study area, which served as a reference for the installation of the center of the sampling unit by the Prodan method. The distance from the 6th tree of the plot was determined using the "Measure" tool in ArGis, since all trees were referenced with local coordinates X, Y (in meters). Furthermore, care was taken to ensure that, when drawing the centers of the sampling units, the trees in two or more sampling units were not intersected.

The estimation of basal area (G) and number of trees per hectare (N) were determined from the distances from the center of the unit to the 6th of the sampling unit (Péllico Netto; Brena, 1997), that is, there is a spatial dependence from the center of the sampling unit to obtain these estimators (Péllico Netto et al., 2012). From them, the horizontal structure was determined (Mueller-Dombois; Ellemberg, 1974). To obtain the estimate of basal area per hectare (G) and the number of trees per hectare (N) using the Prodan method, the formulas available in Table 1 were used.

Statistical analysis was performed using simple random sampling to obtain the sampling error and sampling sufficiency of the basal area per hectare variable, commonly used to identify sampling sufficiency in inventories of native forests in southern Brazil (Sanquetta et al., 2014).). In addition, the collector curve was constructed (species x area curve) in order to identify the accumulation of species with the increase in the sampled area, both in the data from the permanent plots and in the sampling by the Prodan method.



Transect	Number of permanente plot (200m²)	Area (m²)
1	7	1400
2	9	1800
3	18	3600
Total	**34**	**6800**

Figure 1. Location map of the study area indicating the state of Santa Catarina (A); Municipality of Urupema (B), image of an individual of *Dicksonia sellowiana* (C), transects located in a private property (D) and area sampled in each transect (E).

The horizontal structure of the forest fragment was evaluated for the sample obtained by the Prodan method, such as: absolute density (AD), relative density (RD), absolute (AF) and relative frequency (RF), absolute dominance (ADo) and relative dominance (RDo), coverage value (CV%), importance value (IV%).

As most works that evaluate phytosociological studies use fixed area sampling units, this study sought to adapt the calculation formulas of the main estimators with those of the Prodan method, as described in Table 2. The main adaptation for the phytosociological estimators for the Prodan method refers to the calculations of density (equivalent to N) and dominance (equivalent to G), where it is necessary to estimate them by species in each sampling unit. In the case of density (Di), formulas 1 and 2 were used, with formula 1 being applied to trees 1 to 5, and formula 2 to the sixth trees of each sampling unit.

In this case, we proceeded to estimate the equivalence with respect to the hectare of each tree in each sampling unit and, to obtain the value of the absolute density (AD) of each species, the Di results of each plot in which the species occurred were summed.

For the calculation of absolute dominance, the density was similarly used, however, the basal area per hectare that each tree represents in each sampling unit was evaluated. This fractioning of Prodan's original formula is necessary, due to the fact that there are different species in the sample units, and it is necessary to know how much each one of them represents in occupation of the horizontal space of the terrain. Thus, for each of the first 5 trees of each sampling unit, formula 3 was applied and for the sixth trees of each unit, formula 4 was applied.

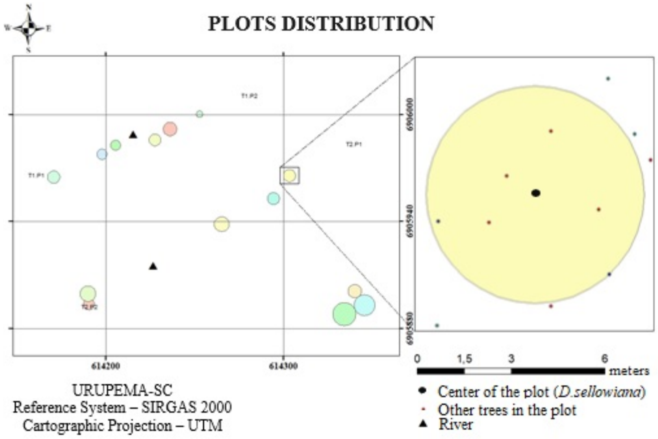


Figure 2. Distribution of sampling units of the Prodan method in the remnant and trees within the plot.

From the basal area of each species in each plot, the absolute dominance (ADo) of each species was obtained.

The other estimators were determined in a manner equivalent to that obtained in the fixed area method, more traditionally used in floristic and phytosociological surveys in Brazil.

Three floristic diversity indices were evaluated, Shannon-Wiener (H'), Pielou's (J) and Simpson's (D) Equability, which were determined by the formulas presented in Table 3.

3. Results and Discussion

By means of statistical analysis of the Prodan method, the average basal area of 69.5 m².ha^{-1} and the absolute sampling error of 12.5 m².ha-1 the average of 1628 individuals per hectare were obtained; that 820.8 individuals per hectare correspond to *Dicksonia sellowiana*. Fig. 3, presents the spatial distribution of this species, over the evaluated transects.

The collector curve, also known as the species accumulation curve, was elaborated as a function of the species sampled in the study area, as shown in Fig. 4, observing the two methodologies employed. In both cases, the stagnation of the curve was observed with the increase in the sampled area. However, in the methodology using the Prodan method, this value was much lower, mainly considering the use of individuals of *D. sellowiana* as a reference to the sampling unit that spatially selected the species included in the sampling.

The phytosociological analysis of the horizontal structure obtained by the Prodan method can be observed in Table 4, where indicators were observed that help to understand the behavior of the forest remnant.

Table 2. Phytosociological estimators determined from sampling by the sampling system using the Prodan method.

Estimator	Formula
Density	$Di= \frac{10.000}{\pi R_6^2}$ *(1)* $Di= \frac{5000}{\pi R_6^2}$ *(2)*
Absolute Density	$AD= \frac{\sum Di}{TU}$
Relative Density	$RD= \frac{AD}{ATD} 100$
Absolute Frequency	$AF= \frac{Ui}{TU}\ 100$
Relative Frequency	$RF= \frac{AF}{\sum AF}\ 100$
Basal Area	$Gi= \frac{d^2 \pi}{R_6^2} * 2500$ *(3)* $Gi= \frac{d^2{}_6}{R_6^2} * 2500$ *(4)*
Absolute Dominance	$ADo= \frac{\sum Gi}{TU}$
Relative Dominance	$RDo= \frac{ADo}{\sum ADo}\ 100$
Coverage Value	$CV= \frac{RD+RDo}{2}$
Importance Value	$IV= \frac{RD+RDo+RR}{3}$

Where: Di = Density that each tree in the sampling unit represents per hectare (number of trees per hectare); R_6 = Distance from the center of the sample unit to the sixth measured tree; Ui = Number of sampling units in which the species is present; TU = Total number of sample units. AD = Absolute density of each species (árv.ha^{-1}); ATD = Absolute total density (árv.ha^{-1}); AF = Absolute frequency; RF; Relative frequency; ADo = Absolute dominance of each species (m².ha^{-1}); $\sum ADo$ = Sum of absolute dominance (m².ha^{-1}); Gi = Basal area per hectare that each tree in the sample unit represents (m².ha^{-1}). d_n = diameter obtained from tree 1 to 5 in each sampling unit (m); d_6 = diameter obtained from the 6th tree for each sampling unit; (1 and 3) Formulas applied to trees 1 to 5 of each sampling unit; (2 and 4) = Formulas applied to the 6th trees of each sample unit. CV = Coverage value in percentage. IV = Value of Importance in percentage.

Table 3. Formulas used to estimate Shannon-Wiener, Pielou and Simpson Equability indices.

Estimator	Formula
Shannon-Wiener Index	$H' = \frac{[ATD.\ln(ATD) - \sum AD.\ln(AD)]}{ATD}$
Pielou's Equability Index	$J= \frac{H'}{Hmax}$
Simpson index	$D= \frac{\sum AD.AD-1}{ATD.ATD-1}$

Phytosociological studies are important for understanding an ecosystem as they provide basic information for biological studies (Guedes-Bruni et al., 1997). Such information can be used in the elaboration and planning of actions that aim at the conservation, management and/or even the recovery of forest formations, trying as much as possible to portray their diversities (Durigan, 2003). In the study by Venturini (2019), evaluating the basal area in the permanent plots of the original transects, an average of 69.4 m².ha^{-1} was obtained, very similar to that observed in this research, which used a differentiated sampling method. These results stand out from those found by Scheer et al., (2011), who determined an average basal area of 33.5 m².ha^{-1} in a high montane forest in the coastal mountain range (Serra do Mar) in the state of Paraná. Gross (2017) founded a basal área ranging from 34.7 m².ha^{-1} to 35.8 m².ha^{-1} in two inventories carried

Table 4. Phytosociological indicators of the horizontal structure of the sampling carried out by the Prodan method using individuals of *Dicksonia sellowiana* as a reference to the sampling unit.

Species	AD	RD	ADo	RDo	AF	RF	CV	IV
Cinnamomum amoenum (Ness & Mart.) Kost.	99.9	6.1	6.7	9.6	35.7	10.2	7.9	8.7
Dicksonia sellowiana Hook.	820.8	50.4	52.4	75.3	100.0	28.6	62.9	51.4
Eugenia hiemalis Cambess.	56.7	3.5	0.3	0.4	21.4	6.1	1.9	3.3
Ilex paraguariensis A. St.-Hil.	163	10.0	2.8	4.0	42.9	12.2	7.0	8.8
Mimosa scabrella Benth.	5.4	0.3	0.4	0.6	7.1	2.0	0.5	1.0
Myrceugenia euosma (O.Berg) D. Legr.	124.2	7.6	2.4	3.4	57.1	16.3	5.5	9.1
Myrceugenia miersiana D. Legr.& Kau.	18.6	1.1	0.2	0.3	14.3	4.1	0.7	1.8
Myrceugenia myrcioides (Cambess.) O. Berg	15.6	1.0	0.04	0.05	7.1	2.0	0.5	1.0
Myrcia palustres DC.	45	2.8	0.2	0.3	14.3	4.1	1.5	2.4
Myrcia laruotteana Cambess.	5.43	0.3	0.05	0.08	7.1	2.0	0.2	0.8
Ocotea porosa (Nees & Mart.) Barroso	67.3	4.1	0.2	0.3	7.1	2.0	2.2	2.2
Persea willdenovii Kosterm.	40.8	2.5	1.5	2.1	14.3	4.1	2.3	2.9
Prunus myrtifolia (L.) Urb.	141.2	8.7	0.5	0.7	14.3	4.1	4.7	4.5
Weinmannia paulliniifolia Pohl	24.0	1.5	1.9	2.8	7.1	2.0	2.1	2.1
Total	**1628**	**100**	**69.5**	**100**	**350**	**100**	**100**	**100**

Where: AD = absolute density ($ind.ha^{-1}$); RD = Relative density (%); ADo = absolute dominance ($m^2.ha^{-1}$); RDo = relative dominance (%); AF = Absolute frequency (%); RF = Relative frequency (%); CV = Coverage value (%) and IV = Importance value (%).
The Shannon-Wiener index (H') obtained was 1.79, the Pielou equability (J) was 0.68 and the Simpson index (D) was 0.29.

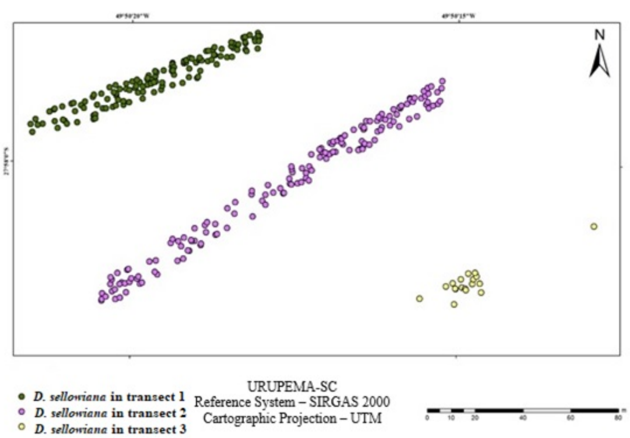


Figure 3. Spatial distribution of *Dicksonia sellowiana* over the three transects.

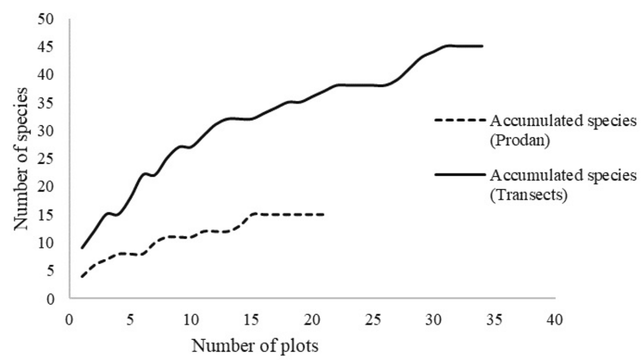


Figure 4. Species accumulation curve considering the permanent plots in transects and sampling by the Prodan method.

out in forest remnants in the Southern Plateau region of Santa Catarina. Which indicated a great dominance in the forest evaluated, mainly by the amount of trees present (1628 $individuals.ha^{-1}$), mainly of small dimensions, which can be observed in the diametric distribution of Fig 5.

The value calculated for the variable N is similar to that obtained by Gross (2017) who observed the density of 1583 and 1546 individuals per hectare in two inventories carried out in forest remnants in the southern plateau region of Santa Catarina. It is also close to the value found by Santana et al., (2018), who observed a density of 2316 individuals per hectare in a fragment of the high montane Mixed Ombrophilous Forest in its extreme north of distribution (Minas Gerais state). Galeski et al., (2020), in a study developed in the original transects of the data from this research, identified a positive correction (0.52) in the number of trees per hectare and a negative correlation (-0.41) and (-0.54) respectively of the basal area and average diameter with the altitude of the place, all of them being significant (p-value < 0.05). It can be inferred that there is a greater amount of small-diameter trees at higher altitudes and greater dominance in places

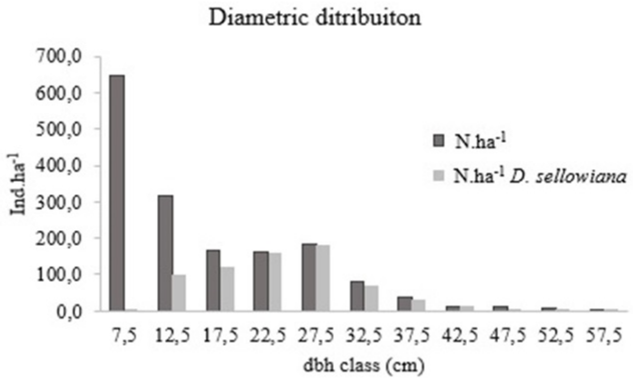


Figure 5. Diametric distribution observed for the community and for *D. Sellowiana* inventoried using the Prodan sampling method.

of lower altitudes, mainly located near rivers that have greater amounts of *Dicksonia sellowiana*, which have larger diameters (Fig. 5) than most other tree species in the area.

It was found that *Dicksonia sellowiana* occurred in 18 of the 34 permanent plots of the original transects, all of them in transect 2, six in transect 1 and only three in transect 3, being present between altitudes 1412 and 1453 as can be seen in Fig. 6. In addition, it was observed that the species is located near water courses and in hillside areas, not occurring at the highest altitudes of the terrain.

Analyzing Figs. 4 and 6, it can be observed that there are 45 species in the evaluated transects, and only 14 species were sampled by the Prodan method, a fact that can be explained by the density of individuals of *Dicksonia sellowiana*. It is important to note that it was not possible to allocate the largest number of sample units randomly without overlapping them. In addition, the 14 species observed in the Prodan sampling indicate their association with *Dicksonia sellowiana*, and that according to Mantovani (2004), the species occurs at high densities, inserted in a specific environment in the interior of forested areas, where in this study area, the species occurs more frequently in the vicinity of water courses, corroborating the results obtained by this study.

It was verified that in the two sampling methods (fixed area and variable area of Prodan) the tendency of stabilization of the collector curves, which indicates the guarantee of sampling sufficiency of the surveys. According to Costa (2019), when the collector curve stabilizes, forming a plateau (Fig.4), sample sufficiency was reached for the community in question. In the case of the survey using the Prodan method, it can be inferred that these 14 species observed are the ones that are most associated or aligned with *Dicksonia sellowiana*. It should be noted that a sample obtained for the floristic and phytosociological evaluation of a forest must represent the spatio-temporal interactions (Schilling; Batista, 2008). Where the sampling units should be coherent in this regard, when using an individual of a species of interest as a reference to the sampling unit, it can be ecologically relevant for the floristic characterization of the associations of this particular species. Furthermore, the Prodan method shows promise for detecting these associations, since the distance from the sixth tree to the center (in this case, a particular species) of the sampling unit shows a biological distance (Pellico Netto et al. 2012) with the species of interest, after presenting a spatial dependence with the center of the sampling unit, in addition to being a simple, practical method (Sanquetta et al., 2014) and quick to apply (Machado, 2022).

It can be seen in Table 4 that *Dicksonia sellowi*ana is the most representative species within the sample units of Prodan, highlighting that the individuals used as the center of the sampling unit were not considered in these analyses, obtaining the most significant values in density, dominance, frequency and coverage and importance values. This is explained by its specificity in the environment of occurrence, and according to Mantovani (2004). It is easily found in river channels, where development is favored by shading and humidity, indicating the tendency of the species to form massifs, with little floristic diversity in the places where they occur, as observed by Gasper et al., (2011), forming compact colonies, due to the accumulation of sediment and moisture (Martins et al., 2011).

Regarding the importance value, *Dicksonia sellowiana* represents more than half of the remainder, with values higher than *Myrceugenia euosma* (O. Berg) D. Legrande and *Ilex paraguariensis* A. St.-Hil., which are second and third respectively in this variable. This value was similar to that found by Venturini (2019), in the same area, but with the approach made with the permanent plots in the transects and not considering *Dicksonia sellowiana* as a reference to the center of the sampling unit. The importance value found for the species in this study was higher than that observed by Silva et al., (2012) in MOF Montane (from 800 to 1200 m altitude), which obtained a value of 2.57% for *Dicksonia sellowiana*. Value higher than that found by Klauberg et al. (2010), who obtained a VI for *Dicksonia sellowiana* of 29.19% in a MOF in Planalto Catarinense and also higher than that found by Lerner (2016), who observed a VI for *Dicksonia sellowiana* of 18.35% in MOF Montane in Paraná. . This suggests the predominance of the species in environments located in areas with ideal altitudes, as observed in this research, or even in areas with less sun exposure on the ground (Mantovani 2004 and Loureiro 2015) or in locations adjacent to waterways.

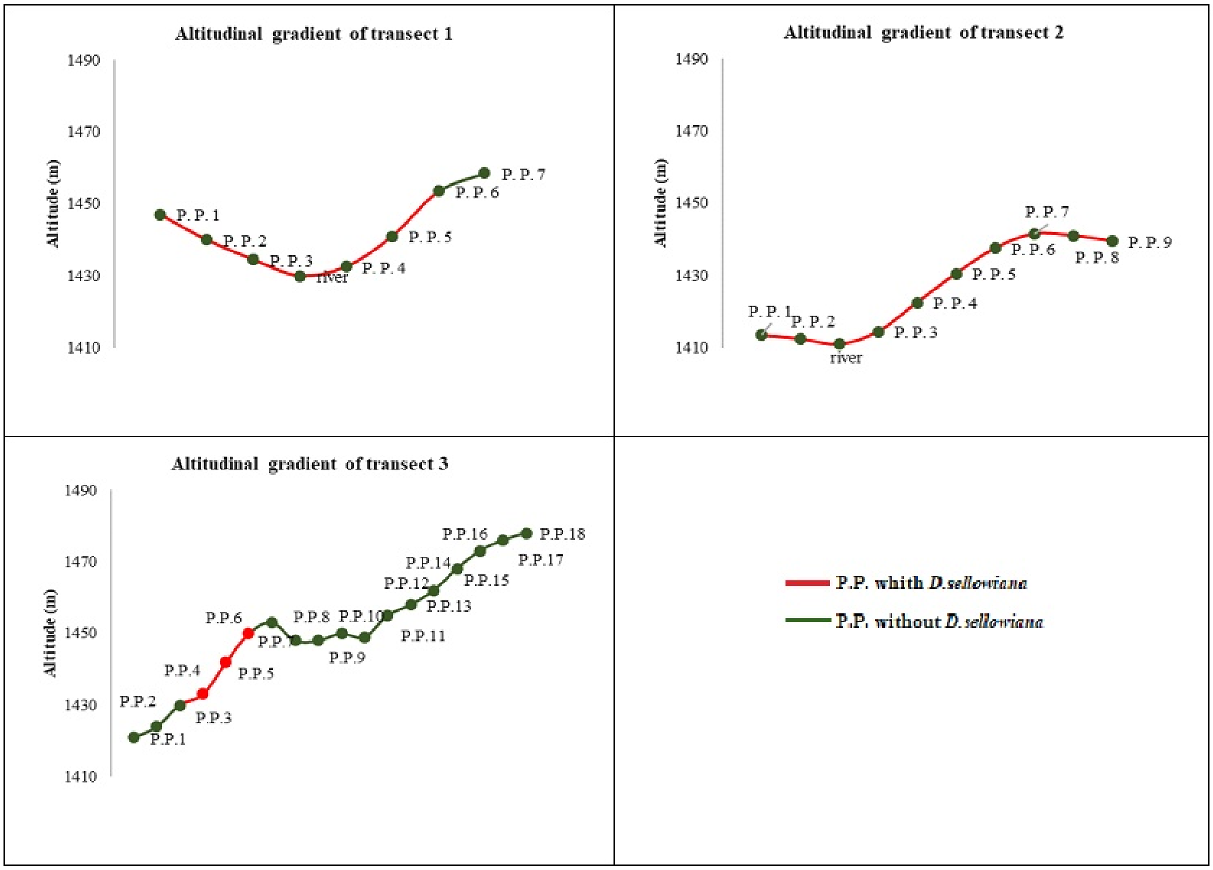


Figure 6. Longitudinal profile of transects with permanent plots, highlighting the sampling units with the presence of *Dicksonia sellowiana.*

The diversity indices analyzed showed lower values than many studies developed by other researchers in remnants in the region. For the Shannon Wiener index (H'), Higuchi et al., (2012) found a value of 3.74 in Lages – SC; Silva et al. (2012) obtained the value of 3.60 in Lages – SC; Higuchi et al., (2013) observed H' of 2.79 in Panel – SC; Klauberg et al. (2010) found the value of 3.05 in the city of Lages - SC and Pscheidt et al., (2015) who obtained an H' value of 3.51 in Lages - SC. It is noteworthy that the cited research used the fixed area method with different sizes in each study (100, 200 and 400 m²) and that the observed values of this research used the Prodan method with an individual of *Dicksonia sellowiana* with reference to the center of the unity. This can influence the low floristic diversity of the place, since the species of interest tends to organize itself in groups and the observed values can represent the floristic diversity of this group to which the species belongs. In contrast, because it used an individual of a species of interest as a reference to the center of the sampling unit and because the species is organized in massifs (Mantovani 2004, Gasper et al., 2011 and Martins et al., 2011), even with the simplicity and practicality of the Prodan method would make it impossible to increase the sampling intensity without overlapping trees in more than one sampling unit. In a way, this corroborates the identification of a low number of species associated with *D. sellowiana*.

To complement the Shannon-Wiener index, the Pielou equability (J), which according to Simões (2017), is an index derived from Shannon-Wiener that allows representing the uniformity of the distribution of individuals among existing species. Lower values were observed than those observed by other authors in the same forest typology such as Silva, et al., (2012) who obtained J = 0.82 and Klauberg et al., (2010) who obtained J = 0.81. The result of 0.68 means that only 68% of the hypothetical maximum diversity of the area was reached, that is, there is no uniform distribution of individuals among the species found, which can be explained by the dominance of *Dicksonia sellowiana* in the sample units.

According to Lopes (2016) for Simpson's dominance index, a community with the highest diversity will have the lowest dominance. Corroborating what was observed in this research and compared with studies in places with greater diversity, such as Klauberg et al., (2010), who obtained a value of 0.068 and Rode et al., (2009) who obtained a value of 0.07 and 0.04, indicating the tendency of *Dicksonia sellowiana* associated with low species diversity, however, with a high degree of endemism in the Atlantic Forest.

4. Conclusion

The Prodan method showed efficiency in the evaluation of forest stock, estimating the average value of basal area and number of trees per hectare in a manner compatible with that obtained by the permanent plots of fixed area located in the study area. The methodology proved to be sensitive to detect the association of species of interest, used as the center of the sampling unit. Since the main phytosociological estimators are obtained as a function of the radius or distance of the sixth trees in each sampling unit, consequently, it has a biological relationship with the center of the sampling unit.

Using the species *Dicksonia sellowiana* as the center of the sampling unit, it resulted in few species present and low floristic diversity, even with sampling sufficiency by the collector curve. It was possible to infer that *D. sellowiana* is associated with characteristic environments with less sun exposure, slopes and presence of watercourses, generating an environment with low floristic diversity, however, with a high degree of endemism in the Atlantic Forest.

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