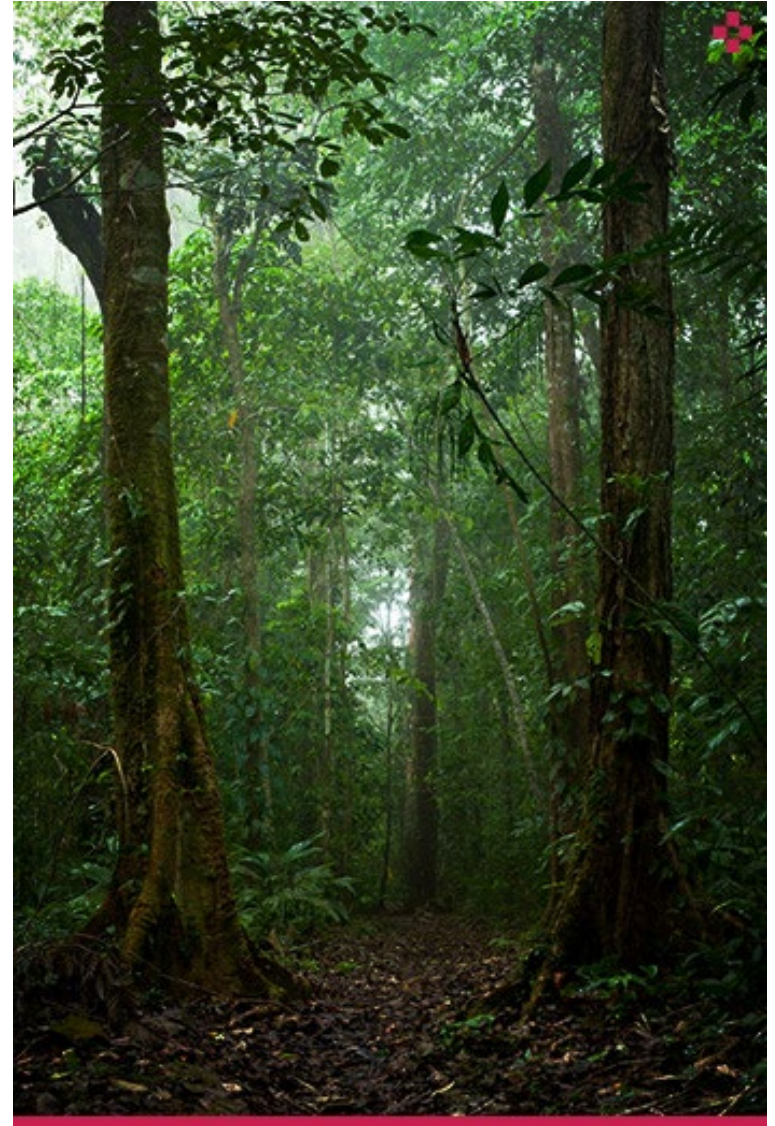

EFFECT OF FOREST MANAGEMENT ON TREE DIVERSITY IN TEMPERATE ECOSYSTEM FORESTS IN NORTHERN MEXICO

Discussion led by Ryan Murrin



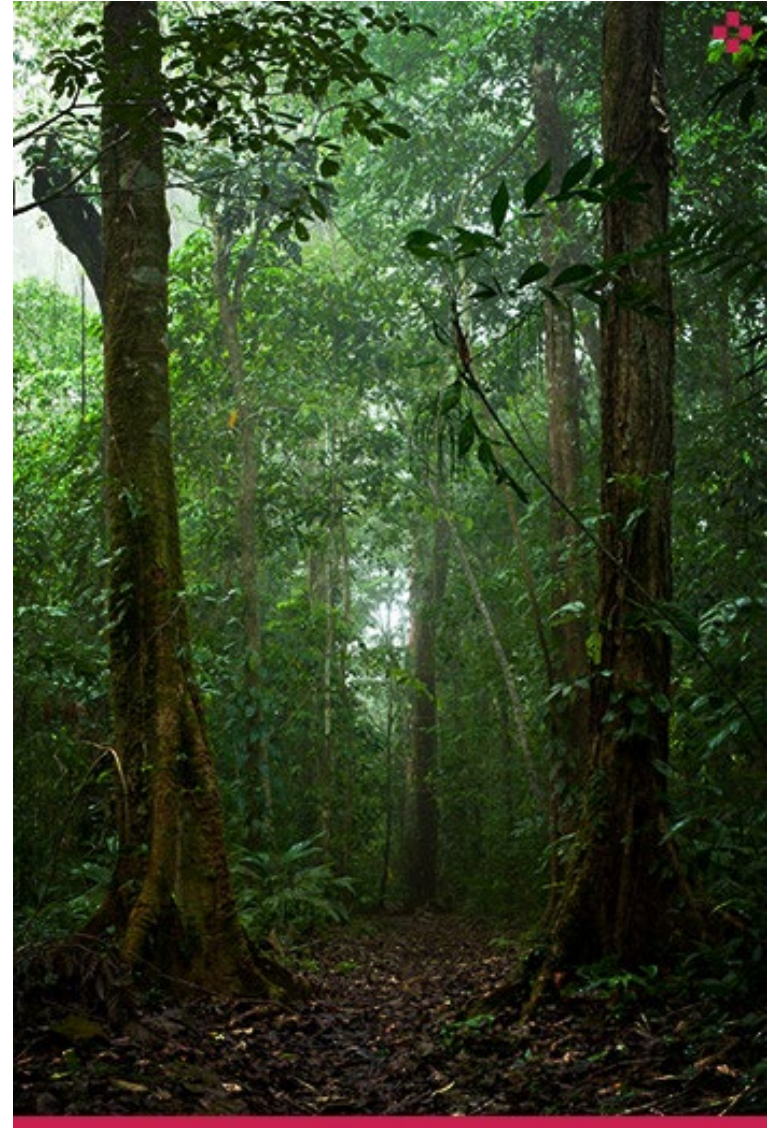
Introduction

- Temperate forest ecosystem represents about 17% of the country
 - 34 million hectares (84,015,829 acres)
- 49 species of pine & 161 oak species present
- Provide ecosystem services for around 18 million people
 - Estimated 9200 rural communities rely on these ecosystem services
 - Biodiversity is key to maintaining these forests



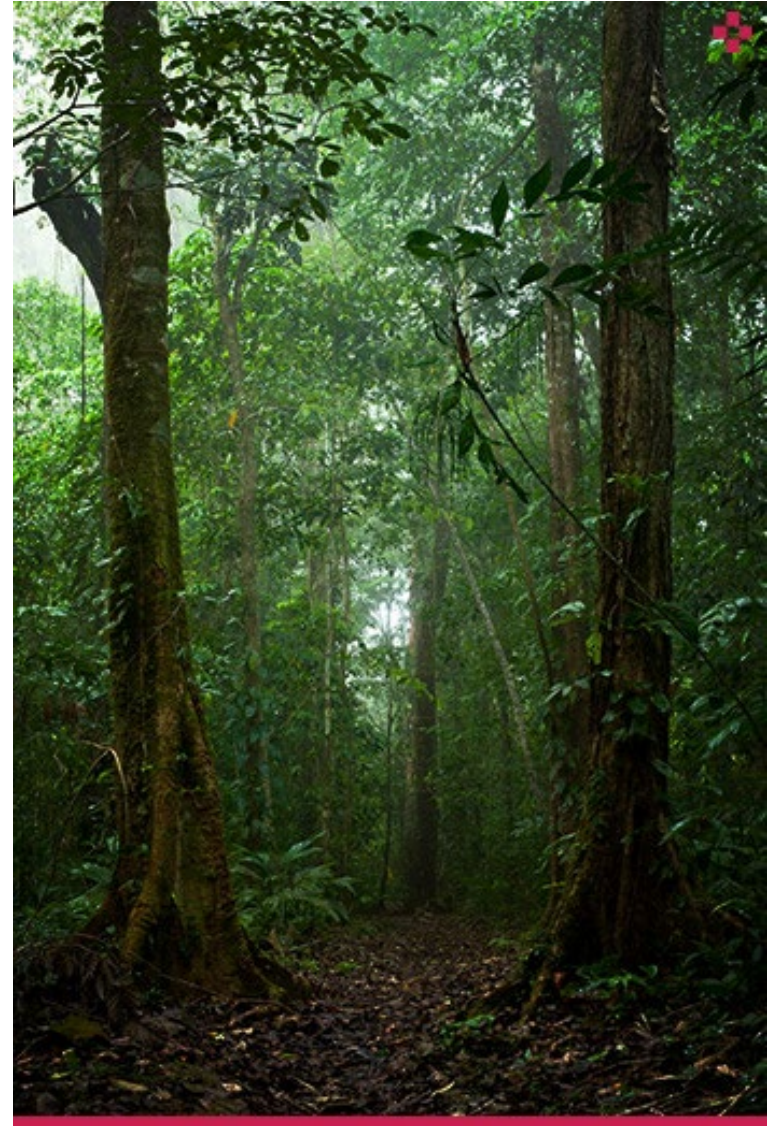
Introduction

- Traditional forest management is based on single tree selection
- Selection is based off commercial value
 - Only preferred species are cut
- This leads to high-grading and reduction in biodiversity
 - Over time, stands become less proficient in timber production



Introduction

- “The purpose of this study was to evaluate the immediate effect of silvicultural practices on tree diversity that included intensive, semi-intensive, conservative, and no treatment (control group).”
- What changes occur in tree diversity as a result of revised forest management schemes?
- How was the tree diversity status before and after the application of such practices?
- Which forest management practice does not affect tree diversity and still provides timber?



Methods

- Study area located within Sierra Madre Occidental Mountains
- Southcentral part of Durango
- Total area: 2,866 ha (7,082 acres)
- Area under timber management: 2,049 ha (5,063 acres)
- Has been subject to timber management since 1920s
- “Currently, the following treatments are applied in the area: clearcuts (12%), seed trees (5%), thinning (27%), and individual selection of trees (56%).”
- 60 yr rotation, 12 yr cutting cycle

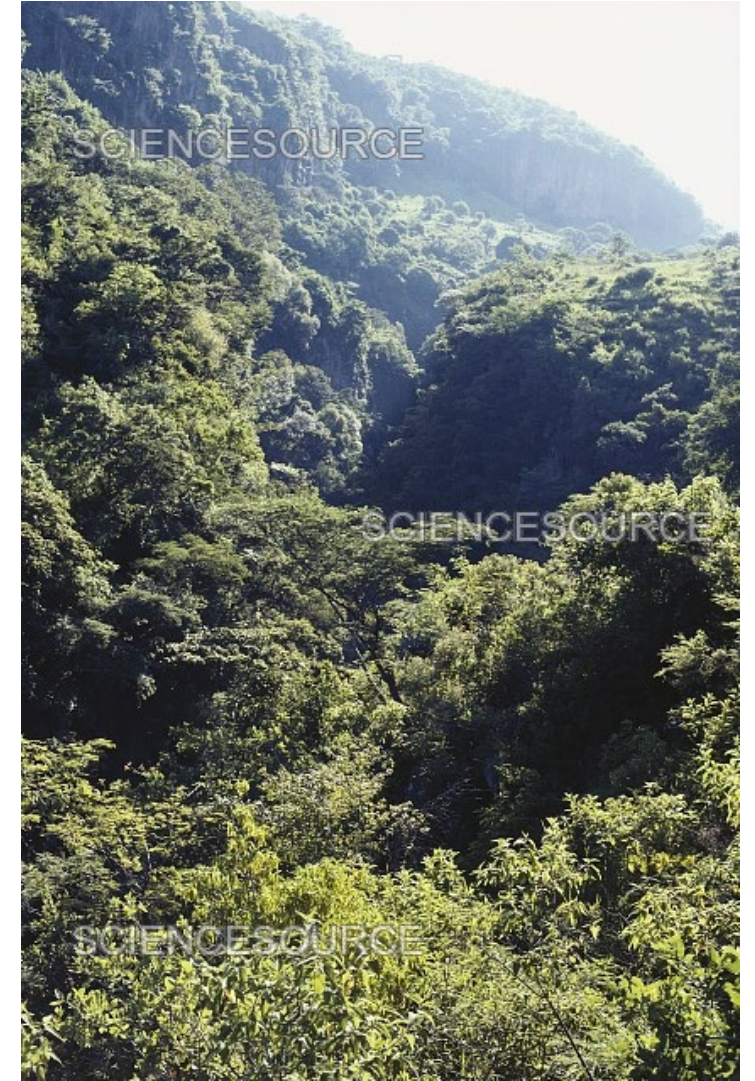
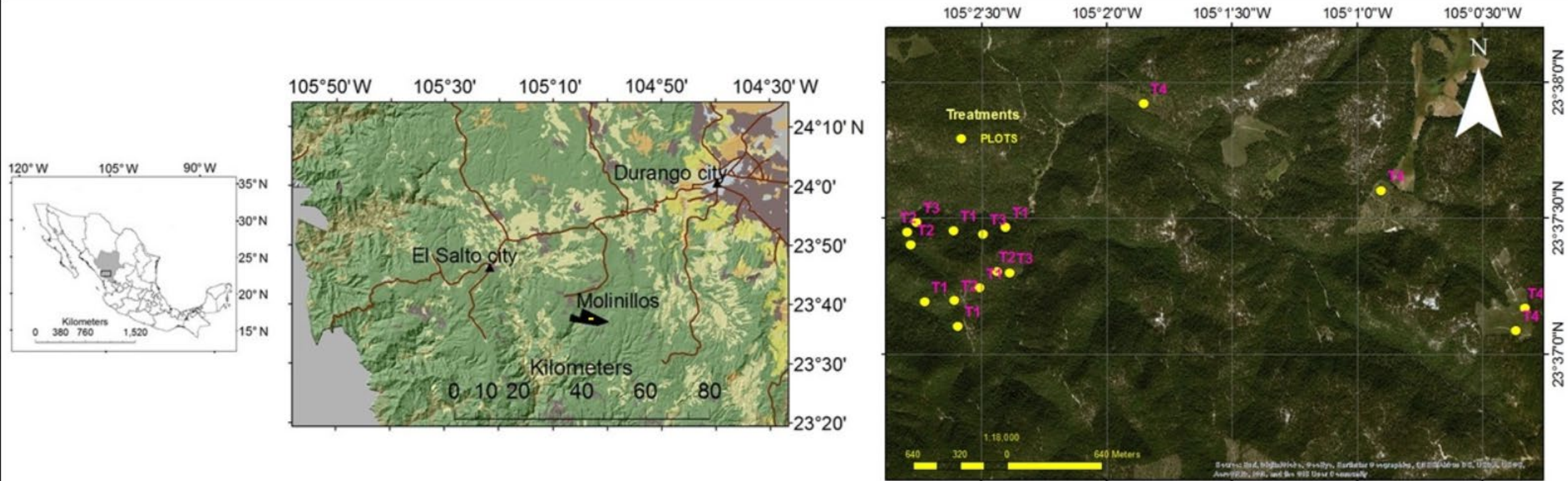
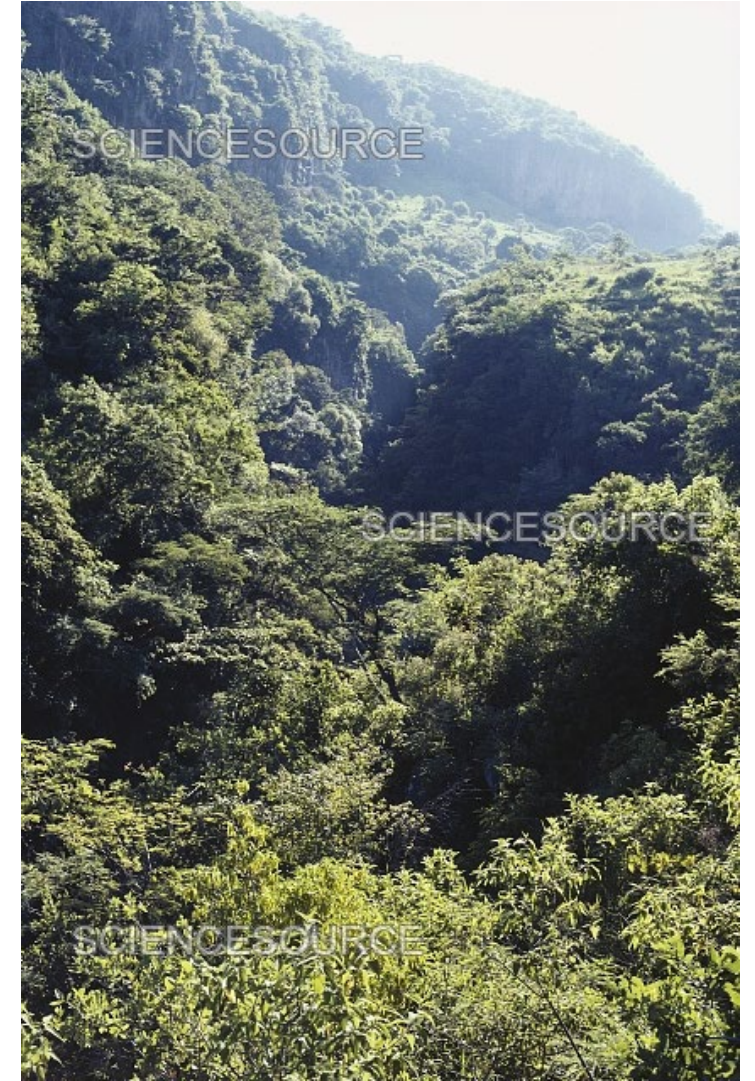


Figure 1.



Methods

- Evaluated clearcut, semi-intensive (59-61% BA removed), conservative treatment (29-31% BA removed), & a control (0% BA removed)
- Plots were installed using simple random design w/ 4 repetitions of each treatment
 - Except for clearcut treatment, only 3
 - 15 plots total

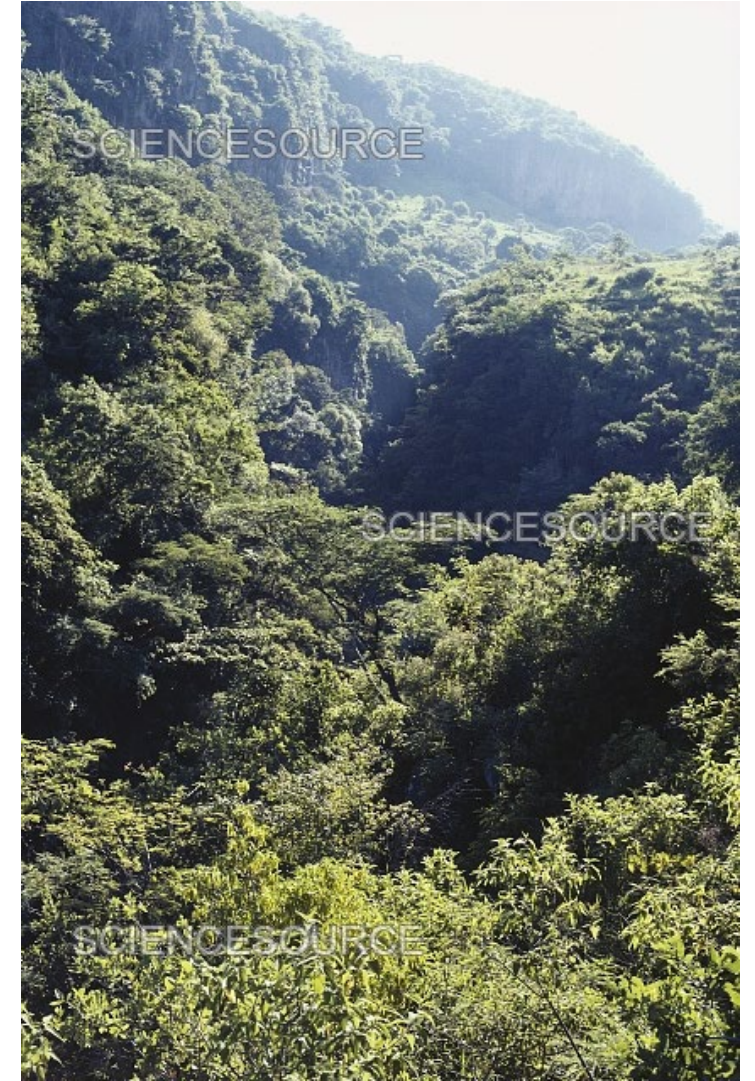


CLASS DISCUSSION:

**WHAT MAY HAVE BEEN THE
REASON(S) FOR ONLY HAVING 3
CLEARCUT PLOTS?**

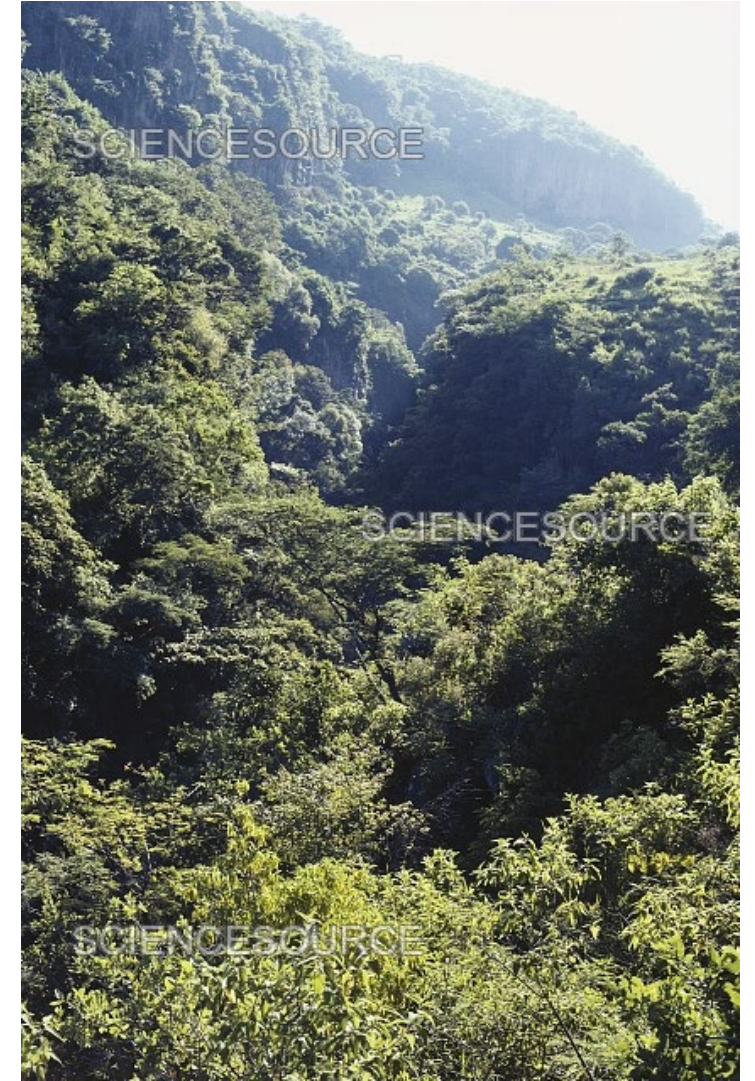
Methods

- Circular plots, area: 2500m²
 - Useful area: 1000 m²
 - Plots established October 2014, treatments occurred in November 2015, reassessment in October 2016
- All trees w/ DBH greater than 7.5 cm (2.95 in) were identified for species & tallied



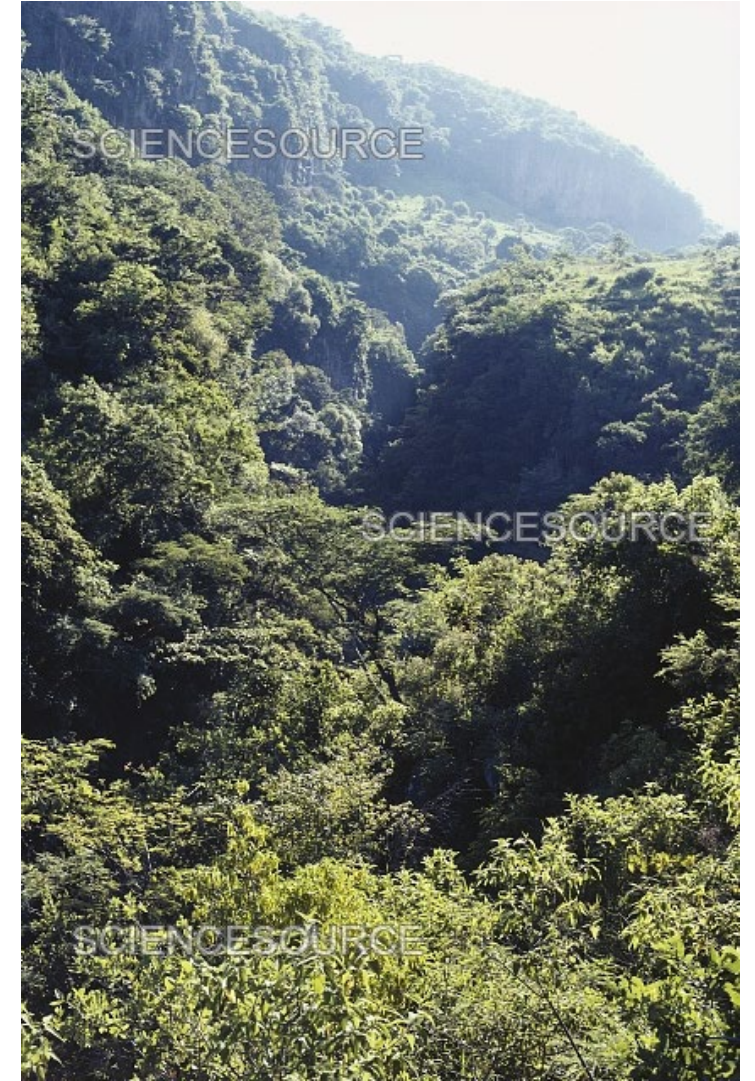
Methods

- Non-traditional approaches were taken to forest management
- Following criteria were observed:
 - a) adhere to the targeted residual basal area, according to the treatment,
 - b) leave a uniform spatial distribution of trees to ensure the protection of soil,
 - c) eliminate sick, infested, or deformed trees, and
 - d) maintaining, as much as possible, the diversity of species, so not one was preferred over the others.
- No limit on diameter when cutting



Methods

- Plots characterized by stand variables before & after treatments
 - BA, canopy area, type of species, number of trees, and tree/total volume
- Volume estimates were done using functions for the region
- Used to determine any possible association w/ diversity indices



Methods

- **Importance Value Index (IVI):** “a structural index used to organize hierarchically the dominance of each species in mixed stands and determines the vegetative hierarchy of each species or genus”
- **Alpha Diversity:** “a measure of species richness (i.e., number of species) that estimates the structure of the community (the proportional distribution of the value of importance of each species per plot)”
- **Evenness Indices:** “express the degree of similarity among the same plots before and after treatment in terms of the species present”

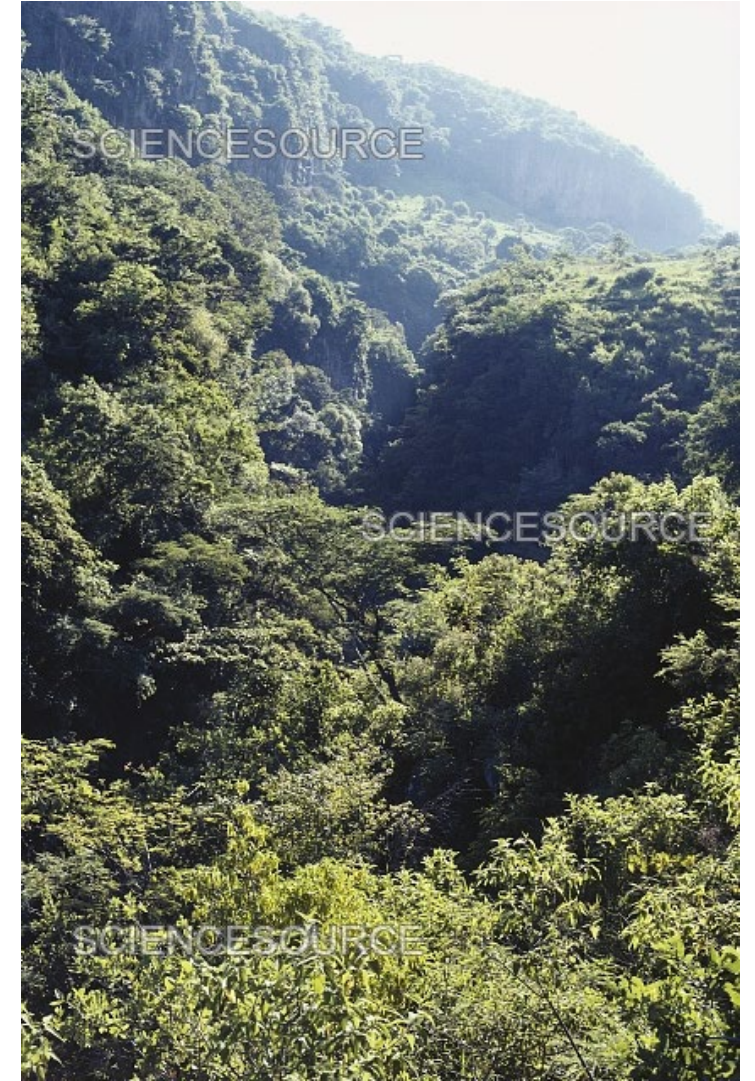




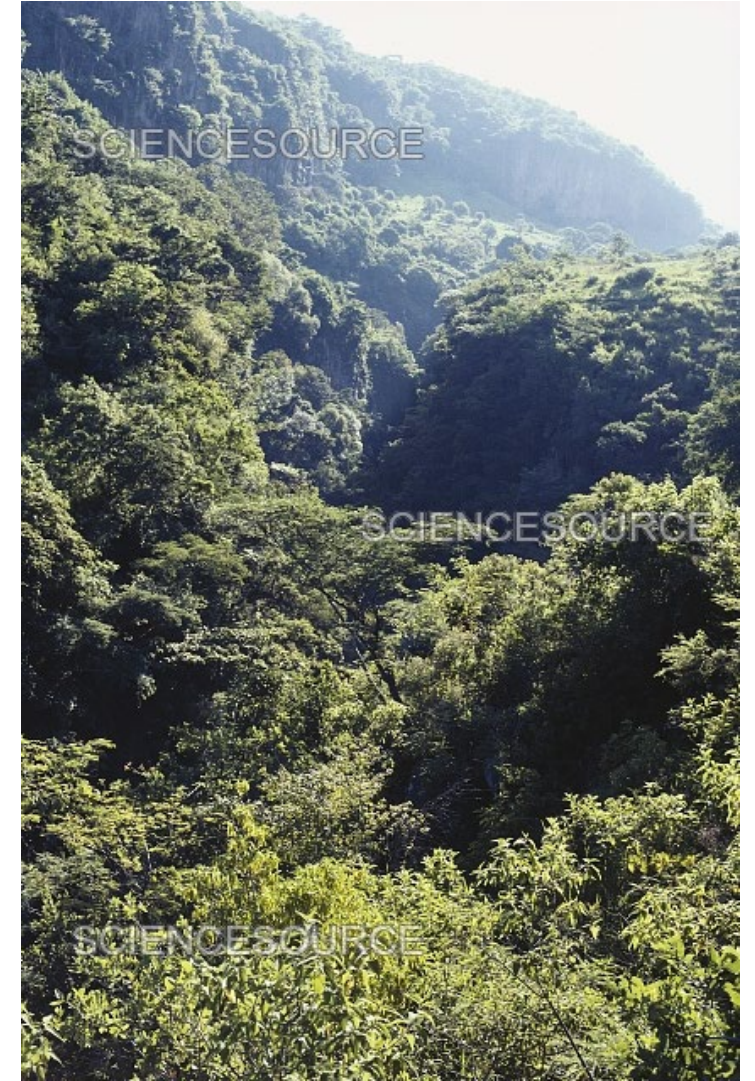
Table 1.

Indices	Description
Importance Value Index (IVI), $IVI = RA + RD + RF$	Relative abundance (RA) = (Absolute density of a species/Absolute density of all species) x 100
	Relative dominance (RD) = (Absolute dominance of a species/Absolute dominance of all species) x 100
	Relative frequency (RF) = (Absolute frequency of a species)/(Absolute frequency of all species) x 100
Alpha diversity	Species richness index (S) = total number of species
	Margalef's Index (D_{mg}) = $(S-1)/\ln(N)$, where N = total number of individuals
	Simpson's diversity index (λ) = $\sum p_i$, where p_i = Proportional abundance of species ($p_i = n_i/N$) and n_i = number of individuals of each species
	Shannon-Wiener index (H') = $-\sum p_i \ln p_i$
	Pielou's index (J') = $H'/\ln(S)$
Evenness indices	Sørensen's Coefficient (S_I) = $2c/(a+b)$, where a = number of species in plot A, b = number of species in plot B, c = number of species in plot A y B
	Jaccard Coefficient (J_I) = $c/(a+b-c)$
	Quantitative Sørensen (S_{Iquant}) = $2pN/(aN + bN)$, where aN = total number of individuals in plot A, bN = total number of individuals in plot B, pN = sum of the lowest abundance of each of the shared species A
	Morisita-Horn Index ($M-H_I$) = $(2\sum(an_i \times bn_j))/((da + db) aN \times bN)$, where an_i = number of individuals of the i-th species in plot A, bn_j = number of individuals of the j-th species in plot B, $da = \sum an_i^2 / aN^2$, $db = \sum bn_j^2 / bN^2$

Source: [34–36].

Methods

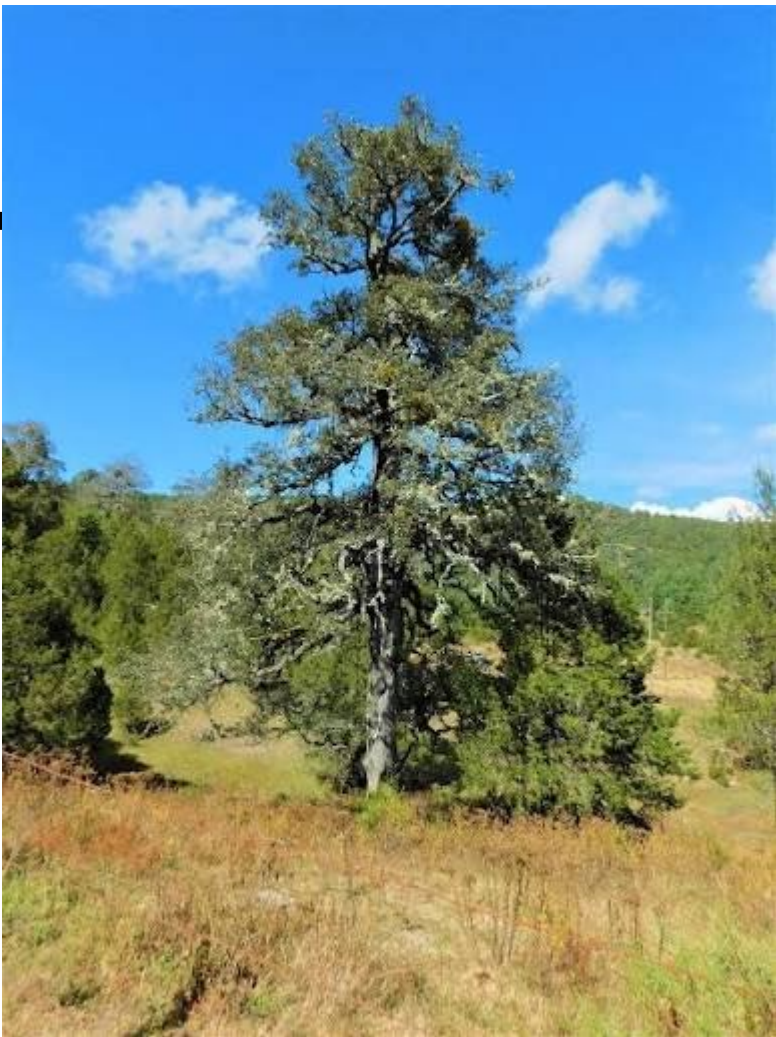
- Data was audited to check for normal distribution or linear regression
- Statistic analysis was done using the Shapiro-Wilkins and Levene's tests
 - All data followed a normal distribution except Margalef's index
- Parametric & non-parametric methods needed to be used
- Correlations used SAS software package w/ a 95% CI



Results

- 18 species were observed across plots, mainly pine, oak, & madrone species
 - Decreased to 16 species after treatments, not statistically significant
 - Most abundant: *Q. sideroxyla*, *P. durangensis*, *P. teocote*, *Q. convallata*
- Grouped into 5 genera & 5 families
- Avg stand density before treatment: 631 trees/ha (1,558 trees/acre)
- Avg BA before treatment: 18.96 m² / ha (82.58 ft² / acre)





Q. sideroxyla



P. durangensis

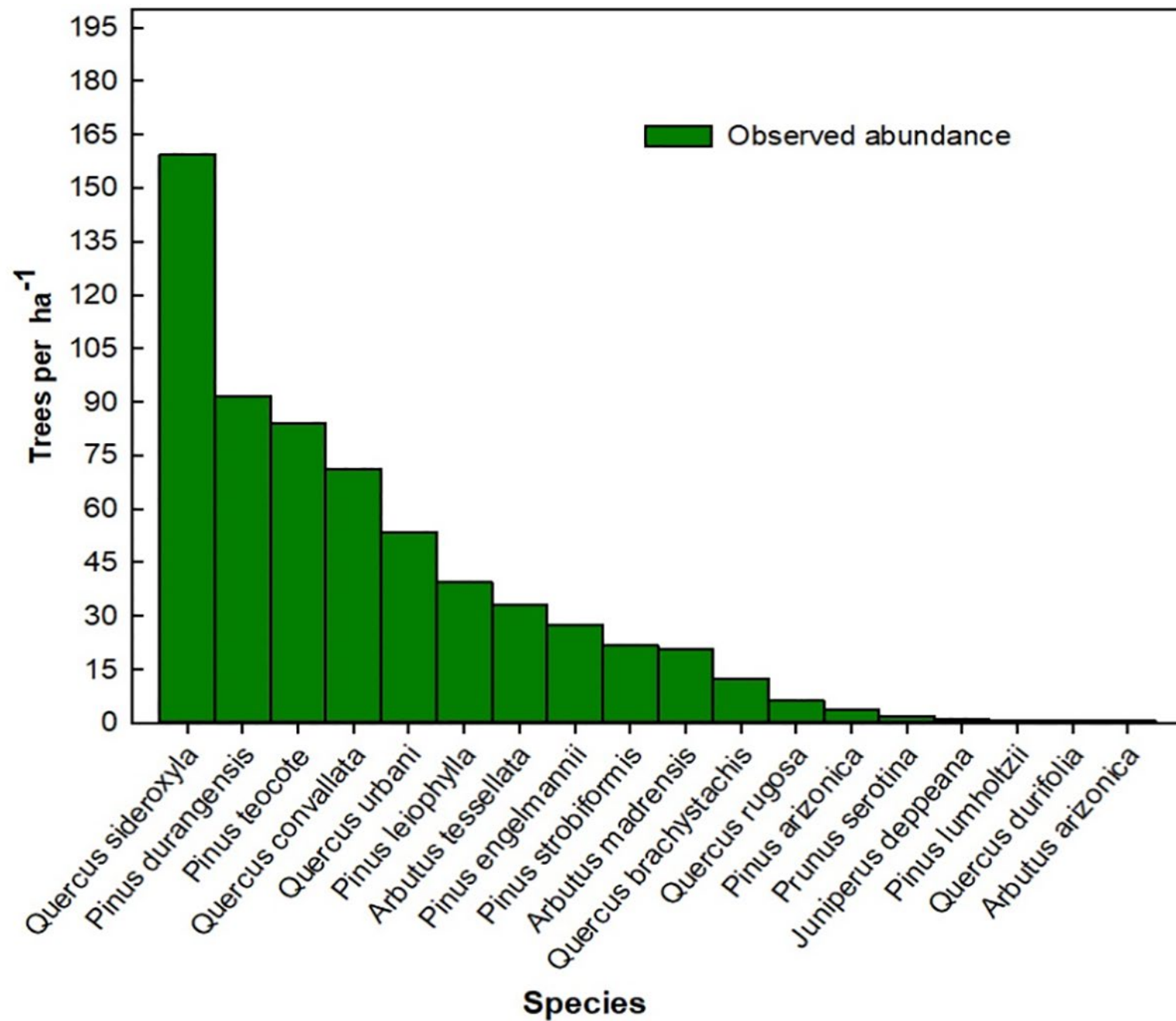


P. teocote

CLASS DISCUSSION:

**WHY IS THE CHANGE IN NUMBER
OF SPECIES NOT STATISTICALLY
SIGNIFICANT?**

Figure 2.



Results

- Avg DBH & total height was not statistically different after treatments
- Mean before treatments: 17.3 cm (6.8 in)
- Mean after treatments: 16.1 cm (6.3 in)
- BA, canopy area, & total volume changed in accordance to treatment applied





Table 2.

Stand variable	Before treatment (G)				After treatment (T)		
	G1: Control	G2: Conservative	G3: Semi-intensive	G4: Intensive*	T1: Control	T2: Conservative	T3: Semi-intensive
<i>Trees/ha</i>	805	645	665	747	805	500	368
<i>Average DBH (cm)</i>	16.40	17.78	17.67	14.89	16.40	16.61	15.29
<i>Maximum DBH (cm)</i>	64.70	55.80	79.10	56.20	64.70	53.00	40.70
<i>Minimum DBH (cm)</i>	7.50	7.50	7.50	7.50	7.5	7.5	7.5
<i>Average height (m)</i>	10.78	11.17	10.83	9.58	10.78	10.62	9.73
<i>Maximum height (m)</i>	30.00	29.90	28.00	30.00	30.00	29.90	27.30
<i>Minimum height (m)</i>	2.30	2.70	2.14	1.90	2.3	2.7	2.14
<i>Basal area (m² ha⁻¹)</i>	23.20	21.18	22.07	14.12	23.20	14.49	8.65
<i>Canopy area (m² ha⁻¹)</i>	12072	7490	9063	5706	12072	5653	3854
<i>Stem volume (m³)</i>	199.6	178.5	186.4	134.3	199.6	122.1	69.3
<i>Total volume (m³ ha⁻¹)</i>	231.3	210.9	223.1	152.0	231.3	143.1	79.3
<i>Cutting intensity (%)</i>					0	31.68	60.3

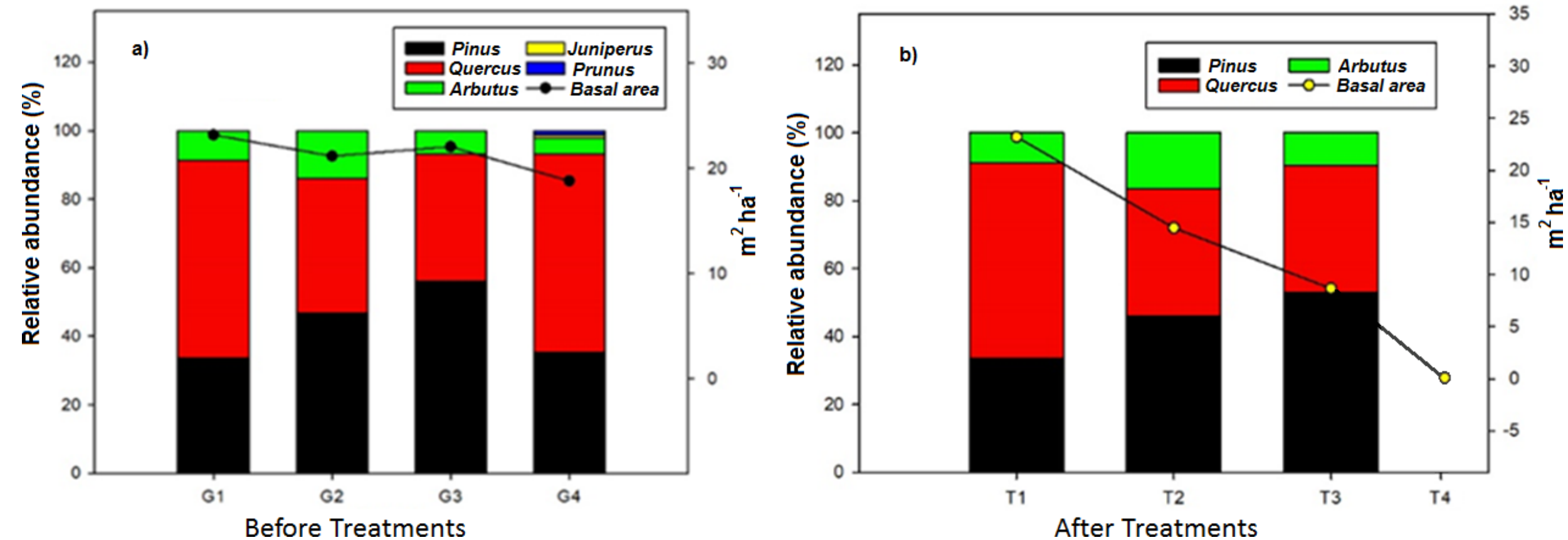
* In the intensive treatment (G4), all trees were removed. Thus, no data exist after treatments.

Results

- Conservative treatment & semi-intensive did not produce a statistically significant change in species composition
 - If trees are selected for removal
- Four main species remained most important after conservative & semi-intensive treatments
 - Species w/ relatively low ecological importance were lost with harvesting



Figure 3.



Results

- Relative dominance of *Pinus* increased
 - Decrease in *Quercus* & *Arbutus* dominance
- Highest ecological importance values: *Pinus* & *Quercus*
- Small decrease in the values of species richness (S), Simpson (λ), and Shannon-Wiener (H') indices
 - Shannon-Wiener and the Simpson indices revealed that the conservative treatment had higher values than the semi-intensive treatment after cutting





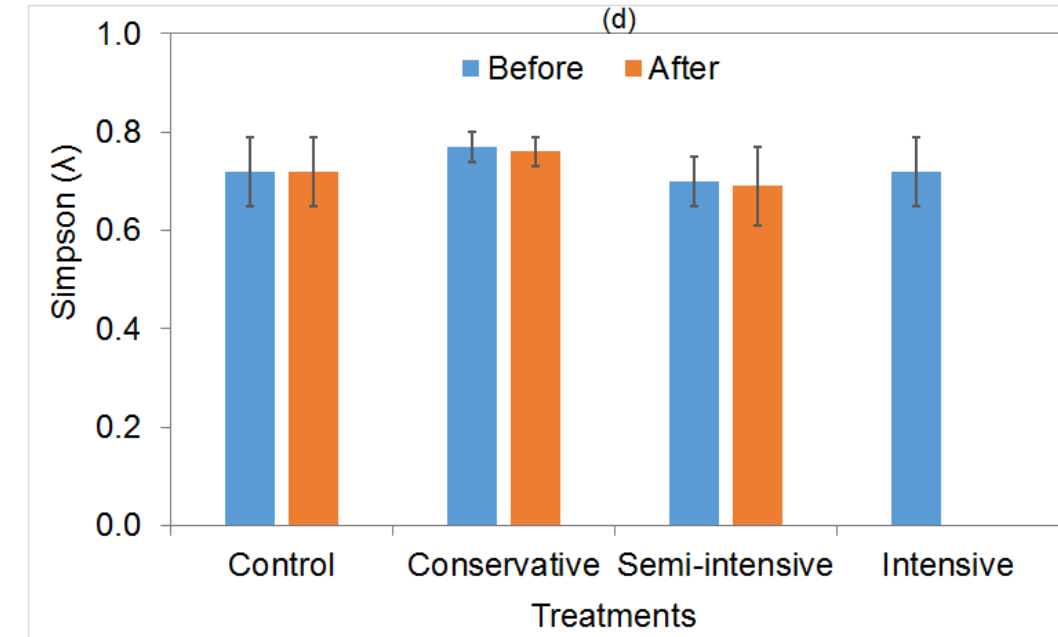
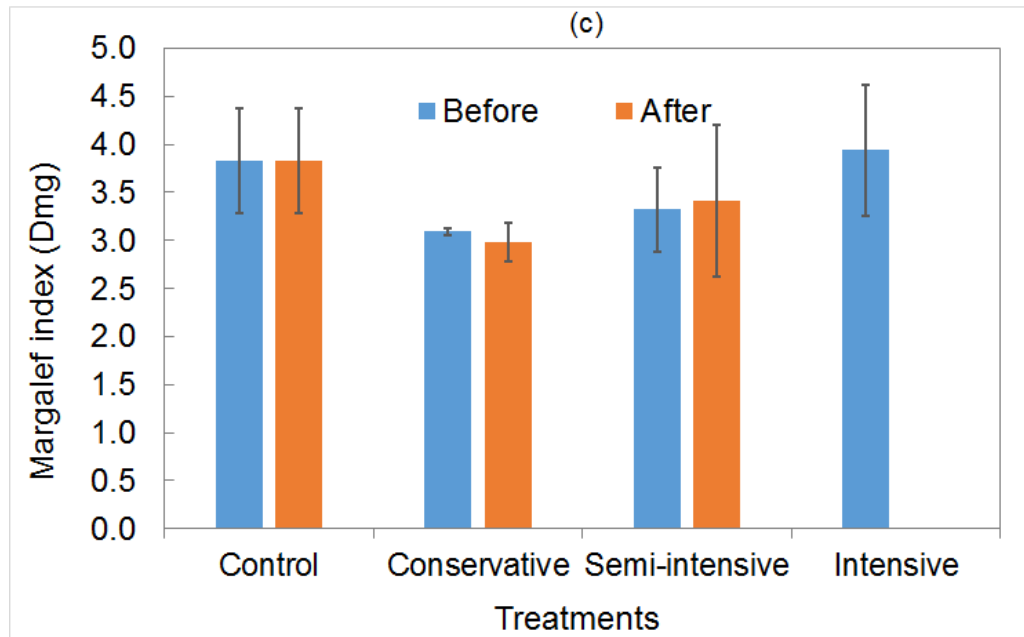
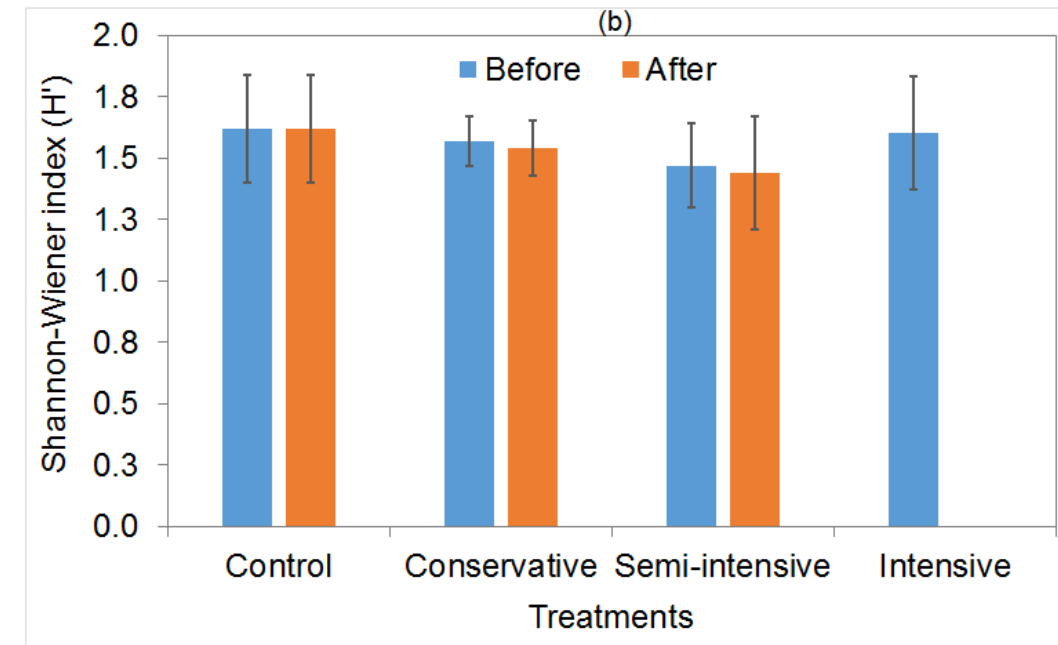
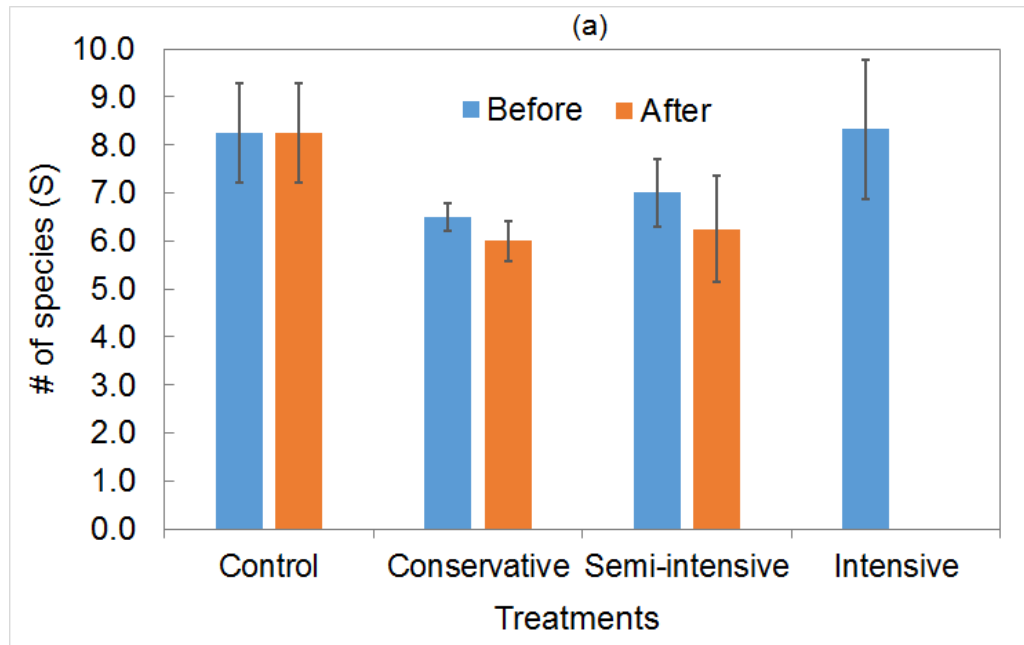
Table 3.

Genus	Before treatment (G)								After treatment (T)							
		Abundance		Dominance		Frequency		IVI		Abundance		Dominance		Frequency		IVI
	BA	N	RA	CA	RD	AF	RF	%	BA	N	RA	CA	RD	AF	RF	%
Treatment: Control, 0% removal																
<i>Quercus</i>	10.70	465	57.8	5499	45.6	3.00	36.36	46.56	10.70	465	57.76	5499	45.55	3.0	36.36	46.56
<i>Pinus</i>	11.00	270	33.5	5918	49	4.00	48.48	43.68	11.00	270	33.54	5918	49.02	4.0	48.48	43.68
<i>Arbutus</i>	1.50	70	8.7	655	5.42	1.25	15.15	9.76	1.50	70	8.70	655	5.42	1.3	15.15	9.76
<i>Total</i>	23.20	805	100	12072	100	8.25	100	100	23.20	805	100	12072	100	8.25	100	100
Treatment: Conservative, 29–31% removal																
<i>Pinus</i>	12.51	303	46.9	4199	56.1	3.00	46.15	49.70	9.13	230	46	3693	58.62	2.5	41.67	48.76
<i>Quercus</i>	6.88	253	39.1	2586	34.5	2.25	34.62	36.09	4.42	188	37.5	1702	30.12	2.25	37.50	35.04
<i>Arbutus</i>	1.78	90	14	706	9.42	1.25	19.23	14.20	0.95	82.5	16.5	637	11.26	1.25	20.83	16.20
<i>Total</i>	21.18	645	100	7490	100	6.50	100	100	14.49	500	100	6032	100	6.00	100	100
Treatment: Semi-intensive, 59–61% Removal																
<i>Pinus</i>	13.86	373	56	5325	58.7	3.75	53.57	56.11	6.10	195	53.06	3193	64.62	3.25	52.00	56.56
<i>Quercus</i>	7.84	248	37.2	3463	38.2	2.00	28.57	34.67	2.28	138	37.41	1152	29.90	1.75	28.00	31.77
<i>Arbutus</i>	0.37	45	6.77	275	3.04	1.25	17.86	9.22	0.27	35	9.52	211	5.48	1.25	20.00	11.67
<i>Total</i>	22.07	665	100	9063	100	7.00	100	100	8.65	368	100	4557	100	6.25	100	100
Treatment: Intensive, 100% Removal																
<i>Pinus</i>	10.34	263	35.3	3029	53.1	3.33	40.00	42.79	0.0	-	-	-	-	-	-	-
<i>Quercus</i>	7.75	433	58	2188	38.3	2.67	32.00	42.78	0.0	-	-	-	-	-	-	-
<i>Arbutus</i>	0.61	33	4.46	321	5.63	1.33	16.00	8.70	0.0	-	-	-	-	-	-	-
<i>Juniperus</i>	0.06	7	0.89	41.9	0.73	0.67	8.00	3.21	0.0	-	-	-	-	-	-	-
<i>Prunus</i>	0.07	10	1.34	126	2.21	0.33	4.00	2.51	0.0	-	-	-	-	-	-	-
<i>Total</i>	18.82	747	100	5706	100	8.33	100	100	0.0	-	-	-	-	-	-	-

BA: Basal area (m² ha⁻¹), N: number of trees per ha, RA: Relative abundance (%), CA = canopy area (m² ha⁻¹), RD: Relative dominance (%), AF: Absolute frequency, RF: Relative frequency (%), IVI: Importance Value Index.



Fig. 4



Results

- Correlation coefficients revealed high associations among number of trees, canopy cover, and total volume
- Diversity indices in general were not associated with stand variables, except the Pielou's evenness index
 - associated with number of trees, canopy cover, basal area, total volume



Table 4.

Stand variables	Basal Area	Canopy area	Total volume	Species richness (S)	Margalef Index (D_{mg})	Simpson's diversity (λ)	Shannon-Weiner (H')	Pielou's evenness (J')
Num. of trees per ha	0.751**	0.675**	0.644**	0.399	0.048	-0.101	-0.049	-0.427*
Basal area ($m^2 ha^{-1}$)	1	0.893**	0.970**	0.03	-0.249	-0.412	-0.358	-0.558**
Canopy area ($m^2 ha^{-1}$)	0.893**	1	0.884**	0.018	-0.273	-0.343	-0.314	-0.514*
Total volume ($m^3 ha^{-1}$)	0.970**	0.884**	1	-0.132	-0.396	-0.516*	-0.481*	-0.593**

** Significant at the 0.01 level

* significant at the 0.05 level. The alpha diversity indices were based on Spearman correlation. All others are based on Pearson correlation.

<https://doi.org/10.1371/journal.pone.0233292.t004>

CLASS DISCUSSION:

**WHAT CAN CAUSE A
CORRELATION VALUE TO BE
NEGATIVE?**

Results

- Evenness indices showed that the proportion of species decreased after the treatment application
- Species composition decreased by 12% in conservative management
 - Semi-intensive: 29% decrease



Table 5.

Parameter	Evenness Indices			
	Qualitative		Quantitative	
	Sørensen's Coefficient (S_I)	Jaccard Coefficient (J_I)	Quantitative Sørensen (S_{Iquant})	Morisita-Horn Index ($M-H_I$)
Conservative management with removal of 29–31% BA (T2)				
Mean	0.9575	0.9225	0.8825	0.99
Minimum	0.91	0.83	0.85	0.98
Maximum	1	1	0.94	1
Standard error	0.0246	0.0452	0.0202	0.00408
Standard dev.	0.04924	0.0903	0.0403	0.00816
Semi-intensive management with removal of 59–61% BA (T3)				
Mean	0.9275	0.875	0.7125	0.96
Minimum	0.8	0.67	0.66	0.93
Maximum	1	1	0.82	0.98
Standard error	0.0475	0.0792	0.0368	0.0108
Standard dev.	0.095	0.1584	0.0736	0.0216

<https://doi.org/10.1371/journal.pone.0233292.t005>

Discussion

- Overall goal was to evaluate immediate effects of silvicultural treatments on species diversity in temperate forests
- In the short term, there were no significant changes in tree diversity in the conservative or semi-intensive treatments
- If silvicultural treatments are not directed towards a particular species, diversity is not modified substantially
 - In the short term



Discussion

- Results do not agree with previous studies in similar ecosystems in which tree diversity did change because of forest management practices
 - Study in Chihuahua
- Differences in these results could be due to the type of successional stages, removal criteria, climatic conditions, and the evaluation time after applying the silvicultural treatments.....



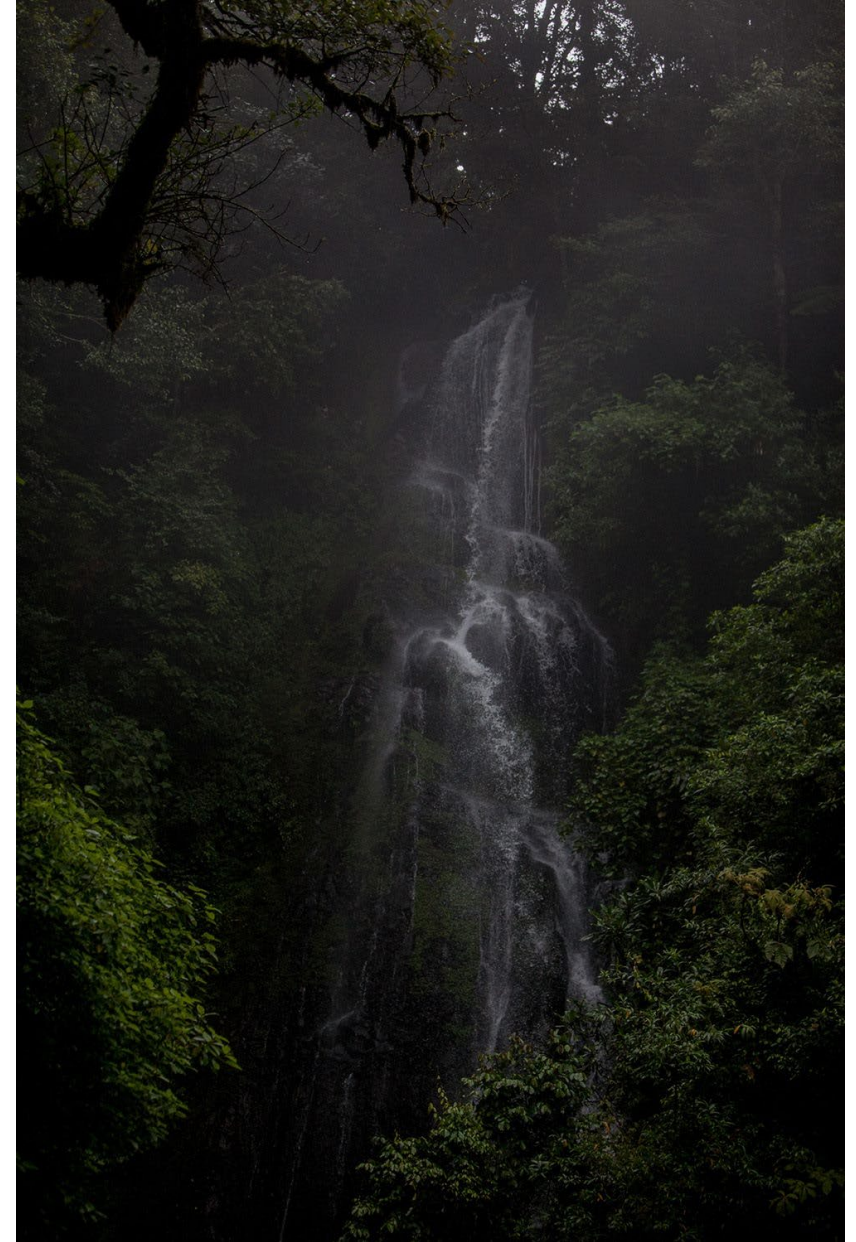
Discussion

- Results imply that no significant changes in tree diversity are expected because of the application of either conservative or semi-intensive treatments
 - both treatments are compatible with timber management and biodiversity conservation
- In the short to mid-term, both the conservative and semi-intensive management scenarios allowed timber harvesting without generating significant changes on tree diversity



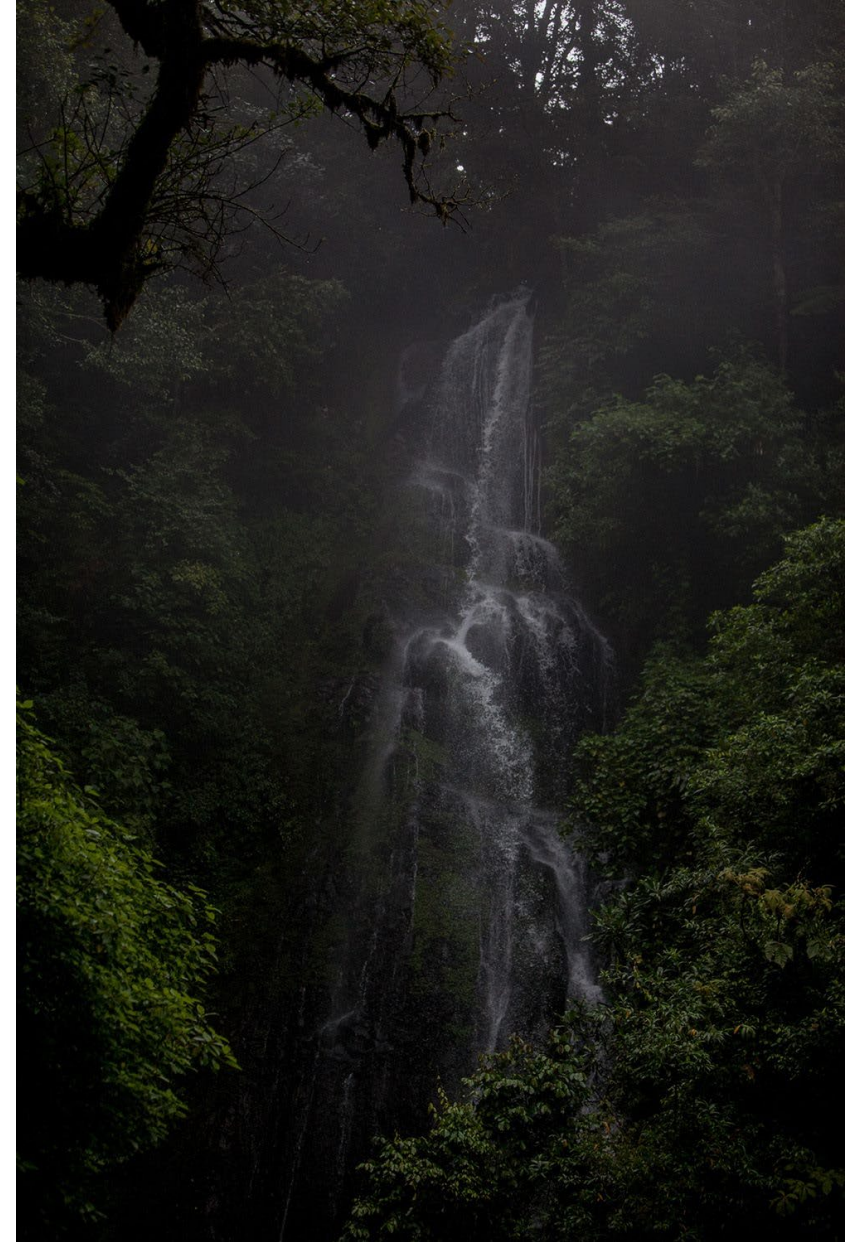
Conclusion

- This study was conducted to evaluate the immediate effect of silvicultural practices on tree diversity that included intensive, semi-intensive, conservative, and no treatment (control group)
- A total of 18 tree species, five genera, and five families were recorded
- Results show that there were no significant changes before and after the application of conservative and semi-intensive treatments



— Recommendations

- The traditional way of selecting trees for removal should be changed to consider all existing species (commercial or not)
- Species with low IVI values be monitored to prevent them from being eliminated after applying silvicultural treatments
- Proper identification and precise inventory of the species and stand variables should be implemented
- A permanent monitoring network of forest resources in productive landscapes should be maintained

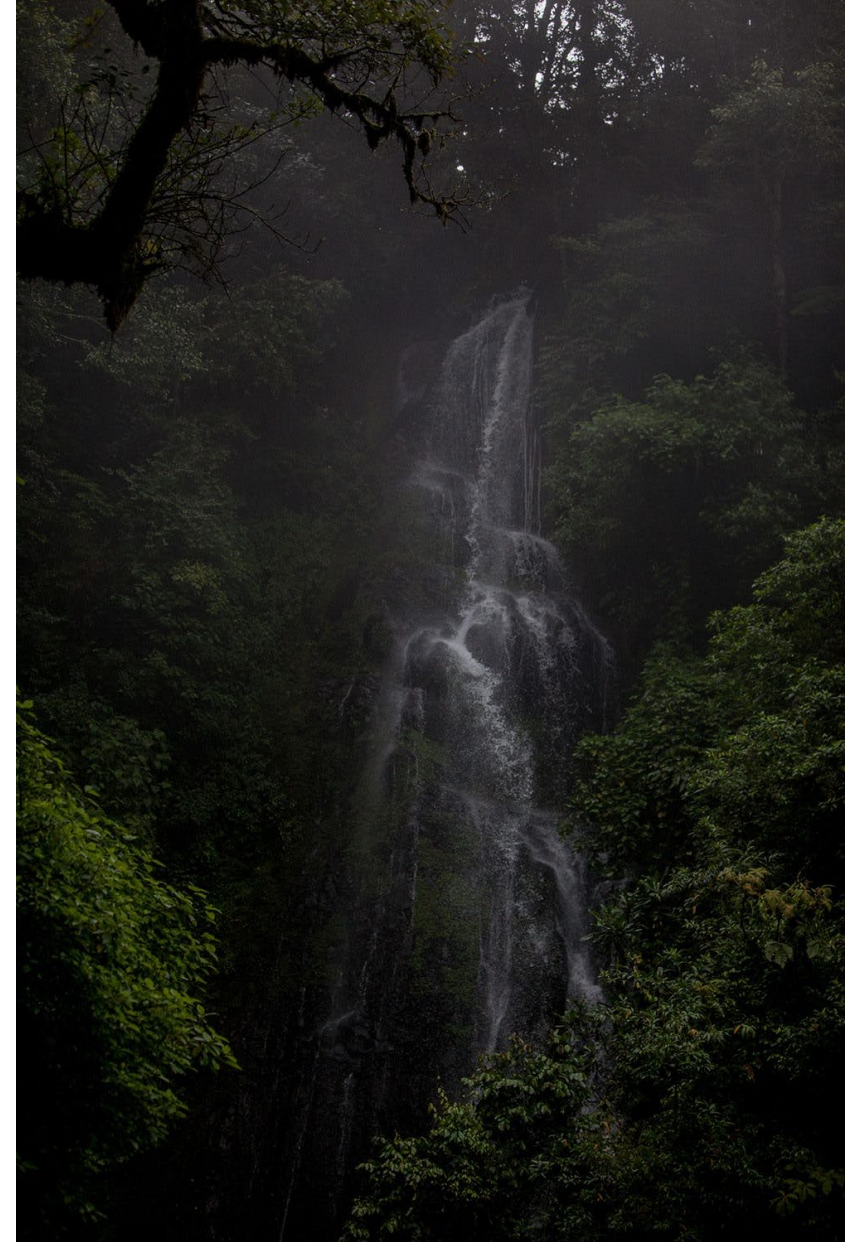


CLASS DISCUSSION:

**WHAT ARE THE MAIN ISSUES WITH
THIS STUDY?**

— My Thoughts

- Silviculture is not a short-term venture, need long term monitoring for more accurate data
 - Clearcut may yield high diversity once established
- How to protect forests from illegal logging?
 - Will the cartels follow these recommendations?
- Would moderate harvesting meet the needs of the people?
- How would a shift from clearcutting to single-tree selection affect the economy of Mexico?



Citations

Bigelow, Seth W, et al. “Hurricane Effects on Climate-Adaptive Silviculture Treatments to Longleaf Pine Woodland in Southwestern Georgia, USA.” *Forestry: An International Journal of Forest Research*, vol. 94, no. 3, Oxford University Press (OUP), Dec. 2020, pp. 395–406, <https://doi.org/10.1093/forestry/cpaa042>. Accessed 28 Sept. 2026.

A photograph of a dirt path leading through a dense forest. The path is made of dirt and small stones, winding through the trees. The forest is lush with green foliage and tall trees. A semi-transparent grey rectangular box is overlaid on the center of the image, containing the text "Thank You for Your Time Questions?".

**Thank You for Your Time
Questions?**