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Cedrela angustifolia Ses. et Moc. ex Dc., Meliaceae: potential species for tropical dendrochronology

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ABSTRACT

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The characteristics of *Cedrela angustifolia*, i.e., its dendrology, ecology, silviculture and wood anatomy were described. This Meliaceae species naturally occurring in Latin America produces annual growth rings with sensibility to climatic variables, such as rainfall and temperature, showing potentiality to climatic reconstruction. The X-ray densitometry of the wood constitutes, besides the usual wood anatomy analysis, a suitable method to delimit the annual growth rings, as well as, to determine the wood density variation from pith to bark and within the growth rings.

Key-words—*Cedrela angustifolia*, Meliaceae, Dendrochronology, X-ray densitometry, Growth rings.

सिड्रेला एंगस्टीफोलिया सेस. एट् मॉक. एक्स डीसी., मीलिएसी : उष्णकटिबन्धीय वृक्षवलयकालानुक्रमिकी हेतु प्रभावी प्रजाति

मारियो टोमाज़ेलो एफ़, पी.सी. बोतोसो, सी.एस. लिसी एवं पी. स्पेतेल्फ

सारांश

प्रस्तुत शोध पत्र में *सिड्रेला एंगस्टीफ़ोलिया* के अभिलक्षणों, जैसे — वृक्षवलयकालानुक्रमिकी, पारिस्थितिकीविज्ञान, वनवर्धन एवं काष्ठ शारीरविज्ञान का वर्णन किया गया है।। ये मीलिएसी प्रजातियाँ, जो प्रायः लैटिन अमरीका में पाई जाती हैं, जलवायुविक पुनर्रचना से प्रभाविता प्रदर्शित करते हुए जलवायुविक चरों, जैसे — जलवृष्टि एवं तापमान के साथ संवेदनशीलता से युक्त वार्षिक वृद्धि वलयों का उत्पादन करती है। सामान्यतः किए जाने वाले काष्ठ शारीरविज्ञान विश्लेषण के अतिरिक्त काष्ठ की एक्स-रे घनत्वमिति वार्षिक वृद्धि वलयों को सीमांकित करने हेतु तथा वृद्धि वलयों के भीतर एवं मज्जा से छाल वल्क के मध्य काष्ठ घनत्व के निर्धारण हेतु सर्वाधिक उपयुक्त प्रविधि है।

संकेत शब्द—*सिड्रेला एंगस्टीफ़ोलिया*, मीलिएसी, वृक्षवलयकालानुक्रमिकी, एक्स-रे घनत्वमिति, वृद्धि वलय.

INTRODUCTION

CEDRELA constitutes an important neotropical genus occurring from Mexico (latitude 26° N) to northern Argentina and the south of Brazil (latitude 28° S), including all countries of Latin America, except Chile. The *Cedrela* species occur in dry and wet low lands up to an altitude of 1,200 m as well in drained soils of the tropical and subtropical forests usually associated with broadleaves and conifers (Hueck, 1972; Rizzini, 1978). They are highly demanding of sunlight, frequently occurring as a pioneer, with high growth rates in secondary forests (Pennington, 1981). The genus consists of seven species, namely (i) *C. angustifolia*, occurring from Mexico to northern Argentina, except on the Antilles Islands, (ii) *C. fissilis*, from Costa Rica to Argentina, (iii) *C. lilloi*, in Peru, Bolivia and Argentina, (iv) *C. montana*, in Venezuela, Colombia and Equador, (v) *C. oaxacensis*, from Mexico to Panama, (vi) *C. odorata*, from Mexico to Argentina, and (vii) *C. weberbauerii*, in Peru (Smith, 1960; Gonzales, 1976; Ramirez & Styles, 1978; Rizzini, 1978). In Brazil three species of *Cedrela* occur naturally; *C. odorata*, considered the Amazonian forest cedar, *C. angustifolia*, the Atlantic forest cedar, and *C. fissilis*, the dry forest cedar, from the state of Minas Gerais to southern Brazil. According to Rizzini (1978) these species are interpenetrating in their areas of natural distribution in the Brazilian central region. Besides these, a fourth species, *C. lilloi*, is cited as occurring in southern Brazil (Carvalho, 1994).

In this paper particular emphasis is given to review the prospects of tree ring analysis of *Cedrela angustifolia* because of its ecological importance, distribution and dendrochronological applications.

CEDRELA ANGUSTIFOLIA: ECOLOGY, DENDROLOGY AND WOOD ANATOMY

In its area of distribution *C. angustifolia* is designated by an extensive list of common names like, cedro, cedro rosa, cedro branco in Brazil; cedro saltenho in Argentina; cedro blanco in Peru, among others ones (Girardi, 1975; Rizzini, 1978).

In Brazil, *C. angustifolia* is commonly found in all moist Atlantic forests, but frequent in the States of Espírito Santo, Rio de Janeiro, Minas Gerais, São Paulo and Paraná and rare in southern Bahia, and of minor importance in the State of Para. It is a large tree, 20-30 m height, shades leaves during the period of maturation of fruits, July-August; and producing new leaves and flowers in August-September (Rizzini, 1978).

In Argentina, *C. angustifolia* occurs in the oriental boundary of the high mountain forest in the Chaquenho Park, from 1700 to 1900 m of altitude (Villalba, 1995). It also occurs in northwestern Argentina and western Bolivia, in the Tucumano-Boliviana forest, at 28° South latitude and 200-1,900 m of altitude. The trees are co-dominant reaching 40 m high and 1·50 m of trunk diameter, presenting the growth period from September to April - May, followed the period leaves fall (Villalba *et al.*, 1985). In the Tucumano-Oranense forest, (at 22-28° south latitude, 800-1,900 m altitude, 1,400 mm/year precipitation) *C. angustifolia* trees reaches 35 m high and 2·50 m trunk diameter at 800 m of altitude, but are smaller and less abundant in high altitudes (Tortorelli, 1956; Villalba *et al.*, 1987).

Descriptions of *C. angustifolia*, including taxonomy, botany, ecological, phenological and silvicultural and related aspects are presented by several studies (Tortorelli, 1956;

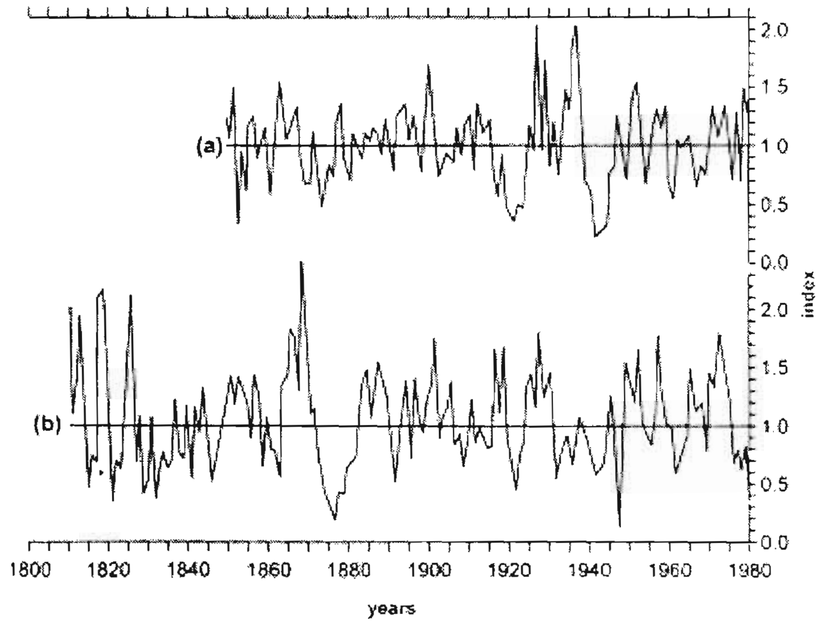

Fig. 1—Chronological series of *Cedrela angustifolia* trees, in Rio Blanco (Jujuy) (a) and Finca del Rey (Salta) (b), Argentina (after Villalba *et al.*, 1985).

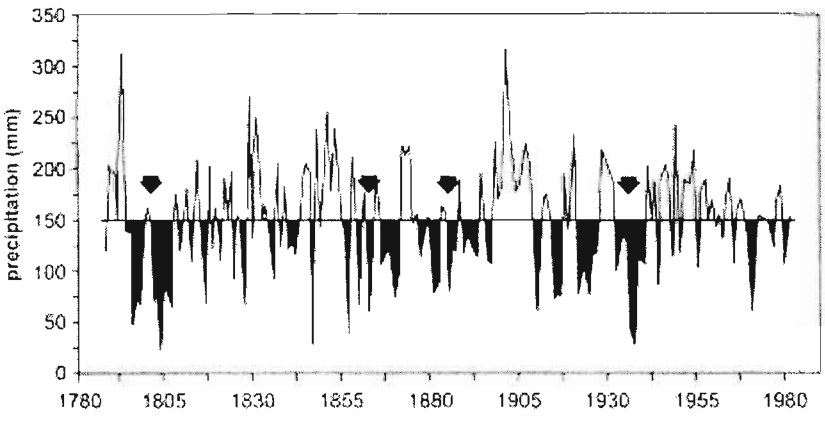

Fig. 2—Precipitation reconstruction of the annual dry period (June-November) since 1788 in Jujuy city, Argentina. Dry periods are indicated by arrows (after Villalba, 1995).

Smith, 1960; Girardi, 1975; Sanchez *et al.*, 1976; Rizzini, 1978).

The wood of *C. angustifolia* has a yellowish-rose coloured sapwood and the heartwood colour varies from reddish-brown to darkened rose beige, depending on the provenance. The wood has a wide utilization in marquetry, carpentry, aeronautics, naval and civil constructions, etc. (Tortorelli, 1956; Rizzini, 1978; Villalba *et al.*, 1985). The anatomical wood characteristics of *C. angustifolia* were described by Peréz Mogollon (1973), Lebacq (1973) and Dechamps (1985), examining wood samples collected from Venezuela, Peru and Brazil, respectively. The presence of well-defined growth rings marked by initial parenchyma bands and vessels forming semi-porous rings have been reported in all these studies.

CEDRELA ANGUSTIFOLIA: POTENTIAL IN TROPICAL DENDROCHRONOLOGY

The Meliaceae is included within the list of many tropical families which seems to be potential for dendrochronological studies with emphasis on its genus *Cedrela* (Chalk, 1983; Tomazello Filho *et al.*, 2000). This tree combines fundamental characteristics like, (i) large trunk diameter and high growth rates, (ii) distinct phenophases with the trees leaf-fall in the dry season, in natural stands and plantations, (iii) wood with important anatomical features, i.e., distinct and well-defined annual growth rings, (iv) medium density wood, permitting the extraction of samples by non-destructive methods. These features make *C. angustifolia* more significant for dendrochronological studies in trees (Villalba *et al.*, 1985, 1987, 1992; Villalba, 1995; Boninsegna & Villalba, 1996).

Two chronologies of *C. angustifolia* were elaborated in Argentina and northern Bolivia from trees growing in low latitude forests, where the growth period is from September to April-May with the fall of leaves and the trees are completely leafless. The distinct and well-defined annual tree rings are formed in response to the phenological phases, presenting a fine uniformity in the cross section of a trunk, which allows to get a high quality cross-dating. For these trees, temperature and precipitation in the beginning of the vegetative growth period seems to induce an increase in the width of growth rings. The statistical analysis of chronologies shows a high average sensitivity and signal-to-noise ratio, with a high percentage of variance explained by the first "eigenvector" and a high correlation between the trees. Consequently, the chronologies have a very strong common signal with a good potential for climatic reconstruction (Villalba *et al.*, 1985) (Fig. 1).

In mountain forests of northwestern Argentina, two chronologies of *C. angustifolia* trees were constructed, establishing the relationship between growth rings and local climatic variations. In xeromorphic environmental conditions the diameter growth of the trees was controlled by temperature and precipitation of spring and beginning of summer. A positive correlation between growth rings and climate was detected in at the upper limits of the occurrence of the species.

Thus, tree ring data of *C. angustifolia* can be used for local climatic reconstruction, like the periodicity of dry periods in northwestern Argentina. In Jujuy city, for example, correlation coefficients between the precipitation of the dry season (June-November) and four tree-rings chronologies were calculated for the period 1909-1979. Then, these correlation coefficients were applied to the growth-ring chronologies until 1788, extending the winter precipitation back to 200 years. The reconstructed climate data reveal extremely dry periods in 1795-1807, 1858-1870, 1877-1892, 1934-1938 (Villalba, 1995) (Fig. 2).

In the transition area of Tucumano-Orense forest and Chaqueño Park, Argentina, tree ring samples were collected from 26 *Cedrela angustifolia* trees. These samples were dated through cross dating technique. Tree growth climate relationship is yet to built. In Cerro Chañar site, 1,600 m a.s.l. and 1,400 mm of annual average precipitation, the trees showed a positive relationship with spring-summer precipitation and a negative relationship with summer temperature. In Río

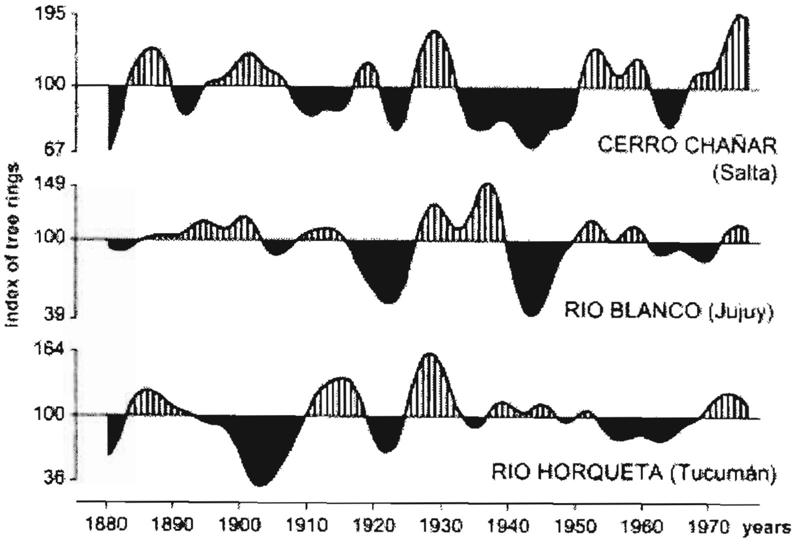

Fig. 3—Chronologies of the growth rings thickness index of *Cedrela angustifolia* trees in Cerro Chanar/Salta and Rio Blanco/Jujuy, Tucumano-Orense forest / Chaquenõ Park, Argentina (after Villalba *et al.*, 1987).

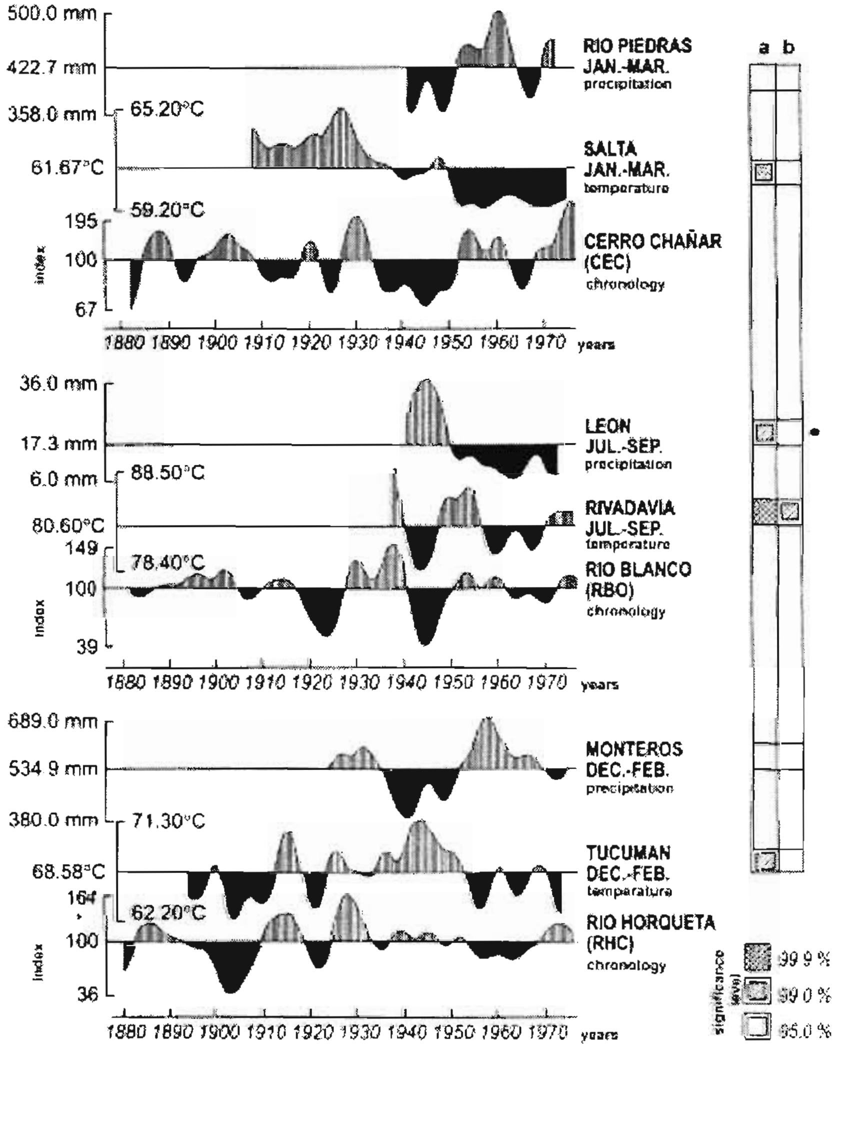

Fig. 4—Comparison of the tendencies of growth ring index of *Cedrela angustifolia* trees in Cerro Chanar e Rio Blanco with seasonal climate. The tendencies were determined by the average of the index with low frequency digital filter. The significance levels are indicated to (a) coefficient of correlation, (b) percentage de acceptance (o) inverse relation (after Villalba *et al.*, 1987).

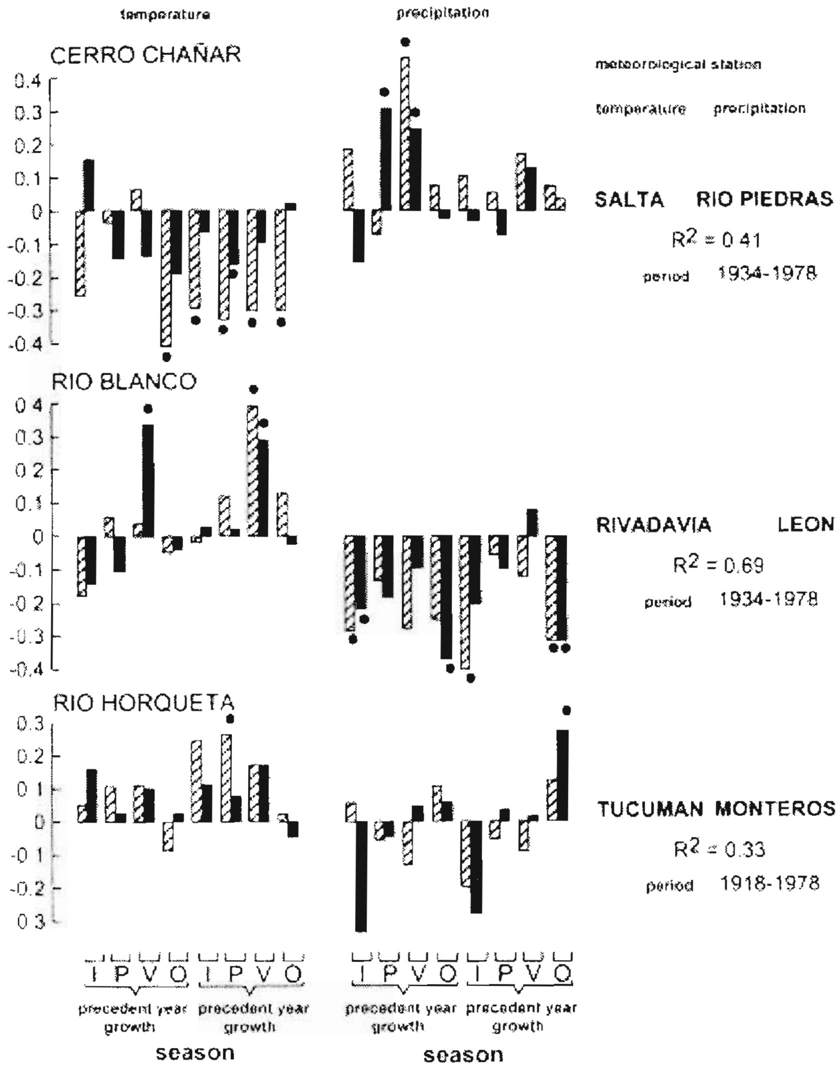

Fig. 5—Correlation function (●) and response function (■) to chronologies de *Cedrela angustifolia* in Cerro Chanar e Rio Blanco. Coefficient of correlation and response function significant at 95% (●). To the response functions the % of variance explained by climate is presented (R2). The climatic seasons are abbreviated as I, winter; P, spring; V, summer; O, autumn (after Villalba *et al.*, 1987).

Blanco site, at 1,870 m of altitude, upper limit of distribution of this species, the summer temperature constitutes the primary climatic parameter inducing tree growth. The precipitation of the end of winter and beginning of spring and autumn seems to be negatively related to trees growth, probably due to an indirect effect on the amount of incident radiation (Villalba *et al.*, 1987) (Figs. 3, 4, 5).

In subtropical northwestern Argentina 12 chronologies were made by Villalba *et al.*, (1992) using tree ring data of *C. angustifolia* and *Juglans* and reconstructed the seasonal and annual precipitation explaining 60-80 % of precipitation variance. A recent literature revision of dendroclimatology in the South Hemisphere, Boninsegna and Villalba (1996) concluded that in the tropical region, the growth rings of *Cedrela angustifolia* trees at 24° S produce chronological series with sensitivity to climatic conditions.

In Brazil, the wood anatomical analysis of *Cedrela angustifolia* trees enables the distinction of clearly visible annual growth rings, delimited by initial parenchyma bands and semi-ring porousity. Under stereomicroscopy it was possible to determine the tree age and annual and cumulative increment rates, with significant variations between the 3 different phases of the tree growth, higher at 1-5th and 16-20th and lower at 6-15th years (Fig. 6). The X-ray densitometry can also be applied for the delimitation of annual growth rings and the determination of wood density variation, from pith to bark. Maximum wood density values of latewood of some years, i.e., 15th year (0·90 g/cm^3) were distinct comparing with other, i.e., 3th, 7th (0·45 g/cm^3), probably due to climatic variation. These results show the potentiality of both methodologies in dendrochronological studies of tropical species, i.e., *Cedrela angustifolia*, including tree age

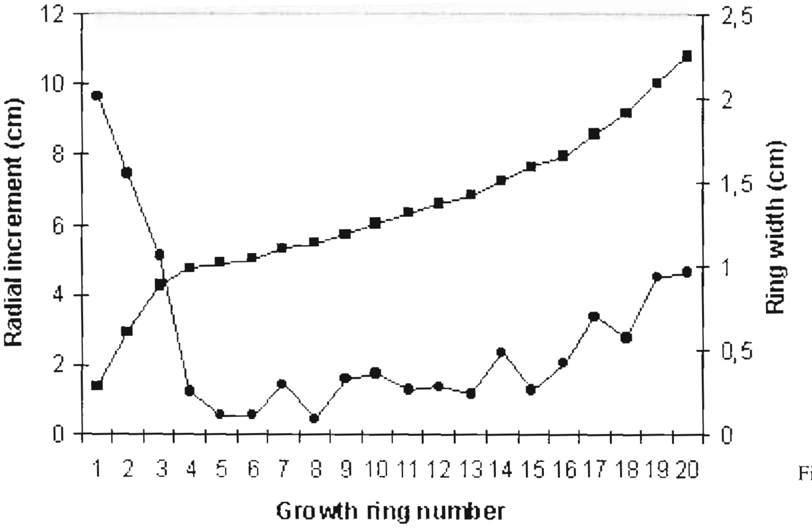

Fig. 6—Annual (•) and cumulative radial (♦) increments of *Cedrela angustifolia* tree.

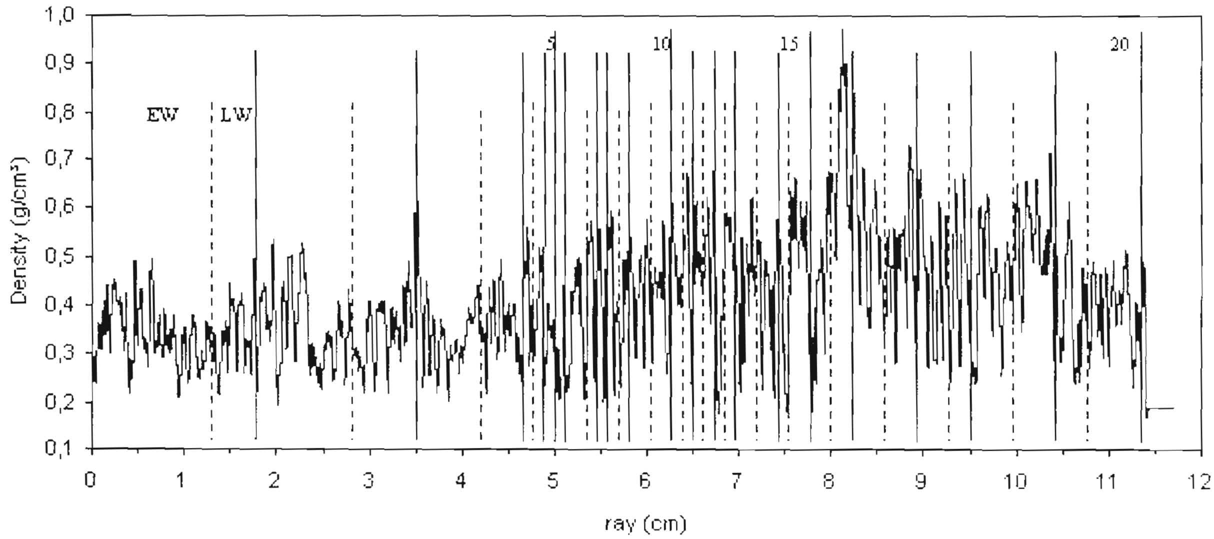

Fig. 7—Wood density profile, by X-ray densitometry, and demarcation of annual growth ring and boundaries of early (EW) and latewood (LW) of *Cedrela angustifolia* tree.

determination, stand dynamics and relationship between climate, etc. (Fig. 7).

CONCLUSIONS

The number of tropical and subtropical species applied in dendrochronology has been increased, allowing the age and growth rate determination through growth-ring analysis. Among the species, emphasis has to be given to *Cedrela*, an important member of the Meliaceae family and, in particular, to *C. angustifolia*. Occurring in large areas of the Latin American continent, in different ecological conditions, *C. angustifolia* produces annual growth-rings with climatic sensitivity used to the construction of chronologies related to climate, population dynamics, phenology, forest management, etc. Usually the tree-ring analysis consisted of the observation and measurement directly on polished wood cross section. However, the X-ray densitometry commonly used in conifer species, can be also applied to *C. angustifolia* for dendrochronological purposes.

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