Cedrela odorata L. Cedro **Hembra,** Spanish-Cedar

Mel iaceae Mahogany family

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Cedro hembra *(Cedrela odorata)* is the most commercially important and widely distributed species in the genus *Cedrela*. Known as Spanish-cedar in English commerce, the aromatic wood is in high demand in the American tropics because it is naturally termite- and rot-resistant. Cedro is widespread but never very common throughout moist tropical American forests; its numbers are continuing to be reduced by exploitation without successful regeneration. An understanding of the exacting site requirements and of associated damage by insects is needed for productive plantations.

Habitat

Native Range

Cedro is a tree of the New World tropics, appearing in forests of moist and seasonally dry Subtropical or Tropical life zones *(24)* from latitude 26" N. on the Pacific coast of Mexico, throughout Central America and the West Indies, to the lowlands and foothills of most of South America up to 1200 m (about 4,000 ft) altitude, finding its southern limit at about latitude 28" S. in Argentina *(12,55)*. Cedro is always found naturally on well-drained soils, often but not exclusively on limestone; it tolerates a long dry season but does not flourish in areas of rainfall greater than about 3000 mm (120 in) or on sites with heavy or waterlogged soils *(5,34,40,66)*. Individual trees are generally scattered in mixed semievergreen or semideciduous forests dominated by other species *(11,23,25,28)* *(fig.* 1).

Figure 1—*Cedro hembra in a mixed forest.*

Climate

Cedro is a climatic generalist, found over a wide geographic range of warm latitudinal belts, from Subtropical Dry Forest (wet transitional part) in Mexico and parts of the West Indies, through Subtropical Moist Forest to Subtropical Wet Forest in the West Indies and Central America, to Tropical Moist and Wet and Tropical Premontane Moist and Wet life zones in the equatorial regions *(24)*. It is most abundant in the lowlands and foothills (other species, C. *montana* and C. *lilloi*, replace it at higher elevations) in moist forests. Its distribution is within the frost-free tropics for the most part, although it has been collected at latitudes 26" N. and 28" S., where occasional light frosts can be expected (26,551. Mean temperatures of 23" to 26" C ('73" to 79° F) are found in the Caribbean part of its range; in tropical South America mean temperature is slightly higher, 28" C (82" F), with a mean minimum of 23" C (73" F) and a mean maximum of 32" C (90° F). At the southern limit of its range in Argentina the mean temperature is 24" C (75" F); mean maximum temperature is 30" C (86" F) and mean minimum is 18" C (64" F) *(16,34,60)*.

Cedro develops best in seasonally dry climates, as reflected in its deciduous habit and its formation of

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(presumably annual) growth rings. It reaches greatest prominence under an annual rainfall of **1200 to 2400 mm (47.2 to 94.5 in)** with a dry season 2 to 5 months long. Both tree growth and reproduction are synchronous with the onset of the rains *(40,53)*. Cedro survives in lower rainfall areas (down to about 1000 mm (40 in) annually) but grows slowly and shows a stunted form *(41,59)*. It also grows sporadically in areas receiving up to 3500 mm (138 in) of rainfall, but only on very well-drained sites *(23,52)*. In Central and South America, in areas with less than 2000 mm (about 80 in) annual rainfall and over limestone-derived soils, cedar may become locally the dominant species (3457).

Soils and Topography

Cedro may be exacting in its soil requirements but these are still imperfectly understood. In the West Indies it is most commonly found on limestone-derived clay soils *(23,35,47)*, but it also grows on well-drained sites over acid soils derived from volcanic rock (Ultisols). The common denominator appears to be drainage and aeration of the soil *(24,52,63)*, not soil pH *(40,64,65)*. In Trinidad the one factor common to all sites supporting good growth was good surface drainage *(10,40)*. In Mexico and Central America, cedro is likewise common on well-drained soils and ruins (48). Soil fertility may also be important, as in some tests cedro grew better in soil enriched with the burned remains of secondary forest *(10,58)*. No definitive studies of nutrient requirements beyond the seedling stage have been performed *(5,63)*. Symptoms of stress due to poor soils are burned appearance of roots, development of "weeping willow" form in saplings (leaves become thin and drooping) or loss of leaves at irregular intervals during the wet season.

Associated Forest Cover

In Puerto Rico, cedro is found in Subtropical Moist and Subtropical Wet life zones but is commonest in the Subtropical Moist life zone over limestone-derived soils *(16,35)*. Other species commonly found in the tree layer of this association in Puerto Rico are tortugo amarillo ***(Sideroxylon foetidissimum),*** sanguinaria ***(Dipholis salicifolia)***, moca ***(Andira inermis)***, aquilon ***(Terebraiia resinosa),*** ucar ***(Bucida buceras)***, cupey ***(Clusia rosea)***, guano ***(Ochroma pyramidale),*** maga ***(Montezuma speciosissima),*** uvilla ***(Coccoloba diversifolia),*** espino rubial ***(Zanthoxylum martinicense),*** almacigo ***(Bursera simaruba),*** and cedro macho ***(Hyeronima clusioides).*** Almost all of these species have a much wider local distribution and greater abundance than cedro itself, however. In the continental part of its range, cedro is often associated with mahogany ***(Swietenia*** spp.) in moist and wet forests, but mahogany is usually present in far greater abundance (52). Compared to the closely related mahoganies, cedro is much more exacting in site requirements, especially drainage. Near the high rainfall end of its climatic range, cedro is invariably found on ridgetops, upper slopes, old building ruins, and road banks, or other areas of unusually well aerated soil (23).

Life History

Reproduction and Early Growth

Flowering and Fruiting-Cedro's reproductive cycle is synchronized with the growing season of the site; throughout its range it flowers at the beginning of the rainy season: May to August in Mexico, the West Indies, and northern South America *(4,30,48)*; September to October in Argentina (34). Flowering begins when new leaves are expanding. The large and much-branched inflorescences bear numerous small, five-part, symmetrical greenish-white flowers. Trees are monoecious; male and female flowers are borne on the same inflorescence but the species is proterogynous (female flowers open first). Fruit development takes about 9 or 10 months and fruits ripen during the next dry season. Trees begin to fruit at an age of 10 to 12 years. The fruit, a large woody capsule, is borne near branch tips. Fruits ripen, split, and shed seeds while still attached to the parent tree.

Seed Production and Dissemination-Fruits open from the top downward to release 40 to 50 winged seeds when ripe. Seed weight is about 8 to 10 percent of dry fruit weight. One kilogram (2.2 lb) contains 20,000 to 50,000 seeds (9,100 to 22,700/lb, approximately). Seeds are 20 to 25 mm (0.75 to 1.0 in) long, wing included, and are wind dispersed. Heavy seed crops are produced annually in some areas and biennially or irregularly in others *(41,59)*. Seeds are shed during the dry season. They lose viability quickly if not stored very dry at reduced temperatures *(12,37,38)*. Germination begins with the onset of the rainy season and is epigeous. Vigorous germination is the rule, with seed viability reportedly up to 90 percent (40). No seed dormancy period is known. Germination is rapid, usually completed within 2 to 4 weeks *(37,38)*.

Seedling Development-Early development of the seedling is rapid as long as moisture and light

are adequate *(5,46,62)*. Shade-grown seedlings saturate photosynthetically at low intensities and are shade tolerant, but sun-grown seedlings require high light intensities for best growth *(27,28,29)*. Shade-grown seedlings are susceptible to sunscald and subsequent insect attack when moved to sun (43). Fertilizer trials showed best growth with 7-6-19 fertilizer *(6)*.

In natural forest, high seedling densities are common near fruiting trees shortly after the beginning of the rainy season, but most of these seedlings disappear by the middle of the rains or a little later; this high natural mortality may be due to shade or competition but is thought to be partly due to damping off or other root problems *(40)*. Seedlings and saplings have extremely shallow root systems and are sensitive to uprooting and root trampling *(10)*. Seedlings average 1 m (3.3 ft) in growth and develop a stem diameter of 10 mm (0.4 in) or more during the first year under favorable conditions (table 1). Early growth is vigorous under partial shade, when the shootborer attack is not severe *(8,51,62)*.

Natural cedro regeneration from seed is good in many parts of Central and South America, but good initial growth is often followed by dieback after 2 to 3 years. This problem may be only partially related to the shootborer and may also reflect the scarcity of appropriate soils, especially in some of the areas subjected to most intensive study. The abundance of cedro regrowth as almost pure stands with no apparent shootborer problems on recent and ancient limestone ruins in areas with a strong dry season (52) suggests that cedro may be a calciphile.

In some parts of the neotropics selective removal of seed trees has left the forest with insufficient stock for natural regeneration, even on favorable sites. Some success has been claimed for artifical regeneration using the taungya method (a system using native farmers who plant the trees interspersed with their food crops, abandoning the field later to return to forest, now enriched with the desired plantation species); line plantings followed by natural liberation are also used *(11,42,58)*. Successful establishment by the taungya system has been achieved in Africa, where extensive areas of well-drained soils are present, and the native shootborer does not attack New World cedro (34).

Vegetative Reproduction-Cedro does not coppice readily nor produce root suckers; it is not fire resistant *(5,40)*. It is capable of pollard regrowth (partial terminal regrowth after moderate wind damage or partial dieback) if the tree is well established. It can be grafted and air-layered *(34,40,56)*.

Sapling and Pole Stages to Maturity

Growth and Yield-Growth data for many plantations are summarized in table 2. Once past the vulnerable early sapling stage, cedro is a very fast-growing tree, adding 2.5 cm (1.0 in) or more in diameter and 2 m (6.6 ft) in height a year under good conditions. Provenance differences in height growth show up most clearly in Africa, where shootborer attacks are not a problem (44). Fast-growing saplings develop straight, clean boles and narrow, thin crowns. The light-demanding saplings escape shootborer attack in 3 to 4 years if robust, and subsequent growth is rapid on favorable sites (58). The smooth, grayish bark of the sapling gradually becomes vertically fissured as the tree matures, and turns somewhat brownish. Large cedros have a straight, clean bole, often 15 to 20 m (49 to 66 ft) to the first limb and a narrowly buttressed base. Maximum height is 30 to 40 m (98 to 131 ft) (34).

Table l-Early seedling growth of cedro hembra *(Cedrela odorata)*

Country	Origin of test material	Germination	Annual growth'				Survival
			Height		D.b.h.		
		pct	*cm*	*in*	*cm*	*in*	*pct*
Puerto Rico (62)							
Full sun	5 Provenances	10 to 62	*26.2*	*10.3*	*8.4*	*3.3*	*98* to 100
St. Croix, VI (62)							
Shade	5 Provenances	nr[2]	29.3	11.5	*8.5*	*3.3*	*93* to *97*
Venezuela (4)	Venezuela	*85* to 90	120	*47.2*	nr	nr	nr
Trinidad (39)	Trinidad	90	100	39.4	nr	nr	"low"
Nigeria *(14,44)*	15 Provenances	nr	133.7	*52.6*	34.8	13.7	*76*
Uganda (30)	12 Provenances	"good"	141.0	*55.5*	*23.5*	*9.3*	*75* to 96
Tanzania (48)	5 Provenances	nr	95	*37.4*	nr	nr	*75*

'All growth data were converted to an annual basis.
[2]Not reported.

Table 2—Growth of cedro hembra *(Cedrela odorata)* in plantations

Plantation site			Origin	Plantation				Annual growth
Location	Rainfall	Soil	of seed	Age	Spacing	D.b.h.	Height	in d.b.h.
	mm			yr	m	cm	m	mm
Puerto Rico *(64,65)*	1900	limestone	6 Provenances	8	2.4	4.4	4.5	5.6
Virgin Is., USA *(64,65)*	1000 to 1200	shallow, over shale	5 Provenances	8	2.4	5.9	4.5	7.4
ivorv Coast *(13)*	1300 to 1500	granite-derived sandy loam	8 Provenances	7.5	nr[1]	18.2	13.7	24.3
Nigeria (Orej *(14,15)*	1600	shallow sandy loam pH 5.5	11 Provenances	7.5	3.6	23.9	14.8	31.9
Tanzania *(36,50)*	1450	"well drained"	8 Provenances	5.6	4	16.1	12.5	28.8
Mexico (59)	1200	limestone-derived	Mexico "Mexicana"	8	0.5	12.0	10	15.0
Ecuador (59)	1200	alluvial, sandy	Cuba	6	2 by 4	24.0	18	40
Jamaica (59)	2500	limestone, light clay	Jamaica	5	2.5 (in lines)	8	nr	16
Mexico (59)	1100	limestone, thin stoney clay	Mexico	8	3	11	6	14
Mexico (59)	900	limestone, sandy clay	Mexico	12	1	8	6	6.7
Panama (59)	2600	alluvial, well drained	Panama	12	1.5 by 3	24	21	20
Honduras (59)	1800	limestone and volcanic	Honduras	13	1.5 by 3	28	15	21.5
Trinidad (59)	2400	limestone, well drained	Trinidad	15	nr	32	23	21.3
Ecuador (59)	1200	alluvial	Cuba	18 to 20	3	50	25	25.0
	in			yr	ft	in	ft	in
Puerto Rico	75	limestone	6 Provenances	8	8.0	1.7	14.8	0.22
Virgin is., USA	39 to 47	shallow, over shale	5 Provenances	8	8.0	2.3	14.8	0.29
ivory Coast	51 to 59	granite-derived sandy loam	8 Provenances	7.5	nr	7.2	44.9	0.96
Nigeria (Ore)	63	shallow sandy loam pH 5.5	11 Provenances	7.5	11.8	9.4	48.6	1.26
Tanzania	57	"well drained"	8 Provenances	5.6	13.1	6.3	41 .0	1.13
Mexico	47	limestone-derived	Mexico "Mexicana"	8	1.6	4.7	32.8	0.59
Ecuador	47	alluvial, sandy	Cuba	6	6.6 by 13.1	9.4	59.0	1.57
Jamaica	98	limestone, light clay	Jamaica	5	8.2 (in lines)	3.1	nr	0.63
Mexico	43	limestone, thin stoney clay	Mexico	8	9.8	4.3	19.7	0.55
Mexico	35	limestone, sandy clay	Mexico	12	3.3	3.1	19.7	0.26
Panama	102	alluvial, well drained	Panama	12	4.5 by 10	9.4	68.9	0.79
Honduras	71	limestone and volcanic	Honduras	13	4.5 by 10	11.0	49.2	0.85
Trinidad	94	limestone, well drained	Trinidad	15	nr	12.6	75.5	0.84
Ecuador	47	alluvial	Cuba	18 to 20	9.8	19.7	82.0	0.98

[1]Not reported.

Natural forests containing cedro in Mexico yielded only 2000 m^3 (about 71,000 ft^3) per year in a total area of 460 000 ha (1,137,000 acres), for an annual yield of 0.004 m^3/ha (0.057 ft^3/acre). Mahogany yields from the same forest were eight times higher. This illustrates the present low stocking of cedro in natural forests, although the low density may be due in part to past exploitation and lack of regeneration *(52,53)*. In contrast, 40-year-old plantations in Africa yielded 455 m^3/ha (6,500 ft^3/acre) at the end of the rotation, and a yield of 150 to 270 m^3/ha (about 2,100 to 3,900 ft^3/acre) over a 35-year rotation was estimated for line-planted cedro in Surinam *(34,58)*. Webb *et al. (61)* cited 11 to 22 m^3/ha (157 to 314 ft^3/acre) per year for managed cedro plantations worldwide. Marshall calculated cedro yield by diameter classes in Trinidad *(40)*; volume tables have been published *(9)*.

Rooting Habit-Some confusion exists regarding the rooting habit of saplings and mature cedros. While early workers all reported a very superficial root system, recent literature (34) suggests that the species can become deeply rooted if the soil is loose and coarse or fissured. This is compatible with previously reported observations of vigorous cedro growth on old masonry and in light and well-aerated soils. Seedlings, at any rate, are very superficially rooted and may be sensitive to mechanical damage from weeding and other soil preparation activities *(10)*.

Reaction to Competition-Although tolerant of weeds during the seedling stage *(63)*, cedro is classed as intolerant of weeds and shade at the sapling stage and beyond (34). Its thin and spreading crown of light green leaves suggests the habit of a light-

demanding species as does its potential for fast growth and its appearance after fire *(34)*, in hedgerows (40) and on ruins (48). It is best described as late successional, as it has a moderately long life span. In Trinidad and elsewhere, cedros with more than 100 growth rings are not uncommon *(1,40)*.

Attempts to ***grow Cedrela*** in plantation systems in Latin America were almost entirely unsuccessful until recently. These early failures *(10, 11,17,23,39,40,51)* have been attributed to poor choice of experimental sites (too wet, wrong soils), increased risk of insect attack in the dense artificial populations *(20)*, and misunderstanding of light requirements (58). However, a few successes may point to fruitful avenues of further experimentation. Under dry conditions, cedar was successfully grown in plantations in Ecuador with no shade and no apparent ***Hypsipyla*** shootborer problems (59). Successful line plantings have been established in Surinam and the taungya system has been used in Mexico *(42,58)*.

Damaging Agents-Cedro can tolerate some crown damage by hurricanes and will often resprout. Shade-grown seedlings are sensitive to sunscald after which they become more vulnerable to insect attack. Cedro from tropical provenances is not likely to be frost tolerant. Provenances showing frost resistance grow more slowly than tropical provenances *(34,44,57)*.

Plantations of cedro have suffered snail damage in Malaysia and Africa. Slugs killed some nursery stock of an exotic provenance in the Virgin Islands, Beetle damage is a problem in some plantations in Africa, but evidently not in the New World *(34,44,62)*.

The most serious insect pest of cedro is the mahogany shootborer ***Hypsipyla grandella (24).*** The larvae of this moth eat the pith just behind the growing tip of fast-growing shoots, causing death of the apical meristem. In turn this slows seedling and sapling growth and may ruin tree form, since multiple leaders or bushiness often result. Shootborer attack may also contribute to seedling mortality, especially in already stressed populations *(3,20)*. Although the borer has been studied extensively *(21,49,63)*, an integrated control system has not yet been developed. It has been observed that pest attacks are least frequent in strongly seasonal climates, where the cycle of insect reproduction is naturally broken at least once a year *(23,63)*. Attack is also less frequent in natural forest where host trees are few and widely scattered, so that large pest populations never build up, under shade as contrasted to full sunlight, and in dormant seedlings *(20,26,62)*. Provenance trials of cedars from a wide geographic range have shown that they may vary in response to attack ***(12)*** and careful selection may allow future development of tolerant strains. Some progress has been made in chemical and biological control strategies *(2,3, 18,19,22)* but, regardless of the chemicals used, the target insect may eventually develop resistance to them.

Special Uses

Cedro wood is still in considerable demand wherever it is available in the American tropics. An attractive, moderately lightweight wood (specific gravity 0.4), its primary use is in household articles used to store clothing. Cedro heartwood contains an aromatic and insect-repelling resin that is the source of its popular name, Spanish-cedar (it resembles the aroma of true cedars *(Cedrus* spp.). The easily worked wood is both rot-resistant in the ground and highly termite-resistant, making it suitable for exterior construction. Cedro works easily and makes excellent plywood and veneer and would be more widely used if it could be successfully plantation grown *(34,35,48,52)*.

Cedro is an important avenue and shade tree in the West Indies and South America, and where imported, in Africa. It has also been used successfully as cacao and coffee shade in Trinidad.

Genetics

Population Differences

The genus *Cedrela* has undergone two major systematic revisions since 1960. The most recent revision reduced the number of species in the genus to seven (53). The common cedro, ***Cedrela odorata*** L., embraces 28 other named species, including C. *mexicana* M. J. Roem. ***The*** taxon ***"C. angustifolia,"*** a very vigorous type now in demand because of its apparent resistance to the shootborer, was left in an indeterminate status due to insufficient herbarium material. The result is that ***C. odorata*** as now constituted is a species showing a high degree of population variation. The West Indian material, upon which the original species description was based, is characterized by glabrous foliage with sessile leaflets, whereas the variety (formerly species) ***"mexicana"*** of Central and South America has varying degrees of pubescence, as well as generally larger leaves with petiolate leaflets, but intermediate varieties exist. Early plantation trials indicated that the variety called ***"mexicana"*** is faster growing than the West Indian race (59).

Races

Recently completed provenance trials *(7,8,12,13, 14,15,26,32,33,35,44,46,50,62,65)* have suggested that many ecological races of cedro exist. Provenance differences showed up most clearly in African trials, where they were not masked by the adverse effects of the shootborer. Efforts are underway to expand provenance trials to include more seed sources for promising types *(12)*.

Hybrids

Smith (51) suggested that the widely distributed species of cedro, *C. odorata* and *C. fissilis*, as well as the doubtful taxon *C. angustifolia* (which he recognized as a separate species), hybridized freely, and that hybrids could explain the great phenotypic variability in these taxa. Unfortunately, there is still no experimental evidence to support or reject the hybridization hypothesis. Recent cytological studies have shown that at least two separate basic diploid chromosome numbers (2n= 50 and 56) occur in C. *odorata;* this occurrence of different intraspecific chromosomal races seems widespread in the Meliaceae and may inhibit free hybridization *(54,56)*.

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