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AN ESTIMATE OF THE YIELD OF CEDRELA ODORATA L.

(Syn. *C. mexicana* Roem.) GROWN IN ASSOCIATION WITH COFFEE

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(Syn. C. mexicana Roem.) Grown in Association with Coffee

INTRODUCTION

The value of Spanish cedar (Cedrela spp.) has been recognized since the days of the Spanish colonies. Traditional exploitation of this genus has been from the high forest, where the member species occur as pioneers in gaps in the forest canopy. Attempts at establishing Cedrela in plantations in Latin America have repeatedly failed, in part due to debilitating attacks of the mahogany shoot borer, Hypsipyla grandella. However, in some areas Cedrela is regularly cultivated by farmers, who reap considerable benefit from the trees either for their own use of the durable, handsome wood or through its sale as a cash crop.

One method of cultivating Cedrela used in Costa Rica is in association with coffee (Coffea spp.). The use of leguminous trees for shade for coffee is common practice. The cultivation of non-leguminous tree species which produce valuable wood within a coffee plantation is a method of diversifying, and possible increasing, the productivity of land planted in coffee. This study is an attempt at quantifying the production of merchantable Spanish cedar grown in association with coffee in two sites in Costa Rica. No attempt has been made to determine the effect of the Cedrela on the production of coffee in the plantations. Hopefully this will be undertaken in a future study.

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### THE SITES

Two sites where Cedrela is grown in association with coffee were chosen for tree measurements. They are Finca Mercedes, Santa Clara de Florencia, San Carlos, Province of Alajuela, and Tabarcia de Puriscal, Province of San Jose, Costa Rica (see figure I).

In San Carlos (altitude 250 m.) on the Atlantic coastal plain with rainfall of about 4100 mm/year and no dry season, the trees were planted as 10 cm. tall seedlings from a nursery on the property. The soil is a clay loam, with a pH of 5.5. Seed was collected from the "finca". Planting was started 27 years ago (1952) and discontinued 9 years ago (1970). The trees were planted with a spacing of 5.5 x 7.5 m. (242 trees/ha.), in an established coffee plantation. Originally Inga sp. was maintained as shade for the coffee. As the cedars grew, the Inga was removed. When the cedars reached commercial size (d=50 cm.) they were cut and taken to the sawmill located on the property. No records of the number of trees planted nor of the number cut nor their yield were kept but about 80 ha. were planted with cedar.

Tabarcia (600 m.) is in an isolated valley in the mountains between the Central Valley and the Pacific with rainfall of 2500-3000 mm/year and a dry season of 3-4 months. The soil is a stoney loam with a pH of 5.7. Regeneration of Cedrela in coffee plantations was mostly natural, trees being thinned and nurtured to commercial size (15-20 years). Some replanting of natural seedlings occurs, and in recent years, seed is collected and sown (1).

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(1) Personal communication, Dr. Luis Fournier

### METHODS

Measurements of Cedrela were taken from standing trees. Diameter at breast height (d) was measured with a diameter tape and tree height and the height of the first main branch or fork were measured using a Blume-Leiss.

In San Carlos, a representative one-quarter hectare plot (50 x 50 m.) was marked, and all trees (21 trees) within the plot were measured. Many Cedrela in this plot had reached merchantable size and been cut, so standing volume data of that plot is an underestimate. The density of the trees is 84 trees/ha.

In Tabarcia, two adjacent stands of Cedrela were measured which had been established with coffee. Recently the coffee was removed, leaving mature stands of trees. The areas of these stands are .51 ha. and .43 ha. The density of trees is 141 trees/ha. and 77 trees/ha., respectively.

In San Carlos, seven trees were felled from the same stand of trees that were measured but outside of the sample plot. The diameter range of the felled trees and their stem form were representative of the trees in the sample plot. From the felled trees, trunk diameters were measured with a diameter tape every meter. Logs were bucked at standard log length (4 "varas" = 3.25 m.) and the smallest diameter of each log recorded. Minimum acceptable log diameter is 8 inches (20.32 cm.). Bark thickness was measured in four randomly chosen places on the end face of each log. The yield of each log was calculated by the method commonly used in Costa Rica. The smallest girth of each log of standard length is measured in inches, divided by four, and squared. The total yield of each tree was compared with its d. After a square transformation of d, a linear regression

was calculated with ( $d^2$ ) as the independent variable and yield (pulgadas ticas) as the dependent variable. The regression coefficients thus calculated were then used to estimate the yield from the sampled trees.

RESULTS

The area represented in the sample plot, the basal area of each plot the density of trees, the average  $d$ , average height and average height of the first main branch or fork are presented in Table I.

TABLE I  
MENSURATIONAL DATA OF SAMPLE PLOTS

Site	Plot Area (ha.)	Basal Area G $m^2/ha.$	Density of trees N trees/ha.	$\bar{d}$ (cm.)	$\bar{h}$ Height (m.)	$\bar{h}$ 1st fork Fork Height ( $\bar{X}$ ) (m.)
San Carlos	.25	12.8	84	42.6	22.76	8.7
Tabarcia A	.51	19.4	141	45.2	23.90	11.3
Tabarcia B	.43	11.6	78	47.5	25.14	10.5

The  $d$ , height of fork, number of pulgadas ticas per tree, tree age (calculated from the number of annual rings at stump height) and diameter growth per year for the seven felled trees are presented in Table II.

TABLE II  
MENSURATIONAL DATA OF SEVEN FELLED TREES

n	d (cm.)	h 1st fork	v (pulgadas ticas) (25% bark)	t (years)	i (cm/yr.)
1	51.5	7.6	528.1	19	2.7
2	47.5	8.6	365.1	18	2.6
3	59.5	6.4	670.4	19	3.1

TABLE II  
MENSURATIONAL DATA OF SEVEN FELLED TREES

n	d (cm.)	h 1st fork	v (pulgadas ticas) (25% bark)	t (years)	i (cm/yr.)
4	43.2	8.1	298.1	19	2.3
5	31.2	6.1	137.1	14	2.2
6	40.5	6.5	275.1	15	2.7
7	39.8	7.4	269.9	19	2.7
$\bar{X}$	44.74	7.24	363.42	17.57	2.5

The graph of d versus volume (Figure II) indicates an exponential relationship between the variables. Therefore a transformation was made of the data by squaring the d. A linear regression was calculated, giving the following equation:

$$\text{Volume (pulgadas ticas)} = 0.21245 (d^2) - 77.002212, r^2 = .980485.$$

This relationship is represented in Figure III.

Using the equation derived from the regression, the following volumes are estimated from the three sample plots:

TABLE III  
ESTIMATED VOLUMES OF SAMPLE PLOTS

Site	v (pulgadas ticas)	$\bar{v}$ (pulgadas ticas)	v (pulgadas ticas/ha.)
San Carlos	7,027.4	334.6	28,110
Tabarcia A	20,952.1	291.0	41,083
Tabarcia B	10,755.7	325.9	25,307

Using a conversion table to convert pulgadas ticas to board feet and cubic meters, the following values are obtained for the standing commercial volume/ha.

TABLE IV

AVERAGE VOLUMES IN PULGADAS TICAS, BOARD FEET, AND CUBIC METERS

V VOLUME/HA.

(25% bark)

Site	Pulgadas Ticas*	Board Feet*	Cubic Meters*
San Carlos	28,110	25,861	146
Tabarcia A	41,083	37,796	214
Tabarcia B	25,307	23,283	132

\*NOTE: 1 pulgada= 0.92 Board Feet= 0.00605 Cubic Meter

DISCUSSION



The volumes obtained from the sample plot in San Carlos are an underestimate since many trees have already reached merchantable size and been removed. Since the diameters of the seven felled trees are similar to the diameters of the trees in the sample plot in San Carlos, the assumption is made that the average age of the trees is the same, namely 17.57 years. The age of the Tabarcia trees was not determined. However, one tree felled in the valley had a mean annual increment of 2.8 cm/year. Using this figure to calculate the average age of the Tabarcia stands, a figure of 16.56 years

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results. A sawmill in Turrialba pays ¢2,00 (U.S.\$ .23) per pulgada tica for cedar logs. Therefore, a gross income of ¢3,199,75/ha./yr. (U.S.\$374.68) from San Carlos, ¢4,961,66/ha./yr. (U.S.\$580.99) from Tabarcia A and ¢3,056,51/ha./yr. (U.S.\$357.91) from Tabarcia B is derived from the mean annual increments of the plots. These figures do not include the cost of establishment and maintenance, felling and hauling of the trees. Furthermore, since the effect of the trees on the coffee yield is unknown, no net gain from the Cedrela-coffee association can be given.

In spite of the above, it is evident that the cultivation of Cedrela in association with coffee is a way of diversifying land use and perhaps providing more efficient utilization of the land. The tree crop represents a medium-range investment that can be harvested according to the financial need of the farmers.

The often-encountered problem in the establishment of Cedrela, Hypsipyla, does not appear to be a problem in the areas sampled. Trees are attacked, but tolerate the attack and continue growing to produce fine boles. Cedrela is claimed to be very demanding in its site; perhaps some low-altitude sites appropriate for coffee are also appropriate for Cedrela. It is probable that tree vigor is enhanced by coffee culture practices, such as fertilization and weeding. Another possibility is that the relatively low density of Cedrela (77-242 trees/ha.) in the early years of the trees and the coffee plants hinder the host location by adult female Hypsipyla. A further possibility is that in San Carlos and Tabarcia there exist a resistant or tolerant variety of Cedrela. None of the above possibilities has been tested.

Establishment of Cedrela can be achieved by natural or artificial seeding or out-planting from nurseries. The use of herbicides in the coffee could hinder natural regeneration. Coffee farmers in Tabarcia, if they use herbicides, take into account Cedrela regeneration.



Harvesting of mature trees should be done after the coffee harvest and before pruning, to minimize damage to the coffee plants. In San Carlos, it appears that an uneven-aged stand is forming as mature trees are removed and natural seeding fills the consequent gaps. In Tabareia, the plantations contain uneven-aged stands due to the prevalence of sustained yield management and natural re-seeding.

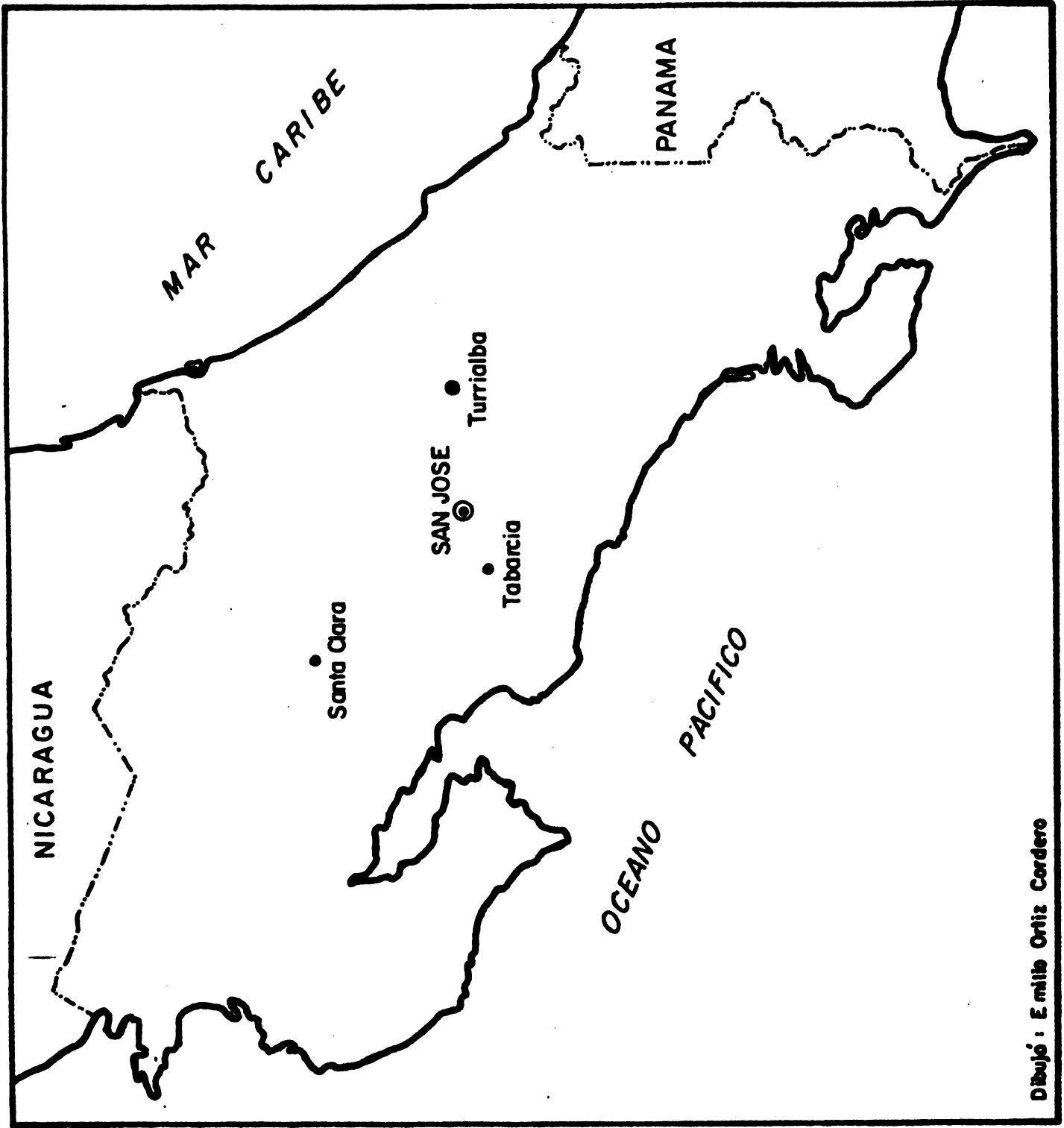
### CONCLUSION

The culture of Cedrela in association with coffee is a method of diversifying and possibly increasing the yield from plantations. The trees exhibit rapid growth and good form, yielding merchantable logs in 15-20 years.

Tree diameter is excellently correlated with merchantable volume, and provides a means of estimating volumes of living stands.

Trees are attacked by Hypsipyla, but seem to tolerate the attack, and rapidly grow past the stage of greatest susceptibility.

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Dibujó : Emilio Ortiz Cordero

Fig. 1

Fig. 2

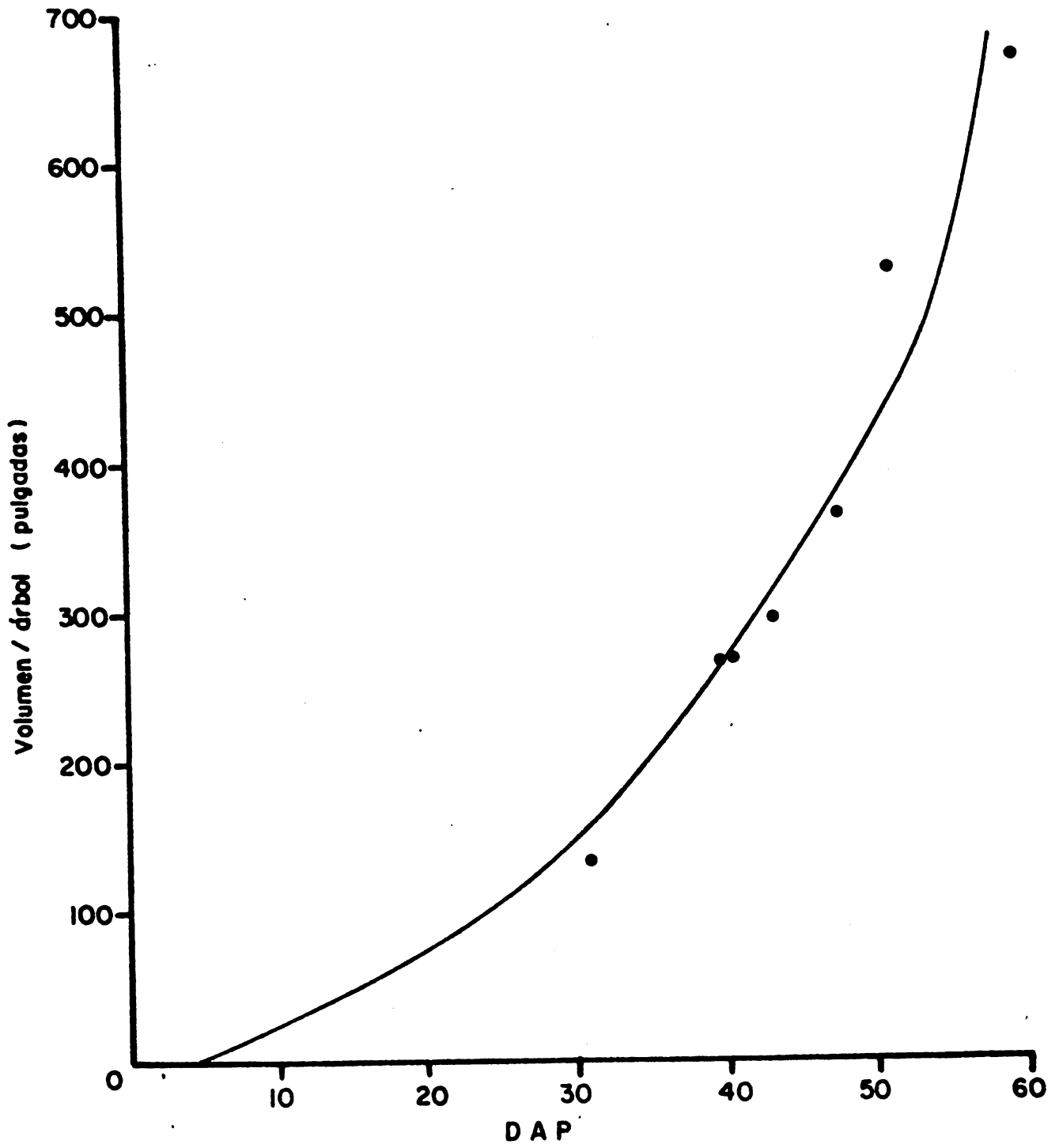


Fig. 3

