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Article

Estructura y composición florística de un bosque de *Pinus-Quercus* en El Porvenir, Chiapas

Structure and floristic composition of a *Pinus-Quercus* forest in El Porvenir, Chiapas State

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Abstract

Pinus-Quercus forests are ecosystems of great ecological importance. Structure and composition are indicators of biodiversity in these forest associations, being two key elements for their stability and conservation. The objective of this study was to characterize a *Pinus-Quercus* forest based on the structural parameters and species composition present in the arboreal stratum in the municipality of *El Porvenir, Chiapas*. Six 400 m² circular sites were established to evaluate the adult trees and their dasometric variables (total height, normal diameter and cover). The structural parameters of the forest (density, dominance, basal area and cover) were used to calculate the indexes of Importance Value, forest value, Holdrige complexity index and similarity index. The results showed the presence of six species; *Pinus maximinoi* exhibited a mean height of 18.88±6.72 m ($p<0.0001$, $F= 5.46$), which is greater than that of other species. In addition, it has the highest normal diameter (30.58±13.64 cm, $p<0.0002$, $F=5.18$), Importance Value (161.07 %) and forest value (108.08 %). The Holdrige complexity index of the forest is 45.22 %. The results obtained made it possible to identify the dimensions, structural parameters, and dominance of the species, with *Pinus maximinoi* being the most valuable.

Key words: Forest arrangement, pine-oak forest, Sørensen's index, Holdrige complexity index, tree density, forest value index.

Resumen

Los bosques de *Pinus-Quercus* constituyen ecosistemas de gran importancia ecológica. La estructura y composición son indicadores de la biodiversidad en estas asociaciones forestales, en las cuales esos dos elementos son clave para su estabilidad y conservación. El objetivo del presente estudio fue caracterizar un bosque de *Pinus-Quercus* a través de los parámetros estructurales y de la composición de especies presentes en el estrato arbóreo en el municipio El Porvenir, Chiapas. Se establecieron seis sitios circulares de muestreo, con una superficie de 400 m² para evaluar el arbolado adulto y sus variables dasométricas (altura total, diámetro normal y cobertura). Los parámetros estructurales del bosque (densidad, dominancia, área basal y cobertura) se emplearon para calcular los índices de Valor de Importancia, valor forestal, complejidad de Holdrige y los índices de similitud. Los resultados mostraron la presencia de seis especies; *Pinus maximinoi* registró una altura

media de 18.88 ± 6.72 m ($p < 0.0001$, $F = 5.46$) superior a los otros taxones. Además, le correspondió el mayor diámetro normal (30.58 ± 13.64 cm, $p < 0.0002$, $F = 5.18$), Valor de Importancia (161.07 %) y valor forestal (108.08 %). El índice de complejidad de Holdrige del bosque fue de 45.22 %. Los resultados obtenidos permitieron identificar las dimensiones, parámetros estructurales y dominancia de las especies; de ellas, *Pinus maximinoi* fue la de mayor valor.

Palabras clave: Arreglo forestal, bosque de pino-encino, coeficiente de Sørensen, complejidad de Holdrige, densidad de arbolado, valor forestal.

Introduction

Globally, forests are one of the largest reservoirs of biological diversity, covering 31 % of the earth's land surface, a percentage equivalent to approximately 39 million km² (FAO, 2015). Resources obtained from forests such as timber, firewood, charcoal, construction material, non-timber products (*i.e.* medicinal plants) and certain environmental services: soil retention, water catchment, biomass, carbon sequestration, habitat and biodiversity conservation (Calderón *et al.*, 2012; Saavedra and Perevochtchikova, 2017), are very important for the rural and urban population. Forests represent a source of monetary income for local people (Cortina-Villar *et al.*, 2012), however, the availability of resources is determined by the composition and structure of their vegetation.

Mexico has 138 million hectares of forest area (70 % of the national territory), and temperate forests cover approximately 24 % of this area (Conafor, 2012). However, between 2005 and 2010, they were gradually reduced at a rate of 155 000 ha per year (INEGI, 2014). These alterations, which occur in ecosystems due to anthropogenic causes, can last for specific times and be irreversible (Thom and Seidl, 2016); therefore, it is essential to have a broad knowledge of the structure and distribution of forest species present in the forests (Méndez-Toribio *et al.*, 2014).

The structure and diversity indices contribute to decision-making regarding forest management, as well as to the detection of natural succession processes and

anthropogenic effects (López-Hernández *et al.*, 2017), which in turn facilitates the establishment of type stands to implement management strategies (Wehenkel *et al.*, 2014) that consider: i) spatial position or distribution, (ii) species diversity and mixture, and (iii) arrangement of vertical and horizontal differentiation (Castellanos-Bolaños *et al.*, 2008).

Structural parameters are a key indicator of biodiversity, ecological stability and future stand development (Franklin *et al.*, 2002; López-Hernández *et al.*, 2017). When the forest has a very simplified composition, some ecosystem functions tend to decrease; on the contrary, a high complexity increases its productivity, diversity and persistence (Castellanos-Bolaños *et al.*, 2008). The objective of this study was to characterize a *Pinus-Quercus* forest in order to obtain information regarding the structural parameters and the association of species present in the tree layer in a property in *El Porvenir* municipality, state of *Chiapas*.

The hypotheses that guided the present research were: i) There are no significant differences in the mean value of height and normal diameter of trees between the evaluated sites and species, ii) At least one dominant species of the *Pinus* genus is present with an Importance value index ≥ 200 ; and iii) The percentage affinity of tree species in the evaluated sites is ≥ 50 %, indicating that the species present have a medium-high similarity type.

Materials and Methods

Study area

El Porvenir municipality is 82.52 km² (5.72 % of the surface of the *Sierra Mariscal* region and 0.1 % of the surface of the state of *Chiapas*, Mexico), it is located

between 1 200 and 3 100 masl (Mejía and Kauffer, 2007). Its climate is Am(w) —i.e., humid temperate with abundant rainfall in summer—, its temperature is 12 to 24 °C, and rainfall fluctuates between 1 200 and 4 000 mm per year (INEGI, 2014). The study was carried out in a 4 ha *Pinus-Quercus* forest plot called "*parcela escolar Canadá*" in the *Malé ejido, El Porvenir, Chiapas*, located between 1708786.84 and 1708554.43 N, and 582378.81 and 582695.54 E, at an average altitude of 2 840 m (Figure 1).

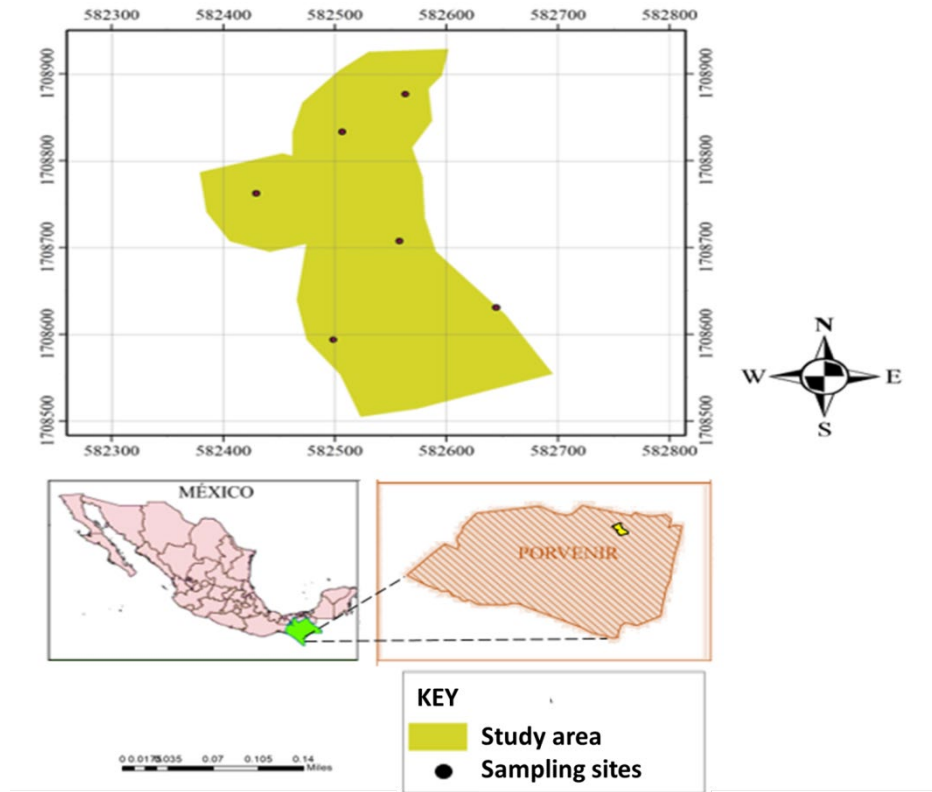


Figure 1. Location of the study area and distribution of sampling sites.

Sampling design

Six randomly distributed circular sites with an area of 400 m² (0.04 ha) were established for the tree inventory (Figure 1). This is equivalent to an inventoried area of 0.24 ha. The number of sites is sufficient to reach an admissible error of 10 %, which is within the interval established for circular sites (Aguirre *et al.*, 1997) with a confidence level of 95 %:

$$E \% = t (s \% \div \sqrt{n}) \quad (1)$$

$$n = t^2 s \% \frac{s \%}{E \%^2} \quad (2)$$

Where:

n = Number of sampling units (sample size)

t = Confidence level value

s % = Estimation of the coefficient of variation of the population

E % = Permissible error

According to Aguirre *et al.* (1997), the size of the sampling site is considered to be sufficient because it is a homogeneous forest with low variance, which allows obtaining significant results. At each site, a tree was considered as the center, from which four chords with a radius of 11.29 m were established in order to estimate the surface area of 400 m².

Structure and composition of adult trees

A forest inventory was carried out in the *Pinus-Quercus* forest following the procedures of Villavicencio-Enríquez and Valdez-Hernández (2003). Woody vegetation with a crown differentiated from the stem was included; the normal diameter (*ND*) was conventionally established, being measured at a height of 1.3 m from the ground. The vertical structure (total tree height) was estimated using a Vertex III Haglöf® hypsometer. Seven height classes were defined, the amplitude of each one corresponding to 5 m. The lower class limit (minimum tree height) was 2 m and the upper limit (maximum height) was >32 m.

The horizontal structure was represented mainly by tree density (*D*), normal diameter (*ND*) and basimetric area (*BA*). The density of standing adult trees and stumps with a $ND \geq 2.5$ cm was evaluated (Villavicencio-Enríquez and Valdez-Hernández, 2003; Zarco-Espinoza *et al.*, 2010). *ND* was measured using a modelo 349-5-A Richter® 5 m diameter tape. Twelve diameter classes were defined with a 5 cm amplitude between each class. The maximum class was >58.5 cm *ND*. In order to determine the canopy cover, the crown diameter was measured using the formula for an ellipse: The crown diameter = π (*axis a* × *axis b*); two measurements were obtained (*axis a*: north-south and *axis b*: east-west) with the model Vertex III® Haglöf hypsometer. The average of both measurements was then calculated. The formulas applied by Zarco-Espinoza *et al.* (2010) were utilized: the basal area (*BA*) was estimated with the formula:

$$BA = \pi 4(ND)^2$$

Where:

$$\pi = 3.1416$$

The relative cover (*RC*) was obtained by applying the formula:

$$RC = \left(\frac{\text{Crown diameter of all species}}{\text{Sampled area}} \right) \times 100$$

Where:

RC = Relative cover

Indexes calculation

In order to dimension the structural composition of the *Pinus-Quercus* forest, two indexes used by Zarco-Espinoza *et al.* (2010) were applied to denote the vertical and horizontal stratification of the species present in the forest: 1) Importance Value Index (*IVI*), and 2) Forest Value Index (*FVI*). Other indices were also determined to delimit the level of complexity and similarity of the species present at each study site: 3) Holdrige Complexity Index (Holdrige *et al.*, 1971), and 4) Sørensen's Affinity Index (Sørensen, 1948).

Statistical analyses

Statistical analyses were performed with the JMP Pro 14 software (Statistical Analysis System, 2019). The results were analyzed by analysis of variance (ANOVA) and comparison of means by Tukey ($p < 0.05$) between the variables evaluated in the study sites. In order to contrast the Sørensen's Affinity Index and corroborate the level of equality between sites with respect to the identified species, the Bray-Curtis (1957) similarity and Jaccard affinity analyses were applied with the Past software, version 3.2 (Hammer *et al.*, 2009).

Results and Discussion

Floristic composition and structure

The *Pinus-Quercus* forest consists of six tree species. *Pinus maximinoi* H. E. Moore (with an average height [h] of 13.29 m and ND of 7.57 cm) and *Pinus ayacahuite* Ehrenb. ex Schltld. (h of 11.01 m and ND of 22.51 cm). The *Quercus* genus was represented by two taxa: *Quercus cortesii* Liebm. (with average h of 8.67 m and DN 15.9 cm) and *Quercus corrugata* Hook (h of 11.1 m and DN of 21.5). Other associated species were *Cupressus lindleyi* Klotzsch ex Endl. (with an average h of 9.42 m and 26.28 cm of DN) and *Prunus serotina* Ehrh ssp. *capuli* (Cav.) Mc Vaugh (with h of 9.75 m and a ND of 13.5 cm).

Vertical structure

Tree height (h) registered a higher percentage for the 7.01 to 12 m height class (41.83 %), similar to that reported in other studies (Castellanos-Bolaños *et al.*, 2010; García *et al.*, 2019) that focus on this dominant class of the vertical stratum. The lowest percentage belonged to the >32 m class. Classes 2 to 7 m, 12.01 to 17 m and 17.01 to 22 m had similar percentages (16.73 %, 14.74 % and 15.14 %) (Figure 2).

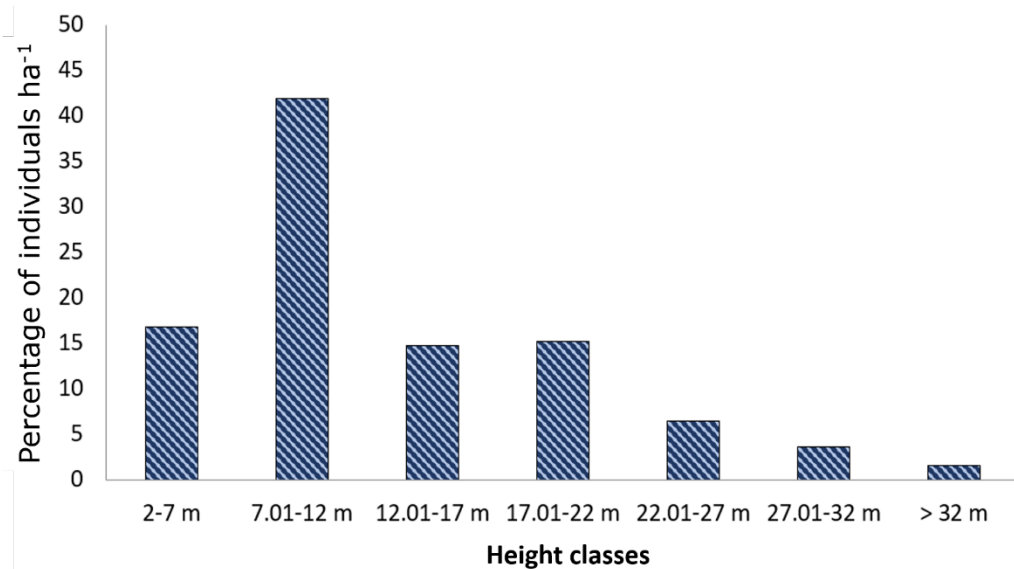


Figure 2. Tree height classes of the *Pinus-Quercus* forest at *El Porvenir, Chiapas*.

The percentage corresponding to the height classes for each of the analyzed species indicated that the highest value (42.86 %) corresponded to *Cupressus lindleyi* in the 2-to-7 m class and the lowest proportion (7.14 %), to the 17.01-to-22 m class.

Although *C. lindleyi* can reach heights between 10 and 30 m and even of up to 40 m (Raddi *et al.*, 2014), no trees were observed with heights greater than 22 m. *P. ayacahuite* had the highest percentage of individuals for the 7.01-to-12 m height class (33.33 %) and the lowest percentage was registered in the 22.01-to-27 m height class (9.8 %); thus, no trees taller than 27.01 m were found (Figure 3). This differs from the result cited by Ramírez-Martínez *et al.* (2018), who registered a mean height of 27.25 m in a *Pinus ayacahuite* forest in the state of Oaxaca, Mexico, where they note the presence of trees over 30 m tall. *Pinus maximinoi* had the highest proportion of individuals in the 17.01 to 22 m height class (46.48 %), the >32 m class had the lowest percentage (2.82 %) and the 22.01 to 27 m and 27.01 to 32 m classes had very similar percentages.

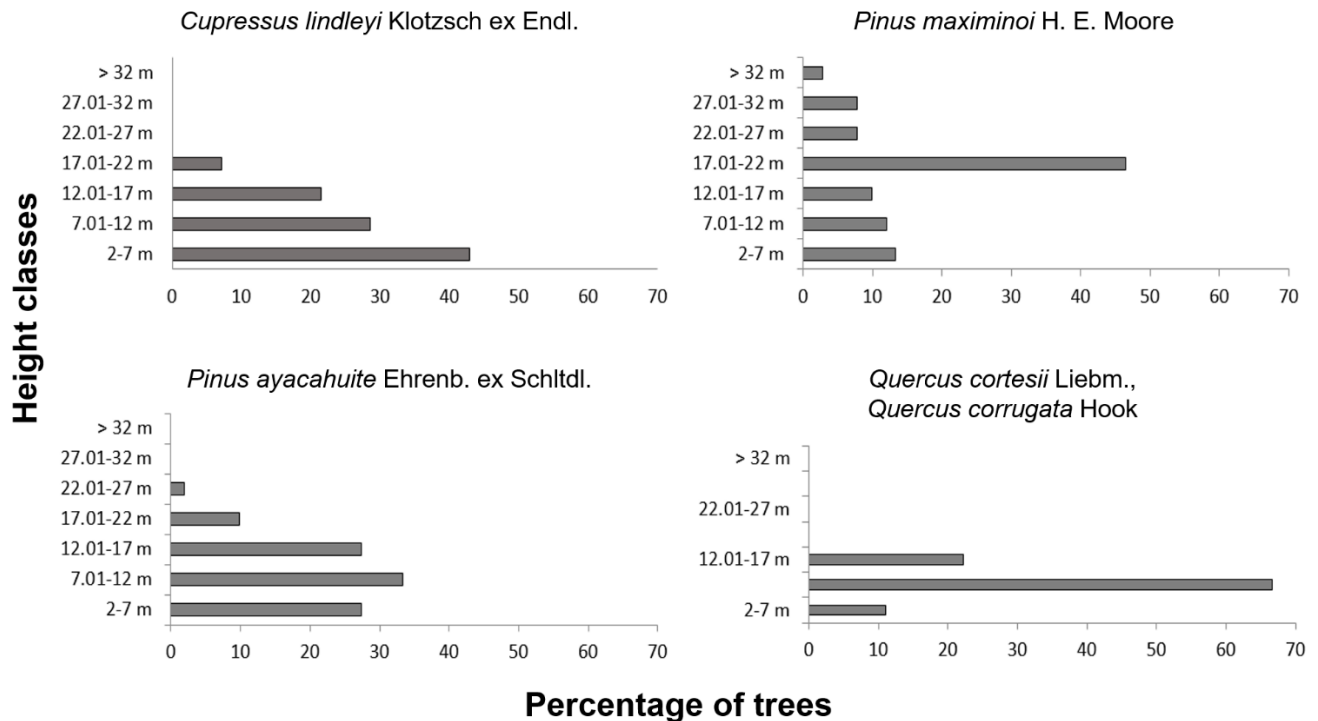


Figure 3. Height classes of the *Pinus-Quercus* forest species.

The results presented here are similar to those documented for *P. maximinoi* in the study by Méndez *et al.* (2018), whose dominant strata are concentrated in the 15 to 22 m and 23 to 28 m height classes. The National Institute of Forest Science (*Instituto Nacional del Bosques, INAB*) (Cano, 2017) cites in Guatemala an average height of 17 to 19 m, similar to that recorded for *P. maximinoi* in *El Porvenir* where it reaches up to 35 m. *Quercus corrugata* and *Q. cortesii* recorded the highest percentage of individuals (60.87 %) for the 7.01 to 12 m height class (Figure 3). Although these species can reach 50 m in height, the suppression exerted by the *Pinus* genus on *Quercus* limits their optimal growth (Hélaridot, 2015).

The results of the analysis of variance (ANOVA) indicated significant differences in the average height of the taxa, with a higher value for *P. maximinoi* (18.88 ± 6.72 m) with respect to *Prunus serotina* (5.25 ± 2.06 m), *Cupressus lindleyi* (9.12 ± 1.77 m) and *Q. corrugata* (8.1 ± 3.55 m), which presented the lowest heights (Figure 4).

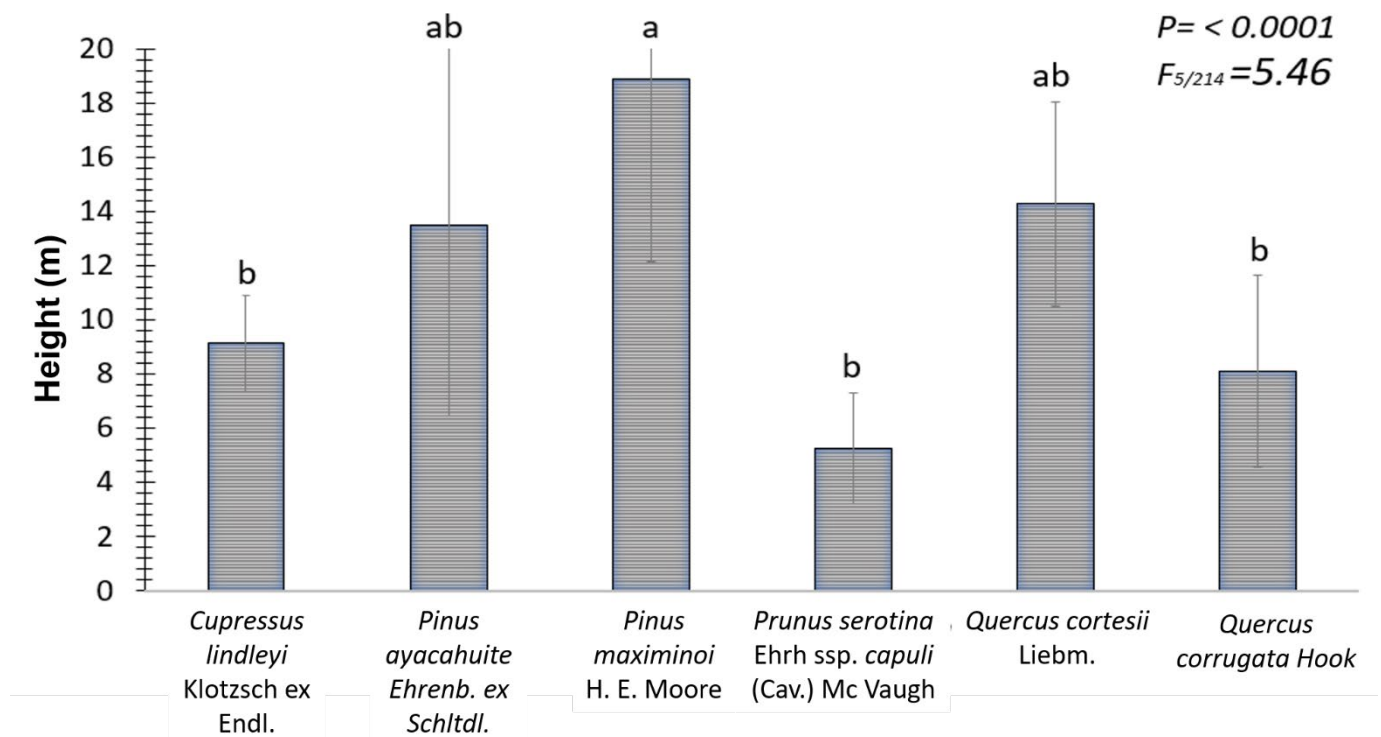


Figure 4. Average height \pm standard deviation of the analyzed tree species.

Horizontal structure

Diameter class II had the highest number of trees (171 ind. ha⁻¹) and class XI (8 ind. ha⁻¹) had the lowest number of trees (Table 1A). The percentage of individuals in all diameter classes was higher for *P. maximinoi*, except in classes I and XII (Table 1B). The basimetric area of all species represented a total of 65.01 m² ha⁻¹, with class XII making the greatest contribution (Table 1C).

Table 1. Tree diameter classes, number (A), percentages (B), and basal area (C) characteristic of each species in the *Pinus-Quercus* forest.

Species	Class (cm)												Total
	I 2.5- 7.5	II 7.6- 12.6	III 12.7- 17.7	IV 17.8- 22.8	V 22.9- 27.9	VI 28- 33	VII 33.1- 38.1	VIII 38.2- 43.2	IX 43.3- 48.3	X 48.4- 53.4	XI 53.5- 58.5	XII >58. 5	
A) Number of individuals/diameter class													
<i>Cupressus lindleyi</i> Klotzsch ex Endl.	1	7	5	0	0	0	0	0	0	0	0	0	13
<i>Pinus ayacahuite</i> Ehrenb. ex Schtdl.	17	9	6	3	4	1	2	0	3	1	1	4	51
<i>Pinus maximinoi</i> H. E. Moore	6	22	17	16	19	7	6	8	3	4	1	19	128
<i>Quercus corrugata</i> Hook	6	2	6	2	1	1	1	1	0	0	0	0	20
<i>Quercus cortesii</i> Liebm.	0	1	0	0	0	1	0	0	0	0	0	1	3
<i>Brunus serotina</i> Ehrh ssp. <i>capuli</i> (Cav.) Mc Vaugh	4	0	0	0	0	0	0	0	0	0	0	0	4
Total (0.24 ha)	34	41	34	21	24	10	9	9	6	5	2	24	219
Total (1 ha)	142	171	142	88	100	42	38	38	25	21	8	100	913
B) Percentage of individuals/diameter class													
<i>Cupressus lindleyi</i> Klotzsch ex Endl.	3	17	15	0	0	0	0	0	0	0	0	0	
<i>Pinus ayacahuite</i> Ehrenb. ex Schtdl.	50	22	18	14	17	10	22	0	0	20	50	0	
<i>Pinus maximinoi</i> H. E. Moore	18	54	50	76	79	70	67	89	0	80	50	17	
<i>Quercus corrugata</i> Hook	18	5	18	10	4	10	11	11	0	0	0	79	
<i>Quercus cortesii</i> Liebm.	0	2	0	0	0	10	0	0	0	0	0	0	
<i>Brunus serotina</i> Ehrh ssp. <i>capuli</i> (Cav.) Mc Vaugh	12	0	0	0	0	0	0	0	0	0	0	4	
Total	100	100	100	100	100	100	100	100	0	100	100	100	
C) Total individuals/percentage/basal area for each diametric class													
All the species	142	171	142	88	100	42	38	38	25	21	8	100	913
% All the species	16	19	16	10	11	5	4	4	3	2	1	11	100
Basal area (m ² ha ⁻¹)	0.07	0.83	1.69	1.98	2.24	2.69	4.86	5.11	9.67	10.04	8.05	20.11	65.01

The average *ND* of the sites evaluated showed significant differences with a higher value at site 3 (66.26 ± 6.76 cm). At the species level, the *ND* showed significant differences, whose maximum value corresponded to *Pinus maximinoi* with a *ND* of 30.58 ± 13.64 cm (Table 2), which is located within the average intervals of eight *Pinus* species evaluated by Corral-Rivas *et al.* (2019). The tree taxon with the lowest *ND* was *Prunus serotina* (3.79 ± 1.08), while the *ND*'s of *P. ayacahuite*, *Q. corrugata* and *Q. cortesii* were very similar to that of *P. maximinoi* (Table 2).

Table 2. Normal diameter (*ND*) in sites and species \pm standard deviation (S.D.), ANOVA, and Tukey's comparison of measures ($p < 0.05$).

Site	ND (cm) \pm S.D.	Statistics	
		P	F _{5/214}
1	26.27 \pm 20.73b	<0.0001	9.03
2	24.21 \pm 18.22b		
3	66.26 \pm 6.76a		
4	31.43 \pm 4.43b		
5	18.51 \pm 2.84b		
6	22.91 \pm 2.78b		
Species	ND (cm) \pm S.D.	Statistics	
		P	F _{5/214}
<i>Cupressus lindleyi</i> Klotzsch ex Endl.	11.40 \pm 2.8b	<0.0002	5.18
<i>Pinus ayacahuite</i> Ehrenb. ex Schltldl.	20.4 \pm 9.84ab		
<i>Pinus maximinoi</i> H. E. Moore	30.58 \pm 13.64a		
<i>Quercus corrugata</i> Hook	28.19 \pm 22.88ab		
<i>Prunus serotina</i> Ehrh ssp. <i>capuli</i> (Cav.) Mc Vaugh	3.79 \pm 1.08c		
<i>Quercus cortesii</i> Liebm.	15.67 \pm 9.75b		

Structural parameters and indexes

Pinus maximinoi registered the highest density (533 ind. ha⁻¹), basal area (50.34 m² ha⁻¹), frequency and dominance, which was reflected in its Importance Value Index (IVI=161.07) (Table 3). This index is high compared to that presented by *P. maximinoi* in other *Pinus-Quercus* forests, such as the one reported by Méndez *et al.* (2018). Table 3 shows the values corresponding to the parameters.

Table 3. Structural parameters in the *Pinus-Quercus* forest.

Species	AD (Ind. ha ⁻¹)	BA (m ² ha ⁻¹)	AF	RD	RDo	RF	IVI
<i>Pinus maximinoi</i> H. E. Moore	533	50.34	100	58.64	77.43	25	161.07
<i>Pinus ayacahuite</i> Ehrenb. ex Schltldl.	213	10.72	100	23.18	16.48	25	64.67
<i>Quercus corrugata</i> Hook	83	1.76	66.67	9.09	2.71	16.67	28.46
<i>Prunus serotina</i> Ehrh ssp. <i>capuli</i> (Cav.) Mc Vaugh	17	0.02	66.67	1.82	0.02	16.67	18.51
<i>Cupressus lindleyi</i> Klotzsch ex Endl.	54	0.47	33.33	5.91	0.72	8.33	14.96
<i>Quercus cortesii</i> Liebm.	13	1.71	33.33	1.36	2.63	8.33	12.33
Total	913	65.01		100	100	100	300

AD = Absolute density; BA = Basal area; AF = Absolute frequency; RD = Relative density; RDo = Relative dominance; RF = Relative frequency; IVI = Importance Value Index.

In relation to tree density (913 ind. ha⁻¹) and the low level of fragmentation, the *Pinus-Quercus* forest evaluated is of a closed type, with a mean density higher than that cited by Santiago *et al.* (2012) in a closed *Pinus-Quercus* forest in the state of

Jalisco (650 ind. ha⁻¹), and Méndez *et al.* (2018) who counted 254 ind. ha⁻¹ in another *Pinus-Quercus* forest located in the state of *Guerrero*, Mexico. Alanís *et al.* (2011) obtained 2 876 ind. ha⁻¹ in a *Pinus-Quercus* forest, a figure three times higher than that obtained in *El Porvenir*. The basimetric area documented here (65.01 m² ha⁻¹) is much lower than that cited (242 m² ha⁻¹) by Santiago *et al.* (2012), however, in this research the trees exhibited larger diametric dimensions.

The highest Forest Value Index (*FVI*) corresponded to *P. maximinoi* (108.08 %). The second species with the highest *FVI* was *P. ayacahuite* (58.65 %), however, this value is higher than the value reported by Graciano-Ávila *et al.* (2017) on a property in the state of *Durango*, Mexico. The Holdrige Complexity Index (*HCI*) of the *Pinus-Quercus* forest corresponded to 45.22 % (Table 4), which is a normal value for temperate forests due to its characteristic homogeneity and low variability in the type of species. Table 4 shows the *FVI*, *HCI* and the values of *ND*, height and cover for all species.

Table 4. Forest Value Index (*FVI*) and Holdrige Complexity Index (*HCI*) of the species found in the study area.

Specie	ND (cm)	H (m)	Co (m ²)	AbND	rND	AbH	rH	AbCo	rCo	FVI	HCI
<i>Pinus maximinoi</i> H. E. Moore	27.57	13.29	1 564.50	0.0028	21.64	0.0013	21.01	0.16	65.42	108.08	45.22
<i>Pinus ayacahuite</i> Ehrenb. ex Schltndl.	22.51	11.01	563.55	0.0023	17.68	0.0011	17.41	0.06	23.57	58.65	
<i>Quercus corrugata</i> Hook	26.28	9.42	140.28	0.0026	20.64	0.0009	14.90	0.01	5.87	41.40	
<i>Prunus serotina</i> Ehrh ssp. <i>capuli</i> (Cav.) Mc Vaugh	21.50	11.10	113.20	0.0022	16.88	0.0011	17.55	0.01	4.73	39.17	
<i>Cupressus lindleyi</i> Klotzsch ex Endl.	13.60	9.75	5.11	0.0014	10.68	0.0010	15.42	0.00	0.21	26.31	
<i>Quercus cortesii</i> Liebm.	15.90	8.67	4.71	0.0016	12.49	0.0009	13.71	0.00	0.20	26.39	
Total	21.23	10.54	2 391.34	0.0127	100	0.0063	100	0.2391	100	300	

ND = Normal diameter; H = Tree height; Co = Canopy cover; $AbND$ = Absolute normal diameter; RDN = Relative normal diameter; AbH = Absolute height; RH = Relative height; $AbCo$ = Absolute cover; RCo = Relative cover.

Complexity and similarity indexes

Sørensen and Bray-Curtis Indexes

The Sørensen Affinity Index (K) defined sites very similar to each other, with an average affinity of 74 % (greater than 50 %). Other studies with $K < 50$ % show low species similarity (Santana *et al.*, 2014), which is equivalent to more heterogeneous forests. The sites with 100 % affinity were site 1 with respect to site 4 and site 2 with respect to site 3 because they have the same dominant taxa. However, when contrasted with the Bray-Curtis Similarity Index, sites 2 and 3 were the only ones that maintained this percentage. This is expressed graphically in the cluster analysis, in which no distance was shown between sites 2 and 3 (Figure 5).

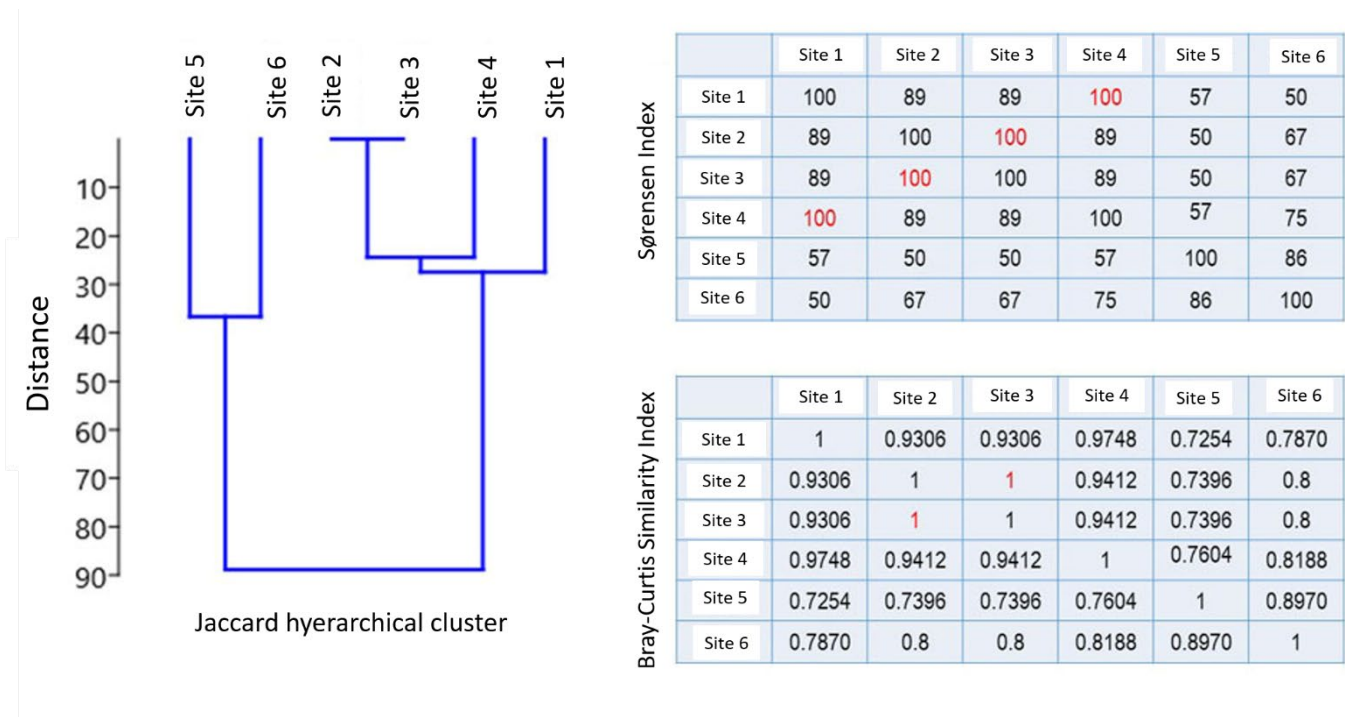


Figure 5. Sørensen index (K), Bray-Curtis Similarity Index and Jaccard cluster analysis for the six sites in the *Pinus-Quercus* forest.

This analysis clearly showed the definition of two groups: the first at a distance of 28 % (sites 1, 2, 3 and 4), and the second, at a distance of 38% (sites 5 and 6).

Conclusions

Based upon the averages of total height (vertical structure) and ND (horizontal structure), the hypothesis (i) which establishes the non-significance between the mean values of the compared sites and species is rejected. Regarding the Importance Value of the dominant species of the genus *Pinus*, none of them exhibits an $IVI \geq 200$, thus the second hypothesis is rejected. Finally, the average percentage

of affinity between tree species in the six sites is $\geq 50\%$, therefore hypothesis (iii), which indicates that the species present have medium to high affinity, is accepted.

The results allow to identify the configuration of the structural parameters and dominance of the associated species of the *Pinus-Quercus* forests in the *Sierra Mariscal* region of the state of *Chiapas*, Mexico. *Pinus maximinoi* is the most important species in the evaluated sites. The two species of the *Quercus* genus show a high level of suppression compared to those of the *Pinus* genus. The understanding of the real dynamics of the *Pinus-Quercus* forest in the study area gives rise to some questions regarding the integrated management and conservation of the resource required to improve the goods and services provided by the ecosystem under study.

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Conflicts of interest

The authors declare that no conflicts of interest.

Contribution by author

Romeo de Jesús Barrios-Calderón, Javier Ernesto Pérez Pérez and Jony Ramiro Torres Velázquez: conceptualization and organization of the research, field work, database integration and writing of the manuscript; Juan Francisco Aguirre-Cadena: writing of the manuscript, database integration and statistical analysis. Pablo Marroquín Morales: elaboration of graphs, map and documentary references; Alfredo Isaac Brindis-Santos and Humberto Osorio Espinoza: adjustments in the discussion of results, critical review of the document, contribution of comments and bibliographic review. All authors participated in the general revision and final corrections of the manuscript.

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