Colegio de Postgraduados

Forest Management and Tree Species Diversity in a Temperate Forest of the Meseta Purhépecha, Michoacán

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ABSTRACT
Objective: To evaluate how traditional forest management practices impact the diversity and structure of temperate forests in the Nuevo San Juan Parangaricutiro Indigenous Community (ICNSJP), with the goal of providing information on the sustainable management of these forests.
Design/methodology/approach: Forest inventory data were collected and analyzed in stands treated with four thinning (A4) through the Silvicultural Development Method (SDM) and contrasted with stands that have not been intervened for more than 30 years (A0). Diversity indices and stand variables were used to statistically compare the effects of the treatments.
Results: In total 20 species were recorded, 13 in A0 and 18 in A4. The true diversity (q1) recorded a value of 3.3±1.6 in A4 and 1.9±0.8 in A0, although this difference was not statistically significant. The species with highest importance value were *Pinus douglasiana* Martinez (30%) for A0 and *P. pseudostrobus* Lindl (27%) for A4.
Limitations on study/implications: According to the SDM, the cutting cycle in A4 has not yet ended since the release and regeneration treatments are missing, therefore, monitoring is recommended to evaluate the effect of the SDM more comprehensively on diversity and structure in the forests of the ICNSJP.
Findings/conclusions: Forest management in the ICNSJP has shown a positive effect in terms of species diversity and due to its commercial value, the development of *P. pseudostrobus* has been favored. In general, forest management has contributed to socioeconomic development by promoting species diversity, a key element for sustainable development.

Keywords: SDM; *Pinus pseudostrobus*; *Pinus douglasiana*; Forest thinning; Pretzsch A index.

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INTRODUCTION

Forest management practices impact the diversity and composition of tree species. The degree of impact depends on the intensity of the treatment and the successional stage of the vegetation. Clear-cutting, which involves the removal of all trees, tends to reduce species diversity (Guevara-Fisher *et al.*, 2021), whereas selection treatments or low-intensity interventions have shown a positive effect on species diversity and composition (Monarrez-Gonzalez *et al.*, 2020). Understanding the impact of these treatments on forest diversity and structure is essential for developing management proposals that ensure conservation, restoration, and appropriate utilization actions in managed forests.

Forest management aims to optimize the utilization of forest resources to meet current needs without compromising the provision of goods and services for future generations (Aguirre-Calderón, 2015). In this context, sustainable forest management is essential for conserving biodiversity, ecosystem values, and landscapes (Hernández-Salas *et al.*, 2013). Consequently, the structure and diversity within an ecosystem serve as indicators of the effects of silvicultural practices and sustainable forest regimes (Han *et al.*, 2022; Xi *et al.*, 2021). Forest management impacts the structure and diversity of natural forests (Corral-Rivas *et al.*, 2005), generally reducing species diversity and abundance by favoring only some (Silva-García *et al.*, 2021).

One way to evaluate the effect of silvicultural treatments is using diversity and structure indices in areas that have been managed and comparing them with stands with little or no intervention (González-Fernández *et al.*, 2022; Hernández-Salas *et al.*, 2013; Jiménez-Pérez & Aguirre-Calderón, 2001; Xi *et al.*, 2021). These indices have been used in various studies to evaluate the impact of forest harvesting on tree species in a forest (Corral-Rivas *et al.*, 2005; Hernández-Salas *et al.*, 2013; Jiménez-Pérez & Aguirre-Calderón, 2001; Návar-Cháidez & González-Elizondo, 2009; Silva-García *et al.*, 2021), to measure differences over time and space (Ramírez-Guaman & Lozano, 2024), as well as to monitor changes caused by different silvicultural treatments or to define appropriate practices that lead to good forest management (Vásquez-Cortez *et al.*, 2018).

Although biodiversity has been extensively researched in other regions, there is a knowledge gap regarding tree diversity and composition in the temperate ecosystems of the Purhépecha Plateau in Michoacán. In this area, timber harvesting has been carried out using the Silvicultural Development Method (SDM) for more than 35 years. The Indigenous Community of Nuevo San Juan Parangaricutiro (ICNSJP) holds Forest Stewardship Council (FSC) certification due to its forest management practices that adhere to official regulations and international standards, enabling them to access the international market for their products (CONAFOR, 2022; Velázquez *et al.*, 2001).

The objective of this study was to evaluate the effect of traditional forest management on the diversity and structure of temperate forests within the ICNSJP. This aims to provide scientific support for decision-making directed towards sustainable forest management in forest communities.

MATERIALS AND METHODS

Study Area

The study was conducted on the Purhépecha Plateau in the state of Michoacán, specifically in the Indigenous Community of Nuevo San Juan Parangaricutiro (ICNSJP) (Figure 1). The forests in this area have been historically managed for the utilization of both timber and non-timber forest products. The ICNSJP is located in the physiographic region of the Trans-Mexican Volcanic Belt and the southwestern end of the Purhépecha

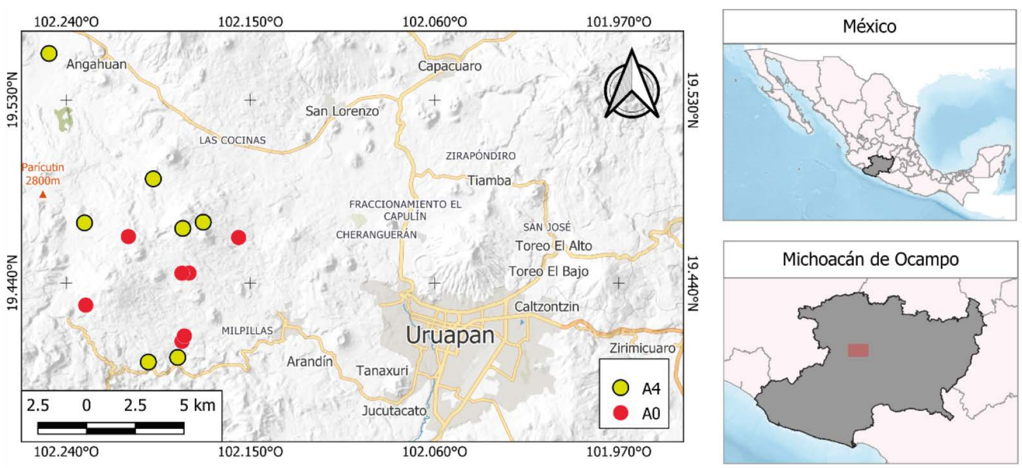

Figure 1. Sampling sites in the Indigenous Community of Nuevo San Juan Parangaricutiro (ICNSJP) in the state of Michoacán.

Sierra. The climate is temperate humid C(w_2)(b) with summer rainfall C(w_2)(w), and the area features rugged topography with slopes ranging from 5% to 80%, at elevations from 1,900 meters above sea level (forestry technical principal building of ICNSJP) to 2,920 meters above sea level (fire tower a Cerro of Pario). Annual precipitation ranges between 1,500 and 2,000 mm, with an average annual temperature of 12 to 14 °C. The soils are of volcanic origin, including medium-textured humic andosols, coarse-textured ochric andosols, coarse-textured dystrophic regosols, and medium-textured haplic faeozems (Bello-González *et al*., 2015).

The area under forest management is 10,653 ha^{-1}, of which 59% of the total area is dedicated to timber production through the SDM. The vegetation is primarily represented by pine forest, pine-oak forest, pine-fir forest, and montane mesophyll forest, with notable species including *Pinus pseudostrobus* Lindl., *P. montezumae* Lamb., *P. leiophylla* Schl. & Cham., *P. devoniana* Martínez., *P. douglasiana* Martínez, *Abies religiosa* (HBK) Schltdl. & Cham., *Quercus rugosa* Née., *Q. obtusata* Humb. & Bonpl., *Q. laurina* Humb. & Bonpl., *Q. castanea* Née., *Q. candicans* Née., *Q. dysophylla* Benth., *Alnus jorullensis* subsp. lutea Furlow., *Carpinus caroliniana* Walter., *Tilia mexicana* Schltdl., and *Ternstroemia pringlei* (Rose) Standl (Bello-González *et al*., 2015).

Data Collection

Two forest strata with stands under management in areas belonging to the ICNSJP were selected. One stratum, which has not received any silvicultural treatment for more than 30 years, was designated as A0, and the other, where four thinning operations (based on the SDM) have been applied, was designated as A4. In each of these areas, seven random sampling sites of 1000 m^2 were established, where data for forest inventories were collected, including diameter at 1.30 meters measured with a diameter tape ($d_{1.3}$, cm), total height obtained with a Forestry PRO II Nikon® laser hypsometer (*h*, *m*), and canopy diameter measured in two projections (N-S and E-W) with a diameter tape (CD, m). Each tree species name was also recorded.

Information Analysis

Species diversity was characterized using the Importance Value Index (*IVI*) and the estimation of diversity indices, such as Shannon's Index (*H*'), its transformed version commonly known as Hill numbers (q1) or true diversity, and the vertical distribution index of species (A) (Table 1). To determine the *IVI* of the species, parameters such as relative abundance (*Ra*), estimated based on the number of trees per hectare (N ha^{-1}), relative dominance (*Rd*), which is obtained as the proportion of basal area (G ha^{-1}), and relative frequency (*Rf*), which is the number of sites where the species occurs, were used (Mostacedo & Fredericksen, 2000). Based on these three (*Ra*, *Rd*, and *Rf*), the Importance Value Index (*IVI*) was calculated to hierarchically rank the dominance of each taxon, in relative values from 0 to 100.

Vertical composition was analyzed using the vertical species distribution index (A) or Pretzsch Index (Pretzsch, 2009; Rubio-Camacho *et al.*, 2014) (Table 1). To determine this index, three height zones were defined: Zone I (80 to 100% of maximum height); Zone II (50 to 80% of maximum height); and Zone III (0 to 50% of maximum height) (Pretzsch, 2009).

In addition to the diversity indices, stand variables were also estimated per site to enable statistical comparison between areas. Among the most important variables are average height (*h*) and basal area per hectare (G ha^{-1}). Their importance lies in their role as indicators of the distribution of dimensions and the density of the stands.

To compare the results between the evaluated areas, the Student's T-test was used, with Welch's modification to correct for heteroscedasticity. The assumption of normality was verified using the Shapiro-Wilk test, and when this assumption was not met, the Wilcoxon test was used for contrasts. All statistical analyses and normality tests were performed using R software version 4.1.2 (R Core Team, 2021).

RESULTS AND DISCUSSION

In the 14 sampling sites, a total of 20 species were recorded, distributed across 8 families. Pinaceae and Fagaceae represented the highest percentage of species (30% each), followed by Betulaceae and Pentaphylacaceae with 10% each. Overall, A4 had a higher number of

Table 1. Equations for Analyzing the Structure and Diversity of the Temperate Forest of the ICNSJP, Michoacán.

Index	Equation	Definitions
Shannon's entropy index	$H' = -\sum_{i=1}^{S} p_i * \ln(p_i)$	S=Number of species P_i=Abundance proportion of the *i*-th species
True diversity index, based on Shannon's entropy	$q1 = \exp(H')$	
Species vertical distribution index (A)	$A = -\sum_{i=1}^{S}\sum_{j=1}^{Z} p_{ij} * \ln p_{ij}$	Z=number of vertical zone; p_{ij}=proportion of the *i*-th species in the *j*-th zone, $p_{ij}=n_{ij}/N$; where n_{ij} is the number of records of the *i*-th species in the *j*-th zone and N is the total number of records.

species with 18, while A0 recorded 13. Finally, of the 20 species recorded, 11 were found in both areas, 7 were present only in A4, and 2 were found only in A0 (Table 2).

Stand Diversity and Structure

Regarding the statistical contrasts of diversity and structure, it was found that the index A did not meet the normality assumption ($p<0.05$), while the others did (the distribution does not differ from a normal distribution). On average, considering the seven sites per area, species richness was recorded as 3 ± 1.2 and 5.7 ± 3.3 for A0 and A4 respectively, although this difference was not statistically significant ($P>0.05$). A similar pattern was observed with true diversity, as A4 had higher values (3.3 ± 1.6), but the difference with A0 (1.9 ± 0.8) was not significant ($p>0.05$). The same occurred when comparing the vertical distribution of species, as index A had an average of 1.2 ± 0.5 and 1.7 ± 0.5 for A0 and A4, without significant differences ($p>0.05$). These results are relevant because, in general terms, sites with repeated thinning showed a positive effect on species diversity. On one hand, diversity did not decrease, and on the other hand, more species were found in A4 even though the average per site was not significant (Table 2).

The obtained results are similar to others in which species composition in pine-oak forests was studied (Ávila-Sánchez *et al.*, 2018). It has been documented that species richness

Table 2. Families and Species Present in the Temperate Forest of the Indigenous Community of Nuevo San Juan Parangaricutiro, Michoacán.

Family	Species	Common name	Records	
			A0	A4
Betulaceae	*Alnus acuminata* Kunth	Tepamo	0	1
	Alnus jorullensis Humboldt, Bonpland & Kunth	Aile	5	1
Clethraceae	*Clethra mexicana* DC.	Cletra	0	5
Ericaceae	*Arbutus xalapensis* Kunth	Madroño	1	2
Fagaceae	*Quercus candicans* Schltdl. & Cham	Encino ancho	1	2
	Quercus castanea Née.	Encino capulincillo	1	12
	Quercus crassipes Bonpl.	Encino colorado	0	1
	Quercus laurina Bonpl.	Encino laurelillo	13	30
	Quercus obtusata Bonpl.	Encino blanco	2	23
	Quercus rugosa Née.	Tocuz	2	39
Pentaphylacaceae	*Cleyera integrifolia* (Benth.) Choisy	Tchcari-charapiti (lengua purépecha)	0	1
	Ternstroemia lineata DC.	Tila	0	43
Pinaceae	*Pinus devoniana* Lindl.	Pino escobeton	20	0
	Pinus douglasiana Mtz.	Pino chino	77	1
	Pinus leiophylla Schiede ex Schltdl. & Cham.	Ocote chino	13	19
	Pinus montezumae Lamb.	Pino lasio	1	36
	Pinus pseudostrobus Lindl.	Canis-pino blanco	37	73
	Pinus teocote Schiede ex Schltdl	Tso-arza (lengua purépecha)	16	0
Salicaceae	*Salix paradoxa* Kunth	Cucharillo	0	1
Symplocaceae	*Symplocos citrea* Lex. ex La Llave & Lex.	Limoncillo	0	6
Total			189	296

and diversity values are related to the type of vegetation, especially in temperate forests of Mexico, which are associated with the altitudinal range where the genera *Pinus* and *Quercus* generally dominate (Ávila-Sánchez *et al.*, 2018; Ubaldo-Velasco *et al.*, 2023). Additionally, various anthropogenic factors have shaped their structure and species composition over time, particularly in temperate forests with forest management.

In the study area, the tree communities are generally dominated by the Pinaceae family in the tree stratum. However, in the lower parts of the forests of the ICNSJP, the *Pinus* forests mix with species of *Quercus*, *Alnus*, and *Arbutus*. These results are similar to those reported for unmanaged temperate forests in other states such as Durango, Chihuahua, Puebla (Caballero-Cruz *et al.*, 2022), and Nuevo León (Manzanilla-Quijada *et al.*, 2020).

The structure, analyzed through stand attributes, showed significant differences. The basal area per hectare had a higher average in A0 (24.6 ± 3.5 m^2) compared to A4 (19.7 ± 3.4 m^2) ($t=2.63$, $df=11.99$, $p=0.021$). A similar pattern was observed with average height, where A0 recorded 24.3 ± 7.99 m and A4 15.4 ± 4.04 m ($t=2.65$, $df=8.87$, $p=0.027$). Additionally, the mean quadratic diameter also shows these differences, with A0 at 37.7 ± 11.6 cm and A4 at 26.1 ± 7.01 cm ($t=2.27$, $df=8.89$, $p=0.046$). This indicates that, on average, trees are larger in A0 and that, in general, this area has a greater basal area, which is related to the conditions of forest mass density.

Importance Value Index by Species

Generally, for A0, the species with the highest importance values was *P. douglasiana*, as it recorded 110 N ha^{-1}, 8.4 G ha^{-1}, and was present in three of the seven sampling sites. The second most important species was *P. pseudostrobus*, while the third was *P. devoniana*. On the other hand, the species with the lowest importance values were *Q. castanea*, *Q. candicans*, and *A. xalapensis* (Table 3). On the other hand, A4 *P. pseudostrobus* was the most important, recording 104 N ha^{-1}, 8 G ha^{-1}, and was present in six of the seven sites. The second most important species was *P. montezumae*, while the third was *Q. rugosa*. The species with the lowest importance values were *A. acuminata*, *S. paradoxa*, and *Q. crassipes* (Table 3). This analysis revealed a difference in the composition of the most important species, highlighting oaks, which are becoming more relevant, such as the species *Q. rugosa*.

Regarding vertical distribution, the maximum height recorded for A0 was 43.9 m and for A4 was 39.9 m, which corresponds to 100% according to Pretzsch's (2009) methodology. In general, it was observed that both in A0 and A4, the species with the greatest height were *P. montezumae* and *P. pseudostrobus*, being the only species found in zone I. However, in both areas (A0 and A4), *P. pseudostrobus* dominates in basal area and number of recorded individuals (Table 4). These results are consistent with the heights recorded in temperate forests in northern Mexico (Rubio-Camacho *et al.*, 2014; Silva-García *et al.*, 2021) and with the work of Ubaldo-Velasco *et al.* (2023), which reports species such as *P. pseudostrobus* and *Q. rugosa* with the highest importance value index (23.3% and 14.3%, respectively) in the upper stratum of a temperate forest in Oaxaca.

For zone II of A0, four species of *Pinus* were found, whereas in A4, four species of *Pinus* and three species of *Quercus* were found, indicating greater competition from tolerant species. Another notable difference is that in A0, the species with the largest basal area and

Table 3. Importance Value Index (*IVI*) by Species in 14 Sampling Sites in Natural Forests of the Indigenous Community of Nuevo San Juan Parangaricutiro, Michoacán.

A0					A4				
Species	**Ra**	**Rd**	**Rf**	**IVI**	**Species**	**Ra**	**Rd**	**Rf**	**IVI**
P. douglasiana	40.7	34.2	14.3	29.7	*P. pseudostrobus*	24.7	40.6	15.0	26.8
P. pseudostrobus	19.6	41.4	19.0	26.7	*P. montezumae*	12.2	22.5	5.0	13.2
P. devoniana	10.6	6.9	4.8	7.4	*Q. rugosa*	13.2	7.0	12.5	10.9
Q. laurina	6.9	5.4	9.5	7.3	*P. leiophylla*	6.4	12.6	7.5	8.8
P. leiophylla	6.9	4.7	9.5	7.0	*T. lineata*	14.5	3.5	7.5	8.5
P. teocote	8.5	4.5	4.8	5.9	*Q. laurina*	10.1	5.8	7.5	7.8
Q. rugosa	1.1	0.1	9.5	3.6	*Q. obtusata*	7.8	2.4	5.0	5.1
A. jorullensis	2.6	0.9	4.8	2.8	*Q. castanea*	4.1	1.3	5.0	3.5
Q. obtusata	1.1	0.5	4.8	2.1	*C. mexicana*	1.7	0.4	7.5	3.2
P. montezumae	0.5	0.6	4.8	2.0	*S. citrea*	2.0	1.3	5.0	2.8
Q. castanea	0.5	0.5	4.8	1.9	*Q. candicans*	0.7	0.9	5.0	2.2
Q. candicans	0.5	0.2	4.8	1.8	*A. xalapensis*	0.7	0.3	2.5	1.2
A. xalapensis	0.5	0.1	4.8	1.8	*P. douglasiana*	0.3	0.6	2.5	1.2
					C. integrifolia	0.3	0.3	2.5	1.0
					A. jorullensis	0.3	0.2	2.5	1.0
					A. acuminata	0.3	0.1	2.5	1.0
					S. paradoxa	0.3	0.1	2.5	1.0
					Q. crassipes	0.3	0.0	2.5	1.0

Where: Ra=Relative Abundance, Rd=Relative Dominance, and Rf=Relative Frequency.

greatest number of recorded individuals was *P. douglasiana*, whereas in A4, *P. pseudostrobus* had the highest values (Table 4). This could be related to the results of the silvicultural actions applied in A4, which are assumed to have favored the development of *P. pseudostrobus*, while in A0, *P. douglasiana* is gaining prominence in stand development. This is explained by the commercial importance of the species in the region, as the wood of *P. pseudostrobus* is marketed on a larger scale than that of *P. douglasiana* (CONAFOR, 2022).

Zone III exhibited the greatest species richness, with 12 species recorded in A0 and 17 in A4. Once again, a dominance of *P. douglasiana* in A0 and *P. pseudostrobus* in A4 is observed (Table 4). This is consistent with findings by García-García *et al.* (2019) for a Pine-Oak forest in Chihuahua, where they report that in the forest management area, the taxa *Pinus* and *Quercus* were dominant, and similarly, most species were found in zone III. These observations align with other studies in temperate forests (Rubio-Camacho *et al.*, 2014).

According to Lamprecht (1990), some species exhibit a continuous vertical distribution, as seen with *P. pseudostrobus* in this study. In this sense, the *Pinus* taxon might ensure its persistence in the composition and structure of the forest since it is present in all altitude zones (García-García *et al.*, 2019). On the other hand, this genus also dominates in terms of basal area (G ha^{-1}), which is considered an indicator of a forest's capacity to produce biomass (Mora, 2022).

Table 4. Vertical Distribution of Three Zones in the Natural Forest of the Indigenous Community of Nuevo San Juan Parangaricutiro, Michoacán.

A0					A4				
Zone	**Species**	**N**	**h (sd)**	**G ha^{-1}**	**Zone**	**Species**	**N**	**h (sd)**	**G ha^{-1}**
I	*P. montezumae*	1	35.7 (-)	0.2	I	*P. montezumae*	6	33.5 (0.7)	1.8
	P. pseudostrobus	**22**	**37.6 (2.1)**	**7.5**		***P. pseudostrobus***	**7**	**36.1 (2.3)**	**2.9**
II	*P. devoniana*	7	24.3 (3.4)	1.0	II	*P. douglasiana*	1	24.3 (-)	0.1
	P. douglasiana	**33**	**23.9 (1.8)**	**4.6**		*P. leiophylla*	12	25.4 (3)	2.2
	P. leiophylla	4	28.6 (4.3)	0.7		*P. montezumae*	16	25.1 (2.6)	2.3
	P. pseudostrobus	12	32.6 (3.4)	2.6		***P. pseudostrobus***	**19**	**24.8 (2.6)**	**3.7**
III	*A. jorullensis*	5	9.5 (2.6)	0.2		*Q. candicans*	1	26.9 (-)	0.1
	Arbutus xalapensis	1	12.1 (-)	0.0		*Q. laurina*	1	22.6 (-)	0.1
	P. devoniana	13	15.3 (4.2)	0.7		*Q. rugosa*	2	24.3 (0.3)	0.3
	P. douglasiana	**44**	**20.2 (2.1)**	**3.8**	III	*A. acuminata*	1	9.5 (-)	0
	P. leiophylla	9	15.9 (5.2)	0.4		*A. jorullensis*	1	15.2 (-)	0
	P. pseudostrobus	3	13.9 (1.7)	0.1		*A. xalapensis*	2	13 (2.3)	0.1
	P. teocote	16	11.1 (4.4)	1.1		*C. mexicana*	5	9.5 (1.6)	0.1
	Q. candicans	1	16.8 (-)	0.0		*C. integrifolia*	1	16.9 (-)	0.1
	Q. castanea	1	18.2 (-)	0.1		*P. leiophylla*	7	11.4 (5.5)	0.3
	Q. laurina	13	14.4 (4.4)	1.3		*P. montezumae*	14	11.9 (3.7)	0.3
	Q. obtusata	2	14.2 (0.1)	0.1		***P. pseudostrobus***	**47**	**11.9 (3.8)**	**1.4**
	Q. rugosa	2	7 (1)	0.0		*Q. candicans*	1	10.8 (-)	0
						Q. castanea	12	8.4 (3.8)	0.3
						Q. crassipes	1	6.6 (-)	0
						Q. laurina	29	12.2 (3.9)	1.1
						Q. obtusata	23	8.2 (2.9)	0.5
						Q. rugosa	37	10.1 (4.2)	1.1
						S. paradoxa	1	7.2 (-)	0
						S. citrea	6	11.9 (2.6)	0.3
						T. lineata	43	8.9 (2.3)	0.7

Where: N=number of individuals, h=total height (m), G ha^{-1}=basal area.

The results obtained align with findings from other studies, indicating that the decrease in tree diversity and the lower number of individuals in vertical zones I and II in temperate forests in Mexico are associated with silvicultural interventions, as well as natural growth and competition among species (García-García *et al.*, 2019; Ramírez-Guaman & Lozano, 2024; Ramírez-Santiago *et al.*, 2019; Rendón-Pérez *et al.*, 2024; Silva-García *et al.*, 2021). These results also support the hypothesis that managed areas differ from each other, even under similar edaphoclimatic conditions, due to the various silvicultural treatments applied during the forest rotation period (García-García *et al.*, 2019; Han *et al.*, 2022; Hernández-Salas *et al.*, 2013; Ramírez-Santiago *et al.*, 2019; Xi *et al.*, 2021). Therefore, both natural and secondary managed forests undergo changes in their composition, structure, and functions due to forest management (Ramírez-Guaman & Lozano, 2024).

In general, forest management in temperate forests is complex with regard to the conservation of tree species diversity and composition (Rendón-Pérez *et al.*, 2024; Rubio-Camacho *et al.*, 2014). This is partly because one of the objectives of the Silvicultural Development Method (SDM) is the regeneration of even-aged and monospecific stands, primarily favoring pine species due to their commercial value in the market. Therefore, forest management strategies need to be objective (Aguirre-Calderón, 2015) and take a holistic approach to ensure the sustainable management of a temperate forest, such as that of the Indigenous Community of Nuevo San Juan Parangaricutiro (ICNSJP). Finally, this study demonstrates that species diversity has actually been improved by the silvicultural treatments applied in A4, as no differences were found compared to the unmanaged stands. However, the dominance of certain species, such as *P. pseudostrobus*, is attributed to the objectives set during the application of the Silvicultural Development Method (SDM) and its economic importance.

CONCLUSIONS

The natural forests of ICNSJP are dominated by the genera *Pinus* and *Quercus*, with specific variations in species predominance according to the treatment. The results indicate that the applied treatments have not negatively affected species diversity, which is considered a positive outcome for ecosystem conservation. However, the greater dominance of *P. pseudostrobus* in treatment A4 could have important commercial implications, given the economic value of this species. This result suggests that certain treatments may be used to favor commercially important species without compromising the overall diversity of the forest. According to the SDM, the cutting cycle in A4 is not yet complete as the release and regeneration treatments; therefore, it is recommended to continue monitoring to more comprehensively evaluate the effect of SDM on diversity and structure in ICNSJP forests.

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