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Review Article

Characterization of a forest in the center west of the province of Chaco, Argentina

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ABSTRACT

This work was carried out with the purpose of generating ecological and silvicultural information oriented to sustainable management. The horizontal structure was evaluated using the importance value index of Curtis and Macintosh, the vertical structure using Finol's methodology. Through the sociological position index, the percentage natural regeneration and the extended importance value index were estimated in order to infer the permanence of the forest ecosystem. The floristic composition was represented by species of the families *Anacardiaceae*, *Apocynaceae*, *Fabaceae*, *Santalaceae*, *Rhamnaceae*, *Sapotaceae*, *Simarubaceae*, *Ulmaceae*, *Zygophyllaceae*, *Capparidaceae*, *Borraginaceae* and *Achatocarpaceae*. In the horizontal structure, the species with the highest rank was *Acacia praecox*, followed in order of importance by *Schinopsis balansae*, *Aspidosperma quebracho blanco* and *Prosopis kuntzei*. According to sociological position, Acacia praecox was the most representative species, followed by *Patagonula americana*, *Schinus longifolius*, *Proposis kuntzei* and *Aspidosperma quebracho blanco*. The species with the best regeneration values were *Achatocarpus nigricans* and *Acacia praecox* in the shrub layer and *Patagonula americana* in the tree layer. The extended importance index consolidated the category of *Acacia praecox* in the community and gave a better category to *Schinopsis balansae*, *Aspidosperma quebracho blanco*, *Prosopis kuntzei* and *Patagonula americana*.

Keywords: Chaco Park; Native Forest; Vertical and Horizontal Structure; Regeneration

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1. Introduction

In recent times, the characterization of the Chaqueño Park has been profoundly challenged, while numerous ecological studies have recently been generated. Although the floristic, diversity and dynamics knowledge base is increasing, it is still fragmentary and too regionally concentrated[1]. Among the physiognomic formations of the Argentine Chaco Region, different types of forests characterized by the dominance of Schinopsis species stand out, such as the quebracho colorado chaqueño (*Schinopsis balansae*) and the quebracho colorado santiagueño (*Schinopsis lorentzii*), characteristic of the Humid Chaco and the Semiarid respectively. The distribution area of these two species overlaps in a SO-NE direction from the SE of the Province of Santiago del Estero and NO of Santa Fe towards the center of Formosa. However, their coexistence in a strict sense is rare[2] and it is likely that this is the case since when following the route of National Route No. 16, the quebracho colorado chaqueño is no longer observed near the town of Los Frentones. There is a clear need to gather detailed information on these ecosystems, unique on the planet, which are modified by the constant action of man, increasing the degree of fractionation or subjecting the forest to continuous pressure as a result of exploitation without criteria.

As Giménez *et al.*[3] state, the growing interest in biodiversity is in the first place, due to the abundance of plants and animals, which is of incalculable value. It is the natural heritage of a country, the result of a long process of evolution that has occurred over time and is unrepeatable. Franklin and Armesto[4] add that the productivity and biological diversity of forest ecosystems depend to a large extent on the structural complexity of forests. Based on these arguments, it is logical to think that it is necessary to know the structure of the forest under study and its ability to regenerate in order to have better information that will help facilitate decision-making for the responsible management of native forest stands.

The fact that Argentina's native forests have been subjected to severe degradation processes does not mean that they have lost their potential; on the contrary, they are forests that can be recovered under silvicultural practices aimed at sustainable management[5]. It is an arduous task to turn the vision of effective regeneration of forest parts into reality, which requires systematizing the existing information and guiding research to find what is lacking. Gadow *et al.*[6] affirms that forest resources fulfill various functions for society and consequently it should be a condition that management is carried out on a scientific basis, which is a difficult challenge. In this perspective, Giménez *et al.*[3] believe that sustainable management is a pillar for the conservation of biological diversity. There are publications aimed at providing a basis for the sustainable management of forests in the Chaco park, such as that of Araujo[7], Araujo *et al.*[8], Araujo *et al.*[9], Brassiolo[10], Giménez *et al.*[3], Hampel[11], Tálamo *et al.*[12], Torrela *et al.*[2] and Wenzel and Hampel[13], although information regarding forest structure in the central western Chaco province is scarce and data regarding regeneration are uncertain.

Early descriptions of the three quebracho forest highlighted the agricultural potential of its soils and warned about this implicit threat to its conservation[2,14], Torrella *et al.*[2] conclude that this forest is not represented in the system of protected areas and is distributed exclusively on private lands. Contributions of this nature are a way to prevent these pristine environments from continuing to be modified without taking the minimum precautions through the application of prudent criteria derived from knowledge translated into terms of sustainability.

The objectives of this work are: to know the floristic composition and the natural order of the trees expressed in numerical data that will provide feasible information to be used to base technical norms oriented to the sensible management of the forest. It is also useful to quantitatively specify the regeneration of the species, since it will orient the capacity of the forest to remain and to react if it is disturbed by any external cause.

2. Material and methods

The study area, located approximately 4 kilometers north of the town of Concepción del Bermejo, is a rectangle defined by picadas and country roads that facilitate access and is defined by the following geographic coordinates: S 26°21'17.83" W 61°01'49.64"; S 26°31'13.47" W 60°48'5.76"; S 26°37'23.27" W 60°50'53.14" and S 26°32'21.04" W 61°04'35.91" (**Figure 1**).

According to Ledesma[15], the original material of the soil, referring to the C horizon and the materials above the C from which the soils develop, corresponds to loess and local fossil loess-alluvial and is located within the climatic subtype cfw'a(h) of the Koppen climatic classification[14]; consequently, humid mesothermal with temperatures of the warmest month higher than 22 °C and the mean annual temperature higher than 18 °C, with rainfall that is markedly scarce in winter, according to Ledesma[15] it can be specified that the area studied is located between the isohyets of 800 to 850 mm per year.

The design of a forest inventory requires the assembly of a series of different techniques, including photogrammetry and photointerpretation techniques, biometric or statistical techniques, dendrometric techniques, data processing techniques, and operational programming and analysis tech-

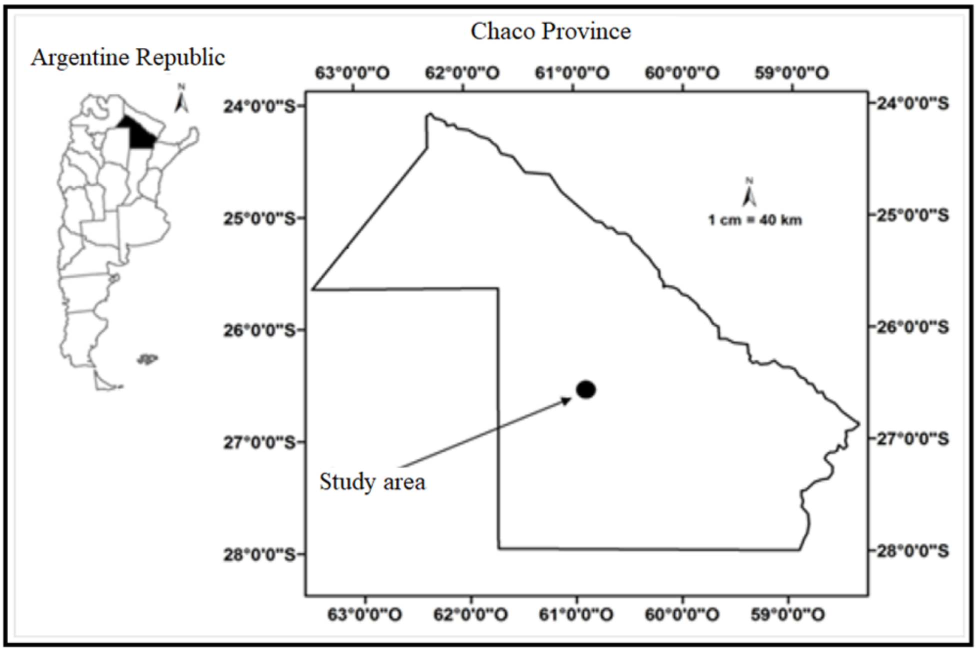

Figure 1. Location of the study area.

niques[16]. A 2012 satellite image was used for the study area, which according to the LANDSAT global path-row reference system corresponds to 228–078. After classifying the satellite image, the surface corresponding to the study area could be differentiated into surface with forest cover and surface without forest cover. Three types or strata were differentiated in the area covered by forest. In order to differentiate these strata, the methodology described by Reuter and Tévez[17] was used due to the heterogeneity and fragmentation of the study area. The study area has a surface area of 30.059 hectares, of which 16.071 hectares belong to forest cover areas. The distribution of the surfaces according to the three identified strata was 1.539, 4.327 and 10.205 hectares.

Within each stratum, five control points were selected, which are located close to local roads and located with the help of a global positioning system. The difference between the strata was visually corroborated, estimating that the stratum of 1,539 hectares corresponds to a high open forest. Following the methodology proposed by Zevallos and Matthei[18], a sampling unit of 1,000 m^2 was determined, consisting of a 10 × 100 m rectangle. The 10 sampling units have the characteristics of continuity, so they together form an area of 1 hectare. The starting point of the first sampling unit was selected in such a way that the integrity of the sample was installed within a fragment of the forest identified as high open forest. Within each sampling unit, a 10 × 5 m subplot was defined at the beginning and at the end. The variables surveyed in each sampling unit were normal diameter (DN) and total height (AT). All woody specimens with DN equal to or greater than 0.10 m were surveyed. In the 50 m^2 subplots the natural regeneration of woody species was surveyed, classifying them into 3 categories: specimens between 0.1 and 0.99 meters in height (I); specimens between 1 and 2 meters in height (II) and specimens greater than 2 meters in height and less than 0.10 meters in normal diameter (III).

The total number of trees and the basal area (AB) discriminated by species were calculated for each sampling unit. Basal area was compared among the ten sampling units by analysis of variance (ANAVA) and Tukey's test was used to determine the homogeneity of the total sample. Each sampling unit was processed. The number of trees and basal area per hectare and per species were then determined.

The specimens of woody species surveyed were identified at the species level using existing flora books: Cáceres[19], Cabral and Core[20], Giménez and Moglia[21] and the species of the herbaceous tapestry were identified by the working group of the natural resources research area. The identified species were grouped into woody and herbaceous.

Horizontal structure was evaluated using the importance value index (IVI). Its magnitude is an excellent indicator of the importance of the vegetation of a species within a stand, since it is sensitive to variables such as aggregation or basal area[22]. Its main advantage is that it is quantitative and precise and does not resign itself to subjective interpretations[23], the same author defines it as an indicator of the phytosociological importance of a species within a community. It is calculated using the following equation:

$$IVI = A\% + D\% + F\%$$

Then:

$$IVI\% = (A\% + D\% + F\%) * 3^{-1}$$

Where:

A% = relative abundance

D% = relative dominance

F% = relative frequency

The abundance index refers to the number of individuals per species and per hectare[24]. The frequency index of each species was calculated based on the presence of the species in each of 10 sampling units that make up the final sample[25], the dominance index of each species was calculated by adding the normal section of all specimens of the species and relating it by quotient with the surface area of the sample[26]. The percentages of relative abundance, frequency and dominance accounting for each of the above indices were calculated for each species.

To define the vegetation floors, the rule known as 20/30/50 was applied[9]. In order to evaluate the vertical structure, the methodology proposed by Finol[27] was used through the Sociological Position Index (PS). First, the phytosociological value of each stratum (Vfe_i) was calculated by relating the number of trees of stratum i (Ne_i) to the total number of trees (N):

$$Vfe_i = Ne_i{}^{*}N^{-1}$$

The phytosociological value ($Vfe_i\%$) percentage of each stratum was calculated according to the following expression:

$$Vfe_i\% = (Ne_i{}^{*}N^{-1})^{*}100$$

In order to simplify the calculations, the simplified phytosociological value (Vfe_is) was calculated according to the following equation:

$$Vfe_is = Vfe_i\%^{*}10^{-1}$$

Then the phytosociological value of a given species per stratum ($Vfes_i$) was deduced according to:

$$Vfes_i = Vfe_i{}^{*}Ne_i$$

The absolute value of sociological position (Ps_{abs}) was calculated based on:

$$Ps_{sabs} = \sum Vfes_i$$

Finally, the value of the relative sociological position ($P_s\%$) was defined by:

$$P_s\% = P_{sabs}{}^{*}100^{*}N^{-1}$$

Natural regeneration was evaluated by relative natural regeneration (Rn%), a parameter proposed by Finol[27]:

$$Rn\% = (A\% + F\% + C\%) * 3^{-1}$$

The values of abundance and absolute and relative frequency of regeneration were calculated in a similar way to the procedure used in the calculations of the horizontal structure.

The regeneration size category was calculated using the same criteria as that used for the calculation of the sociological position index. Regeneration size classes C1, C2 and C3 correspond to categories I, II and III surveyed during the inventory. The relative (VP%) and simplified (VPs) phytosociological values for each regeneration size category and the absolute (Ct) and relative (Ct%) size categories were calculated similarly to the sociological position indices.

The Expanded Importance Value Index (IVIA), an index introduced by Finol[27] takes into account both the horizontal and vertical structure and according to Ramos and Plonczak[28] allows synthesizing the phytosociological contribution of each species in the horizontal and vertical structure of each community. It was calculated according to the following equation:

$$IVIA = A\% + F\% + D\% + Ps\% + Rn\%$$

The program Info Stat version 2013[29] free version was used for data systematization and processing.

3. Results

Tree, shrub and herb species were identified by their scientific and common names. Indices and parameters were calculated to describe the horizontal and vertical structure of the high open forest studied as well as to express the viability of natural regeneration in the forest typology. The data and results were grouped in tables.

Description of the floristic composition. Nineteen woody species of trees and shrubs from 12 different families were recorded (**Table 1**).

Also included in the description were those species that were observed in the study area although they were not surveyed in the sampling units and those species that were not surveyed because their DN was less than 10 cm.

In the herb stratum, 11 species of 7 different families were identified (**Table 2**).

Table 1. Species of the arboreal and shrub stratum

Family	Scientific name	Common name
Achatocarpaceae	*Achatocarpus nigricans* Triana, Ann.	Ink stick
Anacardiaceae	*Schinopsis balansae* Engl.	Chaco red Quebracho
	Schinopsis quebracho colorado (Schlecht) Barkl. et Meyer	Quebracho colorado santiagueño
	Schinus longifolius (Lindl.) Speg.	Molle
Apocynaceae	*Aspidosperma quebracho blanco* Schlecht.	White Quebracho
Borraginaceae	*Patagonula americana* L.	Guayaibí
Capparidaceae	*Capparis retusa* Gris.	Sacha bean
Fabaceae	*Acacia praecox* Griseb.	Doodle
	Caesalpinia paraguarienses (D. Parodi) Burk.	Guayacán
	Prosopis kuntzei Harms Kuntze	Itín
	Prosopis alba Griseb	White carob
Santalaceae	*Acanthosyris falcata* Griseb.	Saucillo
	Jodina rhombifolia Hook et Arn.	Bull shadow
Rhamnaceae	*Condalia microphylla* Cav.	Piquillin
	Ziziphus mistol Griseb.	Mistol
Sapotaceae	*Bumelia obtusifolia* Roem. & Schult.	Guaraniná
Simaroubaceae	*Castela coccinea* Griseb.	Peach
Ulmaceae	*Celtis tala Gillies* ex Planchon	Tala
Zygophyllaceae	*Porlieria microphylla* (Baill.) Descole, O' Donell & Lourteig	Ladle

Table 2. Species of the herb stratum

Family	Scientific name	Common name
Bromeliaceae	*Bromelia hieronymi* Mez	Chaguar
	Bromelia serra Griseb.	Chaguar
Cyperacea	*Carex sp*	-
Cactaceae	*Cereus aethiops* Haw.	Cardón
	Opuntia quiscaloro	Quiscaloro
Fabaceae	*Chaetotylax umbrosus?*	Sachalfalfa
Grasses	*Panicum sp.*	-
	Setaria sp	-
Poaceae	*Setaria fiebrigii?*	Pastured cow
Pteridocea	*Pteridium aquillinum* (L.) Kuhn.	Fern
	Thelypteris dentata (Forssk) E.P. StJohn	Fern

Homogeneity of the sample. The ANAVA using the AB of all specimens in the sample units showed that the sample is internally homogeneous (**Table 3**).

Since the p value was greater than alpha equal to 0.05, it was found that there were no differences between treatments. Tukey's test (alpha equal to 0.05) was used to determine the differences between the arithmetic means of the AB. The comparisons between the arithmetic means indicated the existence of internal homogeneity within the final sample, as shown in **Table 4**, since equal letters confirm that there are no differences between the different sample units.

Calculation of indices and parameters. We counted 275 specimens with a diameter greater than 10 cm and seven old stumps of quebracho colorado, 6 of which had diameters between 20 and 22 cm and the remaining 41 cm in diameter. It was not possible to differentiate whether these stumps belonged to specimens cut from quebracho colorado chaqueño or quebracho colorado santiagueño. The stumps were not included in the calculations.

Table 3. ANAVA table

FV	SC	CM	gl	F	p-value
Model	0.05	9	0.01	1.08	0.3757
Treatment	0.05	9	0.01	1.08	0.3757
Error	1.45	272	0.01	-	-
Total	1.5	281		-	-

Horizontal structure. The importance value index (IVI) was calculated for each of the species of

Table 4. Comparison of arithmetic means of AB

Treatment	Means	N	E. E	F
6	0.03	33	0.01	A
2	0.04	34	0.01	A
8	0.04	26	0.01	A
9	0.04	29	0.01	A
5	0.05	29	0.01	A
7	0.05	22	0.02	A
4	0.06	25	0.01	A
10	0.06	28	0.01	A
1	0.07	34	0.01	A
3	0.08	22	0.02	A

the tree and shrub stratum; it synthesizes the hierarchy of each of them in a dimensionless number and reflects the importance of the species in the community. **Table 5** shows the results of the calculation of each of the indices. The highest ranking species within the community was *Acacia praecox*, followed in order of importance by *Schinopsis balansae*, *Aspidosperma quebracho blanco* and *Prosopis kuntzei*. *Acacia praecox* reached a preponderant place due to its abundance and the fact that it was present in all sample units. *Schinopsis balansae*, Aspidosperma quebracho blanco and *Prosopis kuntzei* justified their hierarchy by their frequency and basal area, to the extent that they had an IVI% value of 39% with abundance values of only 26% adding the three species together. *Schinopsis* quebracho colorado santiagueño was represented by only four specimens in the final sample, although it reached a relative dominance of 10% due to the diameters of the specimens.

Vertical structure. The total heights of the largest specimens reached 23 meters. The vegetation floors were distributed as follows: a) lower floor: specimens < 11.5 meters; b) intermediate floor: specimens ≥ 11.5 meters and < 18.5 meters; c) upper floor: specimens ≥ 18.5 meters.

The results of the calculation of PS and PS% are specified in **Table 6**. The shrub layer included those species that were only in the lower vegetation floor.

In terms of sociological position within the community, Acacia praecox was the most representative species. It was followed in order of importance by *Patagonula americana*, *Schinus longifolius*, *Proposis kuntzei* and *Aspidosperma quebracho blanco*. Both *Acacia praecox* and *Schinus longifolius* belong to the shrub layer, while *Patagonula americana*, *Prosopis kuntzei* and *Aspidosperma quebracho blanco* belong to the tree layer. These three species together with *Schinopsis balansae* and *Schinopsis quebracho colorado* were present in the three vegetation strata.

Table 5. Calculations of horizontal structure indices

Species	A	A%	F	F%	D	D%	IVI	IVI%
Acacia praecox	114	41	10	13	2.30	17	71	24
Acanthosyris falcata	8	3	5	6	0.23	2	11	4
Aspidosperma quebracho blanco	27	10	9	12	2.24	16	38	13
Caesalpinia paraguariensis	13	5	6	8	0.88	6	19	6
Celtis tala	1	0	1	1	0.01	0	2	1
Jodina rhombifolia	6	2	4	5	0.17	1	9	3
Patagonula americana	30	11	9	12	0.50	4	26	9
Prosopis kuntzei	18	7	9	12	1.82	13	31	10
Schinopsis balansae	24	9	10	13	3.64	26	48	16
Schinopsis quebracho colorado	4	1	4	5	1.44	10	17	6
Schinus longifolius	25	9	8	10	0.50	4	23	8
Ziziphus mistol	5	2	3	4	0.11	1	6	2

Note: A = Relative abundance, F=Relative frequency, D = Relative dominance, IVI = Importance Value Index

Table 6. Calculation of vertical structure indexes

Species	Pi	Pm	Ps	PS	PS%
Acacia praecox	113	0	0	919	51
Acanthosyris falcata	5	3	0	45	3
Aspidosperma quebracho blanco	11	14	2	112	6
Caesalpinia paraguariensis	5	8	0	53	3
Celtis tala	1	0	0	8	0
Jodina rhombifolia	5	0	0	41	2
Patagonula americana	25	6	0	213	12
Prosopis kuntzei	15	5	0	130	7
Schinopsis balansae	4	4	4	40	2
Schinopsis quebracho colorado	1	2	1	12	1
Schinus longifolius	25	0	0	203	11
Ziziphus mistol	4	0	0	33	2
Number of trees in each stratum	214	42	7	-	-
Phytosociological value of each stratum	8.14	1.60	0.27	-	-

Note: Pi = Lower Floor, Pm = Intermediate Floor; Ps = Upper Floor, PS = Sociological Position, PS% = Relative Sociological Position.

Natural regeneration. **Table 7** shows the values of the indexes calculated for the natural regeneration of the forest under study. While the results of the calculation of relative natural regeneration (Rn%) are simplified in **Table 8**.

The species with the best regeneration valuescorresponded to the shrub stratum, among which *Achatocarpus nigricans* and *Acacia praecox* stood out. Among the species that make up the arboreal stratum, *Patagonula americana* was rescued. Regarding the "three quebrachos": *Aspidosperma quebracho blanco* and *Schinopsis quebracho colorado* presented very low values of absolute

Table 7. Calculation of natural regeneration indexes

Species	C_1	C_2	C_3	Ct	Ct%	A	A%	F	F%
Acacia praecox	1,070	370	250	6,314	25	1,690	24	20	100
Acanthosyris falcata	30	60	70	498	2	160	2	7	35
Achatocarpus nigricans	990	1,540	520	10,968	43	3,050	43	20	100
Aspidosperma quebracho blanco	10	20	20	159	1	50	1	4	20
Bumelia obtusifolia	0	0	10	21	0	10	0	1	5
Capparis retusa	180	260	170	2,080	8	610	9	19	95
Celtis tala	120	180	100	1,383	5	400	6	18	90
Condalia microphylla	0	20	0	75	0	20	0	1	5
Patagonula americana	480	210	360	3,527	14	1,050	15	20	100
Schinopsis quebracho colorado	10	0	0	41	0	10	0	1	5
Schinus longifolius	40	20	30	303	1	90	1	6	30
Ziziphus mistol	10	20	0	116	0	30	0	2	10
Number of renewals	2,940	2,700	1,530	25,487	100	7,170	100	-	-
Phytosociological value of each stratum	4.10	3.80	2.10	-	-	-	-	-	-

Note: C_1 = Class I, C_2 = Class II, C_3 = Class III, Ct = Absolute size category; Ct% = Relative size category, A = Abundance, A% = Relative abundance, F = Frequency, F% = Relative frequency.

Table 8. Relative natural regeneration of the different species

Species	F%	A%	Ct%	Rn%
Acacia praecox	17	24	25	22
Acanthosyris falcata	6	2	2	3
Achatocarpus nigricans	17	43	43	34
Aspidosperma quebracho blanco	3	1	1	2
Bumelia obtusifolia	1	0	0	0
Capparis retusa	16	9	8	11
Celtis tala	15	6	5	9
Condalia microphylla	1	0	0	0
Patagonula americana	17	15	14	15
Schinopsis quebracho colorado	1	0	0	0
Schinus longifolius	5	1	1	2
Ziziphus mistol	2	0	0	1

Notes: F% = Relative frequency, A% = Relative abundance, Ct% = Relative size category, RN% = Relative natural regeneration.

Table 9. Calculation of IVIA

Species	A%	F%	D%	RN%	PS%	IVIA
Acacia praecox	41	13	17	22	51	143
Acanthosyris falcata	3	6	2	3	3	17
Achatocarpus nigricans	0	0	0	34	0	34
Aspidosperma quebracho blanco	10	12	16	2	6	45
Bumelia obtusifolia	0	0	0	0	0	0
Caesalpinia paraguariensis	5	8	6	0	3	22
Capparis retusa	0	0	0	11	0	11
Celtis tala	0	1	0	4	0	5
Condalia microphylla	0	0	0	5	0	6
Jodina rhombifolia	2	5	1	0	0	9
Patagonula americana	11	12	4	9	2	38
Porlieria microphylla	0	0	0	6	12	17
Prosopis kuntzei	7	12	13	0	7	38
Schinopsis balansae	9	13	26	0	2	50
Schinopsis quebracho colorado	1	5	10	0	1	18
Schinus longifolius	9	10	4	2	11	37
Ziziphus mistol	2	4	1	1	2	9

Note: A% = Relative abundance, F% = Relative frequency, D% = Relative dominance, RN% = Relative natural regeneration, PS% = Relative sociological position, IVIA = Index of value of importance amplified.

abundance, about 50 to 10 specimens per hectare, while no regeneration of *Schinopsis balansae* and *Prosopis kuntzei* was recorded.

The expanded importance index includes the relative natural renewal values of horizontal and vertical structures (**Table 9**).

In the hierarchy defined by the IVIA, the rank represented by Acacia praecox in the community was consolidated. This index gave a new hierarchy to *Schinopsis balansae*, *Aspidosperma quebracho blanco*, *Prosopis kuntzei* and *Patagonula americana* due to their participation in the horizontal and vertical structure, although in all cases the species cited in the first term practically triples the remaining species.

4. Discussion

Cabrera[30] states that in the Chaco Province, *Schinopsis balansae* characterizes the Eastern Chaco District and *Schinopsis lorentzii* characterizes the Western Chaco District. Ragonese and Castiglioni[31] indicate a transition zone where *Schinopsis* quebracho colorado and *Schinopsis balansae* grow in association. Morello and Adámoli[14] speak of large masses of quebrachal of three quebrachos, settled in apparently eolian cords, with a clear NNE-SSO direction. The study area presents a similar woody characterization, although currently it is highly fragmented due to the promotion of agricultural boundaries and the continuous development of timber harvesting forests, and finally only the vegetation patches that retain their intangible characteristics are left. The quantity of stumps found compared to the absolute abundance of *Schinopsis balansae* and *Schinopsis* quebracho colorado indicates that this is a scarcely intervened forest.

In the present work, common families and species were found, even with the same hierarchy in the community with respect to studies conducted by Araujo *et al.*[9] in a representative forest of the Western Chaco Park, and Giménez *et al.*[3] cites some common species in a region identified as Semiarid Argentine Chaco in the province of Santiago del Estero, although in those communities *Schinopsis balansae* is not mentioned. Again Giménez *et al.*[32] refer to a floristic composition similar to the study area in research carried out in an area identified as a transition area and locate them in Miramar (Chaco) and algarrobal (Formosa). Torrela *et al.*[2] proposed a similar situation in an area identified as the central sub humid Chaco in the southeast of Chaco Province, which eventually became a common species in the study area. Finally, as species common to the study region, Hampel[33] mentions *Schinopsis balansae* and *Patagonula americana* in the forested region of the eastern Chaco.

The importance value index represents an objective way to determine the plant species that characterize an association[34] and allows comparing the ecological weight of the species within the plant community[24]. Taking into account this index, Acacia praecox is the most prominent species in the community. Kunst[35] states that shrublands and low forests in the Chaco region are ubiquitous and generally result from the overcutting and overgrazing of savannas and forests, if so, the secondary forest would be ensured by the abundance of Acacia praecox. *Schinopsis balansae*, *Aspidosperma* quebracho blanco, *Prosopis kuntzei* and *Patagonula americana*, the first three identified as heliophilous and the fourth as umbrophilous by Hampel[33] are the most important among the arboreal species, which consolidates the argument that this is a high open forest with practically no anthropic intervention. This argument is supported by the opinion of Araujo *et al.*[9], stating that the fact that *Aspidosperma* quebracho blanco constitutes more than 50% of the stand is typical of exploited forests, while Araujo *et al.*[9] refer to Gaillard de Benitez *et al.* who verified that the form of exploitation produces this type of change in species composition. In addition, Humano *et al.*[36] state that the different species have low ecological importance when they present an IVI% lower than 5, medium importance when the IVI% is between 5 and 14 and high importance when it is equal to or higher than 15. According to this criterion, Acacia praecox and *Schinopsis balansae* are species of high ecological importance, *Aspidosperma* quebracho blanco, *Prosopis kuntzei*, *Patagonula americana*, Schinus longifolius and Schinopsis quebracho colorado are species of medium ecological importance and the rest of the species are of low ecological importance.

The results of the investigation of the vertical structure indicated that three species were present in all vegetation floors: *Aspidosperma* quebracho blanco, *Schinopsis balansae* and *Schinopsis* quebracho Colorado. And according to the criteria established by Finol[27], they ensure their place in the structure and composition of the forest formation. Again, Finol states that the more regular the distribution of the individuals of a species in the vertical structure of a forest (the number of feet decreases gradually as one moves up from the lower stratum), the greater its value in the relative sociological position. In the aforementioned association, the opposite occurs, so it is difficult to infer whether it is indeed stable, especially considering that they grow in a region considered as a transition region by Ragonese and Castiglioni[31], Morello and Adámoli[14], Torrella *et al.*[2] and Morello[37].

The low potential for natural regeneration of tree species that emerges from this study is confirmed by the opinions of some authors, such as Tálamo *et al.*[12] who mentioned that the regeneration of species of forest value, referring to *Aspidosperma* quebracho blanco and *Schinopsis lorentzii*, was low compared to that of other species in the semi-arid Argentine Chaco in the province of Chaco to the north and east of Copo National Park. In turn, Wenzel and Hampel[13] refer to the lower proportion of *Schinopsis balansae* and *Aspidosperma* quebracho blanco in the total regeneration of the Argentine humid Chaco in the province of Chaco and add that the first species cited did not regenerate in the closed high forest and there was little regeneration in open high forests, as was the case with the second species. Grulke[38] also cites a low density of quebracho colorado (6 young trees per hectare) in high-density quebrachales and none in low-density quebrachales for the semi-arid Salta Chaco in the province of Salta. Although other authors such as Araujo *et al.*[9] indicate that the regeneration of *Schinopsis* quebracho colorado is more abundant than that of *Aspidosperma* quebracho blanco in the semi-arid Chaco and cite Brassiolo, who counted up to 835 quebracho colorado regeneration per hectare in a forest exposed to cattle. The same authors again cite Brassiolo indicating that in a site under silvopastoral management, the number of red quebracho individuals (1,857/hectare) was also higher than that of white quebracho (862/hectare). Finally, Araujo *et al.*[9] refer to Brassiolo *et al.*, stating that a minimum of 100 seedlings/hectare of class III red quebracho colorado is needed to consider that there is an established and assured regeneration.

5. Conclusions

It is evident that the three quebrachos cohabit the study site and that the area can be described as a transition area, which makes this community attractive for the implementation of conservation and sustainable management strategies.

The dominant association of the tree community is composed of *Schinopsis balansae* and *Aspidosperma* quebracho blanco.

There was little or no regeneration of the main species. These species gain importance when IVIA is applied, although the values contrast sharply with those of RN%.

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