Effects of Mexico's selective cutting system on pine regeneration and growth in a mixed pine-oak (Pinus-Quercus) forest

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Effects of Mexico's Selective Cutting System on Pine Regeneration and Growth in a Mixed Pine-Oak (Pinus-Quercus) Forest.[1]

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Abstract. Effects of the official selective harvesting system on a mixed pine-oak forest in Oaxaca were evaluated 20 years later and compared to formerly cleared forest areas and unexploited forest. Pine regeneration in selectively cut forest averaged only 5 m^2/ha basal area compared to 40 m^2/ha in formerly cleared areas. The correlation between pine regeneration and reconstructed residual basal area after harvest was R = -0.82. Pine growth increments of 4.6 m^3/ha/year occurred in selectively cut areas, compared to 11.4 m^3/ha/yr in formerly cleared areas. New regulations associated with the forest law of 1986 may include replacement of the official selective cutting method by an even-aged silvicultural management system. However, the lack of markets for oak wood represents an obstacle to the implementation of more intensive harvesting systems necessary to assure sustained yields of pine wood.

Keywords: natural regeneration, silviculture

INTRODUCTION

Over 80% of Mexico's industrial wood comes from pines (SARH 1978), most of which grow intermixed with oaks (Rzedowski 1978) in highland forests which cover 20 million has (SARH/SF 1984). Responsibility for silvicultural management of these and all of Mexico's forests rests entirely with the federal forest service (Ley Forestal 1960/1986). Since the 1950's, the country's forests have been exploited according to the silvicultural system known as the Metodo Mexicano de Ordenacion de Montes' (Mexican Method for Ordering Forests) (Carrillo 1955; Rodriguez 1958; Rodriguez et al 1959; Rodriguez & Rodriguez 1966). This selective cutting regime limits harvest intensity to 35% - 50% of the volume of desired (conifer) species, and at least until 1978 incorporated a diameter limit of 45 cm (Musalem 1979). In mixed forests, the application of this system often translates into selective extraction of less than 20% of total volume (FAPATUX 1980).

The Mexican method seeks to manage uneven aged stands by maintaining a balanced reverse J-shaped diameter distribution. It assumes that continuous regeneration and class-to-class recruitment will provide for sustained yields (Klepac and Mass Porras 1968). As of 1981, although a few foresters had expressed doubts about the validity of these assumptions (Musalem 1979), no field studies to confirm or modify them had been published. It was decided to survey a pine-oak forest 20 years after exploitation to evaluate the effects of prior harvest by this method, particularly with regards to pine regeneration.

THE STUDY SITE

The study was carried out in the Zapotec community of San Pablo Macuiltianguis, in the Sierra de Juarez, Oaxaca. Their approximately 5000 ha of commercial forest is dominated by pines (Pinus patula, P. pseudostrobus, P. ayacahuite, and P. rudis) intermixed with species of oak including Quercus laurina, Q. rugosa, Q. crassifolia, Q. excelsa, Q. candicans, and Q. salicifolia. Madrone (Arbutus glandulosa), alder (Alnus acuminata), and other hardwood species occur as well (FAPATUX 1962; Perez and Perez 1984).

Forest elevations range from 2200 m to 2700 m, averaging 2450 m. Slopes average 45%, and range from 15% to more than 100%. Annual precipitation is between 1500 and 2000 mm and is strongly influenced by humid winter winds from the Gulf, known as 'nortes'. A marked dry season occurs during April and May. Average annual temperature has been estimated at 12* to 14* C (FAPATUX 1977), while a weather station at a slightly lower elevation just on the other side of the mountains registered an average temperature of 16.7* C and a precipitation of 1982 mm (Garcia 1981).

These forests were concessioned to Mexico's first newsprint paper factory, Fabricas de Papel Tuxtepec (FAPATUX), in the late 1950's, as a source of pine wood for cellulose (Diario Oficial November 12, 1956). Selective cutting of pines began about 1959, but the second cutting cycle had not yet been initiated in 1981.

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METHODS

Data Collection

A 25 km timber extraction road known as 'brecha 200', which runs through the forest from west to east, was used as a transect. At 500 m intervals, courses were run perpendicular to the road between 50m and 350 m into the forest, where sample plots were laid out. Distances from the road were selected using a random numbers table.

Among 27 plots located by this method, 4 fell in unexploited forest and one in a former clearcut where a tower had been erected to support power lines. To give statistical context to this plot, an additional plot was located in the clearcut area, and complemented with two plots located in former agricultural fields abandoned 30 years before, one in 'Agua Fria' and one behind the 'Comedor Cerro Machin'. The final data set for this study was based on 30 plots in 3 different forest types (selectively harvested, unexploited, and formerly cleared).

Four radii marked at 3 intervals were used to indicate 1000 m^2 circular plots with nested internal plots of 400 m^2 and 80 m^2. Trees 15 cm dbh and above were measured over the full 1000 m^2 while trees between 5 cm and 14.9 cm dbh were measured over 400 m^2. Trees 2 cm to 4.9 cm dbh were measured only within the 80 m^2 plot. Genus, dbh, crown class, and signs of injury were noted for each tree. Increment cores were taken of at least two small pines and at least two large pines on each plot. The former were used to determine the age and size range of post-harvest regeneration. Cores of large trees were taken to represent the range of diameter classes and provide data on increments.

Data Analysis

Measurements taken in 1982 showed the effects of past conditions on the density of pine regeneration. To relate these effects to causal factors required the reconstruction of the forest as it was just after harvest. While written records were unavailable, tree cores and information obtained by hearsay indicated that 1962 was the average year of regeneration subsequent to harvest and the clearcut for the power lines.

All trees 20 years or younger in 1982 were thus considered post-harvest regeneration. In selectively cut and unexploited forest, nearly all of these trees measured less than 15 cm dbh, but differentiation of regeneration on each plot was verified according to increments, sampled ages, and diameter distributions. To permit comparison between the 20 year old clearcut and the 30 year old abandoned fields, increments for the last ten years were subtracted from all tree diameters on the abandoned field sites.

In the case of the clearcut and the abandoned fields, it was known that residual basal area had been zero at the time of regeneration establishment. To determine residual basal area at this time in selectively harvested forest, increments since 1962 were subtracted from diameters of older trees. Average measured periodic increments of 0.44 cm/yr in pines less than 60 cm dbh and 0.36 cm/yr in pines greater than 60 cm dbh yielded respective diameter reduction factors of 8.8 cm and 7.2 cm over the 20 year post-harvest period.

Oaks were not cored, both because of physical difficulties and because it was not known whether tropical oaks have annual rings. For lack of data on Mexican oak growth, diameters were reduced to 1962 levels using the following increments, derived from an estimated volume increment of 2% a year (Mass P. 1977) and an oak volume table (FAPATUX 1977):

Diam. class	Annual increment	20 year reduction
15 - 19.9	0.35 cm	7.0 cm
20 - 29.9	0.49 cm	9.8 cm
30 - 39.9	0.69 cm	13.8 cm
40 - 49.9	0.79 cm	15.8 cm
50 - 59.9	0.89 cm	17.8 cm
60 and over	1.30 cm	26.0 cm

Using these reduction factors, average 1962 diameters and basal areas were determined for pines and oaks in each 1982 diameter class. Diameter distribution tables for each plot were then used to determine total residual basal area (Table 1).

Table 1. Calculation of residual basal area in selectively cut forest (Site 033).

Avg. class dbh 1982	BA/tree 1962	# trees	Total BA 1962
Pines			
17.5	59 cm^2	1	59 cm^2
25.0	205 cm^2	2	410 cm^2
35.0	537 cm^2	6	3222 cm^2
45.0	1027 cm^2	1	1026 cm^2
55.0	1673 cm^2	2	3346 cm^2
Oaks			
17.5	86 cm^2	2	172 cm^2
25.0	180 cm^2	1	180 cm^2
35.0	351 cm^2	3	1053 cm^2
45.0	579 cm^2	2	1158 cm^2
55.0	863 cm^2	1	863 cm^2

Total residual basal area: 11,491 cm^2/1000 m^2

To compare unexploited forest conditions with selectively cut and formerly cleared forest, a similar process of diameter reduction and transformation to basal area in 1962 was applied, using the same estimates of oak increments as in the selectively cut forest, and the following periodic pine increments measured in the plots:

Diam. class	Annual increment	20 year reduction
15 - 39.9	0.34 cm	6.80 cm
40 - 49.9	0.38 cm	7.60 cm
50 - 59.9	0.30 cm	6.00 cm
60 and over	0.24 cm	4.80 cm

These same transformation tables were used to reconstruct the 1962 diameter distribution of each site. By combining these with a pine volume table (FAPATUX 1977), it was possible to determine 1962-1982 volume increment by forest treatment.

RESULTS AND DISCUSSION

Regeneration

As can be observed in Table 2, the average density of pine regeneration twenty years after selective cutting was 5.2 m^2/ha, only 13% of the nearly 40 m^2/ha on the formerly cleared sites. Regeneration establishment in unexploited forest during this period was negligible.

The residual basal area in each case followed an inverse pattern to regeneration, averaging 34 m^2/ha in unexploited forest, 19.2 m^2 in selectively cut forest, and 0 in the clearcut and abandoned fields. A linear regression between residual basal area and basal area of regeneration yielded a correlation coefficient of R = -0.82, indicating that 67% of the variability in pine regeneration reflects the variation in residual basal area. This inverse relationship is no surprise since basal area is a measure of site occupation. The more growing space (light, water, nutrients) occupied by residual trees, the less is available for regeneration establishment.

Oak regeneration was insensitive to variation in residual basal area, yielding an R^2 of only 0.08. This no doubt reflects oaks' greater shade tolerance. It is notable that only in the unexploited forest, with the highest 'residual' basal area, is the average oak regeneration density approximately equal to and perhaps slightly greater than pine.

Rates of suppression amongst pines followed the same pattern as regeneration density. In formerly cleared areas, 10% of the pines were suppressed by other pines. In selectively cut and unexploited forest, 80% and 100%, respectively, of the pine regeneration was suppressed, by a mixed canopy of pines and oaks. These trees will almost certainly die before reaching commercial size.

Table 2. Pine and Oak Regeneration after 20 Years

	Formerly Cleared	Selectively Cut	Unexploited
Residual BA 1962 m^2/ha	0	19.2 ± 1.7	34.1 ± 3.0
Pine regen. 1982 m^2/ha	39.8 ± 2.8	5.2 ± 1.2	0.2 ± 0.1
Oak regen. 1982 m^2/ha	6.2 ± 2.1	3.6 ± 0.7	0.3 ± 0.2
% pines suppressed	10% ± 4	80% ± 4	100%

Growth

Average periodic diameter increment between 1962 and 1982 differed amongst pines in different forest treatments. Combining data for available diameter classes yielded averages of 1.38 cm/yr in the formerly cleared forest, 0.45 cm/yr in selectively cut forest, and 0.35 cm/yr in unexploited forest. In the first case, rapid growth rates reflect the youth and lower range of diameters of the stands, and decreasing ring widths over the last two or 3 years indicate that these rates are slowing as competition becomes more intense.

Diameter distribution tables for 1962 and 1982 were transformed to volumes to determine the difference in volume increment/ha among forest treatments. These ranged from 4.0 m^3/ha/year in the unexploited forest to 11.4 m^3/ha/yr in the clearcut and abandoned fields (Table 3), comparing favorably with data for a plantation of <u>P. patula</u> in Macuiltianguis, which grew at a rate of 12 m^3/ha/yr during the first 14 years after its establishment (FAPATUX 1977).

Table 3. Volume increments/ha, pine only

	Formerly Cleared	Selectively Cut	Unexploited
Vol. pines 1962	0	125 m^3	460 m^3
Vol. pines 1982	228 m^3	217 m^3	540 m^3
Increment 62-82	228 m^3	92 m^3	80 m^3
Annual incr./ha	11.4 m^3	4.6 m^3	4.0 m^3

Forest dynamics

Selective cutting in the mixed forests of San Pablo Macuiltianguis, as in most of Mexico, was applied exclusively to pines. This has modified the relative dominance of pines and oaks (Table 4). While pines accounted for 64% of the total volume of the forest prior to exploitation (FAPATUX 1962), twenty years after the first selective cut they represented only 54% of the basal area. While formerly cleared sites were completely dominated by pines, only 58% of the dominant trees in selectively cut sites were pines, while 40% of the dominant trees were oaks. The intermediate pine/oak relationship demonstrated by data from the unexploited forest probably reflects the history of this particular area, which appeared to have regenerated after a fire about 40 years before.

Table 4. Forest characteristics and proportions, 1982 (adapted from Negreros & Snook 1984).

	Formerly Cleared	Selectively Cut	Unexploited
Total BA	46.0 ± 3.8	47.1 ± 2.5	60.1 ± 5.4
BA Pines	39.8 ± 2.8	25.4 ± 1.8	45.9 ± 7.7
BA Oaks	6.2 ± 2.1	18.5 ± 2.3	2.8 ± 0.11
% Pines	87%	54%	70% / 64%[1]
% Oaks	13%	39%	5%[2] / 36%[1]
Pines % dom.	100%	58%	84%
Oaks % dom.	0	40%	8%[2]

[1]Data from FAPATUX (1962).

[2]Other hardwood species made up the missing %.

CONCLUSIONS

The low-intensity selective cutting of pines in the pine-oak forests of the Sierra de Juarez has not stimulated adequate pine regeneration to provide for the replacement of harvested trees. On the contrary, these cuttings are encouraging the successional process of replacement of pines by oaks, as has been observed in the United States by various authors, among them Christensen and Peet (1981) and reviewed by Jardel (1985).

Regeneration of pine was eight times greater in basal area (and twice as large in diameter) on sites subject to complete clearing. Growth rates followed the same pattern, annual volume increments of pine reaching levels 2.5 times greater in formerly cleared sites than in selectively cut forest. Thus it seems apparent that patch or strip clear-cutting, a close imitation of agricultural abandonment and fires which apparently maintained pine dominance in these forests in the past, would be much more effective silvicultural methods than selective cutting for ensuring and maximizing future yields ofpine wood needed for cellulose and other industrial purposes.

In fact, against the backdrop of the national guidelines for low-intensity selective cutting, a movement to intensify Mexican silviculture was initiated by a small group of concerned foresters in the mid-70's, and pilot projects using a system of even-aged silvicultural management were established on 2000 ha of mixed conifer forests by the end of the decade. The silvicultural system, called the 'Metodo de Desarrollo Silvicola' (Method of Silvicultural Development) is based on the application of seed tree regeneration cuts and periodic thinnings, and presumes to manage even-aged stands (Musalem 1979). As of 1983, 56,000 ha (less than 3% of Mexico's mixed conifer forests) were under management according to this method, and yielded 25% of the national production that year (SARH/SF 1984).

A new Mexican forestry law was signed this year, replacing the forestry law of 1960 (Diario Oficial May 30, 1986). While the associated forestry regulations will not be published until December, the appearance of the words "management plan" and "sustained yield" in the text of the new law (for the first time) may foreshadow a modification of silvicultural guidelines.

However, there are still obstacles to the implementation of a more intensive silvicultural system in Mexico's pine-oak forests. Among them is the lack of markets for oak wood. Mexico boasts over 120 recognized species of oaks (Rzedowski 1978). Neither their taxonomy nor their wood technology is well known, and there has been little use of oaks for industrial purposes.

Because loggers are paid by the cubic meter by the buyer of the wood, the lack of a demand for oaks makes it unlikely that these trees will be cut. In Macuiltianguis, an average of 140 oaks occurred per hectares, representing nearly 20 m^2 of basal area. This density is greater than the total residual basal area which so severely inhibited pine regeneration after the selective harvest. Unless these trees are cut, adequate pine regeneration cannot be expected. Thus oak markets should be developed as part of a new silvicultural strategy to assure the future of Mexico's pine resource.

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LITERATURE CITED

Carrillo, G.M. 1955. Ordenacion de nuestros bosques. Editorial Cultura, Mexico D.F.

Christensen, N.L. and R.K. Peet. 1981. Secondary forest succession on the North Carolina Piedmont. In: West, D.C., H.H. Shugart & D.B. Botkin (eds.) Forest Succession: Concepts and Application. Springer Verlag, New York. pp. 230-245.

FAPATUX (Fabricas de Papel Tuxtepec). 1962. Proyecto definitivo de la seccion de ordenacion No. 1, Unidad Industrial de Explotacion Forestal. Oaxaca, Mexico, 169 pp.

FAPATUX (Fabricas de Papel Tuxtepec). 1977. Proyecto General de Ordenacion, Estudio Forestal Fotogrametrico, Seccion de Ordenacion I, III, IV. Oaxaca, Mexico, 170 pp.

FAPATUX (Fabricas de Papel Tuxtepec). 1980. Sintesis del estudio sbore la constitucion en 1958 de los bosques mezclados de coniferas y latifoliadas de la Sierra de Juarez, Oaxaca, comparado con lo mismo en 1978.

Garcia, E. 1981. Modificaciones al sistema de clasificacion climatica de Koeppen. Instituto de Geografia, Universidad Nacional Autonoma de Mexico, pp. 155 - 157.

Jardel, E. 1985. Una revision critica del Metodo Mexicano de Ordenacion de Bosques desde el punto de vista de la ecologia de poblaciones. Ciencia Forestal 58:3-16.

Klepac, D. & J. Mass Porras. 1968. El tiempo de paso y su importancia en la ordenacion de montes. Mexico y sus Bosques (enero-febrero): 24-32.

Mass Porras, J. 1977. Los encinos como fuente potencial de madera para celulosa y papel en Mexico. Ciencia Forestal 2(5):45-46.

Musalem L, F.J. 1979. Las bases y primeras acciones del Programa Nacional de Mejoramiento Silvicola en Bosques de Coniferas. Productos Forestales de Michoacan (PROFORMICH), Morelia, Michoacan, 40 pp.

Negreros, P. & L. Snook. 1984. Analisis del efecto de la intensidad de corta sobre la regeneracion de pinos en un bosque mezclada de pino-encino. Ciencia Forestal 47:48-61.

Perez, P.E. & C.G. Perez. 1984. Estudio ecologico floristico y el significado economico de la vegetacion en la comunidad de Macuiltianguis, Oaxaca. Tesis Profesional, Universidad Autonoma de Chapingo, Dpto. de Bosques.

Rodriguez C., R. (1958) Discusion de formulas para el calculo de la productividad maderable y exposicion del Metodo Mexicano de Ordenacion de Montes de especies coniferas. Comision Forestal del Estado de Michoacan.

Rodriguez C., R., R. Mendoza & R. Barrena. 1959. El Metodo Mexicano de Ordenacion de Montes. Apendice 7. Proyecto de Ordenacion Forestal de la Unidad INdustrial de Explotacion Forestal "Michoacana de Occidente".

Rodriguez C., R. & M. Rodriguez. 1966. Generacion del Metodo Mexicano de Ordenacion de Bosques. Mexico y sus Bosques (septiembre - diciembre):2-4.

Rzedowski, J. 1978. Vegetacion de Mexico. Editorial Limusa, Mexico D.F. 432 pp.

SARH (Secretaria de Agricultura y Recursos Hidraulicos). 1978. Estadisticas del Recurso Forestal de la Republica Mexicana. Direccion General del Inventario Forestal. Publicacion #45. Mexico.

SARH/SF (Secretaria de Agricultura y Recursos Hidraulicos/ Subsecretaria Forestal). 1984. Mexico Forestal. Cifras 1983. 59 pp.

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