AN ABSTRACT OF THE THESIS OF

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Rates of Five Important Tree Species in Costa Rica
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Henry A. Froehlich

The growth of *Alnus acuminata* (HBK) O. Ktze, *Cupressus lusitanica* Mill., *Gmelina arborea* Roxb, *Pinus caribaea* var. hondurensis Barr. & Golf., and *Tectona grandis* L. in Costa Rica and twenty seven soil and climatic factors were analyzed to determine the relationship between major environmental factors and growth rates of these five species. The growth of the species was compared within specific climatic zones of Costa Rica, and in the country as a whole. A reduced set of environmental factors was selected that best explains the species growth in the country and in specific geographic zones.

The forestry plots used in this study were installed by the Forest Service of Costa Rica, complemented with a few private farmer plantations. Diameter at breast heigh (dbh), the height, and volume growth of the trees were used as dependent variables. Data for twelve climatic variables were obtained from the national meteorological stations. Fifteen soil characteristics were evaluated for each study site.

The growth of Alnus was found to be related to relative humidity, the distribution of precipitation and the percentage soil base saturation. Within the range evaluated (78-80%) an increase in the mean annual relative humidity will depress growth of this species.

For Cupressus it was found that soil texture (% silt content), altitude of the plots, soil base saturation, as well as cation exchange capacity and nitrogen in the Central Valley of Costa Rica, were the environmental factors most closely related to the growth of this species. For the altitudinal range evaluated (1100-2620 m) a decrease in growth can be expected as altitude increases.

Growth of Gmelina was found to be closely related to soil characteristics: available phosphorus, exchangeable sodium and potassium, cation exchange capacity and organic matter. The general observation from this regression analysis and experience in other countries is that Gmelina requires fertile soils and favorable physical properties for optimum growth. However, this species is growing satisfactorily in all areas below 500 meters of elevation in Costa Rica; no data is available above this elevation.

Amount and distribution of precipitation, exchangeable potassium, magnesium, and sodium, soil texture, and an energy factor (number of hours of light and radiation, or interaction of these two variables) were the factors most closely related to the growth of P. caribaea in the country.

For Tectona it was found that soil texture, temperature, and exchangeable potassium, calcium, and sodium were the factors most

closely related to the growth of this tree in Costa Rica.

The information developed in this study provides a better basis for understanding the growth requirements of these five species. However, planting guidelines must await the inclusion of additional data into the analysis.

Key words: soil fertility, tropical climate, tropical forestry, growth rates, introduction of species, *Alnus acuminata* (HBK) O. Ktze, *Cupressus lusitanica* Mill., *Gmelina arborea* Roxb, *Pinus caribaea* var. hondurensis Barr. & Golf., *Tectona grandis* L.

THE EFFECT OF MAJOR ENVIRONMENTAL FACTORS ON GROWTH RATES OF FIVE IMPORTANT TREE SPECIES IN COSTA RICA

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INTRODUCTION

The testing of species, native and introduced, is a common activity in tropical and subtropical areas, mainly because tropical forests are not as productive as temperate forest in economical terms (yield of marketable wood per unit land area). Tropical forest are very complex (formed of a large number of tree species) and this has made the harvest procedure in these areas a selective activity. Only individual trees are harvested because of the selected utilization by the timber industry. In some cases this low volume per unit area could make the extraction cost so great that the timber harvesting becomes a low-profit activity (Camacho, 1983).

Researchers in many countries of Africa, Asia and America as well as Costa Rica are involved in the process of introducing and testing new tree species. These researchers have reported on growth rates, yield per unit area, and recommendents for future reforestation activities. Some authors (Martinez, 1981; Camacho, 1981) have already made recommendations about the more appropiate species to plant in Costa Rica based on a preliminary analysis of the forest plots in the country.

Evaluation of environmental factors affecting the growth of introduced tree species has not been commonly studied. Exceptions are: Pande (1982) Ferreira and Z. do Couto (1981), Teoh (1981), Fassbender and Tschinkel (1974) and Wasan and Sukwong (1974).

Forestry research in Costa Rica began in 1948 in the Tropical Agronomic Center of Investigation and Teaching (CATIE) (Martinez, 1981). More recently the Forestry Development Project of Select Zones of FAO (Food and Agriculture Organization) in conjuction with the Institute of Lands and Colonization (ITCO) established plots in 1965 (ITCO, 1967), followed by the reforestation project on the slopes of Irazu Volcano started by the Civil Defense in 1967-1968. The Agricultural Diversification Office also initiated in 1970 a reforestation program with private tree farmers. (Camacho, 1981).

The General Forestry Direction Unit (DGF) of the Ministry of Agriculture and Animal Husbandry (MAG), initiated a program in 1971 of study plot installation whose objective was to generate basic information for future policies in commercial forestry plantation projects. This program led to the installation of more than 500 plots with 70 different species distributed throughout the country. Since the beginning of the investigation, the Forestry Department and more recently the Technological Institute of Costa Rica (ITCR), have been using different silvicultural practices in order to protect and provide for the development of those species.

Study plots were initiated in Costa Rica in 1971 with the goal of testing individual species and their behavior in pure stands, and also with the purpose of obtaining a more efficient forest to supply the future demand for wood. Now that most of the natural forest of the country is almost gone, the project becomes more important because the information these plots are providing can be used to direct the future policies and reforestation programs in Costa Rica.

The study of environmental factors that might affect the behavior of these introducted and native species is important. In the specific case of Costa Rica, some experimental plots have been observed since 1948 complemented by the analysis of their soil characteristics; meteorological data are also available from a good distribution of measurement stations. With this basic information, this research project was initiated to determine the effect of major environmental factors on growth rates of important tree species in the country.

Study Objective

The general objective of this study was to determine the relationship between major environmental factors and growth rates of the following five important tree species in Costa Rica: Alnus acuminata (HBK) O. Ktze, Cupressus lusitanica Mill., Gmelina arborea Roxb, Pinus caribaea var. hondurensis Barr. & Golf., and Tectona grandis L. Specific objectives were:

1) To test and compare the behavior of the species in specific climatic zones of Costa Rica and in the country as a whole.

2) To select the set of environmental factors that best explain the species behavior in the country and in specific growth zones.

LITERATURE REVIEW

Silvics of Alnus acuminata (HBK) O. Ktze. [1/]

The common name of this species in Costa Rica is Jaul. Whereas it is also known as alder in temperate areas. Initially this tree was described as Alnus jorullensis HBK, a common species in South America (Holdridge, 1951). Both alders belong to the Betulaceae family.

Species description

A. acuminata is a medium size tree with a wide top and large branches when growing in open places. The leaves are simple, alternate, dentate, and coriaceus. The flowers are grouped in aments. The fruit is a yellow nut, indehiscent and comprised of 80 to 100 winged seeds.

Habitat

In Costa Rica the tree occurs in the tropical region at elevations between 1500 and 2500 m. In the provinces of San Jose, Cartago, Heredia and Alajuela, the species forms the natural forest, and also is found in plantations. (Combe, 1979b).

Geographical range

Jaul is widely distributed throughout Central and South America specifically from Mexico through Central America to Argentina. Holdridge (1951) mentioned that A. acuminata is

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[1/] The description of these species and other silvicultural information was taken from Camacho (1981).

common in Central America.

Climatic range

Alder grows well in places where precipitation ranges between 1500 and 3000 mm/year and where mean annual temperature range from 16°C to 18°C. The species can withstand temperatures below 0°C for a short time. This tree has a high demand for moisture, in both soil and air. It prefers sites well supplied with moisture and having many cloudy days.

The species is found in the Lower Montane Moist Forest and Lower Montane Wet Forest life zones (classification according to Holdridge, 1969).

Edaphic range

Alder can grow well on well drained soils with high organic matter content. The tree is found near streams, in eroded pasture lands, in landslide areas and roads banks. Growth is poor in sites subject to flooding or in swamps.

Silvicultural characteristics

Alder is a pioneer species that needs a lot of light for good development, it requires the soil to be free of weeds at least during the time of establishment, and it also needs a high moisture level in the soil. The tree grows fast and fixes atmospheric nitrogen.

Use

The wood from this species is in high demand by wood processors in Costa Rica. It is utilized as fuel, in light construction, furniture, domestic articles, musical instruments, shoe manufacturing, and the production of pulp and paper. A recent project demonstrated that the wood is also suitable for building of wooden structures (Tuk, 1980).

Silvics of Cupressus lusitanica Mill. 1/

This tree is commonly known as cypress and belongs to the family Cupressaceae. In Costa Rica it is named cipres.

Species description

Cypress forms a large tree with a straight columnar stem channeled in the lower part of the trunk. The leaves are dotted, have scale form and are attached in rows of four to the branches. The female flowers present a globose inflorescense and the male flowers are grouped in aments 2-4 mm long. The fruit is a globose strobile of 6 to 8 scales from 10 to 15 mm in diameter. It is maroon in color.

Habitat

C. lusitanica is an exotic species that has become naturalized in Costa Rica due to its adaptability to the soil and climate of the country. The optimum altitudinal belt for cypress in Costa Rica is from 800 to 3000 m but it can grow at higher or lower altitudes.

1/ The description of this and following tree species was taken from Camacho (1981).

Geographical range

Cypress is native to Mexico and Guatemala. In the Americas it has been artificially propagated from Mexico to Argentina. Spain, Portugal, East Africa, and Oceania are important regions where the species has become an important plantation tree.

Climatic range

Cypress grows in zones with precipitation between 1000 to 4000 mm/year, but can survive long periods of drought. The mean annual temperatures in its habitat are generally greater than 12°C with occasional frost or critically low tempereratures. The tree is well adapted to the Lower Montane Wet Forest and Premontane Wet Forest life zones formations (Holdridge, 1969).

Edaphic range

This species prefers deep soils with good drainage, and high organic matter content. It can adapt to eroded soils but growth will be less than optimum.

Silvicultural characteristics

Cypress is highly demanding of light, but can tolerate some shade. During its first two years it does not survive long periods of dryness. Little is known about the development of this tree in natural conditions; however, our limited data for Costa Rica shows good growth as an introduced species (Camacho, 1981).

Use

Cypress trees have been used for shelterbelts. The wood can be used for rural construction, parquet, domestic articles, telephone poles, railroad ties, and more resently as a decorative wood.

Silvics of Gmelina arborea Roxb.

The common name of _G. arborea_ in Costa Rica is melina and it belongs to the family Verbenaceae.

Species description

G. arborea is a deciduous tree that can grow quite large. The trunk is short if grown in open spaces. In plantations it is straight and without defects. The leaves are opposite, from 10 to 25 cm long and 5 to 15 cm wide, and ovate in form. The flowers are yellow and grouped in terminal panicles. The fruit is a yellow ovoid drupe, smooth when ripe and approximately 2 to 3 cm in diameter.

Habitat

Gmelina was introduced in Costa Rica by the Instituto Interamericano de Ciencias Agricolas (IICA) in the years 1967-1968, forming part of a program of adaptability and provenance trials. It grows in lowlands of the country to a maximum of 600 m where the species has demonstrated very rapid growth and an adaptability to a variety of soils.

Geographical range

The species is distributed geographically throughout India, Nepal, East Pakistan, Thailand, Laos, Cambodia, Vietnam and the southern provinces of China.

Climatic range

In its natural habitat, Gmelina grows best under temperatures between 16°C and 38°C with the presence of a dry season and precipitation between 1800 and 2000 mm/year.

Edaphic range

Gmelina prefers deep, fertile and moist soils with good drainage. It tolerates alkaline and light acid soils. The species does not adapt well to shallow soil or stony sub-soils, nor to very acid soils.

Silvicultural characteristics

Gmelina is one of the exotic species that has been demonstrated to be a fast growing tree requiring very short rotations. It does not tolerate shade and requires a lot of light for its ideal development. The species has been classified as transitory in the hygrophytic forest, invading from open areas where it grows very rapidily. The tree is resistant to fire; however, it is recommended that the trees be protected from it.

Use

The tree has been utilized as a nurse crop for the caoba

(Swietenia macrophylla). Also plantations have been managed by the Taungya System (cropping during the early stage of the tree plantation). The wood is utilized for construction in general, plywood, particleboard, and shipbuilding. It is considered an important species for the production of pulp and paper. Also, many medicinal uses of this tree are reported in its area of natural distribution.

Silvics of Pinus caribaea var. hondurensis Barr. & Golf.

The tree is commonly named caribbean pine and belongs to the Pinaeae family.

Species description

The tree can reach large dimensions, is cylindric and straight or lightly curved. The leaves are grouped in fascicles of 3 to 4 needles, their color is green-yellow, 5 to 30 cm long and 1 to 1.5 mm wide. The female flowers are produced in small tenued cones, alone or grouped. The fruit is a greyish cone, brown or brown-red, with a length of 3 to 14 cm and from 3 to 5 cm wide.

Habitat

This species is naturalized, with a very wide range of distribution in Costa Rica, extending from the Atlantic Zone to the Pacific Zone, and from sea level to an altitude of 900 m. Camacho (1981) reported that it does well also at 1100-1200 m of elevation.

Geographical range

Caribbean pine is naturally distributed in Bahamas Islands, Cuba, and the Caribbean Coast from Honduras to Nicaragua.

Climatic range

The required mean annual temperature is about 25°C, ranging from 18°C to 28°C. The necessary precipitation ranges between 500 to 1000 mm/year. In its place of origin, the precipitation ranges between 500 to 3500 mm/year, requiring a pronounced dry season and an absence of frost.

Edaphic range

This tree grows in a wide variety of soils from poor to fertile soils, from soils in the coasts to soils in the mountains where it usually shows better growth. The species can grow in sandy, infertile alluvial soils, as well as in deep granitic soils. Good soil drainage favors the growth of this tree.

Silvicultural characteristics

In general the species can adapt well to new sites and grow rapidly. Wind may affect the plantations, bending and breaking the trunks, which is a very common problem in windy areas.

Use

This tree is used as firewood, for telephone poles, wood for general construction, furniture, parquet, disinfectants, resins, plywood, particleboard and also in the pulp and paper industry.

Silvics of Tectona grandis Linn.

This tree is popularly named teak and belongs to the Verbenaceae family. In Costa Rica it is named teca.

Species description

Teak can reach a large size. It is a deciduous tree with a clear cylindrical trunk. The large leaves are opposite, eliptic-ovalate and channeled.

Habitat

The date of introduction of teak to Costa Rica and its provenance is not known. However, the species is growing well on the majority of sites where it has been planted. The plantations in the Atlantic Zone (moist environment) are doing as well as in the Pacific Zone (more drier environment). All these forest plots are located below 600 m of elevation.

Geographical range

It is distributed in South-east Asia (India, Burma, Thailand, Laos and Indonesia) from sea level to 1000 m.

Climatic range

The tree is limited to areas with a range of precipitation from 500 to 5000 mm/year. Its optimum growth occurs where rainfall is between 1500 to 2000mm/year. The species is adaptable to climates ranging from wet to dry, with a dry season of 3 to 5 months. The mean annual temperature for optimum growth is between $22^{\circ}C$ to $27^{\circ}C$, however it is adapted to a wider range that goes from $2^{\circ}C$ to $36^{\circ}C$. It does not tolerate frost, which will kill it. In general, teak reach its best growth in warm, slightly wet tropical climates.

Edaphic range

Teak prefers fertile, deep, well drained soils. Since it does not tolerate extremely wet soils it does not grow well in heavy clay soils, but will generally grow in a great variety of geological formations.

Silvicultural characteristics

Teak is an extremely heliophytic species that does not tolerate shade in its first year of growth. Therefore the trees need to be free of weeds. The tree grows fast initially and somewhat slower in later years.

Use

This species is used for construction in general, furniture, bridges, railroad ties, parquet, and is also considered an excellent fuel wood.

Environmental Factors and Effects on Trees Growth

Plant growth is probably controlled by a combination of all environmental factors. However, some factors will exert greater influence than others so that for practical purposes, it is unnecessary to consider all factors in attempting to predict plant growth. Scott (1969) mentioned that the interactions between plants and environment could be one of several types: 1) The major aspect of growth is influenced by a single factor 2) growth is influenced by a few factors and each is of similar importance 3) a few factors influence growth but the importance of each is different, and 4) growth is influenced by a multitude of factors and the effect of each is different. It is possible to determine which of these various alternatives applies by using the results of a stepwise multiple regression analysis involving plant response and measurements of many environmental factors.

Fritts (1974) working with 127 coniferous tree sites in Western North America found that higher-than-average precipitation most commonly results in higher-than-average growth, though on cold sites the effects of precipitation during the cooler part of the year are sometimes lacking or inverse. Precipitation was directly related to growth throughout the entire year for 32% of the sites studied. In the remaining 68% of the sites the effects of precipitation varied from season to season. Temperature was found most commonly inversely related to ring width during autumn, spring, and summer. Site factors appeared most responsible for variations in the growth response. Aspect appeared to be the most critical, followed by altitude and latitude. The author also mentioned that the median percent of tree growth variance accounted for by climate is approximately 60 to 65%.

Graham et al. (1982) related environmental factors to forest regeneration on clearcut and partially cut areas managed by the Bureau of Land Management in the Hungry-Pickett area northwest of Grants Pass, Oregon. The multiple regression equations showed that difficulty of regeneration clearcuttings increases with increasing solar radiation, temperature, rock cover, and depth of the soil A horizon. Moreover, difficulty of regeneration of partial cuts increases with surface gravel cover and is related to slope, aspect, and vegetation. In addition, Minore et al. (1982) used multiple regression analysis to relate environmental factors and vegetation to post-harvest forest regeneration in the Applegate area of southwestern Oregon. Optimal environments for regeneration were identified by aspect, slope, elevation, rock cover, and vegetation.

Of a variety of climatic factors evaluated by Gholz (1979), growing season evaporative demand and mean minimum January air temperatures accounted for most of the variation in leaf area, biomass, and net primary production of Pacific Northwest vegetation. The former apparently reflects limitations imposed by a seasonal summer drought period, and the latter reflects limitations on winter carbon and nutrient accumulation, a major adaptative feature in many evergreen Pacific Northwest ecosystems.

Dry matter production is known to depend on the amount of solar radiation intercepted, which is itself determined by the leaf area of the crop (Biscoe and Gallagher, 1977). Early in the growing season small leaf area indices cause low radiation interception by the crop and this limits crop growth rate. The rate of leaf area expansion is strongly dependent on temperature, and cool weather severely limits leaf expansion rate. Periods of warm, bright weather can also limit both the rate of leaf expansion and the final size of the leaves if water stress develops.

The growth of seedlings of six tree species, *Betula verrucosa*, *Populus trichocarpa*, *Acer pseudoplatanus*, *Larix leptolepis*, *Pinus silvestris*, and *Pinus radiata*, was studied by Pollard and Wareing (1968). There appeared to be no clear differences in relative growth rates between broad-leaved and coniferous species as major classes, but there were significant differences within each group during the summer of 1964. The ability to respond to exceptionally favorable weather conditions appeared to be associated with the seasonal pattern of foliage production and, consequently, with leaf age. The annual relative growth rate showed a rapid decline over the three years of the experiment, and the values of relative growth rate at the end of the experiment were rather similar in all six species. The authors concluded that this was mainly due to 1) reduction of interspecific differences in summer growth rates of deciduous species, and 2) the compensating production of dry matter during the winter in the two pine species. Apparently the length of the growing season, and possibly factors influencing the seasonal trend in net assimilation rate, assume increasing importance as determinants of growth in woody species with increasing age.

In conjunction with the study of the six species above mentioned, seasonal rates of growth and dry-matter production were examined by Sweet and Wareing (1968b) in second year seedlings of

Larix leptolepis, Pinus contorta, and Pinus radiata grown in an unheated glasshouse. The deciduous Larix had a higher rate of production of dry matter than either of the two species of Pinus until the time of leaf fall, and this was accompanied by a greater height and diameter increment. However, between the time of leaf fall in Larix and the end of the growing season, the species of Pinus increased in dry weight by more than 25 percent, and in consequence, Larix, because of its deciduous habit, lost most of the advantage of its fast growth rate. The authors also reported that the comparison of the two pine species showed that P. radiata, while making nearly 3.5 times as much height increment as P. contorta, had only a 45 percent higher dry weight than that species at the end of the experiment.

The effects of a range of thermoperiods and soil temperatures upon growth of Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) seedlings were studied by Lavender and Scott (1972). Plants from varieties glauca and menziesii made maximum growth with soil and air temperatures between 18°C and 24°C during the twenty weeks of the study. Low soil temperatures greatly reduced growth and hastened dormancy of plants grown under all the thermoperiods tested.

Growth of western hemlock and Douglas-fir seedlings was also studied by Brix (1971) under eleven controlled day-night temperature regimes ranging from 8°C to 28°C, and with light intensities of 450 and 1000 ft-C for 100 days after seed germination. Douglas-fir had a broad optimum temperature for growth between 18°C and

24°C, whereas hemlock had a pronounced optimum at 18°C, especially at high light. High temperature was more detrimental to growth of hemlock than of Douglas-fir. Low temperature similarly affected the two plants. Moreover, dry matter production of hemlock was considerably lower than that of Douglas-fir for all growing conditions.

Similar to the study mentioned above, Larson (1967) conducted an experiment in which seedlings of Pinus ponderosa Laws. from seed collected in Arizona, California, and South Dakota were grown for six weeks under various combinations of constant air and soil temperatures from 7°C to 31°C, and combinations of day and night temperatures from 7°C to 31°C. Root growth responded more to soil temperature while top growth responded more to air temperature. Roots grew best in 15°C air and 23°C soil, while height growth was best in 23°C air and 23°C soil. Epicotyl length, root penetration, number of lateral roots, and dry weight of roots were correlated with daily degree hours. The author also mentioned that the source of seed had a pronounced effect on final seedling size.

Sweet and Wareing (1968a), reported the results of four experiments in which the parameters of growth were examined in first-year seedlings of Pinus contorta raised from seed of four different geographic provenances. Highly significant differences in net photosynthesis were shown between provenances over a wide range of light intensities, in plants of both twelve and nineteen weeks of age, when measurement was made at a temperature of 20°C. Leaf-weight ratios (i.e. the ratio of leaf weight: plant weight) also differed significantly between provenances, and there was an overall negative correlation between rates of photosynthesis and leaf-weight ratio. The authors concluded that differences in relative growth rate result from differences in the component variables, photosynthetic rate, and leaf-weight ratio.

Another study was conducted in which rate of CO_2 uptake by Pinus rigida seedlings was found to decrease with age, and the response to changes in light and temperature become less pronounced (Ledig et al. 1977). Growth temperatures had no effect of the photosynthetic temperature optimum, and populations from Quebec, New Jersey, and Tennessee all had the same temperature optimum and response pattern.

The rate of height growth in Pinus silvestris L. stands throughout Great Britain was examined in relation to site factors by White (1982). The site factors included measured geographical variation, topography , soil chemical and physical variables at two levels, several measures of soil phosphorus status, foliar monoterpenes and estimates of mean values of climatic variables. The conclusion of the author was that the variations in growth over Great Britain are associated mainly with solar radiation, soil texture and soil moisture content. For separate parts of the country the solar radiation term disappears from regression equations.

Slatyer (1982) found that the photosynthetic temperature optimum of field populations of Eucalyptus pauciflora decreases with increasing elevation and, at any one elevation, varies seasonally in accord with the annual temperature regime.

These studies certainly demonstrate the importance of environmental factors in influencing seedling and forest growth. From reviewing the available literature, however, it is clear that only limited research has been done with tropical species of interest to Costa Rican scientists. This further illustrates the need for this study.

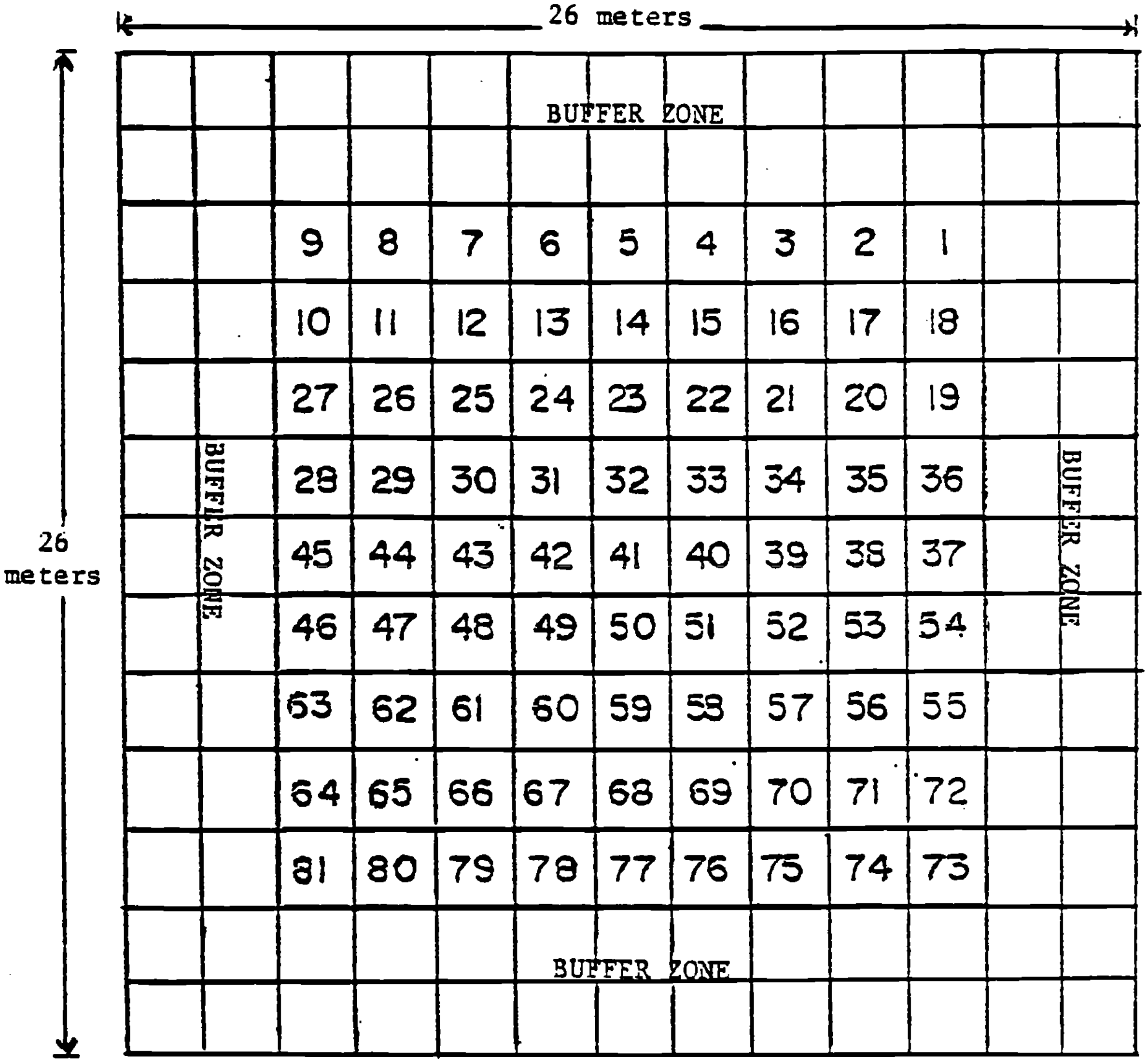
METHODS AND MATERIALS

Establishment of the Study

The project was initiated in 1971. All study plots had 169 trees per plot (81 measure trees), spaced at 2x2 meters. The same methodology and instruments were used in the measurements of all plots (diameter type and Suunto clinometer for the height of the trees) (Figure 1). One of the irregularities of the project is the lack of an initial statistical design (blocks, replication per study area of same species per site) which complicated the interpretation of the data and limited the conclusions which could be drawn. In addition, some areas of the country have not been covered at all (Figure 2).

Various institutions collaborated in the introduction and establishment of forestry species in Costa Rica. Martinez (1981) summarized and measured all the plots older than five years. One year later, Camacho (1981) made a general measurement, analysis, and reorganization of the information including all the plots for which data were available. Both researchers gathered the available information and interpreted, as a whole, the behavior of the forest species.

As a part of the organizatior of the information, data codes were elaborated; one for each species in the study, and another for the location of the plots (See Appendix 9). This last code



9	8	7	6	5	4	3	2	1
10	11	12	13	14	15	16	17	18
27	26	25	24	23	22	21	20	19
28	29	30	31	32	33	34	35	36
45	44	43	42	41	40	39	38	37
46	47	48	49	50	51	52	53	54
63	62	61	60	59	58	57	56	55
64	65	66	67	68	69	70	71	72
81	80	79	78	77	76	75	74	73

Fig. 1. Graph of a forestry study plot showing its dimensions, the 81 trees measured per plot, and the buffer zone.

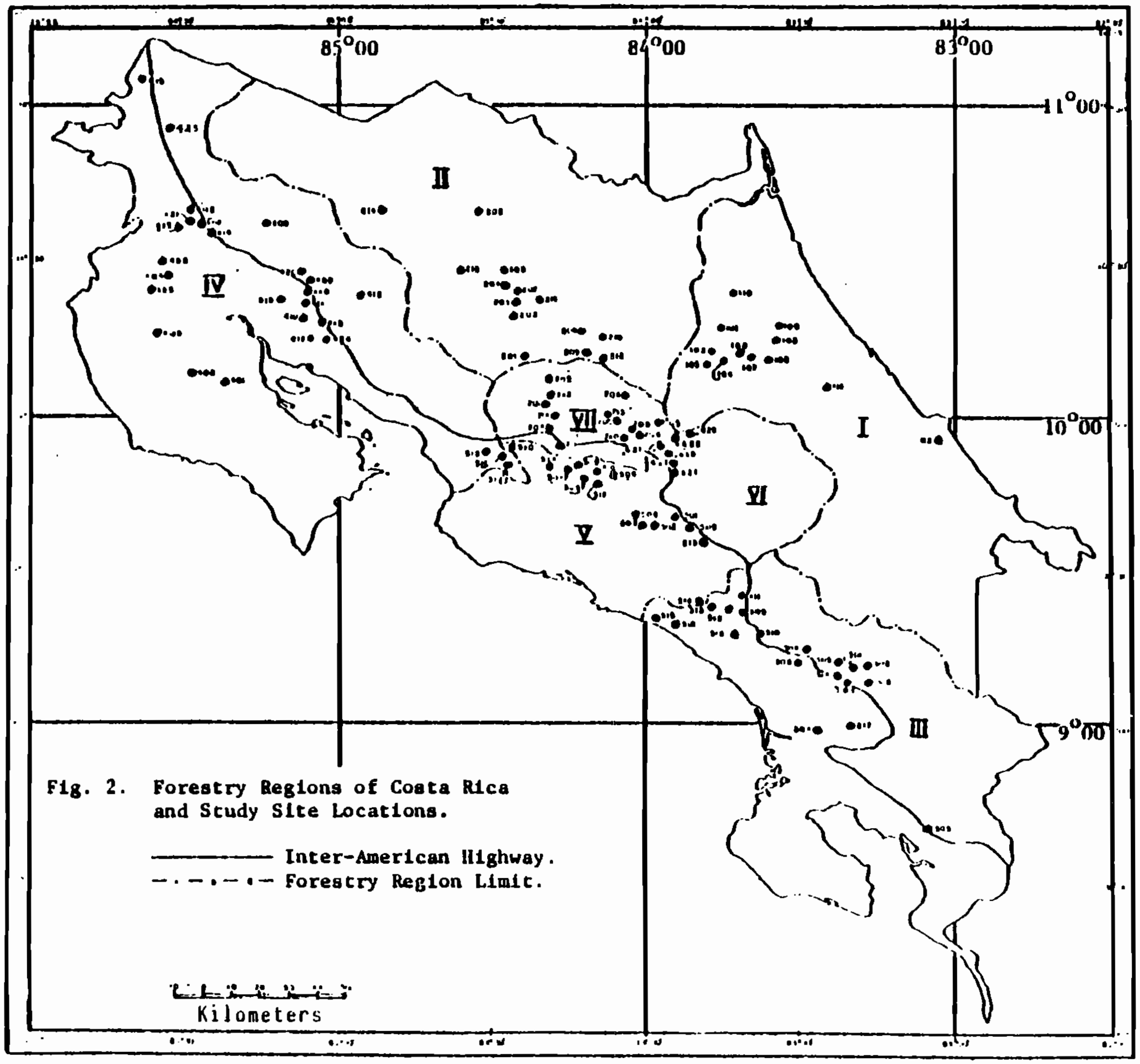


Fig. 2. Forestry Regions of Costa Rica and Study Site Locations.

refers to the division of the country into seven different zones or forestry districts. Those zones have as a criterion of division natural occurrences (rivers, roads, ridge of mountains, etc.) and climatic similarities. For more details see Martinez (1981). This division of the country made possible the evaluation of the species in each particular growing zone.

These two reports (with the exception of the plots in the Tropical Agronomic Center of Teaching and Research (CATIE), Turrialba) summarized all the information related to the tests and introduction of forestry species in Costa Rica. For the investigation realized in CATIE, see Combe and Guevals (1979a).

Data Collection and Measurement

Geographic location

The geographic location of the plots were taken from the archives of the Forestry Department and/or from contour maps of the National Geographic Institute of Costa Rica, (scale 1:50000) utilizing the coordinates of longitude and latitude expressed in degrees and minutes (See Appendix 10).

Climate

The description of climatic conditions were made using data collected between 1970 and 1980 by the National Meteorological Service. Meteorological stations used were as close as possible to the location of the plot. Table 1 presents the location of type A meteorological stations in Costa Rica. The climatic factors used in the regression analysis were maximum temperature, minimum temperature, mean temperature, relative humidity, hours of light, radiation, evaporation, precipitation, and the distribution of precipitation (pluvioso, intermediate, and ecosecos). These three later variables also known as moist, mesic, and dry months. The altitude of the plots was another variable used in this regression analysis. For more details see Camacho (1981) page 113 to 115 and also Appendix 10. A detailed description of the variables and units of measurement are recorded in Appendix 7.

Soils

Data from soil analyses used in this study are the same as those reported by Martinez (1981) and also complemented by the data available in the Forestry Investigation Department. The examination was made at three different depths: 0-5 cm, 5-20 cm, and 20-40 cm. For each area in the investigation five to seven samples of soil were taken for each depth, depending on the homogeneity of the area (drainage, slope, etc.). Results of the physical characteristics and chemical analysis of soil are summarized by Camacho (1981) pages 215-222. See also Appendix 8. The soil variables used in the regression analysis were percent sand, silt, and clay by volume, soil pH, organic matter content, carbon, nitrogen, carbon/nitrogen ratio, available phosphorus, calcium, magnesium, potassium, sodium, cation exchange capacity, and base saturation. For the description of these variables and units of

Table 1. Location of type A meteorological stations in Costa Rica.

NAME	ELEVATION (meters)	LONGITUDE	LATITUDE
Nicoya	120	85°27'	10°09'
Liberia	85	85°32'	10°36'
Puntarenas	3	84°50'	09°58'
Limon	3	83°03'	10°00'
San Jose	1172	84°05'	09°56'
F. Baudrit	840	84°16'	10°01'
Palmar Sur	16	83°28'	08°57'
La Pinera	350	83°20'	09°11'
Palmira	2010	84°23'	10°13'
C.R. Metodista	600	84°24'	10°21'
N. Tronadora	580	84°55'	10°30'
La Mola	70	83°46'	10°21'
Playa Panama	3	85°40'	10°35'
CATIE	602	83°38'	09°53'
Los Diamantes	249	83°49'	10°13'
Linda Vista	1400	83°58'	09°50'
Pacayas	1735	83°49'	09°55'
Cedral	1450	83°33'	09°22'
Coliblanco	2200	83°48'	09°57'
Volcan Irazu	3400	83°51'	09°59'
El Carmen	15	83°29'	10°12'
La Guinea	40	85°28'	10°25'
Taboga	40	85°09'	10°21'
La Lola	40	83°23'	10°06'
San Josecito de H.	1450	84°00'	10°02'
Naranjo	1100	84°23'	10°07'
Esc. C. Ganaderia	450	84°24'	09°57'
Rio Negro	955	82°52'	08°53'

measurement see Appendix 7.

Table 2 presents the twenty eight variables used in the regression analysis, levels of observation, and the names used for the weighted profile values.

Growth Indicators

The growth indicator variables used were volume growth, height, and diameter at breast height (dbh) of the trees. Volume growth was calculated using the formula height growth x dbh growth x age. The volume growth obtained by the above expression is the mean annual increment in volume per tree, because it is calculated from mean annual values of dbh growth and height growth of the trees. It is not the true volume growth, but was used for the practical purpose of these data analyses, and was reported in m^3/ha. Height of the trees were measured with a Suunto clinometer and reported in meters. Diameter of the trees were measured with a diameter tape and adjusted to the nearest millimeter. These measurements were done including the bark of the trees. For more details see Appendix 7, and Table 2.

Shape of the Plots

The criteria followed for the installation of plots was common for all sites and is described by Gonzales (1979) as follows:

Spacing of trees: 2x2 meters
Initial density : 169 trees per plot (13x13 trees)
Area of the plot: 676 square meters (26x26 meters)

Table 2. Environmental factors and growth indicators used in the statistical analysis. Corresponding level of observation and name used for the weighted soil profile value is also included.

	Independent variables [1]	Variable name	Level of observation	Weighted profile
1	age	age	1	-
2	altitude	alt	1	-
3	maximum temperature	tmax	1	-
4	minimum temperature	tmin	1	-
5	mean temperature	tmean	1	-
6	relative humidity	rhum	1	-
7	light	light	1	-
8	radiation	rad	1	-
9	precipitation	precip	1	-
10	evaporation	evap	1	-
11	pluvioso (moist)	pluvioso	1	-
12	intermediate	interm	1	-
13	ecosecos (dry)	ecosecos	1	-
14	sand	sand	3	asand
15	silt	silt	3	asilt
16	clay	clay	3	aclay
17	soil pH	ph	3	aph
18	organic matter	mo	3	amo
19	carbon	c	3	ac
20	nitrogen	n	3	an
21	carbon/nitrogen	cani	3	acani
22	phosphorus	p	3	ap
23	calcium	ca	3	aca
24	magnesium	mg	3	amg
25	sodium	na	3	ana
26	potasium	k	3	ak
27	cation-exchange capacity	cec	3	acec
28	base saturation	satb	3	asatb

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[1] For the description of the variables and units of measurement see Appendix 7.

Data Analysis

Twenty seven environmental factors (twelve climatic variables and fifteen soil variables) and one age variable were included in the regression analysis.

The first step was to screen out some of these variables which were not fundamental to the analysis (growth relationship), subjected to large measurement errors, or whose effects were similar to another independent variables in the list (Neter and Wasserman, 1974).

Initially, species data were combined and analysed for the whole country. In all the cases the dependent variable was volume growth and two regression models were developed. One of them was generated using the twenty seven environmental factors plus age, while in the second highly correlated independent variables were discarded. This second approach was complemented with the more meaninful biological variables (those variables that have proven to more directly affect the growth of trees or major elements).

Neter and Wasserman (1974) and Snedecor and Cochran (1980) agreed that a stepwise procedure is one of the most convenient methods in multiple regression analyses. I used this method because I expected it to yield a good prediction equation with the least possible number of terms. The process followed here is described by SAS (1982), Helwig (1982), Helwig and Council (1979), and also complemented by the method of multiple regression analysis technique (Neter and Wasserman, 1974; Snedecor and Cochran, 1980).

An analysis of the species by zones was done using the same methods as for the first test. This regression by zones and by species was complemented with a multivariate analysis where Principal Component Analysis was used for the summarization of the data following the methodology reported by Morrison (1967), Mardia et al. (1979), and Johnson and Wichern (1982). Canonical Correlation was also used which has the advantage of allowing other growth indicators, like dbh and height growth to be combined with volume growth in the analysis. The methodology followed in the principal component and canonical correlation is reported by SAS (1982).

RESULTS AND DISCUSSION

Multivariate Analysis

The results of the Principal Component Analysis are reported in Table 3. The overall selection among climatic and soil factors is similar and the number of variables selected for each species range from five for *Alnus acuminata* to ten for *Cupressus lusitanica*. Regression analyses were done using the results indicated by Table 3, however, none were significant.

These results of principal component analysis by individual species were used to select the independent environmental variables forming one set of data and the dependent variables dbh, height, and volume growth formed part of the second set of data. These two sets of data were combined through a canonical correlation and the analysis done by individual species. The results obtained from the canonical correlation were difficult to interpret and in some cases did not follow a reasonable pattern. Therefore these results were not utilized in this study.

One of the reasons why the canonical correlation did not give satisfactory results could be the small sample size that was used in the analysis. It is suggested that the relation between number of observations and number of independent variables should be 20:1 (Stafford, 1983 personal communication). In this case, and based

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Stafford Susan. 1983. Forestry Projects Data Analysis. Course offered by the Forest Science Department. Oregon State University. Corvallis, Oregon 97331.

Table 3. Independent environmental variables possibly related to tree growth, as determined by Principal Component Analysis, by species and frequency of inclusion for the five tree species included in the analysis.

Tree Species	Cupressus	Alnus	Gmelina	Pinus	Tectona	Frequency
<u>Climatic factors</u> [1]	precip	precip	-	-	-	2
	tmed	-	tmed	tmed	-	3
	tmax	-	-	-	-	1
	tmin	tmin	-	-	-	2
	rhum	-	-	rhum	-	2
	pluvioso	-	interm	ecosecos	interm	4
	-	rad	rad	-	-	2
	-	-	-	-	light	1
<u>Soil factors</u> [1]	asand	asand	-	-	asand	3
	asilt	-	-	-	-	1
	ana	-	ana	ana	ana	4
	ap	ap	ap	ap	ap	5
	-	-	aca	-	-	1
	-	-	-	acec	-	1
	-	-	-	-	asatb	1
	-	-	-	-	amo	1
	-	-	-	acani	acani	2
	-	-	-	aph	-	1
Number of variables selected by species	10	5	6	8	8	

[1] For the description of the environmental factors and units of measurement see Appendix 7.

on the eight to thirteen independent variables used in the analysis, 160 to 260 observations were needed. The largest sample size available was twenty six observations for Pinus caribaea which is only a fraction of the number suggested. Despite these poor results from the principal component analysis and canonical correlation, I believe that with a larger sample size, these two methods could be useful tools in the interpretation and summarization of such data.

Multiple Regression Analysis

Tables 4 through 10 summarize the results of the multiple regression analysis (using MAXR approach) for predicting the growth of Alnus acuminata, Cupressus lusitanica, Gmelina arborea, Pinus caribaea, and Tectona grandis from various environmental factors.

To look at the "stability" of the individual regression equation and using an analysis of correlation (see Appendix 1 through 5), the best twelve variables were selected and the same criteria, as above, used to compute a second regression equation for each set of data. In most cases there was agreement among the variables selected. In every case the first approach (using the full set of data) gave the highest R^2 value and usually chose a similar number of independent variables. Appendix 6 summarizes these results.

Regression Analysis for Alnus acuminata (HBK) O. Ktze.

A total of eight Alnus growth plots from throughout Costa Rica

Table 4. Environmental variables included in the regression equations to predict tree growth, by species. Variable selection was based on stepwise MAXR approach.

Species	Alnus	Cupressus	Gmelina	Pinus	Tectona	Frequency
Climatic factors 1/	rhum	-	-	-	-	1
	pluvioso	-	-	ecosecos	ecosecos	3
	age	age	-	age	age	4
	-	alt	-	-	-	1
	-	-	-	light	light	2
	-	-	-	-	evap	1
Soil factors 1/	asatb	asatb	-	asatb	-	3
	-	asilt	-	-	aclay	2
	-	-	ap	-	-	1
	-	-	ana	-	ana	2
	-	-	acani	-	acani	2
	-	-	ak	ak	ak	3
Climatic variables	3	2	0	3	4	
Soil variables	1	2	4	2	4	
Total selected	4	4	4	5	8	

1/ For the description of the variables and units of measurement see Appendix 7.

Table 5. Environmental variables included in the regression equations to predict the tree growth, by study species and plot locations. Variable selection based on stepwise MAXR approach.

Species		Alnus	Cupressus	Gmelina	Pinus	Tectona	Frequency
		Zone Number					
<u>Climatic factors</u> [1]	age	7	5	–	1	1 3	5
	alt	–	5	–	–	–	1
	rad	–	–	–	1	–	1
	interm	–	–	–	1	–	1
	precip	–	–	–	3	–	1
	tmax	–	–	–	–	1 3	2
<u>Soil factors</u> [1]	ana	7	–	–	1	3	3
	asilt	–	5	–	1	1 3	4
	acec	–	5	3	3	–	3
	an	–	7	1	–	4	3
	ac	–	–	1	–	–	1
	ap	–	–	4	–	1	2
	amo	–	–	4	–	–	1
	ak	–	–	–	1	–	1
	aph	–	–	–	1	4	2
	amg	–	–	–	1 3	–	2
	acani	–	–	–	3	–	1
	aca	–	–	–	–	1 3	2
	astb	–	–	–	–	4	1
Zone evaluated		7	5 7	1 3 4	1 3	1 3 4	
Number of variables selected by zone		2	4 1	2 1 4	8 4	5 5 3	

[1] For the description of the variables and units of measurement see Appendix 7.

were analyzed, with five of these located in zone 7. The results of the analysis of regression are recorded in Table 6.

The four variables included in the regression model from all eight plots are relative humidity, the number of months with precipitation over 100 mm (pluvioso), age, and the percentage base saturation. The value of R^2 (0.85) is acceptable but the probability of a larger F value (0.12) is low, which means that the significance probability of the F value is not greater than 0.88. The lower F value found here could be due to large variation among the sites that cannot be easily explained by the low number of observations used in the regression analysis.

Relative humidity and the months of the year with high precipitation ($>$100 mm) are the two variables most closely related to alder growth. A. acuminata is a pioneer tree that needs a lot of light and a high level of soil moisture (Camacho, 1981). This seems to agree with the regression analysis results showing a relationship between the growth of the species and the variable pluvioso.

Relative humidity has a negative regression coefficient with a large effect in the regression equation. In other words, with an increase in relative humidity, there will be an expected decrease in growth. However, some interactions between relative humidity, precipitation, and mean temperature should be reviewed since in some plots the precipitation (3759 mm/year) is greater than that generally required for the species, and mean annual temperature (15.2°C) is lower than that normally suggested for the

Table 6. Multiple Regression Analysis Results for <u>Alnus</u> <u>acuminata</u> using stepwise MAXR, for data from growth plots throughout the country as well as from an individual zone.

Zone	No. of obs. (n)	Variables in the analysis (p)	Dependent variable ($\hat{Y}$)	Independent variable(s) selected and order of entrance [1]	Estimated regression equation [2]	R^2	$Pr(F > \hat{F})$
Throughout the country	8	28	volume growth	rhum pluvioso age asatb	$\hat{Y}=2.27-0.012(age)+0.035(pluvioso)-0.029(rhum)+0.0048(asatb)$	0.85	0.1224
7	5	28	volume growth	ana age	$\hat{Y}=0.014-0.012(age)+1.26(ana)$	0.50	0.5046

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[1] age = Plantation age in years.

pluvioso = Number of months of the year with precipitation greater than 100 millimeters.

rhum = Mean annual relative humidity. Expressed in percent.

asatb = Mean soil profile (0-40 cm) base saturation. Expressed in percent.

ana = Mean soil profile (0-40 cm) sodium concentration. Expressed in milliequivalents per 100 grams of soil.

[2] $\hat{Y}$ = Mean tree growth increment in m^3/yr.

species. There is also the possibility that on some plots the soil and atmospheric water is excessive, so that growing conditions improve when the relative humidity decreases. Similar results as these above mentioned were found for El Verde forest in Puerto Rico (Odum, 1970). This author argued that high relative humidity decreased nutrient uptake (because it resulted in reduced evapotranspiration) and therefore he concluded that trees grew better where relative humidity was low. Again, a greater sample size will allow us to have a better understanding of the species responses, as might additional information on such things as soil drainage.

The variable age has a negative coefficient of regression which seems to indicate that the species has already reached its maximum point in the mean annual growth increment curve. That is, the mean annual increment of the plots analyzed will probably decrease as the trees grow older. Range for age of the trees is presented in Appendix 1.

Percent base saturation is positively related to the growth of A. acuminata. This is consistent with the presence of the variable sodium in the regression equation of zone 7. This consistency between regression equations could be due to a high correlation between base saturation and the exchangeable bases (calcium, magnesium, potassium, and sodium) (see Appendix 1). This is assumed because the element sodium has not been found to directly affect the growth of trees unless a deficiency of potassium exists (Lyon et al. 1959). Low significance (probability) of the regression model, and the small sample size, suggests the future need for a revision of this regression model. Further study of the interaction between sodium and other exchangeable bases is also needed.

The regression equation for zone 7 was determined for the purpose of comparing the behavior of the species throughout the country with that of a specific zone. However, given the significance of the F value, the validity of such a model is questionable.

The use of a second approach, analysis based on the reduced set of data, did not help in the testing of the stability of the individual regression equation. The only variable that entered the regression model in each case was age (see Appendix 6a). The other two variables that showed some overlap were percentage base saturation in the regression model for the country and cation-exchange capacity in the second regression equation of zone 7.

No major details of Alnus acuminata have been studied, and the studies found in the literature (Holdridge, 1951; Alvarez, 1956; Budowski, 1957; and Combe, 1979b) only give a general description of the behavior of A. acuminata in Costa Rica.

It is well known, especially to most dairy farmers in the Central Valley of Costa Rica, that Alnus acuminata is a fast growing tree, adapted to most of the soils of the area. Because of its nitrogen-fixing characteristic the pasture grasses also grow as well or better beneath a stand of Alnus than in the open.

Since 1922 this tree has been a by-product for the dairy farms in elevations above 1500 meters. The recommendation is that we gather more information to make possible the formulation of site index curves and ratings for the widespread reforestation of this species in the Central Valley of Costa Rica.

Regression Analysis for Cupressus lusitanica Mill.

Table 7 summarizes the results of the regression analysis for *C. lusitanica*. Thirteen plots were evaluated throughout the country, nine plots in zone 5, and four plots in zone 7.

Three out of four of the variables present in the regression equation for the country are included in the regression model for zone 5. Two minor differences can be identified. One is in the order of entrance of the variables age and silt into the regression equation. The other is the fourth variable entered into the equation. For the regression model of the country percentage base saturation is the variable included and is substituted by cation-exchange capacity in the regression equation of zone 5.

For zone 7, only the variable nitrogen enteres into the regression equation. The R^2 value (0.99) is quite high and probability of a larger F value (0.0023) is low. However, the limited number of observations in the zone limits the drawing of strong conclusions.

Soil in the Central Valley of Costa Rica (zone 7) originated from volcanic ash. The regression analysis results for this zone agree with those of Fassbender and Tschinkel (1974) for plantations of *C. lusitanica* on volcanic ash soil of Colombia. The best equation found by the authors explained 52% of the

Table 7. Multiple Regression Analysis Results for Cupressus lusitanica using stepwise MAXR, for data from growth plots throughout the country as well as from individual zones.

Zone	No. of obs. (n)	Variables in the analysis (p)	Dependente variable ($\hat{Y}$)	Independent [1/] variable(s) selected and order of entrance	Estimated regression equation [2/]	R^2	Pr(F > $\hat{F}$)
Throughout the country	13	28	volume growth	asilt age alt asatb	$\hat{Y}=0.58+0.013(age)-0.000064(alt)+0.021(asilt)+0.0018(asatb)$	0.99	0.0001
5	9	28	volume growth	age asilt alt acec	$\hat{Y}=0.40+0.0093(age)-0.0001(alt)+0.024(asilt)-0.0027(acec)$	0.99	0.0001
7	4	28	volume growth	an	$\hat{Y}=4.57+22.15\ (an)$	0.99	0.0023

1/ age = Plantation age in years.

alt = Elevation above mean sea level in meters.

asilt = Mean soil profile (0-40 cm) silt content in percent.

an = Mean soil profile (0-40 cm) nitrogen content in percent.

asatb = Mean soil profile (0-40 cm) base saturation. Expressed in percent.

acec = Mean soil profile (0-40 cm) cation exchange capacity, in meq/100 g of soil.

2/ $\hat{Y}$ = Mean tree growth increment in m^3/yr.

variation among the sites, and included aluminum phosphates, exchangeable potassium, and exchangeable magnesium as independent variables. Fassbender and Tschinkel (1974) also mentioned that the importance of aluminum phosphates complemented the results of previous investigations which showed that growth of cypress is limited primarily by deficiencies of phosphorus and nitrogen. Based on the correlation analysis the authors concluded that only a few soil characteristics regulate the growth of cypress in the soils studied.

Volcanic ash soils of Medellin, Colombia were studied by Valle (1976). Highly significant correlations were found between site quality and the nitrogen mineralized in fresh soils, which explained 58% of the variation in cypress growth. These results also agree with what was found for zone 7 in the present analysis.

For the regression analysis using data from throughout the country, the variables selected were silt, age, altitude, and percentage base saturation. The negative regression coefficient of the variable altitude seems to indicate that the yield of cypress will decrease with an increase in elevation. However, altitude typically has a direct effect on temperature and it is very possible that an interaction of the two variables is occurring. The range of elevation of cypress included in the analysis is from 1100 to 2620 meters and its altitudinal range reported in the literature is from 800 to 3000 meters. A possible explanation of this negative effect of elevation on the growth of <u>C. lusitanica</u> could relate to the effect of temperature. It was mentioned by

Camacho (1981) that cypress grows better where temperatures are greater than 12°C. Over the range of minimum temperature of the plot evaluated (Appendix 2); the mean annual temperature can drop to 5.4°C, which could negatively affect the growth of the species. Odum (1970) reasoned that relative humidity increased with elevation, and had a depressing effect on growth. This later result could be another possible explanation of the regression analysis result for this species.

Cypress prefers uncompacted deep soils, with good drainage, and with high organic matter content (Camacho, 1981). This observation seems to agree with the presence of the variable silt in the regression equation for the country as, with the exception of organic matter, these conditions can be fulfilled by a soil with high percentage of silt, or one that is balanced among sand, silt and clay. Appendix 2 shows that the mean content of silt for the plots evaluated is 32%, and the addition of the means of sand and silt is greater than 79% of the total volume of the soil. This is a loam, which is generally a very desirable soil texture for most plant species.

The percentage base saturation of the soil is defined as the degree to which all cation exchange sites of the soil are occupied by bases such as calcium, magnesium, potassium, and sodium (Pritchett, 1979), and can be used as an indicator of soil fertility. Percentage base saturation of these soils may be related to cation exchange capacity (CEC). This is not a general relationship, but in this analysis the presence of base saturation in the regression equation of the country could be related to the presence of

CEC in the regression model of zone 5. It is also known that, in general, CEC is highly related to the content of organic matter of the soil. The higher the organic matter content, the greater the value of cation exchange capacity (Hausenbuiller, 1972).

Martinez (1981) conducted a regression analysis for cypress growing in Costa Rica. Thirteen plots were evaluated, all older than five years. A total of eight independent variables were included in the analysis: soil organic matter content (0-5 m depth), pluvioso, interm, ecosecos, altitude, and the texture of the soil from the 0-5 cm, 5-20 cm, and 20-40 cm depths. The dependent variables used were dbh or height. The author found that the variables related to the diameter growth of the species were the content of organic matter from the 0-5 cm depth, the carbon/nitrogen ratio at the same depth, the number of months of the year with precipitation greater than 100 millimeters (pluvioso months), and soil textures from 5-20 cm, and 20-40 cm depths. The regression equation using the height of the trees as a response variable was not significant.

In this study I have used the same number of cypress plots and similar soil chemistry factors as Martinez. The only difference with this study is that Martinez made his measurements in 1980 and I have used data recollected in 1981. Another difference between the analysis done by Martinez and the one reported here is the number of independent variables, which was here increased from eight to twenty eight. This allows for some additional variables to enter the regression equation, possibly giving clearer indication of how these variables are related to growth of this species.

The regression equations developed here cannot be directly compared with those of Martinez (1981) since he used mean annual diameter increment as the dependent variable. My analysis also included numerous other independent variables. Martinez used only soil chemistry values from the 0-5 cm depth, whereas I have used the weighted profile value from the 0-40 cm depth. Finally, Martinez used 10 different soil texture groups, and I used the percentages of sand, silt, and clay by volume. However, it is worth noting that a soil texture variable (silt) is significant in two of my models, as well as those of Martinez.

Different provenances of C. lusitanica were studied by Soares and Rosero (1973) in 3 localities of Costa Rica. The analysis of variance following the nested scheme, used as variables dbh, total height, stem form, concentricity, bark thickness, and number of branches per tree. The correlation analysis carried out between these tree measurements and the site characteristics (altitude, precipitation, mean temperature, slope, and type of drainage) indicated that these characteristics were responsible for 47 and 33% of the total variation in height and dbh, respectively.

The general interpretation of the regression analysis is that the growth of cypress slightly decreases with increasing elevation. Cypress responds better in soils with high content of silt. In the Central Valley (zone 7) growth of the species is strongly related to available nitrogen.

Regression Analysis for Gmelina arborea Roxb.

Gmelina is currently being grown in three different zones of Costa Rica. Five plots were evaluated in zone 1, three plots in zone 3, and four plots in zone 4; for a total of twelve plots analyzed throughout the country.

For the equations developed, the values of R^2 are high and the significances of the F values are above 95% (Table 8). These four regression models indicate that only the soil chemistry factors are related to growth. This species prefers deep moist soils, with good drainage and nutrients (Camacho, 1981). It is also known that G. arborea tolerates from alkaline to light acid soils. This seems to agree with the general results of the regression analysis indicating that soil fertility is the factor most nearly related to the growth of the species.

The above results also agree with those obtained by Golfari (1972) in the equatorial region of Brazil. The climate of this region is tropical, with annual precipitation of 2000 mm, and a dry period of four months. The preliminary results indicate that the species is very sensitive to the soil conditions, preferring porous, deep and fertile soils.

The number of independent variables included in the regression model for plots from throughout the country is four, two for the model of zone 1 and zone 4, and only one variable for the regression

Table 8. Multiple Regression Analysis for *Gmelina arborea* using stepwise MAXR, for data from growth plots throughout the country as well as from individual zones.

Zone	No. of obs. (n)	Variables in the analysis (p)	Dependent variable ($\hat{Y}$)	Independent variable(s) selected and order of entrance[1/]	Estimated regression equation[2/]	R^2	$Pr(F > \hat{F})$
Throughout the country	12	28	volume growth	ap ana acani ak	$\hat{Y}=1.46-2.005(ana)+0.18(ak)+0.013(ap)-0.06(acani)$	0.98	0.0001
1	5	28	volume growth	ac an	$\hat{Y}=0.44+2.49(an)-0.27(ac)$	0.95	0.0495
3	3	28	volume growth	acec	$\hat{Y}=3.05-0.074(acec)$	0.99	0.0156
4	4	28	volume growth	ap amo	$\hat{Y}=0.05+0.0045(amo)+0.091(ap)$	0.99	0.0044

[1/] acec = Mean soil profile (0-40 cm) cation-exchange capacity.

an = Mean soil profile (0-40 cm) nitrogen content. Expressed in percent.

amo = Mean soil profile (0-40 cm) organic matter content. Expressed in percent.

ac = Mean soil profile (0-40 cm) carbon content. Expressed in percent.

ana = Mean soil profile (0-40 cm) sodium content. Expressed in milliequivalents per 100 grams of soil.

ak = Mean soil profile (0-40 cm) potassium content. Expressed in milliequivalents per 100 grams of soil.

ap = Mean soil profile (0-40 cm) phosphorus content. Expressed as available phosphorus in micrograms per milliliter.

acani = Mean soil profile (0-40 cm) carbon-nitrogen ratio.

[2/] $\hat{Y}$ = Mean tree growth increment in m^3/yr.

model in zone 3. The overlap between the regression model is significant. The variable acani (carbon/nitrogen ratio) is present in the regression model for the country. As expected, it compares well with the presence of the variables carbon and nitrogen in the model of zone 1. With respect to other soil chemistry variables, a possible association could exist between sodium and potassium (exchangeable bases) present in the regression model for the country and the variable cation-exchange capacity present in the regression equation of zone 3.

Available phosphorus is present in the regression model for the country and zone 4. In addition, the agreement between the regression equation becomes stronger if the correlation between the variables carbon, nitrogen, and organic matter is taken into consideration, as shown in the matrix of correlation for this species in Appendix 3.

Ojo and Jackson (1973) reported that Gmelina is very sensitive to differences in soil fertility, particularly to deficiencies in nitrogen. In some cases there was a response to nitrogen only when phosphate was also applied. The authors also found that potassium had little effect on the growth of this species.

In general the regression analyses done for the species in Costa Rica agree with those done in Brazil, Nigeria, and Nicaragua (Gomez, 1981); however, the presence of sodium and potassium in the regression equation for plots from throughout the country is difficult to explain. Sodium, as previously mentioned, has not been found essential in the growth of trees and the significance of potassium contradicts the findings of Ojo and Jackson (1973). Interaction between the exchangeable bases may be responsible for the inclusion of these two variables in the regression model, a possibility that should be studied.

The second analysis done to test the "stability" of the regression models also showed the great influence that soil fertility factors have on the growth of G. arborea (Appendix 6c.)

For the regression analysis done by Martinez (1981) for Gmelina in Costa Rica, nine independent variables, were included: soil organic matter content (0-5 cm depth), the carbon/nitrogen ratio (0-5 cm depth), the distribution of the precipitation (pluvioso, interm, and ecosecos), altitude of the plots, and the soil texture from the 0-5 cm, 5-20 cm, and 20-40 cm depths. The response variable that he used was the dbh of the trees. The variables that Martinez found to be most strongly related to the growth in diameter of the species were the soil organic matter content which entered only one of my regressions, and the variable interm (number of months with values of precipitation ranging from 30-100 mm), which did not appear at all in my regressions.

The regression equation developed by Martinez (1981) showed an R^2 value of 0.77 and was significant at the 1% level. The smallest value of R^2 reported in Table 8 is 0.95 and the lowest significance level, 5%. However, agreement between this one and a regression model computed by Martinez (1981) is minimal.

The general observation that can be draw from my regression analysis and from the experiences in other countries, is that *Gmelina* requires fertile soils with good physical properties for optimum growth. However, this species is growing satisfactorily in all the areas below 500 meters of elevation of Costa Rica, and in the case of Nicaragua, it was reported by Gomez (1981) that this species is growing well even in areas with a six month dry season.

These characteristics of *Gmelina arborea* make it a reasonable choice for use in reforestation projects for the tropic low-lands.

Regression Analysis for Pinus caribaea var. hondurensis Barr. & Golf.

Caribbean pine is a very popular plantation species in Costa Rica and is currently growing well even at 1200 meters of elevation. Table 9 presents the regression models for the plantations. Twenty six plots were evaluated for the country, fourteen plots in zone 1, and eight plots in zone 3.

The variables selected for the regression model for data from throughout the country are potassium, percentage base saturation, the distribution of the precipitation (ecosecos or dry months), light, and age. The R^2 value (0.75) indicates a relatively good relationship, and the significance of the F value ($P<0.0001$) is very high. However, the regression models for zones 1 and 3 have better values of R^2 (0.99) and F values comparable to that for the regression model from throughout the country. Various factors could contribute to the strong values of R^2 and F test. White (1932) found for *P. silvestris* in Great Britain that the variation in climatic factors within zones was smaller than for the country.

Table 9. Multiple Regression Analysis Results for Pinus caribaea using stepwise MAXR, for data from growth plots throughout the country as well as individual zones.

Zone	No. of obs. (n)	Variables in the analysis (p)	Dependent variable ($\hat{Y}$)	Independent variable(s) selected and order of entrance [1]	Estimated regression equation [2]	R^2	$Pr(F > \hat{F})$
Throughout the country	26	28	volume growth	ak asatb ecosecos light age	$\hat{Y}=0.05+0.0091(\mathrm{age})-0.082(\mathrm{ecosecos})+0.00017(\mathrm{light})-0.0092(\mathrm{asatb})+0.26(\mathrm{ak})$	0.75	0.0001
1	14	28	volume growth	ak rad interm aph amg asand ana age	$\hat{Y}=3.48+0.011(\mathrm{age})+0.75(\mathrm{interm})-0.008(\mathrm{rad})-0.29(\mathrm{aph})+0.006(\mathrm{asand})+0.076(\mathrm{amg})+0.25(\mathrm{ana})+1.03(\mathrm{ak})$	0.99	0.0001
3	8	28	volume growth	precip acec aph acani	$\hat{Y}=1.09-0.0003(\mathrm{precip})+0.098(\mathrm{aph})-0.0083(\mathrm{acec})-0.011(\mathrm{acani})$	0.99	0.0009

[1] age = Plantation age in years.

ecosecos = Number of months of the year with precipitation less than 30 millimeters.

light = Mean annual value for the daily hours of sunshine.

interm = Number of months of the year with precipitation between 30 and 100 millimeters.

rad = Mean annual radiation. Expressed in calories per square centimeter per day.

precip = Mean annual precipitation in millimeters.

acani = Mean soil profile (0-40 cm) carbon/nitrogen ratio.

asatb = Mean soil profile (0-40 cm) base saturation. Expressed in percent.

ak = Mean soil profile (0-40 cm) potassium content. Expressed in milliequivalents per 100 grams of soil.

aph = Mean profile (0-40 cm) soil pH.

asand = Mean soil profile (0-40 cm) sand content. Expressed in percent by volume.

amg = Mean soil profile (0-40 cm) magnesium content. Expressed in milliequivalents per 100 grams of soil.

ana = Mean soil profile (0-40 cm) sodium content. Expressed in milliequivalents per 100 grams of soil.

acec = Mean soil profile (0-40 cm) cation-exchange capacity.

[2] $\hat{Y}$ = Mean tree growth increment in m^3/yr.

The agreement among the regression models is high, not only because some of the variables brought into the models are the same, but because the variables in one model are strongly related to the other variables selected. An example is the case of variables ecosecos and interm. These variables refer to the amount and distribution of precipitation (dry and mesic months, respectively). Another example is the presence of the variable potassium and percentage base saturation in the regression model of the country, potassium, magnesium, and sodium in the regression model of zone 1, and the variable cation exchange capacity in the regression model of zone 3.

In the analysis of data for all of the growth plots the variables ecosecos and percentage base saturation entered the regression equation with negative coefficients. As previously mentioned, the variable ecosecos indicates the distribution of the precipitation, specifically the number of months of the year in which the precipitation is less than 30 millimeters. Based on the negative coefficient of regression of the variable ecosecos, it can be assumed that the growth of P. caribaea will be unfavorably affected by extended periods of dryness. It was mentioned by Camacho (1981) that the species in its natural habitat could still grows in areas with only 500 millimeters of precipitation per year. This does not contradict the results of the regression analysis for caribbean pine. Most pines are more drought tolerant than other trees, but their growth is still better when they get more water. In the case of Costa Rica, the best growth of the species is at sites with

2000-3000 millimeters of precipitation, and, as will be discussed later, the regression analysis showed that the volume growth of Pinus would be favored by intermediate precipitation. This agrees with the results of the six year-old plantings of caribbean pine in Rhodesia, which showed it to be fast growing in the high rainfall (over 1300 mm per annum) areas of the country at altitudes below 1200 meters (Barnes et al. 1977)

An interesting situation can be observed in Table 9 in relation to the variable precipitation and its distribution (interm and ecosecos). For the regression model of the country, the variable ecosecos is negatively related to the growth of Pinus. For the regression model of zone 3, a similar behavior is displayed by the variable precipitation, which seems to indicate that the species will decrease in growth with an increase in precipitation. The presence of the variable interm with a very strong positive coefficient of regression for zone 2 reinforces the expected influence of precipitation and its distribution on the growth of P. caribaea. That is, the species seems to prefer a balance between extremely wet and dry conditions.

It is also known that Pinus caribaea grows naturally in a wide variety of soils, ranging from poor soils to fertile soils, from coastal to soils in the mountains. It also grows in sandy and infertile soil as well as in deep granitic soils with good drainage (Camacho, 1981). The results obtained in the three regression models agree to a certain degree with this. The percentage base saturation in the regression model for the country and cation-exchange capacity in the regression model of zone 3 have a negative coefficient of regression. However, the cations magnesium, sodium, and potassium show a strong relationship with the growth of Pinus in zone 1. This also agrees to a certain degree with the preliminary trials results in Malaysia. P. caribaea plots used in the afforestation of temuda areas (areas which have been repeatedly subjected to shifting cultivation) showed nutrient deficiencies (Fahlrman, 1976). Fertilizer application to the plots (nitrogen, phosphorus, potassium, and boron) were suggested by the author.

The variable soil pH entered the regression equation of zone 3 with a high regression coefficient. Studies of this area have shown that most of the soils are clayey soils with a high content of bauxite (a clayey substance that is the chief ore of aluminum) (Flores-Silva, 1920) and also, with low values of soil pH. The interpretation of the regression analysis for this zone is that the low values of soil pH limit the growth of this species. The future addition of more information will allow the drawing of stronger conclusions in relation to the effect of soil pH on growth of caribbean pine in Costa Rica.

Another overlap between regression models is the variables age and light in the regression model for the country, and variables age and radiation in the regression model of zone 1. A similar behavior was reported by White (1982) for Pinus silvestris in Great Britain, where variations in growth were associated mainly with solar radiation, soil texture, and soil moisture content.

The presence of variables light and radiation in the regression model for the country and zone 1, indicates that the species grows better under open light conditions or areas with greater number of hours of sunshine.

The variable age is important in the regression models because the range varies widely for the plots of this species. In the case of P. caribaea the variable is positively correlated with growth which may indicate that the growth in the plots has not reached the maximum point in its mean annual increment curve.

The greatest number of observations analyzed in this study was for P. caribaea, not only throughout the country but also by zones. For example, the number of plots included for zone 1 is larger than the total number of plots analyzed for Alnus, Cupressus and Gmelina. This should provide stronger results and more stable regression models. This can be observed in Appendix 6d where the use of two different approaches gives similar regression models.

Martinez (1981) found that the factor that was most closely related to the diameter and height growth of P. caribaea was the number of months of the year with precipitation greater than 100 mm (pluvioso). Eight soil variables included in his analysis were pH, organic matter content, carbon/nitrogen ratio, available phosphorus, cation exchange capacity (all of them from 0-5 cm depth) texture at three different levels 0-5 cm, 5-10 cm, and the 20-40 cm depth. Two other variables were the distribution of the precipitation (pluvioso, interm and ecosecos) and altitude of the plots.

The three regression equations presented in Table 9 agree to certain degree with the findings of Martinez (1981). That is, the variable precipitation and those variables related to its distribution are present in the model from throughout the country and the zone 1 model as well. However, in the present study it was determined that more variables than those associated with precipitation are related to the growth of this species.

The R^2 value reported by Martinez (1981) is 0.31 for the regression equation that used the mean annual increment in diameter as the response variable, and 0.30 when height was used as the dependent variable. The smallest value of R^2 reported in the present study is 0.75 for the regression model for the country, and included five variables (table 9). The regression models for zones 1 and 3 had an R^2 of 0.99 and very high significance.

A study conducted by Brito et al. (1975) in Venezuela showed that soil texture and its distribution in the profile, as well as soil drainage (Brito et al. 1975; Alterna, 1971) were the most important parameters for the growth of _P_. _caribaea_. However, soil texture was an important factor only for the regression model of zone 1 (variable sand).

The general observation of my regression analysis is that precipitation and its distribution through the years, the chemistry of the soil (specifically the exchangeable bases), and an energy factor (number of hours of sunshine and radiation received or interaction of these two variables) are the factors most closely related to the growth of caribbean pine in Costa Rica.

Regression Analysis for *Tectona grandis* L.

Table 10 summarizes the results of the regression analysis for teak. Twenty one plots from throughout the country were evaluated and these were distributed as follows: seven plots in zone 1, eight in zone 3, and six plots in zone 4.

A review of Table 10 shows that climatic and soil chemistry factors are strongly related to growth of this species, with soil factors being particularly significant.

The regression equation for data from throughout the country indicates a balance between climatic and soil factors. Three climatic and five soil variables are present in the models. For the other three regression models, soil variables dominate the regression equation.

The agreement among the variables in the regression models is high, both directly and indirectly. However, the inclusion of a few new variables was also part of the regression analysis results for *T. grandis*.

The range of precipitation for this species is between 500 and 5000 mm/year. However its best growth is between 1500 and 2000 mm/year (Camacho, 1981). This optimum precipitation is only reached in the driest part of Costa Rica, which is zone 4 in the study. This agrees with the regression analysis results of zone 4, which show only soil factors in the regression equation. It is possible, therefore, that the climatic factors are not limiting the growth of teak within this particular region.

Table 10. Multiple Regression Analysis for <u>Tectona grandis</u> using stepwise MAXR, for data from growth plots throughout the country as well as individual zones.

Zone	No. of obs. (n)	Variables in the analysis (p)	Dependent variable ($\hat{Y}$)	Independent variable(s) selected and order of entrance [1/]	Estimated regression equation [2/]	R^2	$Pr(F > \hat{F})$
Throughout the country	21	28	volume growth	aclay light evap ecosecos ana ak age acanl	$\hat{Y}$=0.30-0.0084(age)+0.14(ecosecos)+ 0.0005(light)-0.0008(evap)- 0.005(aclay)-0.42(ans)+0.36(ak)+ 0.02(acanl)	0.73	0.0048
1	7	28	volume growth	ap asand age aca tmax	$\hat{Y}$=2.63+0.13(age)-0.19(tmax)+ 0.028(asand)-0.11(aca)+0.18(ap)	0.99	0.1115
3	8	28	volume growth	asilt aca ana age tmed	$\hat{Y}$=7.89-0.031(age)-0.074(tmed)+ 0.015(asilt)+0.037(aca)- 29.17(ana)	0.99	0.0001
4	6	28	volume growth	an asatb aph	$\hat{Y}$=4.81-0.74(aph)+0.0017(asatb)+ 1.25(an)	0.99	0.0015

[1/] age = Plantation age in years.

ecosecos = Number of months of the year with precipitation less than 30 millimeters.

light = Mean annual value for the daily hours of sunshine.

evap = Mean annual evaporation. Expressed in millimeters.

tmax = Mean annual maximum temperature in degree celcius.

tmed = Mean annual average temperature in degree celcius.

aca = Mean soil profile (0-40 cm) calcium content. Expressed as milliequivalents per 100 grams of soil.

asilt = Mean soil profile (0-40 cm) silt content. Expressed in percent by volume.

an = Mean soil profile (0-40 cm) nitrogen content. Expressed in percent.

aclay = Mean soil profile (0-40 cm) clay content. Expressed in percent by volume.

asand = Mean soil profile (0-40 cm) sand content. Expressed in percent by volume.

ana = Mean soil profile (0-40 cm) sodium content. Expressed in milliequivalents per 100 grams of soil.

ak = Mean soil profile (0-40 cm) potassium content. Expressed in milliequivalents per 100 grams of soil.

acanl = Mean soil profile (0-40 cm) carbon/nitrogen ratio.

aph = Mean profile (0-40 cm) soil pH.

ap = Mean soil profile (0-40 cm) phosphorus content. Expressed as available phosphorus in micrograms per milliliter.

asatb = Mean soil profile (0-40 cm) base saturation. Expressed in percent.

[2/] $\hat{Y}$ = Mean tree growth increment in m^3/yr.

These results agree with the results of Yadab and Sharma (1973) for the region of Madhya Pradesh, India, where the climatic conditions as well as the soil calcium content were found to be very significant in the natural distribution of teak in the area. However, when the mean annual rainfall of the areas studied were in the range of 1400 to 1500 mm/year, climatic factors assumed lesser importance and the edaphic factors appear to be the greater value in these particular areas.

Also related to the above results is the presence of the variable ecosecos (dry months) which shows a very strong coefficient in the regression model for the country. This suggests that the species is well adapted to dry areas for a period of three to five months, which is also what was mentioned by Camacho (1981). Using Appendix 5 it is possible to determine that the mean period of dryness for the plots evaluated is less than 1.5 months. For zones 1 and 3, where the majority of plots are located, there are only two dry months in the year. Teak, thus appears to grow best with moderate precipitation (1500-2000 mm/year), and a period of dryness lasting from 3 to 5 months.

The best growth temperature for teak is between 22°C and 27°C (Camacho, 1981). The mean annual temperature for the plots analyzed is 24.7°C, and the values of maximum and minimum temperature are still within the optimum range reported for the species. It was therefore surprising that the variables maximum and mean temperature were included in the regression model of zone 1, and zone 3, with a negative regression coefficient. Results like this should be reviewed especially if more information is available for the analysis.

Another noticeable trend is the presence of exchangeable bases (sodium, potassium, and calcium) and the percentage base saturation in the regression models. As mentioned, the occurrence of teak in the south-west region of Madhya Pradesh is favored by a higher exchangeable calcium level under drier conditions (Yadab and Sharma, 1973).

Variables phosphorus and nitrogen in the regression model of zone 1 and zone 4, respectively, also have a strong regression coefficient. The significance of these variables is consistent with the general observation that this species responds well in fertile soils. Moreover, this also agrees with the results obtained for this species in India and Nigeria (Ojo, 1973). *T. grandis* in India showed responses to ammonium sulphate, superphosphate, or a combination of the two. For early growth stages of teak in Nigeria it was found to respond to superphosphate, often accompanied by a nitrogen-phosphorus interaction.

A multiple regression analysis of the growth of *T. grandis* was done by Martinez (1981) using twelve environmental factors. These twelve variables are the same mentioned for the analysis of *P. caribaea*. He found that the variables most strongly associated with growth in diameter were soil organic matter from the 0-5 cm depth, soil cation-exchange capacity from the 0-5 cm depth, the distribution of precipitation (mesic months), and soil texture in the 5-40 cm depth. For height growth only soil texture from 5-40 cm was found significant.

The agreement between my regression models and that of Martinez is minimal. The R^2 value reported by Martinez, using the mean annual diameter increment as the dependent variable is 0.79, and 0.59 using the mean annual height increment. The smallest R^2 value shown in Table 10 is 0.78 for the regression model of the country which uses the mean annual increment in volume as the dependent variable. The regression analysis done by Martinez (1981) was based on fewer environmental factors than used here, and those were the variables more highly correlated between themselves. In addition, he used mean annual increments in diameter and height of the trees as the dependent variables, while I selected the mean annual increment in volume as the dependent variable.

The general observation that can be drawn from the regression analysis for this species is that soil texture and exchangeable bases are the factors most closely related to the behavior of the teak in Costa Rica. More data would possibly reduce the number of independent variables entered into the regression model or increase the overlap between the different regression models for this species in the zones as well as in the country as a whole.

General Observations from the Regression Analysis

Growth curves for the five tree species analysed in this study were included in Camacho's (1981) study. These curves give a graphical representation of the growth variation within and between zones (see Figures 3 to 11 in Appendix 11). Some of these curves, as in the case of Figure 11, show a large variation in tree growth in a given zone. Moreover, the comparison of Figures 10 and 11 seems to indicate that the growth variation within zone 3 is greater than between zones 1 and 3. A possible explanation of the above results is that soil characteristics vary greatly within zone 3, and because of this, teak is responding to changes in soil properties. This is in agreement to the general regression analysis results of my study, in which the soil factors were more frequently entered into the regression models than the other variables.

The regression analysis produced useful equations for predicting the growth of trees of interest in Costa Rica. It yielded many statistically significant relationships (e.g., Table 4), and the overall number of environmental factors was reduced from twenty eight to twelve for the analysis of data from the entire country. For the analyses by zones and by species, nineteen variables were found to affect the growth of these five species (see Table 5). However, the number of environmental factors that remained in the regression equation for individual species was reduced to four for _Alnus_, _Cupressus_, and _Gmelina_, five for _Pinus_, and eight for _Tectona_. The values of R^2 for the regression equations ranged from 0.75 for _P. caribaea_ to 0.99 for _C. lusitanica_. In the regression analysis by zones, the number of environmental factors that remained in the regression equation was similar as those for the country, however, the selection of a lower number of variables was also frequent for species _Alnus_, _Cupressus_, and _Gmelina_.

The variables selected for the regression models of the country were not necessarily the same as those for specific zones. There is no reason to expect the analysis for the country to select the same variables that were selected in the analysis of a specific zone. The variation of any given environmental variable within a zone is likely to be quite different than within the country. For example, in a zone with uniformly high precipitation, factors other than moisture (nutrients, soil texture, etc.) limit growth; whereas for the country as a whole, differences in precipitation may be the dominant factor influencing growth.

The reduction in the number of variables selected in the analysis by zones (compared to the analysis for the country), plus a noticeable increase in R^2 indicates that the variation in the environmental factors is reduced if the regression analysis is done by specific geographic regions. This makes sense statistically and agrees with the results above. However, the small number of observation considered in the regression analysis by zones does not allow this to be presented as a strong conclusion. To draw stronger conclusions more data must be obtained.

The four variables most frequently included in the regression equations of these five species in the country were the distribution of the precipitation, percent soil base saturation, soil potassium content, and the age of the trees.

For the analysis of individual zones, the five variables that most frequently entered the regression equations were soil sodium content, soil cation exchange capacity, soil nitrogen content, soil silt content, and the age of the trees.

The overall number of environmental factors that entered the regression equations of these species in the country was similar for climatic and soil factors. In contrast, for the regression equations by specific zones, the overall number of soil factors greatly increased. Clearly the variation in climate is reduced if the analysis is done by zones, however, the small number and dispersed location of meteorological stations (particularly station type A) results in extrapolations that introduce another source of variation affecting these results.

Three different dependent growth variables (dbh, height, and volume growth) were combined through a multivariate analysis. The summarization of the data by the principal component analysis was effective in reducing the number of environmental factors, although the following step (canonical correlation) did not give satisfactory results. In most cases the analyses were difficult to interpret and did not follow a reasonable pattern. Despite this, multivariate analysis could become a useful tool in the summarization and interpretation of such data, especially if the sample size is increased.

CONCLUSIONS

Although cause and effect should not be assumed from a regression analysis, the consistency of the results obtained in this study allows the following conclusions.

1) The relationships between the growth of these species and environmental influences were successfully determined by the regression analysis, in the sense that the selection of variables, using different methods, was consistent throughout the study.
2) Variation in climatic variables was reduced when the analysis was done by zones, in such a way that soil characteristics were the factors most frequently included in the regression models.
3) Regression models with stronger relationships (R^2 values) were found when the analysis was done by individual zones than for the country.
4) Environmental factors affecting the growth of the species in a zone were not necessarily the same as those affecting the species in the entire country.
5) For individual species in different growth zones, one or more similar independent variables were frequently selected. However, the addition of other variables into the regression models was also common, showing the response of the species to changes in the environment.

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APPENDICES

APPENDIX 1 [1/]

Population statistics and correlation matrices for climatic and soil factors used in the regression analysis of Alnus acuminata

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[1/] For the description of the variables and unit of measurement see appendix 7.

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                                                  SPECIES=JAML

VARIABLE      N               MEAN              STD DEV                SUM              MINIMUM              MAXIMUM


ALT          14      1934.28571429         555.59689712     27080.00000000      1100.00000000        2620.00000000
TMAX         14        19.51428571           5.35994505       273.20000000        12.00000000          26.30000000
TMIN         14        12.14285714           4.60446510       170.00000000         5.40000000          17.00000000
TMED         14        15.20000000           5.04640009       212.80000000         7.90000000          20.20000000
HHUM         14        83.37142857           4.11907917      1167.20000000        77.90000000          88.50000000
ETHMI        14      1871.64285714         255.75397846     26203.00000000      1215.00000000        2440.00000000
RAD          14       420.35000000          68.13830675      5884.90000000       328.40000000         471.00000000
PRECIP       14      2810.35714286         720.28131331     39345.00000000      2009.00000000        3759.00000000
EVAP         14       599.07142857          95.02183092      8387.00000000       490.00000000         801.00000000
PLUVIOSO     14         8.64285714           1.54954797       121.00000000         7.00000000          11.00000000
INTEMM       14         1.42857143           0.51355259        20.00000000         1.00000000           2.00000000
ECOSECOS     14         1.92857143           1.49173547        27.00000000                  0           4.00000000
AGE          14         7.36428571           4.23876019       103.10000000         0.60000000          13.00000000
ASAND         9        63.43055556          11.17179609       570.87500000        45.75000000          80.00000000
ASILT         9        28.30555556           8.16220116       254.75000000        14.50000000          34.00000000
ACLAY         9         8.25000000           5.08674749        74.25000000         5.50000000          20.25000000
ACA           8         2.77421875           2.09510259        22.19375000         1.16750000           6.82750000
AMG           8         0.90265625           1.00799758         7.22125000         0.24000000           2.75500000
ANA           8         0.28468750           0.08231785         2.27750000         0.20125000           0.45750000
AK            8         0.34671875           0.32232688         2.77375000         0.12000000           0.99625000
ACEC          8        31.78437500          19.96552134       254.27500000        13.91250000          58.86250000
ASATB         8        14.60312500           5.94743623       116.82500000         4.27500000          22.68750000
APH           8         5.58750000           0.40016738        44.70000000         4.75000000           5.93750000
AC            8         4.89687500           2.81163510        39.17500000         2.61250000           9.18750000
AMO           8         8.44687500           4.87249821        67.57500000         4.51250000          15.85000000
AN            8         0.46406250           0.29012291         3.71250000         0.21250000           0.87500000
AP            8         6.38125000           3.38529514        51.05000000         3.72500000          14.50000000
ACANI         8        11.53593750           1.73878341        92.28750000         9.10000000          13.06250000
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                    CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 14

              ALT      TMAX      TMIN      TMED      RHUM     LIGHT       RAD    PRECIP      EVAP  PLUVIOSO    INTERM  ECOSECOS       AGE

ALT       1.00000  -0.75195  -0.90768  -0.79860  -0.78815   0.24748   0.77977  -0.60161   0.36919  -0.01685  -0.43828   0.16839   0.73088
           0.0000    0.0019    0.0001    0.0006    0.0008    0.3936    0.0010    0.0228    0.1939    0.9544    0.1170    0.5650    0.0030

TMAX     -0.75195   1.00000   0.93731   0.98462   0.62657   0.11441  -0.48596   0.51898  -0.04561   0.01270   0.61240  -0.22402  -0.68685
           0.0019    0.0000    0.0001    0.0001    0.0165    0.6968    0.0781    0.0572    0.8769    0.9656    0.0199    0.4413    0.0067

TMIN     -0.90768   0.93731   1.00000   0.97054   0.82149  -0.17705  -0.65042   0.64500  -0.24580   0.08317   0.61948  -0.29966  -0.76055
           0.0001    0.0001    0.0000    0.0001    0.0003    0.5430    0.0118    0.0127    0.3970    0.7774    0.0181    0.2979    0.0016

TMED     -0.79860   0.98462   0.97054   1.00000   0.71315  -0.04956  -0.51777   0.57162  -0.12015   0.02066   0.65494  -0.24431  -0.72753
           0.0006    0.0001    0.0001    0.0000    0.0042    0.8664    0.0579    0.0327    0.6820    0.9441    0.0104    0.3920    0.0032

RHUM     -0.78815   0.62657   0.82149   0.71315   1.00000  -0.55441  -0.52923   0.80267  -0.60018   0.44178   0.40987  -0.60001  -0.57391
           0.0008    0.0165    0.0001    0.0042    0.0000    0.0396    0.0516    0.0005    0.0233    0.1138    0.1455    0.0233    0.0319

LIGHT     0.24748   0.11441  -0.17705  -0.04956  -0.55441   1.00000   0.27214  -0.37419   0.44840  -0.17446  -0.28221   0.27837   0.15398
           0.3936    0.6968    0.5430    0.8664    0.0396    0.0000    0.3466    0.1872    0.1078    0.5508    0.3283    0.3352    0.5992

RAD       0.77977  -0.48596  -0.65042  -0.51777  -0.52923   0.27214   1.00000  -0.52760   0.23180   0.01759  -0.53814   0.16698   0.37311
           0.0010    0.0781    0.0118    0.0579    0.0516    0.3466    0.0000    0.0525    0.4252    0.9524    0.0471    0.5683    0.1889

PRECIP   -0.60161   0.51898   0.64500   0.57162   0.80267  -0.37419  -0.52760   1.00000  -0.81042   0.61813   0.39508  -0.77810  -0.11601
           0.0228    0.0572    0.0127    0.0327    0.0005    0.1872    0.0525    0.0000    0.0004    0.0185    0.1621    0.0010    0.6929

EVAP      0.36919  -0.04561  -0.24580  -0.12015  -0.60018   0.44840   0.23180  -0.81042   1.00000  -0.67532   0.06869   0.67784  -0.10616
           0.1939    0.8769    0.3970    0.6820    0.0233    0.1078    0.4252    0.0004    0.0000    0.0080    0.8155    0.0077    0.7179

PLUVIOSO -0.01685   0.01270   0.08317   0.02066   0.44178  -0.17446   0.01759   0.61813  -0.67532   1.00000  -0.27618  -0.94367   0.21574
           0.9544    0.9656    0.7774    0.9441    0.1138    0.5508    0.9524    0.0185    0.0080    0.0000    0.3392    0.0001    0.4588

INTERM   -0.43828   0.61240   0.61948   0.65494   0.40987  -0.28221  -0.53814   0.39508   0.06869  -0.27618   1.00000  -0.05738  -0.36700
           0.1170    0.0199    0.0181    0.0104    0.1455    0.3283    0.0471    0.1621    0.8155    0.3392    0.0000    0.8455    0.1968

ECOSECOS  0.16839  -0.22402  -0.29966  -0.24431  -0.60001   0.27837   0.16698  -0.77810   0.67784  -0.94367  -0.05738   1.00000  -0.09776
           0.5650    0.4413    0.2979    0.3920    0.0233    0.3352    0.5683    0.0010    0.0077    0.0001    0.8455    0.0000    0.7395

AGE       0.73088  -0.68685  -0.76055  -0.72753  -0.57391   0.15398   0.37311  -0.11601  -0.10616   0.21574  -0.36700  -0.09776   1.00000
           0.0030    0.0067    0.0016    0.0032    0.0319    0.5992    0.1889    0.6929    0.7179    0.4588    0.1968    0.7395    0.0000
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                           CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

             ASAND     ASILT     ACLAY       ACA       AMG       ANA        AK      ACEC     ASAIH       APH        AC       AMO        AN        AP     ACANI

ASAND      1.00000  -0.90925  -0.74140  -0.55618  -0.36671   0.80694  -0.42555   0.11025  -0.56118   0.19772   0.25776   0.25559   0.21222  -0.26117  -0.01919
            0.0000    0.0007    0.0217    0.1521    0.3744    0.0155    0.2932    0.7949    0.1478    0.6388    0.5377    0.5412    0.6139    0.5289    0.9640
                 9         9         9         8         8         8         8         8         8         8         8         8         8         8         8

ASILT     -0.90925   1.00000   0.39514   0.19179   0.00025  -0.74019   0.00140  -0.55084   0.55210   0.11477  -0.58184  -0.58165  -0.56047   0.21121   0.42502
            0.0007    0.0000    0.2921    0.6456    0.9995    0.0157    0.9974    0.1578    0.1558    0.7867    0.1286    0.1304    0.1485    0.5417    0.2919
                 9         9         9         8         8         8         8         8         8         8         8         8         8         8         8

ACLAY     -0.74140   0.39514   1.00000   0.79466   0.68180  -0.57117   0.79155   0.49062   0.34986  -0.51516   0.25757   0.25886   0.31311   0.19927  -0.50251
            0.0217    0.2921    0.0000    0.0186    0.0625    0.1392    0.0191    0.2171    0.3956    0.1914    0.5380    0.5359    0.4501    0.6361    0.2044
                 9         9         9         8         8         8         8         8         8         8         8         8         8         8         8

ACA       -0.55618   0.19179   0.79466   1.00000   0.97127  -0.69202   0.97512   0.47011   0.65017  -0.15704   0.22192   0.22615   0.15857  -0.13116  -0.79161
            0.1521    0.6456    0.0186    0.0000    0.0001    0.0572    0.0001    0.2398    0.0808    0.7104    0.5974    0.5936    0.7011    0.7569    0.0192
                 8         8         8         8         8         8         8         8         8         8         8         8         8         8         8

AMG       -0.36671   0.00025   0.68180   0.97127   1.00000  -0.54157   0.98205   0.50427   0.62807  -0.05824   0.24996   0.25176   0.39366  -0.29128  -0.87111
            0.3744    0.9995    0.0625    0.0001    0.0000    0.1656    0.0001    0.1986    0.0954    0.8910    0.5505    0.5476    0.3346    0.4840    0.0048
                 8         8         8         8         8         8         8         8         8         8         8         8         8         8         8

ANA        0.80694  -0.74019  -0.57117  -0.69202  -0.54157   1.00000  -0.52056   0.02601  -0.65710   0.09405   0.09978   0.09625  -0.00306  -0.26879   0.23788
            0.0155    0.0157    0.1392    0.0572    0.1656    0.0000    0.1859    0.9511    0.0766    0.8247    0.8142    0.8206    0.9943    0.5198    0.5705
                 8         8         8         8         8         8         8         8         8         8         8         8         8         8         8

AK        -0.42555   0.00140   0.79155   0.97512   0.98205  -0.52056   1.00000   0.59491   0.53644  -0.21166   0.33308   0.31466   0.45941  -0.18402  -0.87255
            0.2932    0.9974    0.0191    0.0001    0.0001    0.1859    0.0000    0.1167    0.1705    0.6148    0.4201    0.4478    0.2521    0.6557    0.0047
                 8         8         8         8         8         8         8         8         8         8         8         8         8         8         8

ACEC       0.11025  -0.55084   0.49062   0.47011   0.50427   0.02601   0.59491   1.00000  -0.34767  -0.74956   0.93912   0.93910   0.95775   0.30054  -0.81610
            0.7949    0.1578    0.2171    0.2398    0.1986    0.9511    0.1167    0.0000    0.3987    0.0323    0.0005    0.0005    0.0002    0.4695    0.0134
                 8         8         8         8         8         8         8         8         8         8         8         8         8         8         8

ASAIH     -0.56118   0.55210   0.34986   0.65017   0.62807  -0.65710   0.53644  -0.34767   1.00000   0.56965  -0.57518  -0.57110  -0.43845  -0.53714  -0.19472
            0.1478    0.1558    0.3956    0.0808    0.0954    0.0766    0.1705    0.3987    0.0000    0.1405    0.1358    0.1375    0.2772    0.1698    0.6440
                 8         8         8         8         8         8         8         8         8         8         8         8         8         8         8

APH        0.19772   0.11477  -0.51516  -0.15704  -0.05824   0.09405  -0.21166  -0.74956   0.56965   1.00000  -0.81014  -0.81033  -0.75233  -0.80913   0.30502
            0.6388    0.7867    0.1914    0.7104    0.8910    0.8247    0.6148    0.0323    0.1405    0.0000    0.0148    0.0147    0.0311    0.0149    0.4626
                 8         8         8         8         8         8         8         8         8         8         8         8         8         8         8

AC         0.25776  -0.58184   0.25757   0.22192   0.24996   0.09978   0.33308   0.93912  -0.57518  -0.81014   1.00000   0.99999   0.98628   0.50727  -0.64968
            0.5377    0.1286    0.5380    0.5974    0.5505    0.8142    0.4201    0.0005    0.1358    0.0148    0.0000    0.0001    0.0001    0.1994    0.0812
                 8         8         8         8         8         8         8         8         8         8         8         8         8         8         8

AMO        0.25559  -0.58165   0.25886   0.22615   0.25176   0.09625   0.31466   0.93910  -0.57110  -0.81033   0.99999   1.00000   0.98667   0.50838  -0.65070
            0.5412    0.1304    0.5359    0.5936    0.5476    0.8206    0.4478    0.0005    0.1375    0.0147    0.0001    0.0000    0.0001    0.1981    0.0806
                 8         8         8         8         8         8         8         8         8         8         8         8         8         8         8

AN         0.21222  -0.56047   0.31311   0.15857   0.39366  -0.00306   0.45941   0.95775  -0.43845  -0.75233   0.98628   0.98667   1.00000   0.43189  -0.75779
            0.6139    0.1485    0.4501    0.7011    0.3346    0.9943    0.2521    0.0002    0.2772    0.0311    0.0001    0.0001    0.0000    0.2853    0.0294
                 8         8         8         8         8         8         8         8         8         8         8         8         8         8         8

AP        -0.26117   0.21121   0.19927  -0.13116  -0.29128  -0.26879  -0.18402   0.30054  -0.53714  -0.80913   0.50727   0.50838   0.43189   1.00000   0.12743
            0.5289    0.5417    0.6361    0.7569    0.4840    0.5198    0.6557    0.4695    0.1698    0.0149    0.1994    0.1981    0.2853    0.0000    0.7637
                 8         8         8         8         8         8         8         8         8         8         8         8         8         8         8

ACANI     -0.01919   0.42502  -0.50251  -0.79161  -0.87111   0.23788  -0.87255  -0.81610  -0.19472   0.30502  -0.64968  -0.65070  -0.75779   0.12743   1.00000
            0.9640    0.2919    0.2044    0.0192    0.0048    0.5705    0.0047    0.0134    0.6440    0.4626    0.0812    0.0806    0.0294    0.7637    0.0000
                 8         8         8         8         8         8         8         8         8         8         8         8         8         8         8
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APPENDIX 2 [1/]

Population statistics and correlation matrices for climatic and soil factors used in the regression analysis of *Cupressus lusitanica*

[1/] For the description of the variables and unit of measurement see appendix 7.

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                                        SPECIES=CIPRES
VARIABLE        N             MEAN            STD DEV               SUM           MINIMUM           MAXIMUM


ALT            18    1860.61111111       518.76517851    33491.00000000     1100.00000000     2620.00000000
TMAX           18      21.46111111         4.69594805      386.30000000       12.00000000       24.20000000
TMIN           18      12.36111111         3.24565572      222.50000000        5.40000000       15.30000000
TMED           18      16.96111111         4.42494784      305.30000000        7.90000000       19.50000000
HHHM           18      82.90000000         2.89461976     1492.20000000       77.90000000       88.30000000
LIGHT          18    1918.00000000        61.19688573    34524.00000000     1687.00000000     1939.00000000
RAD            18     463.07777778        31.61114211     8335.40000000      328.40000000      471.00000000
PRECIP         18    2364.11111111       585.15678029    42554.00000000     1378.00000000     3346.00000000
EVAP           18     624.00000000        59.87044837    11232.00000000      490.00000000      650.00000000
PLUVIOSO       18       7.83333333         1.20049010      141.00000000        6.00000000       11.00000000
INTERM         18       1.66666667         0.68599434       30.00000000                 0        3.00000000
ECOSECOS       18       2.50000000         1.15044748       45.00000000                 0        4.00000000
AGE            18      12.64444444         8.38017424      227.60000000        5.00000000       30.00000000
ASAND          14      46.50892857        17.54269958      651.12500000       11.25000000       79.87500000
ASILT          14      32.78571429         7.10150116      459.00000000       14.50000000       45.00000000
ACLAY          14      20.69642857        15.01783004      289.75000000        5.50000000       60.50000000
ACA            13       5.59884615         4.53598159       72.78500000        0.38750000       13.47500000
AMG            13       1.97557692         1.50883739       25.68250000        0.24000000        3.98625000
ANA            13       0.38240385         0.34811601        4.97125000        0.18000000        1.49250000
AK             13       0.65403846         0.42584938        8.50250000        0.12000000        1.52875000
ACEC           13      37.94423077        16.71938681      493.27500000       13.91250000       56.27500000
ASATB          13      21.35192308        12.18314436      277.57500000        5.57500000       45.77500000
APH            13       5.64134615         0.35367802       73.33750000        4.75000000        6.26250000
AC             13       4.98269231         2.11683012       64.77500000        2.61250000        9.18750000
AMO            13       8.57884615         3.65144230      111.52500000        4.51250000       15.85000000
AN             13       0.46057692         0.23098781        5.98750000        0.21250000        0.87500000
AP             13       7.94134615         7.53120658      103.23750000        3.11250000       30.65000000
ACAUI          13      11.61634615         1.75881992      151.01250000        9.42500000       14.90000000
```

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	ASAND	ASILT	ACLAY	ACA	AMG	ANA	AK	AEC	ASATH	APH	AC	AOM	AN	AP	ACANI
ASAND	1.00000 0.0000 14	-0.53112 0.0507 14	-0.91697 0.0001 14	-0.07424 0.8095 11	-0.25846 0.4084 11	-0.00109 0.9920 11	-0.25825 0.3943 11	-0.36181 0.2256 11	0.14062 0.6468 13	-0.01251 0.9676 11	-0.20884 0.4952 11	-0.20900 0.4932 13	-0.08850 0.7737 13	0.18440 0.5465 11	-0.18011 0.5555 13
ASILT	-0.53112 0.0507 14	1.00000 0.0000 14	0.14834 0.6112 14	-0.18884 0.5183 11	0.01158 0.9700 11	0.18000 0.5562 11	-0.03300 0.9144 13	0.24691 0.4161 11	-0.27129 0.3651 11	-0.09927 0.7469 13	0.12298 0.6890 13	0.12747 0.6781 13	0.19709 0.5187 13	-0.15467 0.6119 11	-0.23567 0.4387 13
ACLAY	-0.91697 0.0001 14	0.14834 0.6112 14	1.00000 0.0000 14	0.11807 0.6528 11	0.25211 0.4060 11	-0.05650 0.8545 11	0.27444 0.3642 11	0.28651 0.3426 13	-0.05292 0.8637 11	0.04569 0.8822 13	0.17152 0.5751 13	0.17101 0.5764 13	0.02499 0.9354 13	-0.11690 0.6556 11	0.26201 0.3872 13
ACA	-0.07424 0.8095 11	-0.18884 0.5111 11	0.11807 0.6528 11	1.00000 0.0000 11	0.94742 0.0001 11	0.47178 0.1036 11	0.64194 0.0175 11	0.67241 0.0118 11	0.81198 0.0007 11	0.44492 0.1280 13	0.21124 0.4885 11	0.20184 0.5084 13	0.27001 0.3721 13	-0.14411 0.6386 11	-0.56559 0.0439 11
AMG	-0.25846 0.4044 11	0.01158 0.9700 11	0.25211 0.4060 13	0.94742 0.0001 11	1.00000 0.0000 11	0.46654 0.1081 11	0.78985 0.0011 11	0.71631 0.0059 13	0.79975 0.0010 13	0.45999 0.1131 13	0.18722 0.5402 13	0.17918 0.5581 13	0.25344 0.4035 13	-0.10477 0.7334 11	-0.58215 0.0368 11
ANA	-0.00109 0.9920 11	0.18000 0.5562 13	-0.05650 0.8545 11	0.47178 0.1036 13	0.46654 0.1081 11	1.00000 0.0000 11	0.06159 0.8416 11	0.37951 0.2009 11	0.29885 0.3213 13	0.60973 0.0269 13	0.30224 0.3155 13	0.30036 0.3187 13	0.34667 0.2459 13	-0.25251 0.4052 11	-0.38279 0.1965 11
AK	-0.25825 0.3941 13	-0.03300 0.9144 13	0.27444 0.3642 11	0.64194 0.0175 11	0.78985 0.0011 13	0.06159 0.8416 11	1.00000 0.0000 13	0.46087 0.1110 11	0.77690 0.0018 11	0.07603 0.8103 13	0.06662 0.8288 13	0.05980 0.8461 11	0.11226 0.7150 11	0.39708 0.1791 11	-0.39108 0.1865 11
AEC	-0.36181 0.2256 11	0.24691 0.4161 13	0.28651 0.3426 13	0.67241 0.0118 11	0.71631 0.0059 11	0.37951 0.2009 13	0.46087 0.1110 11	1.00000 0.0000 11	0.21764 0.4743 11	-0.26580 0.3801 13	0.73644 0.0041 13	0.73312 0.0044 13	0.77517 0.0019 13	-0.22135 0.4674 11	-0.74618 0.0034 13
ASATH	0.14062 0.6468 11	-0.27129 0.3651 11	-0.05292 0.8637 11	0.81198 0.0007 11	0.79975 0.0010 11	0.29885 0.3213 11	0.77690 0.0018 11	0.21764 0.4743 13	1.00000 0.0000 11	0.44286 0.1297 13	-0.16909 0.5790 13	-0.18002 0.5562 13	-0.10602 0.7303 13	0.28314 0.3482 11	-0.29607 0.3260 11
APH	-0.01251 0.9676 11	-0.09927 0.7469 13	0.04569 0.8822 13	0.44492 0.1280 11	0.45999 0.1131 13	0.60973 0.0269 13	0.07603 0.8101 13	-0.26580 0.3801 11	0.44286 0.1297 11	1.00000 0.0000 13	-0.49023 0.0890 13	-0.49115 0.0868 13	-0.46776 0.1051 13	-0.21285 0.4439 11	0.17044 0.5777 11
AC	-0.20884 0.4952 13	0.12298 0.6890 11	0.17152 0.5751 13	0.21124 0.4885 11	0.18722 0.5402 11	0.30224 0.3155 11	0.06662 0.8288 11	0.73644 0.0041 13	-0.16989 0.5790 13	-0.49021 0.0890 13	1.00000 0.0000 13	0.99993 0.0001 13	0.97494 0.0001 13	0.07741 0.8015 13	-0.51928 0.0672 11
AOM	-0.20900 0.4932 11	0.12747 0.6781 13	0.17101 0.5764 13	0.20184 0.5084 13	0.17918 0.5581 13	0.30036 0.3187 13	0.05980 0.8461 13	0.73312 0.0044 11	-0.18002 0.5562 11	-0.49115 0.0868 13	0.99993 0.0001 11	1.00000 0.0000 13	0.97481 0.0001 13	0.07432 0.8093 13	-0.53717 0.0584 13
AN	-0.08850 0.7737 11	0.19709 0.5187 11	0.02499 0.9354 11	0.27001 0.3721 11	0.25344 0.4015 13	0.34667 0.2459 11	0.11226 0.7150 11	0.77517 0.0019 11	-0.10602 0.7301 11	-0.46976 0.1053 13	0.97494 0.0001 13	0.97481 0.0001 11	1.00000 0.0000 13	0.01528 0.9609 13	-0.70229 0.0076 11
AP	0.18440 0.5465 11	-0.15467 0.6119 11	-0.11690 0.6556 11	-0.14411 0.6386 11	-0.10477 0.7334 13	-0.25251 0.4052 11	0.39708 0.1791 13	-0.22135 0.4674 11	0.28314 0.3482 11	-0.21285 0.4439 13	0.07741 0.8015 13	0.07432 0.8093 13	0.01528 0.9089 13	1.00000 0.0000 11	0.17145 0.5749 11
ACANI	-0.18011 0.5555 11	-0.23567 0.4387 13	0.26201 0.3872 13	-0.56559 0.0439 11	-0.58215 0.0368 11	-0.38279 0.1965 11	-0.39108 0.1839 11	-0.74618 0.0034 11	-0.29607 0.3260 11	0.17044 0.5777 11	-0.51928 0.0672 13	-0.53717 0.0584 13	-0.70229 0.0076 11	0.17145 0.5749 11	1.00000 0.0000 11

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                                CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 18

                ALT      TMAX      TMIN      TMED      RHUM     LIGHT       RAD    PRECIP      EVAP  PLUVIOSO    INTERM  ECOSECOS       AGE

ALT         1.00000  -0.64295  -0.69681  -0.64926  -0.51948   0.03932   0.19754   0.10295   0.14092   0.24188  -0.64322   0.13114  -0.02728
             0.0000    0.0040    0.0016    0.0035    0.0271    0.8769    0.4320    0.6844    0.5770    0.3335    0.0040    0.6040    0.9144

TMAX       -0.64295   1.00000   0.94963   0.99896   0.51281   0.17163  -0.05521   0.19248   0.15269  -0.21825   0.46868  -0.05172  -0.10986
             0.0040    0.0000    0.0001    0.0001    0.0295    0.4959    0.8277    0.4441    0.5453    0.3843    0.0498    0.8385    0.6641

TMIN       -0.69681   0.94963   1.00000   0.95896   0.74270  -0.07952  -0.22598   0.30831  -0.16450  -0.07574   0.46675  -0.19928  -0.06760
             0.0016    0.0001    0.0000    0.0001    0.0004    0.7538    0.3672    0.2132    0.5142    0.7652    0.0509    0.4279    0.7898

TMED       -0.64926   0.99896   0.95896   1.00000   0.54752   0.13522  -0.04731   0.19843   0.11888  -0.20504   0.46832  -0.06529  -0.09743
             0.0035    0.0001    0.0001    0.0000    0.0187    0.5927    0.8521    0.4299    0.6385    0.4144    0.0500    0.7969    0.7005

RHUM       -0.51948   0.51281   0.74270   0.54752   1.00000  -0.63479  -0.25865   0.36576  -0.73724   0.22345   0.27846  -0.39921   0.11118
             0.0271    0.0295    0.0004    0.0187    0.0000    0.0047    0.3000    0.1355    0.0005    0.3728    0.2632    0.1008    0.6605

LIGHT       0.03932   0.17163  -0.07952   0.13522  -0.63479   1.00000   0.13458  -0.41850   0.80281  -0.64135   0.17655   0.56397   0.02526
             0.8769    0.4959    0.7538    0.5927    0.0047    0.0000    0.5944    0.0839    0.0001    0.0041    0.4834    0.0148    0.9208

RAD         0.19754  -0.05521  -0.22598  -0.04731  -0.25865   0.13458   1.00000  -0.41877   0.50855  -0.24254  -0.12127   0.32540   0.16512
             0.4320    0.8277    0.3672    0.8521    0.3000    0.5944    0.0000    0.0837    0.0312    0.3122    0.6317    0.1876    0.5126

PRECIP      0.10295   0.19248   0.30831   0.19843   0.36576  -0.41850  -0.41877   1.00000  -0.35812   0.65569  -0.15655  -0.59046  -0.34501
             0.6844    0.4441    0.2132    0.4299    0.1355    0.0839    0.0837    0.0000    0.1445    0.0031    0.5350    0.0098    0.1609

EVAP        0.14092   0.15269  -0.16450   0.11888  -0.73724   0.80281   0.50855  -0.35812   1.00000  -0.44686   0.00573   0.46288  -0.14224
             0.5770    0.5453    0.5142    0.6385    0.0005    0.0001    0.0312    0.1445    0.0000    0.0630    0.9820    0.0531    0.5734

PLUVIOSO    0.24188  -0.21825  -0.07574  -0.20504   0.22345  -0.64135  -0.24254   0.65569  -0.44686   1.00000  -0.35714  -0.81054  -0.39214
             0.3335    0.3843    0.7652    0.4144    0.3728    0.0041    0.3122    0.0031    0.0630    0.0000    0.1457    0.0001    0.1075

INTERM     -0.64322   0.46868   0.46675   0.46832   0.27846   0.17655  -0.12127  -0.15655   0.00573  -0.35714   1.00000  -0.22361   0.16645
             0.0040    0.0498    0.0509    0.0500    0.2632    0.4834    0.6317    0.5350    0.9820    0.1457    0.0000    0.3724    0.5092

ECOSECOS    0.13114  -0.05172  -0.19928  -0.06529  -0.39921   0.56397   0.32540  -0.59046   0.46288  -0.81054  -0.22361   1.00000   0.30995
             0.6040    0.8385    0.4279    0.7969    0.1008    0.0148    0.1876    0.0098    0.0531    0.0001    0.3724    0.0000    0.2107

AGE        -0.02728  -0.10986  -0.06760  -0.09743   0.11118   0.02526   0.16512  -0.34501  -0.14224  -0.39214   0.16645   0.30995   1.00000
             0.9144    0.6641    0.7898    0.7005    0.6605    0.9208    0.5126    0.1609    0.5734    0.1075    0.5092    0.2107    0.0000
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APPENDIX 3 [1/]

Population statistics and correlation matrices for climatic and soil factors used in the regression analysis of *Gmelina arborea*

[1/] For the description of the variables and unit of measurement see appendix 7.

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                                              SPECIES=MELINA

VARIABLE     N              MEAN            STD DEV              SUM            MINIMUM            MAXIMUM


ALT         16      194.75000000       166.96606442     3116.00000000       20.00000000       500.00000000
TMAX        16       30.61250000         2.08642437      489.80000000       27.00000000        32.80000000
TMIN        16       21.18125000         1.44229464      338.90000000       18.00000000        22.90000000
TMED        16       25.22500000         1.73721919      403.60000000       22.30000000        27.20000000
HUMM        16       83.14375000         4.77897740     1330.30000000       76.50000000        88.00000000
LIGHT       16     2054.81250000       399.69100384    32877.00000000     1563.00000000      2557.00000000
RAD         16      361.27500000        64.64638685     5780.40000000      291.40000000       485.40000000
PRECIP      16     3278.87500000      1306.86775026    52462.00000000     1335.00000000      4642.00000000
EVAP        16     1042.62500000       668.83718681    16682.00000000      369.00000000      2008.00000000
PLUVIOSO    16        9.00000000         2.33809039      144.00000000        6.00000000        12.00000000
TOTEMM      16        1.00000000         1.09544512       16.00000000                 0         3.00000000
ECOSECOS    16        2.00000000         2.09761770       32.00000000                 0         5.00000000
AGE         16        6.04375000         2.64901711       96.70000000        1.00000000        12.00000000

ASAND       12       46.19791667        28.42791222      554.37500000       16.75000000        81.75000000
ASILT       12       29.54166667        10.77709763      354.50000000       13.75000000        50.00000000
ACLAY       12       24.26041667        15.90369260      291.12500000        3.00000000        55.75000000
ACA         12        9.87520833        10.71402889      118.50250000        0.77875000        40.20125000
AMG         12        2.07125000         1.69406736       24.85500000        0.29625000         5.55125000
ANA         12        0.28979167         0.09173491        3.47750000        0.21250000         0.53625000
AK          12        0.51447917         0.35725972        6.17375000        0.09500000         1.25750000
ACEC        12       36.61875000         9.85235825      439.42500000       12.78750000        48.65000000
ASATM       12       34.79583333        25.70866902      417.55000000        4.76250000        87.96250000
APH         12        6.10104167         0.67387234       73.21250000        4.83750000         7.06250000
AC          12        3.44895833         1.69164419       41.38750000        1.20000000         6.98750000
AMO         12        5.85520833         2.97174888       70.26250000        2.07500000        11.98750000
AN          12        0.32395833         0.20994171        3.88750000        0.11250000         0.75000000
AP          12        9.87604167        16.35056770      118.51250000        2.11250000        59.81250000
ACANT       12       11.46041667         2.67527523      137.52500000        8.28750000        16.72500000
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                          CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 16

               ALT      TMAX      TMIN      TMED      RHUM     LIGHT       RAD    PRECIP      EVAP  PLUVIOSO    INTERM  ECOSECOS       AGE

ALT        1.00000  -0.49583  -0.85378  -0.70447   0.42594  -0.41252   0.03067   0.25521  -0.37844   0.08675   0.23838  -0.22119   0.08379
            0.0000    0.0508    0.0001    0.0023    0.1000    0.1123    0.9102    0.3401    0.1484    0.7494    0.3740    0.4104    0.7577

TMAX      -0.49583   1.00000   0.66727   0.93021  -0.62311   0.74678   0.33982  -0.56898   0.68823  -0.50291   0.13418   0.49050   0.04923
            0.0508    0.0000    0.0047    0.0001    0.0099    0.0009    0.1978    0.0214    0.0032    0.0471    0.6203    0.0537    0.8563

TMIN      -0.85378   0.66727   1.00000   0.87123  -0.39343   0.43771   0.07062  -0.46741   0.44411  -0.30380  -0.13866   0.41104   0.10326
            0.0001    0.0047    0.0000    0.0001    0.1316    0.0899    0.7949    0.0679    0.0848    0.2527    0.6086    0.1137    0.7035

TMED      -0.70447   0.93021   0.87123   1.00000  -0.62672   0.68081   0.24941  -0.63468   0.70112  -0.47598  -0.06306   0.56347   0.12433
            0.0023    0.0001    0.0001    0.0000    0.0094    0.0037    0.3516    0.0083    0.0025    0.0624    0.8165    0.0230    0.6464

RHUM       0.42594  -0.62311  -0.39343  -0.62672   1.00000  -0.91825  -0.55654   0.75473  -0.94844   0.74878  -0.04075  -0.81334   0.16704
            0.1000    0.0099    0.1316    0.0094    0.0000    0.0001    0.0252    0.0007    0.0001    0.0008    0.8809    0.0001    0.5364

LIGHT     -0.41252   0.74678   0.43771   0.68081  -0.91825   1.00000   0.51686  -0.72620   0.89201  -0.80983   0.33650   0.72694  -0.21634
            0.1123    0.0009    0.0899    0.0037    0.0001    0.0000    0.0404    0.0014    0.0001    0.0001    0.2025    0.0014    0.4210

RAD        0.03067   0.33982   0.07062   0.24941  -0.55654   0.51686   1.00000  -0.58924   0.59129  -0.59487   0.02532   0.64984  -0.05167
            0.9102    0.1978    0.7949    0.3516    0.0252    0.0404    0.0000    0.0163    0.0159    0.0151    0.9258    0.0064    0.8493

PRECIP     0.25521  -0.56898  -0.46741  -0.63468   0.75473  -0.72620  -0.58924   1.00000  -0.90520   0.85756  -0.00037  -0.95567  -0.20347
            0.3401    0.0214    0.0679    0.0083    0.0007    0.0014    0.0163    0.0000    0.0001    0.0001    0.9989    0.0001    0.4498

EVAP      -0.37844   0.68823   0.44411   0.70112  -0.94844   0.89201   0.59129  -0.90520   1.00000  -0.80547  -0.00719   0.90157   0.03174
            0.1484    0.0032    0.0848    0.0025    0.0001    0.0001    0.0159    0.0001    0.0000    0.0002    0.9789    0.0001    0.9071

PLUVIOSO   0.08675  -0.50291  -0.30380  -0.47598   0.74878  -0.80983  -0.59487   0.85756  -0.80547   1.00000  -0.44249  -0.88356   0.01615
            0.7494    0.0471    0.2527    0.0624    0.0008    0.0001    0.0151    0.0001    0.0002    0.0000    0.0861    0.0001    0.9527

INTERM     0.23838   0.13418  -0.13866  -0.06306  -0.04075   0.33650   0.02532  -0.00037  -0.00719  -0.44249   1.00000  -0.02901  -0.27569
            0.3740    0.6203    0.6086    0.8165    0.8809    0.2025    0.9258    0.9989    0.9789    0.0861    0.0000    0.9151    0.3014

ECOSECOS  -0.22119   0.49050   0.41104   0.56347  -0.81334   0.72694   0.64984  -0.95567   0.90157  -0.88356  -0.02901   1.00000   0.12598
            0.4104    0.0537    0.1137    0.0230    0.0001    0.0014    0.0064    0.0001    0.0001    0.0001    0.9151    0.0000    0.6420

AGE        0.08379   0.04923   0.10326   0.12433   0.16704  -0.21634  -0.05167  -0.20347   0.03174   0.01615  -0.27569   0.12598   1.00000
            0.7577    0.8563    0.7035    0.6464    0.5364    0.4210    0.8493    0.4498    0.9071    0.9527    0.3014    0.6420    0.0000
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                         CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 12

           ASAND     ASILT     ACLAY       ACA       AMG       ANA        AK      ACEC     ASATM       APH        AC       AMO        AN          AP     ALAMI

ASAND    1.00000  -0.63710  -0.85275  -0.18623  -0.66582  -0.45407  -0.64194   0.20269  -0.36696  -0.04467   0.65444   0.67397   0.78446    -0.19365  -0.19405
          0.0000    0.0259    0.0004    0.5622    0.0181    0.1381    0.0244    0.5275    0.2406    0.8904    0.0209    0.0162    0.0025      0.5465    0.7050

ASILT   -0.63710   1.00000   0.14069   0.23704   0.72026   0.57050   0.73175  -0.03283   0.40981   0.42685  -0.35572  -0.38669  -0.50310     0.48801   0.28465
          0.0259    0.0000    0.6628    0.4582    0.0082    0.0527    0.0068    0.9193    0.1858    0.1664    0.2565    0.2143    0.0955      0.1075    0.3699

ACLAY   -0.85275   0.14069   1.00000   0.07858   0.36715   0.19665   0.32869  -0.23810   0.19365  -0.23188  -0.59956  -0.60366  -0.66669    -0.08195   0.31326
          0.0004    0.6628    0.0000    0.8082    0.2404    0.5402    0.2969    0.4561    0.5465    0.4683    0.0393    0.0377    0.0179      0.8001    0.3215

ACA     -0.18623   0.23704   0.07858   1.00000   0.29455   0.14130   0.28863  -0.03232   0.87064   0.66226  -0.44096  -0.43795  -0.38340     0.00564  -0.04526
          0.5622    0.4582    0.8082    0.0000    0.3527    0.6614    0.3629    0.9206    0.0002    0.0190    0.1513    0.1545    0.2186      0.9861    0.8889

AMG     -0.66582   0.72026   0.36715   0.29455   1.00000   0.59202   0.73624   0.08086   0.50214   0.40024  -0.36012  -0.38082  -0.46692     0.11541   0.12769
          0.0181    0.0082    0.2404    0.3527    0.0000    0.0426    0.0061    0.8027    0.0962    0.1973    0.2499    0.2220    0.1259      0.7209    0.6925

ANA     -0.45407   0.57050   0.19665   0.14130   0.59202   1.00000   0.68699   0.29946   0.18669   0.18636  -0.14775  -0.20079  -0.15210    -0.05478  -0.40184
          0.1381    0.0527    0.5402    0.6614    0.0426    0.0000    0.0136    0.3443    0.5613    0.5620    0.6468    0.5315    0.6370      0.8657    0.1954

AK      -0.64194   0.73175   0.32869   0.28863   0.73624   0.68699   1.00000   0.09128   0.43215   0.37598  -0.28653  -0.30815  -0.38603     0.14487   0.05151
          0.0244    0.0068    0.2969    0.3629    0.0061    0.0136    0.0000    0.7731    0.1606    0.2284    0.3666    0.3298    0.2152      0.6533    0.8737

ACEC     0.20269  -0.03283  -0.23810  -0.03232   0.08086   0.29946   0.09128   1.00000  -0.36097  -0.26536   0.71450   0.69371   0.70344    -0.24890  -0.52841
          0.5275    0.9193    0.4561    0.9206    0.8027    0.3443    0.7731    0.0000    0.2490    0.4045    0.0083    0.0123    0.0107      0.4351    0.0774

ASATM   -0.36696   0.40981   0.19365   0.87064   0.50214   0.18669   0.43215  -0.36097   1.00000   0.84751  -0.70645  -0.70015  -0.66042     0.01742   0.13777
          0.2406    0.1858    0.5465    0.0002    0.0962    0.5613    0.1606    0.2490    0.0000    0.0005    0.0102    0.0112    0.0194      0.9572    0.6694

APH     -0.04467   0.42685  -0.23188   0.66226   0.40024   0.18636   0.37598  -0.26536   0.84751   1.00000  -0.44315  -0.43720  -0.37711    -0.09814   0.00534
          0.8904    0.1664    0.4683    0.0190    0.1973    0.5620    0.2284    0.4045    0.0005    0.0000    0.1491    0.1552    0.2269      0.7615    0.9869

AC       0.65444  -0.35572  -0.59956  -0.44096  -0.36012  -0.14775  -0.28653   0.71450  -0.70645  -0.44315   1.00000   0.99799   0.94135    -0.05623  -0.28308
          0.0209    0.2565    0.0393    0.1513    0.2499    0.6468    0.3666    0.0083    0.0102    0.1491    0.0000    0.0001    0.0001      0.8622    0.3726

AMO      0.67397  -0.38669  -0.60366  -0.43795  -0.38082  -0.20079  -0.30815   0.69371  -0.70015  -0.43720   0.99799   1.00000   0.93888    -0.06419  -0.25562
          0.0162    0.2143    0.0377    0.1545    0.2220    0.5315    0.3298    0.0123    0.0112    0.1552    0.0001    0.0000    0.0001      0.8429    0.4226

AN       0.78446  -0.50310  -0.66669  -0.38340  -0.46692  -0.15210  -0.38603   0.70344  -0.66042  -0.37711   0.94135   0.93888   1.00000    -0.23858  -0.54224
          0.0025    0.0955    0.0179    0.2186    0.1259    0.6370    0.2152    0.0107    0.0194    0.2269    0.0001    0.0001    0.0000      0.4552    0.0686

AP      -0.19365   0.48801  -0.08195   0.00564   0.11541  -0.05478   0.14487  -0.24890   0.01742  -0.09814  -0.05623  -0.06419  -0.23858     1.00000   0.51240
          0.5465    0.1075    0.8001    0.9861    0.7209    0.8657    0.6533    0.4351    0.9572    0.7615    0.8622    0.8429    0.4552      0.0000    0.0748

ALAMI   -0.19405   0.28465   0.31326  -0.04526   0.12769  -0.40184   0.05151  -0.52841   0.13777   0.00534  -0.28308  -0.25562  -0.54224     0.51240   1.00000
          0.7050    0.3699    0.3215    0.8889    0.6925    0.1954    0.8737    0.0774    0.6694    0.9869    0.3726    0.4226    0.0686      0.0748    0.0000
```

APPENDIX 4 [1]

Population statistics and correlation matrices for climatic and soil factors used in the regression analysis of *Pinus caribaea*

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[1] For the description of the variables and unit of measurement see appendix 7.

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                                                   SPECIES=PINUS

VARIABLE      N            MEAN            STD DEV              SUM            MINIMUM            MAXIMUM


ALT          30    465.80000000       118.27784415    13974.0000000        90.00000000      1140.00000000
TMAX         30     26.95000000         3.53043418      808.5000000        20.80000000        32.80000000
TMIN         30     18.81000000         2.08466412      564.3000000        13.80000000        22.60000000
TMED         30     22.35333333         2.33160198      670.6000000        19.10000000        27.20000000
HUM          30     85.83000000         2.86803429     2574.9000000        77.80000000        88.50000000
LIGHT        30   1749.06666667       356.02788861    52472.0000000      1215.00000000      2440.00000000
RAD          30    366.59333333        60.01438870    10997.8000000       291.40000000       485.40000000
PRECIP       30   3568.16666667       842.48413812   107045.0000000      1708.00000000      4535.00000000
EVAP         30    628.36666667       340.73576407    18851.0000000       369.00000000      1839.00000000
PLUVIOSO     30      9.93333333         1.85571500      298.0000000         7.00000000        12.00000000
INVERN       30      1.06666667         0.94443318       32.0000000                  0         3.00000000
ECOSECOS     30      1.03333333         1.21721170       31.0000000                  0         4.00000000
AGE          30      6.73666667         2.88901794      202.1000000         3.00000000        18.00000000

ASAND        26     44.15865385        22.31825768     1148.12500000       10.75000000        81.75000000
ASILT        26     24.66346154         8.46705151      641.25000000       11.00000000        50.00000000
ACLAY        26     31.74038462        20.60294042      825.25000000        3.00000000        66.00000000
ALA          26      4.21932692         3.78791246      109.70250000        0.29625000        13.47500000
AMG          26      1.34110577         1.21820987       34.86875000        0.12500000         4.21000000
ANA          26      0.28822115         0.11655802        7.49375000        0.16000000         0.59750000
AK           26      0.40764423         0.31687307       10.59875000        0.06125000         1.14875000
ACEC         26     36.98653846        10.33767075      961.65000000       18.17500000        55.26250000
ASATB        26     17.72548077        12.40132126      460.86250000        2.57500000        44.03750000
APH          26      5.72403846         0.49997404      148.82500000        4.83750000         6.85000000
AC           26      4.05576923         1.50622554      105.45000000        1.37500000         7.05000000
AMO          26      6.95144231         2.61060432      180.73750000        2.38750000        12.16250000
AN           26      0.36826923         0.16808594        9.57500000        0.12500000         0.75000000
AP           26      5.02644231         4.86284809      130.68750000        1.55000000        22.75000000
ACANI        26     11.69182692         3.17639131      303.98750000        7.57500000        18.70000000
```

CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 26

	ASAND	ASILT	ACLAY	ACA	AMG	ANA	AK	ACEC	ASATB	APH	AC	AMO	AN	AP	ACANI
ASAND	1.00000	-0.34457	-0.92452	-0.33144	-0.37550	-0.02362	-0.22888	0.31928	-0.46880	0.00670	0.67524	0.67756	0.71263	-0.26525	-0.14693
	0.0000	0.0847	0.0001	0.0960	0.0587	0.9088	0.2607	0.1119	0.0157	0.9741	0.0001	0.0001	0.0001	0.1903	0.4738
ASILT	-0.34457	1.00000	-0.01694	0.74541	0.71664	0.29989	0.75146	0.18961	0.71992	0.66590	-0.35909	-0.38476	-0.25224	0.63172	-0.30854
	0.0847	0.0000	0.9348	0.0001	0.0001	0.1366	0.0001	0.3536	0.0001	0.0002	0.0716	0.0523	0.2138	0.0005	0.1251
ACLAY	-0.92452	-0.01694	1.00000	0.02948	0.09634	-0.10392	-0.06303	-0.40730	0.18278	-0.28725	-0.57480	-0.56696	-0.65450	0.01041	0.27229
	0.0001	0.9348	0.0000	0.8863	0.6397	0.6134	0.7597	0.0389	0.3715	0.1548	0.0021	0.0025	0.0003	0.9597	0.1784
ACA	-0.33144	0.74541	0.02948	1.00000	0.90912	0.35691	0.76407	0.42317	0.83142	0.64588	-0.18955	-0.20893	-0.04625	0.36127	-0.38551
	0.0960	0.0001	0.8863	0.0000	0.0001	0.0735	0.0001	0.0312	0.0001	0.0004	0.3537	0.3057	0.8225	0.0698	0.0518
AMG	-0.37550	0.71664	0.09634	0.90912	1.00000	0.53847	0.80404	0.41628	0.80258	0.55503	-0.27287	-0.29448	-0.11263	0.36917	-0.41396
	0.0587	0.0001	0.6397	0.0001	0.0000	0.0046	0.0001	0.0344	0.0001	0.0032	0.1774	0.1442	0.5838	0.0633	0.0355
ANA	-0.02362	0.29989	-0.10392	0.35691	0.53847	1.00000	0.47711	0.27698	0.31503	0.13266	-0.15108	-0.17296	0.04505	0.10228	-0.43537
	0.9088	0.1366	0.6134	0.0735	0.0046	0.0000	0.0137	0.1707	0.1170	0.5183	0.4613	0.3981	0.8270	0.6190	0.0262
AK	-0.22888	0.75146	-0.06303	0.76407	0.80404	0.47711	1.00000	0.39790	0.66331	0.62983	-0.19900	-0.21634	-0.13293	0.33987	-0.26051
	0.2607	0.0001	0.7597	0.0001	0.0001	0.0137	0.0000	0.0441	0.0002	0.0006	0.3298	0.2885	0.5174	0.0894	0.1987
ACEC	0.31928	0.18961	-0.40730	0.42317	0.41628	0.27698	0.39790	1.00000	0.01593	0.15246	0.60307	0.58762	0.74238	0.02478	-0.48643
	0.1119	0.3536	0.0389	0.0312	0.0344	0.1707	0.0441	0.0000	0.9385	0.4572	0.0011	0.0016	0.0001	0.9043	0.0117
ASATB	-0.46880	0.71992	0.18278	0.83142	0.80258	0.31503	0.66331	0.01593	1.00000	0.65700	-0.50203	-0.51568	-0.35355	0.39704	-0.31346
	0.0157	0.0001	0.3715	0.0001	0.0001	0.1170	0.0002	0.9385	0.0000	0.0003	0.0090	0.0070	0.0764	0.0446	0.1189
APH	0.00670	0.66590	-0.28725	0.64588	0.55503	0.13266	0.62983	0.15246	0.65700	1.00000	-0.28029	-0.28309	-0.02618	0.19994	-0.47587
	0.9741	0.0002	0.1548	0.0004	0.0032	0.5183	0.0006	0.4572	0.0003	0.0000	0.1655	0.1611	0.8990	0.3273	0.0140
AC	0.67524	-0.35909	-0.57480	-0.18955	-0.27287	-0.15108	-0.19900	0.60307	-0.50203	-0.28029	1.00000	0.99861	0.81155	-0.11043	0.10028
	0.0001	0.0716	0.0021	0.3537	0.1774	0.4613	0.3298	0.0011	0.0090	0.1655	0.0000	0.0001	0.0001	0.5912	0.6259
AMO	0.67756	-0.38476	-0.56696	-0.20893	-0.29448	-0.17296	-0.21634	0.58762	-0.51568	-0.28309	0.99861	1.00000	0.81077	-0.13895	0.10982
	0.0001	0.0523	0.0025	0.3057	0.1442	0.3981	0.2885	0.0016	0.0070	0.1611	0.0001	0.0000	0.0001	0.4984	0.5933
AN	0.71263	-0.25224	-0.65450	-0.04625	-0.11263	0.04505	-0.13293	0.74238	-0.35355	-0.02618	0.81155	0.81077	1.00000	-0.20724	-0.45997
	0.0001	0.2138	0.0003	0.8225	0.5838	0.8270	0.5174	0.0001	0.0764	0.8990	0.0001	0.0001	0.0000	0.3097	0.0181
AP	-0.26525	0.63172	0.01041	0.36127	0.36917	0.10228	0.33987	0.02478	0.39704	0.19994	-0.11043	-0.13895	-0.20724	1.00000	-0.00692
	0.1903	0.0005	0.9597	0.0698	0.0633	0.6190	0.0894	0.9043	0.0446	0.3273	0.5912	0.4984	0.3097	0.0000	0.9732
ACANI	-0.14693	-0.30854	0.27229	-0.38551	-0.41396	-0.43537	-0.26051	-0.48643	-0.31346	-0.47587	0.10028	0.10982	-0.45997	-0.00692	1.00000
	0.4738	0.1251	0.1784	0.0518	0.0355	0.0262	0.1987	0.0117	0.1189	0.0140	0.6259	0.5933	0.0181	0.9732	0.0000

```
                                   CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 30

                 ALT      TMAX      TMIN      TMED      HRMM     LIGHT       RAD    PRECIP      EVAP  PLUVIOSO    INTERM  ECOSECOS       AGF

ALT          1.00000  -0.40256  -0.75616  -0.59079  -0.28705   0.18610   0.30051  -0.44845   0.18875  -0.67621   0.71369   0.47220   0.23130
              0.0000    0.0274    0.0001    0.0006    0.1240    0.3248    0.1066    0.0129    0.3178    0.0001    0.0001    0.0084    0.2188

TMAX        -0.40256   1.00000   0.75031   0.95386  -0.33141   0.67291   0.12286   0.08128   0.35172   0.07421  -0.31853   0.08466  -0.24070
              0.0274    0.0000    0.0001    0.0001    0.0714    0.0001    0.5178    0.6694    0.0566    0.6967    0.0862    0.6565    0.2001

TMIN        -0.75616   0.75031   1.00000   0.88931   0.03767   0.20298  -0.24452   0.36345   0.11880   0.44675  -0.61511  -0.22844  -0.12591
              0.0001    0.0001    0.0000    0.0001    0.8431    0.2820    0.1928    0.0484    0.5118    0.0133    0.0003    0.2247    0.5073

TMED        -0.59079   0.95386   0.88931   1.00000  -0.19775   0.50570   0.02326   0.15910   0.29904   0.20004  -0.46519   0.01636  -0.24704
              0.0006    0.0001    0.0001    0.0000    0.2949    0.0044    0.9029    0.4010    0.1084    0.2891    0.0096    0.9316    0.1881

HRMM        -0.28705  -0.33141   0.03767  -0.19775   1.00000  -0.77814  -0.76455   0.60281  -0.58390   0.52583  -0.24646  -0.58406   0.05122
              0.1240    0.0714    0.8431    0.2949    0.0000    0.0001    0.0001    0.0004    0.0007    0.0028    0.1892    0.0007    0.7881

LIGHT        0.18610   0.67291   0.20298   0.50570  -0.77814   1.00000   0.67491  -0.46445   0.69407  -0.47280   0.10849   0.59415  -0.12621
              0.3248    0.0001    0.2820    0.0044    0.0001    0.0000    0.0001    0.0097    0.0001    0.0083    0.5682    0.0005    0.5063

RAD          0.30051   0.12286  -0.24452   0.02326  -0.76455   0.67491   1.00000  -0.74224   0.64380  -0.64001   0.31381   0.72449  -0.11404
              0.1066    0.5178    0.1928    0.9029    0.0001    0.0001    0.0000    0.0001    0.0001    0.0001    0.0913    0.0001    0.5485

PRECIP      -0.44845   0.08128   0.36345   0.15910   0.60281  -0.46445  -0.74224   1.00000  -0.64988   0.87863  -0.63054  -0.84768  -0.04715
              0.0129    0.6694    0.0484    0.4010    0.0004    0.0097    0.0001    0.0000    0.0001    0.0001    0.0002    0.0001    0.8046

EVAP         0.18875   0.35172   0.11880   0.29904  -0.58390   0.69407   0.64380  -0.64988   1.00000  -0.64434   0.20973   0.81168  -0.11435
              0.3178    0.0566    0.5118    0.1084    0.0007    0.0001    0.0001    0.0001    0.0000    0.0001    0.2660    0.0001    0.5474

PLUVIOSO    -0.67621   0.07421   0.44675   0.20004   0.52583  -0.47280  -0.64001   0.87863  -0.64434   1.00000  -0.80406  -0.88441  -0.07478
              0.0001    0.6967    0.0133    0.2891    0.0028    0.0083    0.0001    0.0001    0.0001    0.0000    0.0001    0.0001    0.6945

INTERM       0.71369  -0.31853  -0.61511  -0.46519  -0.24646   0.10849   0.31381  -0.63054   0.20973  -0.80406   1.00000   0.44794   0.13051
              0.0001    0.0862    0.0003    0.0096    0.1892    0.5682    0.0913    0.0002    0.2660    0.0001    0.0000    0.0131    0.4918

ECOSECOS     0.47220   0.08466  -0.22844   0.01636  -0.58406   0.59415   0.72449  -0.84768   0.81168  -0.88441   0.44794   1.00000  -0.02389
              0.0084    0.6565    0.2247    0.9316    0.0007    0.0005    0.0001    0.0001    0.0001    0.0001    0.0131    0.0000    0.9003

AGF          0.23130  -0.24070  -0.12591  -0.24704   0.05122  -0.12621  -0.11404  -0.04715  -0.11435  -0.07478   0.13051  -0.02389   1.00000
              0.2188    0.2001    0.5073    0.1881    0.7881    0.5063    0.5485    0.8046    0.5474    0.6945    0.4918    0.9003    0.0000
```

APPENDIX 5 [1]

Population statistics and correlation matrices for climatic and soil factors used in the regression analysis of *Tectona grandis*

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[1] For the description of the variables and unit of measurement see appendix 7.

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                                                    SPECIES=TECA

VARIABLE      N          MEAN          STD DEV              SUM           MINIMUM           MAXIMUM


ALT          28    192.85714286    171.08124868    5400.00000000      20.00000000      550.00000000
TMAX         28     30.06428571      3.05822683     841.80000000      20.80000000       32.80000000
TMIN         28     20.75714286      1.82501721     581.20000000      17.00000000       22.90000000
TMED         28     24.71785714      2.12429571     692.10000000      19.10000000       27.20000000
HHUM         28     83.83928571      4.43131443    2347.50000000      76.50000000       88.50000000
LIGHT        28   1978.53571429    412.80239037   55399.00000000    1215.00000000     2557.00000000
RAD          28    366.76428571     65.22806814   10269.40000000     274.50000000      485.40000000
PRECIP       28   3346.14285714   1092.68099490   93692.00000000    1497.00000000     4642.00000000
EVAP         28    914.67857143    553.96911624   25611.00000000     369.00000000     2008.00000000
PLUVIOSO     28      8.82142857      2.27797134     247.00000000       6.00000000       12.00000000
INTERM       28      1.71428571      1.46204177      48.00000000                0        5.00000000
ECOSECOS     28      1.46428571      1.75292650      41.00000000                0        5.00000000
AGE          28      5.88214286      6.59949794     164.70000000       0.70000000       30.00000000
ASAND        21     39.97619048     19.45313155     839.50000000       8.25000000       77.75000000
ASILT        21     27.56547619      9.31410181     578.87500000      13.75000000       50.00000000
ACLAY        21     32.46428571     18.29417355     681.75000000       5.00000000       66.00000000
ACA          21     12.01321429     13.77357564     252.27750000       0.48125000       51.37500000
AMG          21      2.65482141      2.62213416      55.75125000       0.15375000        9.68875000
ANA          21      0.32285714      0.24819289       6.78000000       0.21250000        1.35750000
AK           21      0.48708333      0.34863715      10.22875000       0.08625000        1.18500000
ACEC         21     35.73630952     12.86576301     750.46250000      17.56250000       67.40000000
ASATH        21     38.70952381     28.95144073     812.90000000       4.76250000       94.26250000
APH          21      6.03333333      0.66587148     126.70000000       4.83750000        7.06250000
AC           21      3.19464286      1.26434332      67.08750000       1.46250000        6.72500000
AMO          21      5.46130952      2.21719454     114.68750000       2.52500000       11.61250000
AN           21      0.27976190      0.15398235       5.87500000       0.11250000        0.67500000
AP           21      8.64702381     12.55986471     181.58750000       1.01250000       59.81250000
ACANI        21     11.86011905      2.77799843     249.06250000       7.13750000       16.72500000
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                            CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 28

               ALT      TMAX      TMIN      TMED      HUMR     LIGHT       RAD    PRECIP      EVAP  PLUVIOSO    INTERM  ECOSECOS       AGE

ALT        1.00000  -0.55621  -0.87643  -0.72506   0.46367  -0.50532  -0.11303   0.23980  -0.37216   0.10856   0.19647  -0.30494  -0.14382
            0.0000    0.0021    0.0001    0.0001    0.0129    0.0061    0.5669    0.2190    0.0512    0.5824    0.3163    0.1146    0.4653

TMAX      -0.55621   1.00000   0.75349   0.94459  -0.48549   0.73015   0.24647  -0.16535   0.47420  -0.15459  -0.02639   0.22291   0.21120
            0.0021    0.0000    0.0001    0.0001    0.0088    0.0001    0.2061    0.4004    0.0108    0.4322    0.8940    0.2542    0.2807

TMIN      -0.87643   0.75349   1.00000   0.90796  -0.37697   0.49887   0.07748  -0.18964   0.33744  -0.02507  -0.24351   0.23568   0.22085
            0.0001    0.0001    0.0000    0.0001    0.0480    0.0069    0.6952    0.3336    0.0787    0.8992    0.2118    0.2273    0.2587

TMED      -0.72506   0.94459   0.90796   1.00000  -0.50554   0.67737   0.17766  -0.25470   0.51708  -0.15239  -0.13066   0.30702   0.21507
            0.0001    0.0001    0.0001    0.0000    0.0061    0.0001    0.3658    0.1909    0.0048    0.4388    0.5075    0.1120    0.2717

HUMR       0.46367  -0.48549  -0.37697  -0.50554   1.00000  -0.87252  -0.63035   0.58818  -0.91365   0.60758   0.03038  -0.81491  -0.13365
            0.0129    0.0088    0.0480    0.0061    0.0000    0.0001    0.0003    0.0010    0.0001    0.0006    0.8780    0.0001    0.4978

LIGHT     -0.50532   0.73015   0.49887   0.67737  -0.87252   1.00000   0.52633  -0.48246   0.82545  -0.57813   0.14527   0.63012   0.13560
            0.0061    0.0001    0.0069    0.0001    0.0001    0.0000    0.0040    0.0093    0.0001    0.0013    0.4608    0.0003    0.4914

RAD       -0.11303   0.24647   0.07748   0.17766  -0.63035   0.52633   1.00000  -0.46439   0.54651  -0.51527   0.01643   0.65589   0.43708
            0.5669    0.2061    0.6952    0.3658    0.0003    0.0040    0.0000    0.0128    0.0026    0.0050    0.9339    0.0001    0.0200

PRECIP     0.23980  -0.16535  -0.18964  -0.25470   0.58818  -0.48246  -0.46439   1.00000  -0.74563   0.89428  -0.40764  -0.82215  -0.26462
            0.2190    0.4004    0.3336    0.1909    0.0010    0.0093    0.0128    0.0000    0.0001    0.0001    0.0313    0.0001    0.1736

EVAP      -0.37216   0.47420   0.33744   0.51708  -0.91365   0.82545   0.54651  -0.74563   1.00000  -0.71374   0.07826   0.86225   0.13692
            0.0512    0.0108    0.0787    0.0048    0.0001    0.0001    0.0026    0.0001    0.0000    0.0001    0.6922    0.0001    0.4872

PLUVIOSO   0.10856  -0.15459  -0.02507  -0.15239   0.60758  -0.57813  -0.51527   0.89428  -0.71374   1.00000  -0.63864  -0.76686  -0.18795
            0.5824    0.4322    0.8992    0.4388    0.0006    0.0013    0.0050    0.0001    0.0001    0.0000    0.0003    0.0001    0.3382

INTERM     0.19647  -0.02639  -0.24351  -0.13066   0.03038   0.14527   0.01643  -0.40764   0.07826  -0.63864   1.00000  -0.00413  -0.06158
            0.3163    0.8940    0.2118    0.5075    0.8780    0.4608    0.9339    0.0313    0.6922    0.0003    0.0000    0.9834    0.7556

ECOSECOS  -0.30494   0.22291   0.23568   0.30702  -0.81491   0.63012   0.65589  -0.82215   0.86225  -0.76686  -0.00413   1.00000   0.29561
            0.1146    0.2542    0.2273    0.1120    0.0001    0.0003    0.0001    0.0001    0.0001    0.0001    0.9834    0.0000    0.1267

AGE       -0.14382   0.21120   0.22085   0.21507  -0.13365   0.13560   0.43708  -0.26462   0.13692  -0.18795  -0.06158   0.29561   1.00000
            0.4653    0.2807    0.2587    0.2717    0.4978    0.4914    0.0200    0.1736    0.4872    0.3382    0.7556    0.1267    0.0000
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                                  CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / N = 21

          ASAND     ASILT     ACLAY       ACA       AMG       ANA        AK      ACEC     ASATB       APH        AC       AMO        AN         AP    ACANI

ASAND   1.00000  -0.36010  -0.88002  -0.16813  -0.37136  -0.04978  -0.15948   0.08081  -0.29086   0.01051   0.53906   0.55030   0.62787  -0.07522 -0.25725
         0.0000    0.1088    0.0001    0.4663    0.0974    0.8303    0.4899    0.7277    0.2008    0.9639    0.0117    0.0097    0.0023    0.7459   0.2603

ASILT  -0.36010   1.00000  -0.12617   0.36048   0.57458   0.23122   0.67275   0.20748   0.51972   0.59931  -0.36928  -0.39870  -0.33202   0.46348 -0.07410
         0.1088    0.0000    0.5858    0.1084    0.0064    0.3132    0.0008    0.3668    0.0157    0.0041    0.0995    0.0734    0.1414    0.0343   0.7496

ACLAY  -0.88002  -0.12617   1.00000  -0.00377   0.10124  -0.06136  -0.17228  -0.19072   0.04534  -0.31593  -0.38521  -0.38218  -0.49864  -0.15579  0.31069
         0.0001    0.5858    0.0000    0.9871    0.6561    0.7850    0.4552    0.4076    0.8453    0.1630    0.0846    0.0873    0.0214    0.5001   0.1704

ACA    -0.16813   0.36048  -0.00377   1.00000   0.74760   0.67778   0.56408   0.58116   0.91004   0.75459  -0.31275  -0.31043  -0.20796   0.07754 -0.37239
         0.4663    0.1084    0.9871    0.0000    0.0001    0.0007    0.0077    0.0057    0.0001    0.0001    0.1675    0.1708    0.3657    0.7383   0.0964

AMG    -0.37136   0.57458   0.10124   0.74760   1.00000   0.68789   0.63184   0.63017   0.76317   0.61305  -0.35159  -0.35677  -0.25407   0.07742 -0.40511
         0.0974    0.0064    0.6561    0.0001    0.0000    0.0006    0.0021    0.0022    0.0001    0.0021    0.1159    0.1124    0.2664    0.7171   0.0683

ANA    -0.04978   0.23122  -0.06136   0.67778   0.68789   1.00000   0.58054   0.57548   0.51226   0.36182  -0.11558  -0.13042  -0.09586   0.13084 -0.47423
         0.8303    0.3132    0.7850    0.0007    0.0006    0.0000    0.0058    0.0061    0.0176    0.1070    0.6179    0.5731    0.6794    0.5719   0.0299

AK     -0.15948   0.67275  -0.17228   0.56408   0.63184   0.58054   1.00000   0.36122   0.65759   0.64017  -0.29190  -0.30744  -0.27788   0.24177 -0.17661
         0.4899    0.0008    0.4552    0.0077    0.0021    0.0058    0.0000    0.1077    0.0012    0.0018    0.1992    0.1752    0.2226    0.2869   0.4443

ACEC    0.08081   0.20748  -0.19072   0.58116   0.63017   0.57548   0.36122   1.00000   0.38555   0.32163   0.34000   0.32723   0.50194  -0.01897 -0.69178
         0.7277    0.3668    0.4076    0.0057    0.0022    0.0061    0.1077    0.0000    0.0843    0.1551    0.1316    0.1476    0.0204    0.9350   0.0005

ASATB  -0.29086   0.51972   0.04534   0.91004   0.76317   0.51226   0.65759   0.38555   1.00000   0.84897  -0.51437  -0.50922  -0.40461   0.05546 -0.23969
         0.2008    0.0157    0.8453    0.0001    0.0001    0.0176    0.0012    0.0843    0.0000    0.0001    0.0170    0.0184    0.0689    0.8113   0.2953

APH     0.01051   0.59931  -0.31593   0.75459   0.61305   0.36182   0.64017   0.32163   0.84897   1.00000  -0.34853  -0.34623  -0.22838  -0.01263 -0.23734
         0.9639    0.0041    0.1630    0.0001    0.0021    0.1070    0.0018    0.1551    0.0001    0.0000    0.1215    0.1242    0.3194    0.9567   0.3002

AC      0.53906  -0.36928  -0.38521  -0.31275  -0.35159  -0.11558  -0.29190   0.34000  -0.51437  -0.34853   1.00000   0.99765   0.89249   0.01215 -0.05651
         0.0117    0.0995    0.0846    0.1675    0.1159    0.6179    0.1992    0.1316    0.0170    0.1215    0.0000    0.0001    0.0001    0.9583   0.8078

AMO     0.55030  -0.39870  -0.38218  -0.31043  -0.35677  -0.13042  -0.30744   0.32723  -0.50922  -0.34623   0.99765   1.00000   0.89138  -0.00043 -0.04044
         0.0097    0.0734    0.0873    0.1708    0.1124    0.5731    0.1752    0.1476    0.0184    0.1242    0.0001    0.0000    0.0001    0.9985   0.8618

AN      0.62787  -0.33202  -0.49864  -0.20796  -0.25407  -0.09586  -0.27788   0.50194  -0.40461  -0.22838   0.89249   0.89138   1.00000  -0.15177 -0.42944
         0.0023    0.1414    0.0214    0.3657    0.2664    0.6794    0.2226    0.0204    0.0689    0.3194    0.0001    0.0001    0.0000    0.5114   0.0520

AP     -0.07522   0.46348  -0.15579   0.07754   0.07742   0.13084   0.24177  -0.01897   0.05546  -0.01263   0.01215  -0.00043  -0.15177   1.00000  0.27578
         0.7459    0.0343    0.5001    0.7383    0.7171    0.5719    0.2869    0.9350    0.8113    0.9567    0.9583    0.9985    0.5114    0.0000   0.2263

ACANI  -0.25725  -0.07410   0.31069  -0.37239  -0.40511  -0.47423  -0.17661  -0.69178  -0.23969  -0.23734  -0.05651  -0.04044  -0.42944   0.27578  1.00000
         0.2603    0.7496    0.1704    0.0964    0.0683    0.0299    0.4443    0.0005    0.2953    0.3002    0.8078    0.8618    0.0520    0.2263   0.0000
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APPENDIX 6 [1]

Multiple regression analysis for *Alnus acuminata*, *Cupressus lusitanica*, *Gmelina arborea*, *Pinus caribaea*, and *Tectona grandis* using stepwise maximum R square improvement (MAXR)

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[1] For the description of the variables and unit of measurement see appendix 7.

Appendix 6a. Multiple Regression Analysis for Alnus acuminata using stepwise maximum R square improvement (MAXR). The analysis was done for the species in the whole country and individual zones. Two model were used, one with the full set of variables (P=28), and one with a reduced set of variables (P=12).

Zone	No. of obs.	Variables in the analysis (p)	Dependent variable $(\hat{Y})$	Independent variable(s) selected 1/	Estimated regression equation 2/	R^2	$Pr(F > \hat{F})$
The Country	13	28	volume growth	age pluvioso rhum asatb	$\hat{Y}=2.27-0.012(age)+0.035(pluvioso)-0.029(rhum)+0.0048(asatb)$	0.85	0.1224
The Country	13	12	volume growth	age alt precip acec	$\hat{Y}=-1.25-0.009(age)+0.0004(alt)+0.00033(precip)-0.0082(acec)$	0.84	0.1336
7	5	28	volume growth	ana age	$\hat{Y}=0.014-0.012(age)+1.26(ana)$	0.50	0.5046
7	5	12	volume growth	age ecosecos	$\hat{Y}=0.29-0.012(age)+0.033(ecosecos)$	0.50	0.5046

1/ age = Plantation age in years.

pluvioso = Number of month of the year with precipitation greater than 100 millimeters.

rhum = Mean annual relative humidity. Expressed as percentage.

alt = Elevation above mean sea level in meters.

precip = Mean annual precipitation in millimeters.

ecoseocos = Number of month of the year with precipitation less than 30 millimeters.

acec = Mean soil profile cations exchange capacity. Expressed as milliequivalent per 100 grams of soil.

asatb = Mean soil profile base saturation. Expressed as a percentage.

ana = Mean soil profile sodium content. Expressed as milliequivalent per 100 grams of soil.

2/ $\hat{Y}$ = Mean tree growth increment in m^3/yr.

Appendix 6b. Multiple Regression Analysis for Cupressus lusitanica using stepwise maximum R square improvement (MAXR). The analysis was done for the species in the whole country and individual zones. Two model were used, one with the full set of variables (P=28), and one with a reduced set of variables (P=12).

Zone	No. of obs.	Variables in the analysis (p)	Dependent variable ($\hat{Y}$)	Independent variable(s) selected [1/]	Estimated regression equation [2/]	R^2	$Pr(F > \hat{F})$
The Country	13	28	volume growth	age alt asilt asatb	$\hat{Y}=-0.58+0.013(\text{age})-0.000064(\text{alt})+0.021(\text{asilt})+0.0018(\text{asatb})$	0.99	0.0001
The Country	13	12	volume growth	age precip ecosecos acec aph amo	$\hat{Y}=1.95+0.005(\text{age})-0.00031(\text{precip})+0.13(\text{ecosecos})+0.59(\text{acec})-0.30(\text{aph})+0.009(\text{amo})$	0.99	0.0001
5	9	28	volume growth	age alt asilt acec	$\hat{Y}=-0.40+0.0093(\text{age})-0.0001(\text{alt})+0.024(\text{asilt})-0.0027(\text{acec})$	0.99	0.0001
5	9	12	volume growth	age aclay acec aph	$\hat{Y}=-0.82+0.022(\text{age})-0.0057(\text{aclay})+0.004(\text{acec})+0.13(\text{aph})$	0.98	0.0008
7	4	28	volume growth	an	$\hat{Y}=-4.57+22.15(\text{an})$	0.99	0.0023
7	4	12	volume growth	an	$\hat{Y}=-4.57+22.15(\text{an})$	0.99	0.0023

1/ age = Plantation age in years.
alt = Elevation above mean sea level in meters.
precip = Mean annual precipitation in millimeters.
ecosecos = Number of months of the year with precipitation. less than 30 millimeters.
aclay = Mean soil profile clay content in percentage by volume.
asilt = Mean soil profile silt content in percentage by volume.
an = Mean soil profile nitrogen content in percentage.
asatb = Mean soil profile base saturation. Expressed as percentage.
acec = Mean soil profile cations exchange capacity.
aph = Mean profile soil pH.
amo = Mean soil profile organic matter content as percentage.

2/ $\hat{Y}$= Mean tree growth increment in m^3/yr.

Appendix 6c. Multiple Regression Analysis for <u>Gmelina arborea</u> using stepwise maximum R square improvement (MAXR). The analysis was done for the species in the whole country and individual zones. Two model were used, one with the full set of variables (P=28), and one with a reduced set of variables (P=12).

Zone	No. of obs	Variables in the analysis (p)	Dependent variable $(\hat{Y})$	Independent variable(s) selected [1/]	Estimated regression equation [2/]	R^2	$Pr(F > \hat{F})$
The Country	12	28	volume growth	ana ak ap acani	$\hat{Y}=1.46-2.005(ana)+0.18(ak)+0.013(ap)-0.06(acani)$	0.98	0.0001
The Country	12	12	volume growth	age acec an ap amo	$\hat{Y}=0.78-0.029(age)-0.011(acec)+1.6(an)+0.012(ap)-0.065(amo)$	0.84	0.0216
1	5	28	volume growth	an ac	$\hat{Y}=0.44+2.49(an)-0.27(ac)$	0.95	0.0495
1	5	12	volume growth	an alt	$\hat{Y}=0.11-1.15(an)+0.0046(alt)$	0.88	0.1195
3	3	28	volume growth	acec	$\hat{Y}=3.05-0.074(acec)$	0.99	0.0156
3	3	12	volume growth	acec	$\hat{Y}=3.05-0.074(acec)$	0.99	0.0156
4	4	28	volume growth	amo ap	$\hat{Y}=-0.05+0.0045(amo)+0.091(ap)$	0.99	0.0044
4	4	12	volume growth	amo ap	$\hat{Y}=-0.05+0.0045(amo)+0.091(ap)$	0.99	0.0044

1/ age = Plantation age in years.
alt = Elevation above mean sea level in meters.
acec = Mean soil profile cations exchange capacity
an = Mean soil profile nitrogen content. Expressed as a percentage.
amo = Mean soil profile organic matter content. Expressed as a percentage.
ac = Mean soil profile carbon content. Expressed as a percentage.
ana = Mean soil profile sodium content. Expressed as milliequivalents per 100 grams of soil.
ak = Mean soil profile potassium content. Expressed as milliequivalent per 100 grams of soil.
ap = Mean soil profile phosphorus content. Expressed as available phosphorus in micrograms per millimeter.
acani = Mean soil profile carbon/nitrogen ratio

2/ $\hat{Y}$ = Mean tree growth increment in m^3/yr.

Appendix 6d. Multiple Regression Analysis for *Pinus caribaea* using stepwise maximum R square improvement (MAXR). The analysis was done for the species in the whole country and individual zones. Two model were used, one with the full set of variables (P=28), and one with a reduced set of variables (P=12).

Zone	No. of obs	Variables in the analysis (p)	Dependent variable ($\hat{Y}$)	Independent variable(s) selected [1/]	Estimated regression equation [2/]	R^2	$Pr(F > \hat{F})$
The Country	26	28	volume growth	age ecosecos light asatb ak	$\hat{Y}=0.051+0.0091(age)-0.082(ecosecos)+0.00017(light)-0.0092(asatb)+0.26(ak)$	0.75	0.0001
The Country	26	12	volume growth	age ecosecos ak asatb	$\hat{Y}=0.31+0.0057(age)-0.064(ecosecos)+0.33(ak)-0.0085(asatb)$	0.67	0.0001
1	14	28	volume growth	age interm rad aph asand amg ana ak	$\hat{Y}=3.48+0.011(age)+0.75(interm)-0.008(rad)-0.29(aph)+0.006(asand)+0.076(amg)+0.25(ana)+1.03(ak)$	0.99	0.0001
1	14	12	volume growth	age alt precip aclay asatb an ap	$\hat{Y}=3.9+0.019(age)+0.0006(alt)-0.0007(precip)-0.013(aclay)-0.023(asatb)-0.72(an)+0.05(ap)$	0.97	0.0002
3	8	28	volume growth	precip aph acec acani	$\hat{Y}=1.09-0.0003(precip)+0.098(aph)-0.0083(acec)-0.011(acani)$	0.99	0.0009
3	8	12	volume growth	precip aph acec asatb	$\hat{Y}=0.91-0.00034(precip)-0.01(acec)+0.0024(asatb)+0.13(aph)$	0.99	0.0011

1/ age = Plantation age in years.

ecosecos = Number of month of the year with precipitation less than 30 millimeters.

light = Mean annual value for the daily hours of sunshine.

interm = Number of month of the year with precipitation between 30 and 100 millimeters.

rad = Mean annual radiation. Expressed as calories per square centimeter per day.

alt = Elevation above mean sea level in meters.

precip = Mean annual precipitation in millimeters.

ap = Mean soil profile phosphorus content. Expressed as available phosphorus in micrograms per milliliter.

acani = Mean soil profile carbon/nitrogen ratio.

asatb = Mean soil profile base saturation. Expressed as a percentage.

ak = Mean soil profile potassium content. Expressed in milliequivalents per 100 grams of soil.

aph = Mean profile soil pH.

asand = Mean soil profile sand content. Expressed as a percentage by volume.

amg = Mean soil profile magnesium content. Expressed in milliequivalent per 100 grams of soil.

ana = Mean soil profile sodium content. Expressed in milliequivalent per 100 grams of soil.

aclay = Mean soil profile clay content. Expressed as a percentage by volume.

an = Mean soil profile nitrogen content. Expressed as a percentage.

acec = Mean soil profile cations exchange capacity.

2/ $\hat{Y}$ = Mean tree growth increment in m^3/yr.

Appendix 6a. Multiple Regression Analysis for <u>Tectona grandis</u> using stepwise maximum R square improvement (MAXR). The analysis was done for the species in the whole country and individual zones. Two model were used, one with the full set of variables (P=28), and one with a reduced set of variables (P=12).

Zone	No. of obs	Variables in the analysis (p)	Dependent variable ($\hat{Y}$)	Independent [1] variable(s) selected	Estimated regression equation [2]	R^2	$Pr(F > \hat{F})$
The Country	21	28	volume growth	age ecosecos light evap aclay ana ak acani	$\hat{Y}=-0.30-0.0084(age)+0.14(ecosecos)+0.0005(light)-0.0008(evap)-0.005(aclay)-0.42(ana)+0.36(ak)+0.02(acani)$	0.78	0.0048
The Country	21	12	volume growth	age precip aph ap amo	$\hat{Y}=-1.2+0.0036(age)+0.00007(precip)+0.16(aph)+0.0052(ap)+0.019(amo)$	0.67	0.0030
1	7	28	volume growth	age tmax asand aca ap	$\hat{Y}=2.63+0.13(age)-0.19(tmax)+0.028(asand)-0.11(aca)+0.18(ap)$	0.99	0.1115
1	7	12	volume growth	age ak acec aph ap	$\hat{Y}=-11.69+0.13(age)-10.93(ak)+0.063(acec)+1.67(aph)+0.48(ap)$	0.99	0.1198
3	8	28	volume growth	age tmed asilt aca ana	$\hat{Y}=7.89-0.031(age)-0.074(tmed)+0.015(asilt)+0.037(aca)-29.17(ana)$	0.99	0.0001
3	8	12	volume growth	age precip ak acec asatb ap	$\hat{Y}=-0.69-0.032(age)+0.00021(precip)+1.07(ak)-0.00062(acec)-0.00034(asatb)+0.0024(ap)$	0.99	0.0058
4	6	28	volume growth	aph asatb an	$\hat{Y}=4.81-0.74(aph)+0.0017(asatb)+1.25(an)$	0.99	0.0015
4	6	12	volume growth	aph asatb an	$\hat{Y}=4.81-0.74(aph)+0.0017(asatb)+1.25(an)$	0.99	0.0015

[1] For the description of the variables and unit of measurement see appendix 7.

[2] $\hat{Y}$ = Mean tree growth increment in m^3/yr.

APPENDIX 7

DESCRIPTION OF THE VARIABLES USED IN THE STATISTICAL ANALYSIS AND UNIT OF MEASUREMENT.

Volume growth: The formula used for the calculus of tree volume growth was diameter x height x age. The volume growth obtained by the above expression is the mean annual increment in volume growth per tree because it is calculated from mean annual values of diameter and height of the trees. It is not the true volume growth of the trees, but was used for practical purpose of these data analysis.

DBH: Mean annual increment in diameter at breast height, standarized to 1.30 meters above the surface of the soil. Measured with a diametric tape and adjusted to the nearest millimeter.

Height: Reported as a mean annual increment in tree height and measured as the distance from the soil surface to the terminal bud. Measured with a Suunto clinometer and also with a stadia in young plantations.

Basal area: Calculated from the expression

$$G = \sum_{i=1}^{n} g_{i/S}$$

Where: G= Basal area per hectare in m^2.

g= Basal area of individual trees at the breast height in m^2.

n= Number of trees.

S= Area occupied for the stand in hectares.

Age: Considered since the day of the establishment of the plantation and taken from the archives of the Forestry Department and also directly from the owner of the plantation.

Altitude: Elevation of the plots in meters above mean sea level. Taken from the contour maps and corroborated with an altimeter and adjusted for the closest meter.

Sand, Silt and Clay: Three major physical components of the soil and are expressed as a percentage by volume. The sum of these three parameter is equal to 100%. For those plots for which information was not available in the files of the Forestry Department, the analysis was done in the soil laboratory of CATIE. The methodology used was the suggested by Forsythe (1975).

Temperature: Reported as a maximum, minimum and mean daily air temperature obtained from hourly values. Expressed in degree celsius ($^{\underline{o}}$C).

Relative humidity: Humidity of the air obtained from the mean of hourly observations and is expressed as percentage.

Light and Global Radiation: Light, expressed as number of daily hours of sunshine (full exposure). Radiation indicates the total of calories per square centimeter per day, received in a horizontal surface.

Precipitation: The observation period of rainfull is the twenty four hours, between 07:00 and 07:00 the following day.

The values are reported as total for daily, monthly, and annual precipitation in millimeters.

Evaporation: Measurement of the evaporation with the Pich evaporimeter and also with the tank type A. The values are daily and for the same period and units than that of precipitation (millimeters).

Soil pH: Indicates the degree of acidity and/or alkalinity of the soil. Range from 0-7 for acid soils, 7-14 for alkaline soils. Specifically, pH is defined as either the negative logarithm of H^+-ion concentration or as the logarithm of the reciprocal of the H^+-ion concentration.

Pluvioso, Intermedium and Ecosecos: Variables also knowed as moist, mesic and dry, respectively and indicates the distribution or occurrence of rain. Method suggested by Aubreville (1975), and is formed of three digits. The first indicates the number of months of the year with precipitations greater than 100 millimeters (pluvioso or moist months), the second, the number of months with precipitation between 30-100 millimeters (intermediate or mesic months), and the third for those months with precipitation less than 30 millimeters (ecosecos or dry months).

Chemical and physical properties: For the chemical analysis of the soil was used the methodology described by Diaz Romeu and Hunter as mentioned by Martinez (1981). The values for organic matter, carbon, and nitrogen are expressed as a percentage. Phosphorus is reported as available phosphorus in micrograms per milliliter of soil. The exchangeable bases (calcium, magnesium, potasium, and sodium) and cation-exchange capacity are reported as milliequivalent per 100 grams of soil. Base saturation expressed as a percentage.

Asand: Mean soil profile value for sand in the soil. Expressed as percentage of soil by volume.

Asilt: Mean soil profile value for silt in the soil. Expressed as percentage of soil by volume.

Aclay: Mean soil profile value for clay in the soil. Expressed as percentage of soil by volume.

Aph: Mean soil profile value of pH.

Amo: Mean soil profile value of organic matter content. Expressed as percentage.

Ac: Mean soil profile carbon content. Expressed as percentage.

An: Mean soil profile nitrogen content. Expressed as percentage.

Acani: Mean soil profile carbon/nitrogen ratio.

Ap: Mean soil profile phosphorus content. Expressed as available phosphorus.

Aca: Mean soil profile calcium content. Expressed in milliequivalents per 100 grams of soil.

Amg: Mean soil profile magnesium content. Expressed in milliequivalents per 100 grams of soil.

Ana: Mean soil profile sodium content. Expressed in milliequivalents per 100 grams of soil.

Ak: Mean soil profile potassium content. Expressed in milliequivalents per 100 grams of soil.

Acec: Mean soil profile cation exchange capacity. Expressed in milliequivalents per 100 grams of soil.

Asatb: Mean soil profile base saturation. Expressed as percentage.

APPENDIX 8 [1/]

Species, site characteristics, growth indicators, and other environmental factors used in the regression analysis

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[1/] For the description of the variables and unit of measurement see appendix 7.

SPECIES-SITE CHARACTERISTICS AND GROWTH INDICATORS

OBS	DATACODE	SPECIES	SITE	PLOT	AGE	DBH	HEIGHT	BAREA	VOLUME
1	710011	MELINA	101	1	6.5	20.00	21.38	5.14	0.277940
2	710011	PINUS	101	1	6.5	22.46	16.02	3.59	0.247015
3	710011	TECA	101	1	6.4	17.14	19.06	3.15	0.204559
4	710011	MELINA	102	1	7.0	25.20	22.43	4.51	0.396921
5	710011	PINUS	102	1	6.0	26.11	20.66	5.63	0.326187
6	710011	TECA	103	1	4.0	17.25	14.00	0.44	0.110400
7	710011	PINUS	104	1	4.5	33.77	23.77	11.61	0.404007
8	710011	TECA	104	1	4.6	26.10	31.10	3.92	0.374667
9	710011	MELINA	105	1	4.5	40.00	33.11	10.50	0.595980
10	710011	MELINA	105	2	7.5	33.84	21.46	7.85	0.544977
11	710011	PINUS	105	1	7.4	24.76	18.13	4.19	0.353718
12	710011	PINUS	105	2	7.1	23.00	20.50	3.26	0.314765
13	710011	PINUS	105	3	7.0	22.14	22.45	4.39	0.354129
14	710011	TECA	105	1	8.0	20.25	21.75	1.06	0.352350
15	710011	TECA	105	2	5.8	9.65	10.17	1.06	0.056921
16	710011	MELINA	107	1	7.5	23.86	17.86	3.75	0.319605
17	710011	PINUS	107	1	7.4	22.02	16.48	4.82	0.268538
18	710011	TECA	107	1	6.9	8.84	8.69	0.84	0.053806
19	710011	PINUS	108	1	5.7	19.64	16.14	2.98	0.180684
20	710011	TECA	108	1	5.8	24.31	24.11	3.69	0.342766
21	710011	TECA	110	1	0.7	42.85	15.71	0.27	0.047122
22	710011	TECA	112	1	0.8	30.09	30.00	1.68	0.072000
23	710011	CIPRES	201	1	30.0	7.09	5.00	0.72	0.105000
24	710011	PINUS	202	1	4.0	34.00	24.80	8.37	0.505920
25	710011	PINUS	203	1	8.0	27.00	21.50	4.59	0.464400
26	710011	PINUS	204	1	5.1	29.00	17.40	4.27	0.275123
27	710011	PINUS	205	1	6.0	35.00	22.30	4.58	0.468300
28	710011	PINUS	206	1	6.0	14.09	13.00	2.25	0.140400
29	710011	JAUL	208	1	5.0	12.00	11.60	3.13	0.081600
30	710011	PINUS	211	1	12.0	24.00	20.00	3.82	0.576009
31	710011	JAUL	212	1	8.0	15.00	18.60	1.05	0.223200
32	710011	CIPRES	212	1	8.0	13.00	9.50	1.49	0.094800
33	710011	PINUS	301	1	5.0	20.60	11.40	3.49	0.121540
34	710011	TECA	301	1	5.0	5.40	6.20	0.08	0.016740
35	710011	MELINA	302	1	6.9	28.01	17.24	2.02	0.342712
36	710011	PINUS	302	1	4.0	11.75	7.25	0.72	0.034075
37	710011	TECA	302	1	9.0	16.88	14.00	1.22	0.212688
38	710011	MELINA	303	1	7.9	40.76	29.10	6.45	0.925170
39	710011	TECA	303	1	8.8	25.34	22.04	2.87	0.491676
40	710011	MELINA	304	1	5.0	24.60	12.40	8.05	0.474520
41	710011	TECA	304	1	5.8	24.20	28.40	5.40	0.341640
42	710011	TECA	305	1	3.8	24.73	27.16	4.57	0.257113
43	710011	PINUS	306	1	1.0	21.00	14.00	2.60	0.088200
44	710011	PINUS	307	1	4.9	24.80	16.18	2.61	0.182560
45	710011	PINUS	308	1	18.0	11.00	11.10	0.56	0.223740
46	710011	PINUS	309	1	6.0	25.90	21.10	6.22	0.314500
47	710011	TECA	310	1	5.0	4.88	4.20	0.26	0.010080
48	710011	PINUS	312	1	8.0	20.00	20.00	2.36	0.320000
49	710011	PINUS	313	1	5.0	23.00	18.40	3.12	0.211600
50	710011	TECA	314	1	2.9	16.00	17.10	0.43	0.079344
51	710011	TECA	314	2	4.3	8.00	10.60	0.27	0.016464
52	710011	TECA	315	1	0.9	19.88	5.55	0.72	0.009431
53	710011	JAUL	316	1	8.6	20.00	20.00	0.48	0.024000
54	710011	TECA	401	1	4.0	20.00	26.80	4.62	0.300160
55	710011	TECA	401	1	10.0	10.00	8.00	0.85	0.240000

SPECIES,SITE CHARACTERISTICS,AND GROWTH INDICATORS

OBS	DATACODE	SPECIES	SITE	PLOT	AGE	DBH	HEIGHT	BAREA	VOLUME
56	F10011	TECA	405	1	25.0	3.00	6.70	2.28	0.150750
57	F10011	MELINA	406	1	12.0	18.00	14.40	13.50	0.311040
58	F10011	PINUS	407	1	4.0	11.00	11.00	0.77	0.083600
59	F10011	MELINA	410	1	7.0	17.71	19.00	4.52	0.275543
60	F10011	TECA	410	1	2.0	21.50	7.50	0.91	0.032250
61	F10011	MELINA	411	1	6.0	30.00	23.33	5.06	0.419940
62	F10011	TECA	412	1	2.0	38.00	17.00	0.77	0.281200
63	F10011	MELINA	413	1	2.5	31.00	24.00	4.80	0.178560
64	F10011	TECA	414	1	7.0	19.00	16.40	2.52	0.218120
65	F10011	MELINA	416	1	6.8	29.55	28.82	8.05	0.579109
66	F10011	TECA	417	1	2.0	26.00	16.50	1.43	0.085800
67	F10011	MELINA	420	1	6.8	17.94	14.41	2.30	0.175790
68	F10011	JAML	501	1	9.0	13.11	11.22	1.84	0.132385
69	F10011	CIPRES	501	1	9.0	15.00	12.00	3.46	0.162000
70	F10011	CIPRES	501	2	9.1	15.00	9.55	4.55	0.130357
71	F10011	CIPRES	502	1	14.0	14.00	11.70	2.31	0.229320
72	F10011	CIPRES	503	1	30.0	15.00	7.00	1.47	0.315000
73	F10011	CIPRES	504	1	30.0	18.00	11.00	4.47	0.594000
74	F10011	JAML	505	1	6.0	17.64	16.32	3.52	0.195762
75	F10011	CIPRES	505	1	6.8	15.88	6.47	3.62	0.069866
76	F10011	CIPRES	506	1	7.0	21.00	15.90	3.85	0.231730
77	F10011	CIPRES	507	1	5.0	15.80	14.40	2.09	0.113760
78	F10011	CIPRES	507	2	8.0	13.50	10.50	2.78	0.113400
79	F10011	PINUS	507	1	7.0	17.85	10.71	4.22	0.133821
80	F10011	MELINA	510	1	1.0	43.00	15.00	3.27	0.064500
81	F10011	TECA	510	1	2.0	16.50	6.00	1.03	0.019800
82	F10011	TECA	512	1	1.0	10.00	3.00	0.17	0.003000
83	F10011	PINUS	514	1	6.0	23.83	16.83	4.41	0.240635
84	F10011	MELINA	516	1	2.0	49.50	47.50	9.22	0.470250
85	F10011	TECA	516	1	2.0	27.50	29.00	1.73	0.159500
86	F10011	PINUS	517	1	3.8	16.57	10.00	2.00	0.062966
87	F10011	JAML	518	1	0.7	14.28	7.14	0.25	0.007137
88	F10011	CIPRES	519	1	6.8	15.58	7.79	2.95	0.082530
89	F10011	JAML	622	1	9.0	18.55	17.11	3.80	0.285651
90	F10011	JAML	622	2	12.4	13.00	14.50	1.80	0.233740
91	F10011	JAML	622	3	13.0	12.00	17.50	3.78	0.273000
92	F10011	JAML	622	4	12.4	10.00	14.90	2.00	0.184760
93	F10011	CIPRES	622	1	13.0	14.00	7.90	1.63	0.143790
94	F10011	CIPRES	622	2	13.0	13.00	8.20	1.85	0.138580
95	F10011	CIPRES	622	3	13.0	12.00	7.80	2.17	0.121680
96	F10011	CIPRES	624	1	8.0	21.00	24.50	4.25	0.411600
97	F10011	CIPRES	626	1	9.8	11.83	8.67	2.76	0.100515
98	F10011	JAML	704	1	8.8	12.95	16.02	2.43	0.182564
99	F10011	PINUS	707	1	7.0	23.00	16.00	4.47	0.257600
100	F10011	PINUS	708	1	11.0	21.00	18.40	6.08	0.425040
101	F10011	JAML	709	1	7.7	22.98	18.57	3.13	0.328589
102	F10011	JAML	709	2	9.0	17.08	18.00	3.13	0.289656
103	F10011	CIPRES	710	1	7.1	20.00	14.92	3.02	0.211864
104	F10011	PINUS	711	1	8.0	20.25	15.00	6.01	0.243000
105	F10011	JAML	712	1	0.7	21.42	12.85	0.54	0.019267
106	F10011	PINUS	713	1	7.0	23.72	17.42	5.82	0.289242

SITES AND CORRESPONDING CLIMATIC CONDITIONS

OBS	DATACODE	SITE	ALT	ELEV	TMAX	TMIN	TMED	RHUM	LIGHT	RAD	PRECIP	EVAP	SOILPH	PLUVIOSO	INTERM	ECOSECOS
1	F10012	101	90	70	30.4	21.7	25.3	85.5	1662	381.6	4526	534	6.2	12	0	0
2	F10012	102	260	249	28.4	20.5	23.8	88.0	1561	291.4	4526	369	5.7	12	0	0
3	F10012	103	150	70	30.4	21.7	25.3	85.5	1662	383.6	4526	522	5.3	12	0	0
4	F10012	104	240	249	28.4	20.5	23.8	88.0	1561	291.4	4526	369	5.6	12	0	0
5	F10012	105	249	249	28.4	20.5	23.8	88.0	1561	291.4	4526	369	5.9	12	0	0
6	F10012	107	100	249	28.4	20.5	23.8	88.0	1561	291.4	4526	369	4.8	12	0	0
7	F10012	108	100	249	28.4	20.5	23.8	88.0	1561	291.4	4526	369	6.2	12	0	0
8	F10012	110	250	70	30.4	21.7	25.3	85.5	1662	383.6	4526	522	5.3	12	0	0
9	F10012	112	20	3	30.3	21.8	25.3	85.0	1822	274.5	2283	695	5.8	7	5	0
10	F10012	201	1736	2010	14.7	12.7	14.9	88.3	1867	471.0	1838	490	5.2	7	2	3
11	F10012	202	580	600	26.8	18.9	22.0	85.0	1785	383.6	4535	453	5.1	11	1	0
12	F10012	203	540	600	26.8	18.9	22.0	85.0	1785	383.6	4535	453	5.6	11	1	0
13	F10012	204	120	600	26.8	18.9	22.0	85.0	1785	383.6	3554	453	6.0	11	1	0
14	F10012	205	122	600	26.8	18.9	22.0	85.0	1785	383.6	3182	453	6.0	11	1	0
15	F10012	206	160	600	26.8	18.9	22.0	85.0	1785	381.6	3182	453	6.2	11	1	0
16	F10012	208	1900	2010	18.7	12.7	14.9	88.3	1687	471.0	3315	490.	5.2	11	1	0
17	F10012	211	410	600	26.8	18.9	22.0	85.0	1785	383.6	4111	453	5.8	12	0	0
18	F10012	212	1900	2010	18.7	12.7	14.9	88.3	1687	471.0	3315	490	5.2	11	1	0
19	F10012	301	180	150	31.3	19.3	24.5	86.5	1922	359.5	3672	759	5.0	8	3	1
20	F10012	302	500	150	31.3	19.3	24.5	86.5	1922	359.5	3666	759	5.5	10	1	1
21	F10012	303	500	150	31.3	19.3	24.5	86.5	1922	359.5	3672	759	5.8	8	3	1
22	F10012	304	20	20	31.8	22.7	26.0	87.0	2232	336.8	3667	619	6.6	9	3	0
23	F10012	305	30	20	31.8	22.7	26.0	87.0	2232	336.8	3667	638	6.1	9	3	0
24	F10012	306	410	1450	20.8	17.0	19.1	88.5	1215	350.1	3646	533	5.4	11	1	1
25	F10012	307	415	1450	20.8	17.0	19.1	88.5	1215	350.1	3646	513	5.9	10	1	1
26	F10012	308	570	1450	20.8	17.0	19.1	88.5	1215	350.1	2714	533	5.1	8	2	2
27	F10012	309	590	350	31.3	19.3	24.5	86.5	1922	359.5	2714	759	5.0	8	2	2
28	F10012	310	530	1450	20.8	17.0	19.1	88.5	1215	350.1	2667	533	5.6	8	3	1
29	F10012	312	680	1450	20.8	17.0	19.1	88.5	1215	350.1	3081	533	5.3	9	2	1
30	F10012	313	700	1450	20.8	17.0	19.1	88.5	1215	350.1	3192	533	5.6	9	2	1
31	F10012	314	340	350	31.3	19.3	24.5	86.5	1922	359.5	3192	759	5.7	8	4	0
32	F10012	315	400	1450	20.8	17.0	19.1	88.5	1215	350.1	2342	533	5.7	6	1	1
33	F10012	316	1109	1450	20.8	17.0	19.1	88.5	1215	350.1	3081	533	5.6	7	2	1
34	F10012	401	20	120	31.9	22.3	25.9	78.9	2165	485.4	2223	1128	6.7	7	1	4
35	F10012	403	50	120	31.9	22.3	25.9	78.9	2165	485.4	1844	1128	6.7	6	2	4
36	F10012	405	22	45	32.8	22.6	27.2	79.0	2150	485.4	1821	1019	6.6	6	2	4

SITES AND CORRESPONDING CLIMATIC CONDITIONS

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OBS DATACODE SITE  ALT ELEV  TMAX TMIN TMED RHUM LIGHT  RAD   PRECIP EVAP SOILPH PLUVIOSO INTERM ECOSECOS

 37  F10012  406   120   85  32.8 22.6 27.2 79.0 2150  485.4  1635  1839  6.9       7        0       5
 38  F10012  407   120   85  32.8 22.6 27.2 79.0 2150  485.4  1708  1839  6.8       7        1       4
 39  F10012  410    50   40  32.6 22.4 27.2 76.5 2557  350.1  1664  2008  6.8       7        1       4
 40  F10012  411    50   40  32.6 22.4 27.2 76.5 2557  350.1  1664  2008  6.3       7        1       4
 41  F10012  412    60   40  32.6 22.4 27.2 76.5 2557  350.1  2210  2008  6.7       7        1       4
 42  F10012  413    90   85  32.8 22.6 27.2 79.0 2150  485.4  1335  1839  6.3       7        0       5
 43  F10012  414    30   85  32.8 22.6 27.2 79.0 2150  485.4  1497  1839  6.7       6        1       5
 44  F10012  416   400  590  27.0 20.6 23.0 85.9 1785  343.6  2391   732  6.7       6        2       4
 45  F10012  417    30   40  32.6 22.4 27.2 76.5 2557  350.1  1821  2008  6.7       6        2       4
 46  F10012  420    50   40  32.6 22.4 27.2 76.5 2557  350.1  1615  2008  6.8       6        1       5
 47  F10012  501  2100 1400  24.2 13.8 19.5 83.0 1939  471.0  2993   650  5.4       7        2       3
 48  F10012  502  1550 1400  24.2 13.8 19.5 83.0 1939  471.0  2177   650  5.7       7        2       3
 49  F10012  503  1520 1400  24.2 13.8 19.5 83.0 1939  471.0  2177   650  5.6       7        2       3
 50  F10012  504  1750 1400  24.2 13.8 19.5 83.0 1939  471.0  2177   650  5.3       7        2       3
 51  F10012  505  2100 1400  24.2 13.8 19.5 83.0 1939  471.0  2993   650  4.7      10        2       0
 52  F10012  506  1570 1400  24.2 13.8 19.5 83.0 1939  471.0  2177   650  6.3       8        1       1
 53  F10012  507  1100 1400  24.2 13.8 19.5 83.0 1939  471.0  2502   650  5.9       8        2       2
 54  F10012  510   150  840  28.4 18.0 22.3 77.8 2440  453.2  3479  1316  6.3       8        2       2
 55  F10012  512   250  840  28.4 18.0 22.3 77.8 2440  453.2  3079  1316  5.9       8        2       2
 56  F10012  514   160  450  30.7 20.6 24.9 88.0 2440  453.2  1205  1406  5.9       9        0       1
 57   F10012  516    30    3  32.6 22.9 26.8 81.6 2291  317.5  4642   765  5.3       9        2       1
 58   F10012  517   900 1400  24.2 13.8 19.5 83.0 1939  471.0  2584   594  5.9       7        2       3
 59   F10012  518  1500 1172  24.8 16.7 19.7 85.2 1885  328.4  2177   801  6.3       7        2       3
 60   F10012  519  2500 1400  24.2 13.8 19.5 83.0 1939  471.0  2556   650  4.7       8        0       4
 61   F10012  622  2620 1400  12.0  5.4  7.9 77.9 1939  471.0  2009   650  5.9       8        1       3
 62   F10012  624  1375 1400  24.2 13.8 19.5 83.0 1939  471.0  1378   650  5.9       7        3       2
 63   F10012  625  1400 1400  24.2 13.8 19.5 83.0 1939  471.0  1403   650  5.9       6        2       4
 64   F10012  704  1420 1450  22.5 15.3 17.8 85.9 1885  328.4  3759   502  5.9      11        1       0
 65   F10012  707   700  450  30.7 20.6 24.9 80.2 2440  453.2  2158   667  6.3       7        2       3
 66   F10012  708  1180 1172  24.8 16.7 19.7 85.2 1885  328.4  1111   801  6.4       8        3       1
 67   F10012  709  1450 1450  22.5 15.3 17.8 85.9 1885  328.4  3759   502  5.9       9        2       1
 68   F10012  710  1450 1450  22.5 15.3 17.8 85.9 1885  328.4  3146   502  5.9       9        2       1
 69   F10012  711   900  840  28.4 18.0 22.3 77.8 2440  453.2  2559  1316  6.3       8        1       3
 70   F10012  712  1400 1100  26.3 15.8 20.2 81.6 2440  453.2  2158   667  6.3       7        1       4
 71   F10012  713  1100 1172  24.8 16.7 19.7 85.2 1885  328.4  1600   801  6.4       8        2       2
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SITES AND CORRESPONDING SOIL FERTILITY

OBS	DATACODE	SITE	DEPTH1	PH1	MO1	C1	N1	CANI1	P1	CA1	MG1	K1	NA1	CEC1	SATBASE1	DEPTH2	PH2	MO2	C2	N2	CANI2	P2	CA2	MG2	K2	NA2	CEC2	SATBASE2	DEPTH3	PH3	MO3	C3	N3	CANI3
1	FS0384	101	1	59	56	33	3	102	320	1241	412	121	37	444	408	2	62	36	21	2	91	185	1262	428	105	48	429	429	3	64	11	8	1	78
2	FS0384	102	1	57	142	82	9	83	74	387	121	29	27	528	107	2	56	135	79	9	88	32	243	68	20	31	516	70	3	58	103	60	6	99
3	FS0384	103	1	52	67	39	4	105	168	149	269	72	25	165	207	2	51	52	30	1	100	151	259	131	50	26	317	147	3	54	36	19	2	121
4	FS0384	104	1	51	142	82	9	90	53	152	111	51	27	569	95	2	56	125	72	7	98	40	233	64	35	25	556	64	3	59	103	60	6	105
5	FS0384	105	1	57	99	57	7	81	40	576	171	66	28	489	172	2	57	96	54	7	82	32	481	99	31	24	458	121	3	59	78	46	5	84
6	FS0384	107	1	47	71	41	4	106	67	111	55	19	25	336	61	2	48	58	34	3	117	46	82	34	10	24	299	50	3	49	41	24	2	125
7	FS0384	108	1	60	61	35	4	98	50	381	149	17	26	195	303	2	62	44	25	2	133	46	376	146	23	33	213	271	3	64	35	21	2	105
8	FS0384	202	1	49	113	65	6	119	76	160	67	41	30	449	66	2	51	70	41	4	93	32	46	20	22	116	287	88	3	53	57	33	4	92
9	FS0384	203	1	57	86	50	5	102	32	45	18	13	26	422	23	2	56	80	47	5	101	19	110	107	54	32	431	75	3	56	74	43	4	102
10	FS0384	204	1	68	62	36	3	104	40	51	28	26	21	428	30	2	60	48	28	3	81	32	620	162	50	23	398	215	3	61	51	30	3	95
11	FS0384	205	1	50	66	38	3	147	67	788	189	53	23	397	243	2	59	49	28	1	92	46	930	333	81	39	398	348	3	62	37	21	2	89
12	FS0384	206	1	61	115	67	6	110	40	778	181	23	33	371	126	2	63	38	22	4	56	12	1140	336	40	27	419	368	3	63	36	20	3	82
13	FS0384	208	1	47	184	107	11	95	135	194	85	15	43	393	85	2	54	164	95	9	102	67	120	65	36	37	660	39	3	54	137	80	7	108
14	FS0384	211	1	60	93	54	5	117	60	28	18	16	70	605	22	2	57	67	39	4	88	40	620	498	152	66	456	294	3	57	58	34	4	96
15	FS0384	301	1	50	80	47	4	133	85	75	35	14	20	257	169	2	52	62	36	1	120	55	50	16	9	22	238	306	3	49	50	29	2	133
16	FS0384	302	1	57	83	48	4	127	75	1070	366	79	20	398	168	2	56	44	26	2	151	40	607	216	43	22	379	306	3	53	38	18	1	135
17	FS0384	303	1	59	80	46	2	257	565	1020	322	58	20	392	168	2	58	80	47	3	167	569	800	246	44	22	284	306	3	58	52	30	2	145
18	FS0384	304	1	53	57	33	2	186	25	61	26	6	18	255	46	2	68	29	17	2	106	81	4460	157	50	28	354	999	3	77	27	16	2	86
19	FS0384	305	1	61	75	44	4	106	25	1726	691	66	20	493	508	2	63	43	25	3	89	12	1727	619	32	23	451	533	3	58	25	14	2	72

OBS	P3	CA3	MG3	K3	NA3	CEC3	SATBASE3	APH	AMO	AC	AN	ACANI	AP	ACA	AMG	AK	ANA	ACEC	ASATB
1	151	1188	418	87	62	386	457	6.2625	2.7000	1.9750	0.1625	8.5875	18.4875	12.2237	4.21000	0.98000	0.53625	40.8375	44.0375
2	19	191	45	11	29	456	41	5.7125	11.9875	6.9875	0.7500	9.1625	3.0750	2.1500	0.61375	0.14625	0.24500	48.6500	7.0125
3	49	296	118	66	25	312	162	5.1375	4.4875	2.5625	0.2625	11.1125	12.2125	2.4875	1.51750	0.49750	0.25375	31.8000	16.2000
4	25	278	58	18	25	566	78	5.7125	11.6125	6.7250	0.6750	10.0500	3.4125	2.7037	0.66875	0.28500	0.25250	55.2625	7.0875
5	19	281	51	11	21	417	86	5.0000	8.6625	5.0375	0.6000	8.2875	2.6500	3.6297	0.85000	0.25125	0.24000	45.1375	10.8875
6	12	66	20	7	29	296	62	4.8375	5.1125	2.9875	0.2625	11.9625	4.1625	0.7787	0.29625	0.09500	0.26125	29.6375	4.7625
7	40	381	106	17	11	155	296	6.2750	4.2125	2.4250	0.2250	11.4625	4.3500	3.3312	1.26375	0.21750	0.32125	18.1750	28.7000
8	19	52	13	12	25	422	10	5.1750	6.9875	4.0000	0.4250	4.5750	1.0750	0.6125	0.25375	0.24375	0.59750	37.3250	5.6250
9	19	58	47	28	22	411	36	5.6125	7.7750	4.5375	0.4500	10.1625	2.0625	0.8137	0.65875	0.38375	0.26250	42.9875	4.9750
10	48	668	188	68	26	312	215	6.0500	5.1250	3.0000	0.3000	9.1375	3.7000	5.6912	1.58250	0.52000	0.23250	39.3750	20.1875
11	40	730	295	66	10	422	261	6.0625	4.5125	2.5750	0.2500	9.7375	4.5625	8.0125	2.46500	0.60000	0.12500	40.9875	29.1375
12	12	800	211	29	10	161	112	6.2750	4.6625	2.6625	0.1750	7.5750	1.5500	9.2375	2.77375	0.32375	0.29250	37.5000	33.4750
13	25	95	33	21	51	596	15	5.1125	15.3000	8.9000	0.8250	10.4125	5.4500	1.1675	0.51500	0.26875	0.45750	58.8625	4.2750
14	19	210	241	78	19	608	166	5.7375	5.6500	3.2875	0.4125	9.4625	1.2000	1.3100	3.09500	0.98000	0.52500	44.9875	18.5000
15	55	40	10	7	21	207	101	5.0250	5.8250	3.3875	0.2625	12.8125	6.3750	0.4812	0.15375	0.04625	0.21250	22.4875	28.6250
16	55	400	175	15	21	148	101	5.3875	4.1875	2.4750	0.1750	14.0000	5.6875	5.6137	2.11500	0.42375	0.21250	36.5500	28.6250
17	600	560	159	61	21	262	101	5.4000	6.6000	3.8375	0.2375	16.7250	59.8125	6.7750	2.16500	0.55250	0.21250	28.6500	28.6250
18	76	4080	115	48	25	151	999	7.0625	3.1500	1.8500	0.2000	10.5000	8.1500	40.2012	1.19625	0.43500	0.25250	34.5125	87.9625
19	5	1481	693	26	21	412	471	5.0250	3.8000	2.1875	0.2625	8.2625	1.0125	16.0375	6.65000	0.32250	0.22625	46.6750	49.8875

SITES AND CORRESPONDING SOIL FERTILITY

OBS	DATACODE	SITE	DEPTH1	PH1	MO1	C1	N1	CANI1	P1	CA1	MG1	K1	NA1	CEC1	SATBASE1	DEPTH2	PH2	MO2	C2	N2	CANI2	P2	CA2	MG2	K2	NA2	CEC2	SATBASE2	DEPTH3	PH3	MO3	C3	N3	CANI3
20	FS0384	306	1	56	86	49	3	144	53	157	88	52	19	285	112	2	51	71	41	2	196	32	70	28	28	22	264	56	3	55	54	31	2	159
21	FS0384	307	1	56	101	58	5	117	81	568	158	58	22	388	254	2	59	78	45	4	117	46	197	78	32	19	268	194	3	61	73	42	3	141
22	FS0384	308	1	50	144	84	6	152	67	138	69	25	28	448	56	2	52	131	76	4	176	46	51	36	19	17	421	29	3	52	109	63	1	204
23	FS0384	309	1	51	99	58	3	180	74	61	23	11	23	336	35	2	58	79	46	3	170	74	12	15	5	24	305	25	3	50	76	44	3	164
24	FS0384	310	1	67	62	36	3	113	135	3420	221	144	25	387	985	2	58	87	51	1	180	60	114	29	15	19	294	60	3	51	70	41	3	157
25	FS0384	312	1	51	111	64	5	123	51	181	88	21	16	327	94	2	54	42	25	2	151	19	29	8	4	16	224	26	3	53	27	16	1	141
26	FS0384	313	1	53	87	51	4	144	19	228	56	26	20	319	101	2	52	67	39	3	144	60	121	29	14	28	271	72	3	51	74	43	2	204
27	FS0384	314	1	56	78	46	3	152	46	159	69	17	24	211	127	2	57	60	35	2	152	46	108	39	19	21	194	97	3	58	38	22	1	155
28	FS0384	401	1	64	72	42	4	105	194	4840	963	211	107	681	899	2	67	58	34	1	6	166	4940	966	116	141	665	926	3	69	46	27	2	112
29	FS0384	403	1	67	81	48	4	127	53	3150	565	118	23	435	887	2	67	50	29	3	108	19	2510	619	54	11	468	687	3	69	36	21	2	117
30	FS0384	405	1	65	39	22	2	98	89	1041	114	222	27	229	701	2	66	29	17	1	127	40	963	349	98	34	227	616	3	67	19	11	1	121
31	FS0384	406	1	69	52	30	2	132	60	842	129	47	36	356	295	2	70	10	6	1	73	67	340	65	26	20	129	351	3	70	21	12	1	172
32	FS0384	407	1	65	74	43	3	144	25	683	131	52	27	378	236	2	69	23	13	1	110	19	375	94	66	30	208	272	3	69	12	7	1	117
33	FS0384	410	1	67	66	38	3	133	60	1714	540	109	25	361	662	2	68	48	28	2	126	25	1662	511	61	28	347	658	3	70	32	19	1	133
34	FS0384	411	1	62	60	35	4	100	96	1307	495	155	28	349	570	2	63	54	31	1	184	46	1315	425	137	30	359	511	3	64	42	25	2	102
35	FS0384	412	1	66	100	59	4	148	127	2190	413	191	22	439	688	2	67	67	39	1	130	51	1740	299	105	24	401	542	3	69	61	35	3	142
36	FS0384	413	1	62	111	64	5	126	46	1112	258	131	24	377	405	2	63	93	54	4	131	25	872	186	58	33	479	240	3	64	63	37	1	141
37	FS0384	414	1	64	55	32	3	122	112	1931	408	67	23	588	414	2	67	48	28	2	132	67	2570	407	58	26	338	906	3	69	35	20	2	126
38	FS0384	501	1	54	137	79	7	115	74	782	352	160	23	516	255	2	54	97	56	6	93	60	620	280	99	20	489	208	3	55	60	35	4	90

OBS	P3	CA3	MG3	K3	NA3	CEC3	SATBASE3	APH	AMO	AC	AN	ACANI	AP	ACA	AMG	AK	ANA	ACEC	ASATB
20	25	65	24	22	20	243	54	5.4125	6.6125	3.8000	0.2125	17.1000	3.1125	0.7862	0.31500	0.28000	0.20625	25.6125	6.2000
21	60	476	76	19	18	261	226	5.9625	7.8375	4.5500	0.3625	12.9000	5.7375	4.5687	0.83000	0.27750	0.18875	26.4500	21.7500
22	46	54	31	11	18	385	30	5.1750	12.1625	7.0500	0.3750	18.7000	4.8625	0.6237	0.37625	0.15750	0.17875	40.6125	3.2875
23	89	20	8	5	24	241	24	5.0125	8.0000	4.6500	0.1000	16.8250	8.1500	0.2462	0.12500	0.06125	0.21875	27.6875	2.5750
24	25	78	29	12	26	255	57	5.2625	7.5375	4.4125	0.1000	16.0125	5.1875	5.0925	0.53250	0.29625	0.23250	28.6125	17.4125
25	12	33	17	4	16	204	14	5.3125	4.3125	2.5375	0.1875	14.3250	1.9750	0.5000	0.22500	0.06375	0.16000	22.6875	3.8500
26	25	131	31	11	23	252	78	5.1625	7.3000	4.2500	0.2625	17.4000	3.7375	1.3912	0.33375	0.14000	0.24500	26.7500	7.8625
27	19	74	27	18	21	153	91	5.7375	5.1250	2.9875	0.1625	15.3500	3.2500	0.9737	0.16750	0.18250	0.21375	17.5625	9.7750
28	143	5360	974	91	139	679	966	6.7625	5.3750	3.1500	0.2625	7.1375	15.8750	51.3750	9.68875	1.15375	1.35750	67.4000	94.2625
29	25	2500	896	31	17	481	676	6.8000	4.7125	2.7375	0.2625	11.4875	2.6250	25.8500	4.50750	0.50500	0.33000	47.1375	70.6500
30	25	917	324	100	39	239	576	6.6375	2.5250	1.4625	0.1125	12.0375	3.8625	9.4975	1.12125	1.14500	0.35625	23.3250	61.4125
31	12	353	64	33	21	78	669	6.9875	2.0750	1.2000	0.1125	12.9875	3.8625	4.0925	0.72500	0.31500	0.22500	12.7875	50.3000
32	25	336	102	78	38	169	323	6.8500	2.1875	1.3750	0.1250	11.7750	2.2750	3.9400	1.02625	0.70250	0.29625	20.9750	29.3000
33	25	1789	577	38	33	375	629	6.8875	4.2250	2.4750	0.1625	13.0375	2.9375	16.9200	5.55125	0.55500	0.30125	36.2750	64.4000
34	40	1289	376	118	45	363	502	6.3375	4.8750	2.8500	0.2625	10.2500	4.9250	13.0100	4.04250	1.25750	0.37250	35.9750	52.1375
35	67	1630	321	110	31	361	578	6.7875	6.8125	3.9375	0.3125	13.8250	6.9250	17.6925	3.24250	1.18500	0.28250	38.6750	57.8250
36	12	884	238	102	35	452	277	6.3375	8.0250	4.6750	0.3625	11.5375	2.1125	9.0800	2.17000	0.89125	0.32875	45.2750	27.9125
37	96	2660	440	65	29	381	839	6.7625	4.2375	2.4500	0.2125	12.7750	8.7125	25.3512	4.21625	0.62625	0.27125	39.0500	81.1000
38	19	705	251	85	21	454	214	5.4500	8.3500	4.8375	0.5125	9.4250	4.1250	6.9275	2.75500	0.99625	0.20875	47.4875	22.6875

SITES AND CORRESPONDING SOIL FERTILITY

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OBS DATACODE SITE DEPTH1 PH1  MO1   C1  N1 CANI1  P1   CA1  MG1  K1  NA1 CEC1 SATHASE1 DEPTH2 PH2 MO2 C2 N2 CANI2  P2   CA2  MG2  K2 NA2 CEC2 SATHASE2 DEPTH3 PH3 MO3 C3 N3 CANI3

 39 FS0384  502   1    55   151   88   9   98  922  1591  613 485   28  426   638      2     58   61  17  3  123   330   599  243 158  22  220   464      3     58   44  26  2  130
 40 FS0384  503   1    55   141   82   6  134  112    58  122  58   18  360    75      2     56  124  72  5  138   143    40   59  44  18  303    53      3     58   56  32  2  161
 41 FS0384  504   1    54   241  140  13  110  176  1054  345  90   21  604   250      2     52  125  72  9   85   119   105   77  43  44  431    62      3     54  117  68  6  111
 42 FS0384  505   1    47   281  163  15  111  194   735  215 126   28  699   158      2     47  145  84  9   99   194   344   72  32  19  456   103      3     48  134  80  7  120
 43 FS0384  506   1    64   161   93   9  100   46   190  167  62  880  401   324      2     63  107  62  6   99    40  1870  651 104  54  611   439      3     62  129  75  8   92
 44 FS0384  507   1    61    99   57   5  112   53   710  354  61   93  584   209      2     58   80  46  5   98    32  1490  421 110  72  514   407      3     57  101  60  5  117
 45 FS0384  622   1    59    64   37   3  141   59   220   65  21   25  195   169      2     58   35  20  2  126    58   110   13   9  27  114   139      3     58   48  28  2  131
 46 FS0384  624   1    66   110   54   4  148   60   240  170  31   22  414   112      2     55   48  28  2  131    46   160  106  21  25  444    70      3     55   40  23  2  127
 47 FS0384  704   1    61   123   72   7  108   60   150  263  26   34  255   105      2     58  117  68  7   96    46   770  293  81  18  422   275      3     60   82  47  6   83
 48 FS0384  707   1    62    78   45   4  119  400   580  189  91   24  463   191      2     63   80  47  4  108   260   460  176  71  24  454   161      3     64   76  44  4  108
 49 FS0384  708   1    66    70   40   2  184   46   190   99  44   24  393    91      2     63   84  49  4  132    40   970  235 117  22  452   297      3     62   76  44  3  142


OBS  P3  CA3  MG3  K3 NA3 CEC3 SATHASE3  APH      AMO      AC      AN     ACANI     AP       ACA      AMG       AK      ANA      ACEC     ASATH

 39 135  605  230  66  25  227   404   5.7625   6.4500  3.7875  0.3250  12.3375  30.6500   7.2600  2.82750  1.52875  0.24250  24.9250  45.7750
 40  19   33   22  41  18  217    53   5.6875   9.2125  5.3250  0.3625  14.9000   7.7125   0.3875  0.44375  0.64250  0.18000  26.4625   5.5750
 41  67   67   56  33  25  413    42   5.3250  13.5500  7.4500  0.8000  10.1125  10.0125   2.0462  1.00000  0.43875  0.31625  45.3625   7.5500
 42  96  213   45  20  17  563    51   4.7500  15.8500  9.1875  0.8750  11.1000  14.5000   3.2737  0.76375  0.37750  0.20125  53.9125   8.4875
 43  12  570  220  54  38  567   156   6.2625  12.4750  7.2375  0.7375   9.5625   1.6750  10.1000  3.75000  0.73750  1.49250  56.2750  28.3125
 44  25 1400  393  76  21  532   356   5.7875   9.2875  5.4375  0.5000  10.9250   3.1125  13.4750  3.98625  0.06875  0.49125  53.1750  35.6750
 45  58  160   22  12  33  144   157   5.8125   4.5125  2.6125  0.2125  13.0625   5.8125   1.4875  0.26000  0.12000  0.29750  11.9125  15.1750
 46  66  750  409 154  25  429   312   5.6375   5.1750  3.0000  0.2250  13.1125   4.7750   4.6500  2.65500  0.88750  0.24625  43.2750  19.6250
 47  25  380  160  61  22  387   161   5.9375  10.0250  5.8000  0.6500   9.1000   3.7250   4.9750  2.22750  0.65125  0.22000  38.3625  20.6750
 48 160 1120  294  82  19  184   305   6.3375   7.7750  4.5250  0.4000  10.9375  22.7500   8.0500  2.36625  0.79000  0.21500  42.0125  28.1750
 49  25 1170  204 111  23  463   130   6.2875   7.8250  4.5375  0.3250  14.3500   3.3250   9.7250  2.02500  1.14875  0.22750  45.0125  28.7750
```

SITES AND SOIL PHYSICS CHARACTERISTICS

OBS	DATACODE	SITE	SAND1	SILT1	CLAY1	SAND2	SILT2	CLAY2	SAND3	SILT3	CLAY3	ASAND	ASILT	ACLAY
1	FS0383	101	17	60	23	19	52	29	15	46	39	16.750	50.000	33.250
2	FS0383	102	41	16	3	83	14	3	81	16	3	81.750	15.250	3.000
3	FS0383	103	25	34	41	31	24	45	29	24	47	29.250	25.250	45.500
4	FS0383	104	77	16	7	79	16	5	77	18	5	77.750	17.000	5.250
5	FS0383	105	73	18	9	69	24	7	69	24	7	69.500	23.250	7.250
6	FS0383	107	39	20	41	45	14	41	43	12	45	43.250	13.750	43.000
7	FS0383	108	67	28	5	63	32	5	73	22	5	68.500	26.500	5.000
8	FS0383	202	54	22	24	52	24	24	50	18	32	51.250	20.750	28.000
9	FS0383	203	48	28	24	59	39	29	59	26	24	57.625	31.125	25.875
10	FS0383	204	16	30	54	14	25	60	12	24	64	13.250	25.500	61.250
11	FS0383	205	14	36	50	16	32	52	6	28	66	10.750	30.500	58.750
12	FS0383	206	26	32	42	22	26	52	8	22	70	15.500	24.750	59.750
13	FS0383	208	66	26	8	82	14	4	82	12	6	80.000	14.500	5.500
14	FS0383	211	48	30	22	56	22	22	52	20	28	53.000	22.000	25.000
15	FS0383	212	66	26	8	82	14	4	82	12	6	79.875	14.500	5.500
16	FS0383	301	30	20	50	16	18	66	12	18	70	15.750	18.250	66.000
17	FS0383	302	36	26	38	16	28	56	14	26	60	17.500	26.750	55.750
18	FS0383	303	42	46	12	42	42	16	44	40	16	43.000	41.500	15.500
19	FS0383	304	26	26	48	54	28	18	58	24	18	52.500	25.750	21.750
20	FS0383	305	32	34	34	32	26	42	20	26	54	26.000	27.000	47.000
21	FS0383	306	32	32	36	30	28	42	16	20	64	23.250	24.500	52.250
22	FS0383	307	64	26	10	62	24	14	60	24	16	61.250	24.250	14.500
23	FS0383	308	70	14	16	68	16	16	66	16	18	67.250	15.750	17.000
24	FS0383	309	38	20	42	60	12	28	32	12	56	43.250	13.000	43.750
25	FS0383	310	52	30	18	46	18	36	32	16	52	39.750	18.500	41.750
26	FS0383	312	46	26	28	28	18	54	18	16	66	25.250	18.000	56.750
27	FS0383	313	36	26	38	34	20	46	28	18	54	31.250	19.750	49.000
28	FS0383	314	66	24	10	36	22	42	30	16	54	34.250	19.250	46.500
29	FS0383	401	36	36	29	40	29	31	40	27	33	39.500	28.875	31.750
30	FS0383	403	16	46	38	14	44	42	2	38	60	8.250	41.250	50.500
31	FS0383	405	48	32	20	50	30	20	60	34	6	54.750	32.250	13.000
32	FS0383	406	52	30	18	62	26	12	52	28	20	55.750	27.500	16.750
33	FS0383	407	50	37	13	48	30	22	48	24	28	40.250	27.875	23.875
34	FS0383	410	34	30	36	30	30	40	40	44	16	35.500	37.000	27.500
35	FS0383	411	36	37	27	32	29	39	30	31	39	31.500	31.000	37.500
36	FS0383	412	36	42	22	38	38	24	34	34	32	35.750	36.500	27.750
37	FS0383	413	38	43	19	39	47	14	37	33	30	37.875	34.500	22.625
38	FS0383	414	36	31	33	34	25	41	22	29	49	28.250	27.750	44.000
39	FS0383	501	42	38	20	36	30	34	54	36	10	45.750	34.000	20.250
40	FS0383	502	54	28	18	48	32	20	56	30	14	52.750	30.500	16.750
41	FS0383	503	30	30	40	12	28	60	6	28	66	11.250	28.250	60.500
42	FS0383	504	52	26	22	34	38	28	36	50	14	37.250	42.500	20.250
43	FS0383	505	48	32	20	60	28	12	50	38	12	53.500	33.500	13.000
44	FS0383	506	54	22	24	36	44	20	44	38	18	42.250	38.250	19.500
45	FS0383	507	28	36	36	42	30	28	42	28	30	40.250	29.750	30.000
46	FS0383	622	64	30	6	64	30	6	58	36	6	61.000	33.000	6.000
47	FS0383	624	28	46	26	18	46	36	18	44	38	19.250	45.000	35.750
48	FS0383	704	60	34	6	70	24	6	68	26	6	67.750	26.250	6.000
49	FS0383	707	38	48	14	36	42	22	32	42	26	34.250	42.750	23.000
50	FS0383	708	50	32	18	44	34	22	40	34	26	42.750	33.750	23.500

APPENDIX 9 [2/]

Numerical code for the species in investigation in Costa Rica and location of the plots inside the country

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2/ The information was taken from Camacho, (1981) and Martinez, (1981).

CODE FOR SPECIES IN INVESTIGATION IN COSTA RICA

001	Acacia auriculiformis A. Cunn. ex Benth.
002	Acacia mangium Willd
003	Acrocarpus fraxinifolius Wight
004	Albizia falcataria (L.) Fosberg
005	Alnus acuminata (HBK) O. Ktze
006	Anacardium excelsum (Bert y Balb) Skeels
007	Anthocephalus chinensis (Roxb) Miq.
094	Astronium graveolens Jacq.
008	Beilschmiedia anay (Blake) Kosterm
009	Bombacopsis quinatum (Jacq) Dugand
010	Brosimum alicastrum Swartz
011	Brosimum utile (HBK) Pittier
012	Bursera simaruba (L.) Sarg.
013	Calliandra callothyrsus Meissn
014	Calophyllum brasiliense Camb.
015	Carapa guianensis Aubl
095	Casuarina equisetifolia L.
016	Cedrela mexicana (L.) Roem.
017	Cedrela tonduzii (C.) DC.
018	Ceiba pentandra (L.) Gaerth
019	Cordia alliodora (Ruiz y Pavón) Cham
020	Cordia apurensis
091	Cordia Gerascanthus off. Gerascanthus
021	Cryptomeria japonica D. Don.
022	Cupressus lusitanica Mill
096	Cupressus macrocarpa (Gord)
023	Cybistax donnell-smithii (Rose) Seibert
024	Dalbergia cubilquitzensis Pittier
025	Dalbergia retusa Hensl
097	Delonex regia (Bojer) Raf.
026	Didymopanax morototoni (Aubl) Decne y Planch
027	Diphysa robinioides Benth
028	Dipterodendrum costarricensis Radlk
029	Dipterodendrum elegans Radlk
030	Drymis granadiensis (L.)
031	Enterolobium cyclocarpum (Jack) Griseb
032	Eucalyptus alba Reinw
033	Eucalyptus camaldulensis Dehnh
034	Eucalyptus citriodora Hook
035	Eucalyptus cloeziana F. Muell
036	Eucalyptus decepta Blakely
037	Eucalyptus deglupta Blume
038	Eucalyptus globulus Labill
039	Eucalyptus grandis Hillex Maiden
040	Eucalyptus longifolia Link y Otto
041	Eucalyptus macrocarpa Hokk
042	Eucalyptus maculata Hokk
043	Eucalyptus maidenii F. Muell
044	Eucalyptus robusta Smith
045	Eucalyptus saligna Smith
046	Eucalyptus tereticornis Smith
047	Eugenia jambos Linn
048	Fraxinus uhdei Lindelsh
049	Gliricidia sepium (Jack) Steud
050	Gmelina arborea Roxb
051	Grevillea robusta A. Cunn
098	Guazuma ulmifolia Lam
052	Hibiscus elatus (DC.) Swartz
053	Hymenaea courbaril L.
054	Jacaranda copaia (Aubl) D. Don
099	Jacaranda mimosifolia D. Don
055	Juglans olanchanum Standl y Will
056	Leucaena leucocephala (Lam) de Wit
093	Minquartia guianensis Aubl
100	Montanoa dumicola Klatt
057	Myroxylon balsamum (L.) Harms
058	Pentaclethra macroloba (Willd) Ktze
059	Pinus canariensis C. Smith
060	Pinus caribaea var. bahamensis Barr y Golf
061	Pinus caribaea var. caribaea Barr y Golf
062	Pinus caribaea var. hondurensis Barr y Golf
063	Pinus elliottii (Engelm) Little y Dorman
064	Pinus engelmannii Carr.
065	Pinus kesiya Royle y Gordon
066	Pinus oocarpa Schiede.
067	Pinus patula Schl y Cham.
068	Pinus pinaster Aiton
069	Pinus pseudostrobus Lindl
070	Pinus radiata D. Don
071	Pinus rudis Endl.
072	Pinus taeda L.
101	Pithecolobium pseudo-tamarindus Britt Standl
073	Pithecolobium saman (Jack) Benth
102	Platimyscium pleiostachyum Donn Sm.
103	Platimyscium pinnatum (Jacq) Dugand
074	Podocarpus oleifolius Don
104	Pseudolmedia spuria (Sw.) Grisebach
075	Quercus corrugata Hook
076	Schizolobium parahybum (Vell) Blake
077	Sesbania grandiflora (L.) Pers.
078	Simarouba glauca D.C.
079	Sterculia apetala (Jack) Karst.
090	Stryphnodendron excelsum Harms
092	Swartzia panamensis Benth
080	Swietenia humilis Zucc
081	Swietenia macrophylla G. King
082	Tabebuia chrysantha (Jack) Nichol.
105	Tabebuia palmeri Rose.
083	Tabebuia rosea (Vertol) DC.
084	Tectona grandis Linn
085	Terminalia amazonia (Gmel) Exell.
086	Terminalia ivorensis A. Chev
087	Terminalia lucida Hoffm.
089	Toona ciliata M. Roem
088	Trema micrantha (L.) Blume
106	Trichosperma mexicanum (DC.) Baill.

CODE FOR SITES IN INVESTIGATION IN COSTA RICA AND TOTAL OF PLOT PER LOCACTION. 1971-1981

site code		No. of plot per site
	Forestry Region 1: Atlantic Zone	
101	San Cristóbal-Roxana-Pococí	(4)
102	Guápiles - Pococí - Instituto Agropecuario	(11)
103	Guácimo - Limón - Hacienda Santa María	(4)
104	Guápiles - Pococí - Hacienda La Granja	(8)
105	Guápiles - Pococí - Estación Experimental Los Diamantes	(45)
106	Guácimo - Limón Hacienda La Rosalía	(6)
107	Guácimo - Limón - Hacienda La Cabaña	(7)
108	Guácimo - Limón - Instituto Agropecuario	(8)
109	Pocora - Pococí - Hacienda Bremen	(4)
110	Cariari - Pococí - Los Angeles de	(6)
111	Río Hondo - Siquirres	(3)
112	La Bomba - Limón	(4)
	Forestry Region 2: North Zone	
201	Zarcero - Alfaro Ruíz - Finca de León Rojas	(1)
202	Ciudad Quesada - San Carlos - Contiguo Bar El Jade	(2)
203	Ciudad Quesada - Barrio El Carmen - Colegio Agroindustrial	(3)
204	Platanar - San Carlos - Detrás del Templo del lugar	(1)
205	Muelle - San Carlos - Frente Aserradero	(1)
206	Santa Rosa - Cutris - Finca Familia Quesada	(2)
207	Cedral Sur - Ciudad Quesada - Finca El Cedral de José Quirós	(1)
208	Vara Blanca de Heredia - Finca de Rogelio Aguilar	(1)
209	Vara Blanca de Heredia - Finca Abras	(4)
210	Vara Blanca de Heredia - Finca La Legua	(1)
211	La Marina de San Carlos - Hacienda La Marina	(2)
212	Vara Blanca de Heredia - Finca El Cortijo de Miguel Sanz	(2)
213	Los Angeles de la Fortuna - San Carlos, Zona Finca ITCO	(6)
214	Instituto Agropecuario de Upala - Alajuela	(3)
	Forestry Region 3: South Pacific Zone	
301	Buenos Aires - Puntarenas - Aeropuerto	(9)
302	Salitre de Buenos Aires - Puntarenas	(23)
303	Bajo [illegible] - Buenos Aires - Puntarenas	(9)
304	Palmar Norte - Instituto Agropecuario	(15)
305	Río Claro - Golfito - Instituto Agropecuario Guaycará	(8)
306	Volcán - Buenos Aires - Entrada al pueblo	(1)
307	Volcán - Buenos Aires - Finca de los Seita	(2)
308	San Pedro de Buenos Aires - Finca Santa Cecilia	(2)
309	San Pedro de Buenos Aires - Finca La Terranova	(1)
310	San Isidro - Pérez Zeledón - Ganadera El Santo	(4)
311	San Isidro de El General - Finca de la U.N.A.	(1)
312	Pedregoso de San Isidro de El General - Finca de Luis Cordero	(1)
314	Santa Marta de Buenos Aires - Finca Ron-Ron	(2)
315	Pejibaye de Pérez Zeledón - Instituto Agropecuario	(6)
316	Los Angeles de Pérez Zeledón	(4)
317	Boruca - Buenos Aires -.Puntarenas	(3)
	Forestry Region 4: Dry Pacific Zone	
401	Mansión - Nicoya - Hacienda El Limonal	(2)
402	Nicoya - Vivero Forestal del MAG	(2)
403	Santa Cruz - Finca de Eduardo Cabalceta	(2)
404	Filadelfia - Detrás del Seguro Social	(2)
405	Paso Tempisque - Finca de Juan Carlos Guillén	(2)
406	Colorado - Finca de Narciso Rivas	(4)
407	Liberia - Finca El Pelón de la Bajura	(1)
408	Bagaces - Ruta al Volcán Miravalles	(1)
409	Cañas - Vivero El Pochote	(1)
410	Taboga - Cañas - Estación Experimental Enrique Jiménez Núñez	(15)
411	Taboga - Cañas - Hacienda La Roca	(3)
412	San Joaquín de Abangares - Finca de Enrique Baseviches	(2)
413	Liberia - Hacienda La Flor	(2)
414	Liberia - Hacienda El Real	(2)
415	La Cruz - Hacienda La Mary	(1)

Cont....

site code		No. of plot. per site
416	San Luis de las Juntas de Abangares	(4)
417	La Palma de las Juntas de Abangares	(10)
418	Bebedero - Cañas - Ingenio Taboga	(1)
419	Cañas - Hacienda La Javilla de Rodolfo Zeledón	(1)
420	Cañas- Hacienda La Pacífica	(2)
421	Liberia - Centro Universitario de Guanacaste	(8)
422	La Cruz - Finca Pocosol	(1)
423	Belén - Filadelfia - Coopeguanacaste	(1)
424	La Palma de Abangares	(1)
	Forestry Region 5: Central Pacific Zone	
501	Quebradilla de Dota - Finca de Sucesión Ureña	(10)
502	Santa María de Dota - Finca de Rodrigo Solís	(4)
503	San Marcos de Tarrazú - Finca de Humberto Creña	(1)
504	San Pablo de León Cortés - Finca de Jorge Arguedas	(1)
505	La Chonta de Dota - Hacienda el Robledal de José Ma. Castro	(8)
506	Tarbaca - Finca Tara de Oscar Chacón	(1)
507	Palmichal de Acosta - Finca de Benito Meza	(13)
508	San Cristóbal de Palmichal de Acosta - Finca de Jorge Mora P.	(1)
509	Palmichal de Acosta - Finca El Ripial	(2)
510	San Pablo de Turrubares - Instituto Agropecuario	(6)
511	San Luis de Turrubares	(3)
512	San Francisco de Turrubares	(3)
513	San Juan de Mata - Turrubares	(3)
514	La Gloria de Puriscal - Instituto Agropecuario	(6)
515	Matapalo de Aguirre - Instituto Agropecuario	(3)
516	Matapalo de Aguirre - Finca de Eliécer Castro	(2)
517	Acosta - Centro Agrícola Cantonal	(3)
518	Acosta - Ganadera Caragral de Mario Rivas Zeledón	(1)
519	La Cima de Dota - Finca de Iván Deliens	(3)
	Forestry Region 6: Central Valley Zone (East)	
	Los primeros 20 dígitos se han reservado para los ensayos establecidos en el Centro Agronómico Tropical de Investigación y Enseñanza (CATIE)	
621	Ochomogo - Finca de la Municipalidad de Cartago	(9)
522	Río Reventado - Parque Recreativo de Prusia	(19)
623	San Isidro de Tejar - Finca de Ramón González	(1)
624	San Isidro de Tejar - Finca Cocorí	(1)
625	Tierra Blanca - Cartago - Centro de Adaptación Social	(3)
626	Taras - Cartago - Los Diques	(5)
	Forestry Region 7: Central Valley Zone (West)	
701	Alajuela - Barrio San José Estación Experimental Fabio Baudrit	(6)
702	San Isidro de Grecia - Finca La Inés	(1)
703	Cebadilla de Turrúcares - La Garita (I.C.E.)	(1)
704	San Jerónimo de Moravia - Finca de Oscar Madrigal	(4)
705	San Isidro de Coronado - Finca de R. Castro	(1)
706	San José de La Montaña - Heredia - Finca de los Steinvorth	(1)
707	Grecia - Finca La Argentina	(2)
708	Santo Tomás de Santo Domingo - Rancho Arizona	(4)
709	San Jerónimo de Moravia - Finca de Freddy Solís	(3)
710	San Jerónimo de Moravia - Finca de Coralia Alpízar	(1)
711	Ciudad Colón - San José - Hacienda El Rodeo	(2)
712	Sarchí - Alajuela - Hacienda La Luisa	(6)
713	San Pablo de Heredia - Compañía Pfizer	(2)

APPENDIX No. 10.

Sites number, location in coordinate of latitude and longitude, elevation above mean sea level, and corresponding meteorological station to which they were refered.

SITE			METEOROLOGICAL STATION		
Number	Latitude - Longitude	Elev.	Latitude - Longitude	Elev.	Name
101	10°17' - 83°43'	90	10°21' - 83°46'	70	La Mola
102	10°12' - 83°47'	260	10°13' - 83°49'	249	Los Diamantes
103	10°17' - 83°34'	150	10°21' - 83°46'	70	La Mola
104	10°13' - 83°44'	240	10°13' - 83°49'	249	Los Diamantes
105	10°13' - 83°46'	249	10°13' - 83°49'	249	Los Diamantes
106	10°17' - 83°40'	70	10°21' - 83°46'	70	La Mola
107	10°12' - 83°41'	100	10°13' - 83°49'	249	Los Diamantes
108	10°12' - 83°41'	100	10°13' - 83°49	249	Los Diamantes
109	10°12' - 83°37'	70	10°13' - 83°49'	249	Los Diamantes
110	10°18' - 83°40'	250	10°21' - 83°46'	70	La Mola
111	10°05' - 83°25'	200	10°06' - 83°23'	40	La Lola
112	09°55' - 83°01'	20	10°00' - 83°03'	3	Limon
201	10°11' - 84°24'	1736	10°13' - 84°23'	2010	Palmira
202	10°19' - 84°26'	580	10°21' - 84°24'	600	C.Rural Metodista
203	10°19' - 84°26'	540	10°21' - 84°24'	600	C.Rural Metodista
204	10°25' - 84°28'	120	10°21' - 84°24'	600	C.Rural Metodista
205	10°28' - 84°27'	122	10°21' - 84°24'	600	C.Rural Metodista

APPENDIX No. 10. Cont....

206	10°36' - 84°29'	160	10°21' - 84°24'	600	C.Rural Metodista
207	10°22' - 84°26'	590	10°21' - 84°24'	600	C.Rural Metodista
211	10°23' - 84°22'	410	10°21' - 84°24'	600	C.Rural Metodista
212	10°09' - 84°09'	1900	10°13' - 84°23'	2010	Palmira
213	10°27' - 84°34'	80	10°21' - 84°24'	600	C.Rural Metodista
214	10°54' - 83°01'	30	10°21' - 84°24'	600	C.Rural Metodista
301	09°10' - 83°20'	380	09°11' - 83°20'	350	La Pinera
302	09°12' - 83°19'	500	09°11' - 83°20'	350	La Pinera
303	09°10' - 83°22'	500	09°11' - 83°20'	350	La Pinera
304	08°58' - 83°27'	20	08°57' - 83°28'	16	Palmar Sur
305	08°41' - 83°04'	30	08°57' - 83°28'	16	Palmar Sur
306	09°12' - 83°28'	410	09°22' - 83°33'	1450	Cedral
307	09°13' - 83°27'	415	09°22' - 83°33'	1450	Cedral
308	09°15' - 83°31'	570	09°22' - 83°33'	1450	Cedral
309	09°16' - 83°22'	590	09°11' - 83°20'	350	La Pinera
310	09°17' - 83°38'	550	09°22' - 83°33'	1450	Cedral
312	09°23' - 83°40'	680	09°22' - 83°33'	1450	Cedral
313	09°23' - 83°43'	700	09°22' - 83°33'	1450	Cedral
314	09°10' - 83°23'	340	09°11' - 83°20'	350	La Pinera
315	09°49' - 83°43'	400	09°22' - 83°33'	1450	Cedral
316	09°29' - 83°46'	1110	09°22' - 83°33'	1450	Cedral

APPENDIX No. 10. Cont....

317	09°00' - 83°19'	650	09°11' - 83°20'	350	La Pinera
401	10°07' - 85°17'	20	10°09' - 85°27'	120	Nicoya
402	10°08' - 85°28'	120	10°09' - 85°27'	120	Nicoya
403	10°14' - 85°36'	50	10°09' - 85°27'	120	Nicoya
404	10°27' - 85°33'	17	10°36' - 85°32'	85	Liberia
405	10°30' - 85°34'	22	10°36' - 85°32'	85	Liberia
406	10°40' - 85°28'	120	10°36' - 85°32'	85	Liberia
407	10°33' - 85°23'	120	10°36' - 85°32'	85	Liberia
410	10°20' - 85°12'	50	10°21' - 85°09'	40	Taboga
411	10°22' - 85°06'	50	10°21' - 85°09'	40	Taboga
412	10°15' - 85°05'	60	10°21' - 85°09'	40	Taboga
413	10°36' - 85°33'	98	10°36' - 85°32'	85	Liberia
414	10°33' - 85°32'	30	10°36' - 85°32'	85	Liberia
416	10°18' - 84°58'	400	10°30' - 84°55'	580	Nueva Tronadora
417	10°15' - 85°05'	30	10°21' - 85°09'	40	Taboga
418	10°24' - 85°10'	20	10°21' - 85°09'	40	Taboga
419	10°24' - 85°05'	50	10°21' - 85°09'	40	Taboga
420	10°28' - 85°07'	50	10°21' - 85°09'	40	Taboga
421	10°37' - 85°27'	140	10°36' - 85°32'	85	Liberia
422	10°53' - 85°36'	250	10°36' - 85°32'	85	Liberia
423	10°24' - 85°36'	30	10°35' - 85°40'	3	Playa Panama

APPENDIX No. 10. Cont....

424	10°18' - 85°03'	50	10°21' - 85°09'	40	Taboga
501	09°42' - 83°59'	2100	09°50' - 83°58'	1400	Linda Vista
502	09°39' - 83°58'	1550	09°50' - 83°58'	1400	Linda Vista
503	09°40' - 84°01'	1520	09°50' - 83°58'	1400	Linda Vista
504	09°41' - 84°02'	1750	09°50' - 83°58'	1400	Linda Vista
505	09°42' - 83°67'	2380	09°50' - 83°58'	1400	Linda Vista
506	09°49' - 84°07'	1670	09°50' - 83°58'	1400	Linda Vista
507	09°50' - 84°15'	1110	09°50' - 83°58'	1400	Linda Vista
508	09°50' - 84°13'	1110	09°50' - 83°58'	1400	Linda Vista
509	09°50' - 84°15'	1000	09°50' - 83°58'	1400	Linda Vista
510	09°54' - 84°26'	350	10°01' - 84°16'	840	Fabio Baudrit
511	09°51' - 84°27'	300	10°01' - 84°16'	840	Fabio Baudrit
512	09°52' - 84°28'	250	10°01' - 84°16'	840	Fabio Baudrit
513	09°52' - 84°31'	100	10°01' - 84°16'	840	Fabio Baudrit
514	09°39' - 84°37'	360	09°57' - 84°24'	450	E.C. Ganaderia
515	09°20' - 83°57'	10	09°58' - 84°50'	3	Puntarenas
516	09°19' - 83°56'	30	09°58' - 84°50'	3	Puntarenas
517	09°49' - 84°12'	900	09°50' - 83°58'	1400	Linda Vista
518	09°49' - 84°08'	1500	09°56' - 84°05'	1172	San Jose
519	09°41' - 83°54'	2500	09°50' - 83°58'	1400	Linda Vista
621	09°55' - 83°57'	1560	09°50' - 83°58'	1400	Linda Vista
622	09°58' - 83°52'	2620	09°59' - 83°51'	3400	Volcan Irazu

APPENDIX No. 10. Cont....

623	09°51' - 83°56'	1350	09°50' - 83°58'	1400	Linda Vista
624	09°50' - 83°58'	1375	09°50' - 83°58'	1400	Linda Vista
625	09°56' - 83°53'	2350	09°59' - 83°51'	3400	Volcan Irazu
626	09°52' - 83°56'	1400	09°59' - 83°58'	1400	Linda Vista
703	09°56' - 84°21'	400	09°57' - 84°24'	450	E.C. Ganaderia
704	10°01' - 84°01'	1420	10°02' - 84°00'	1450	S. Josecito de H.
707	10°01' - 84°22'	700	09°57' - 84°24'	450	E.C. Ganaderia
708	09°59' - 84°05'	1180	09°59' - 84°05'	1172	San Jose
709	10°01' - 84°01'	1450	10°02' - 84°00'	1450	S. Josecito de H.
710	10°01' - 84°01'	1450	10°02' - 84°00'	1450	S. Josecito de H.
711	09°55' - 84°16'	800	10°01' - 84°16'	840	Fabio Baudrit
712	10°09' - 84°20'	1400	10°07' - 84°23'	1100	Naranjo
713	09°59' - 84°07'	1100	09°56' - 84°05'	1172	San Jose

APPENDIX 11

Initial 10 years growth curves for the species and study sites in Costa Rica

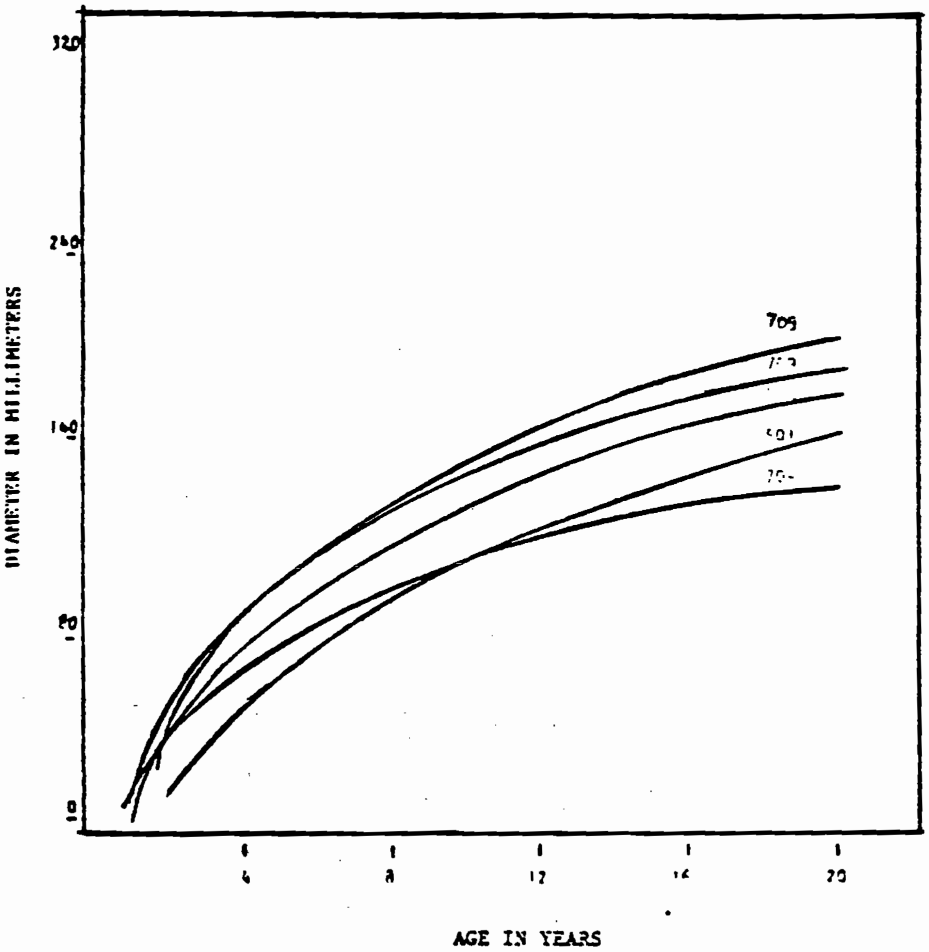

Fig. 3. Initial 10 years growth curves for different Alnus acuminata study sites in zones 5 and 7 of Costa Rica. Individual curve (number above the curve) is based on the mean of the 81 trees measured per plot.

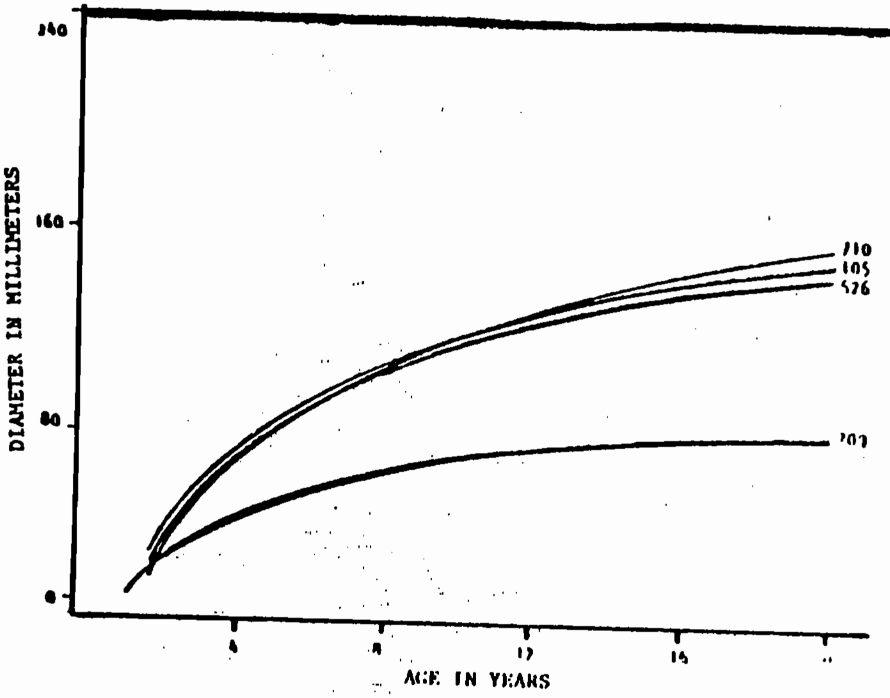

Fig. 4. Initial 10 years growth curves for different Cupressus lusitanica study sites in Costa Rica. Individual curve (number above the curve) is based on the mean of the 81 trees measured per plot.

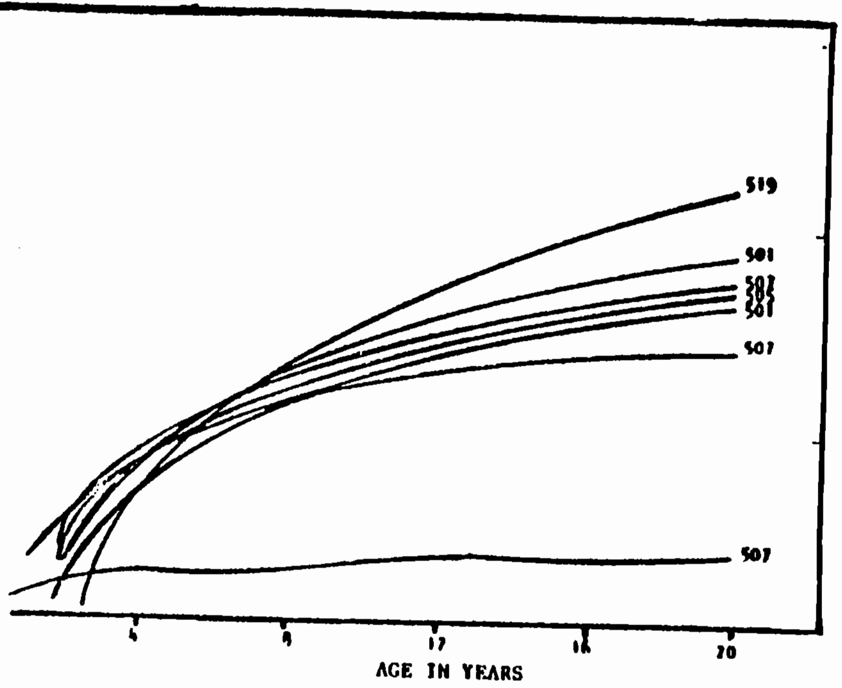

Fig. 5. Initial 10 years growth curves for different Cupressus lusitanica study sites in zone 5 of Costa Rica. Individual curve (number above the curve) is based on the mean of the 81 trees measured per plot.

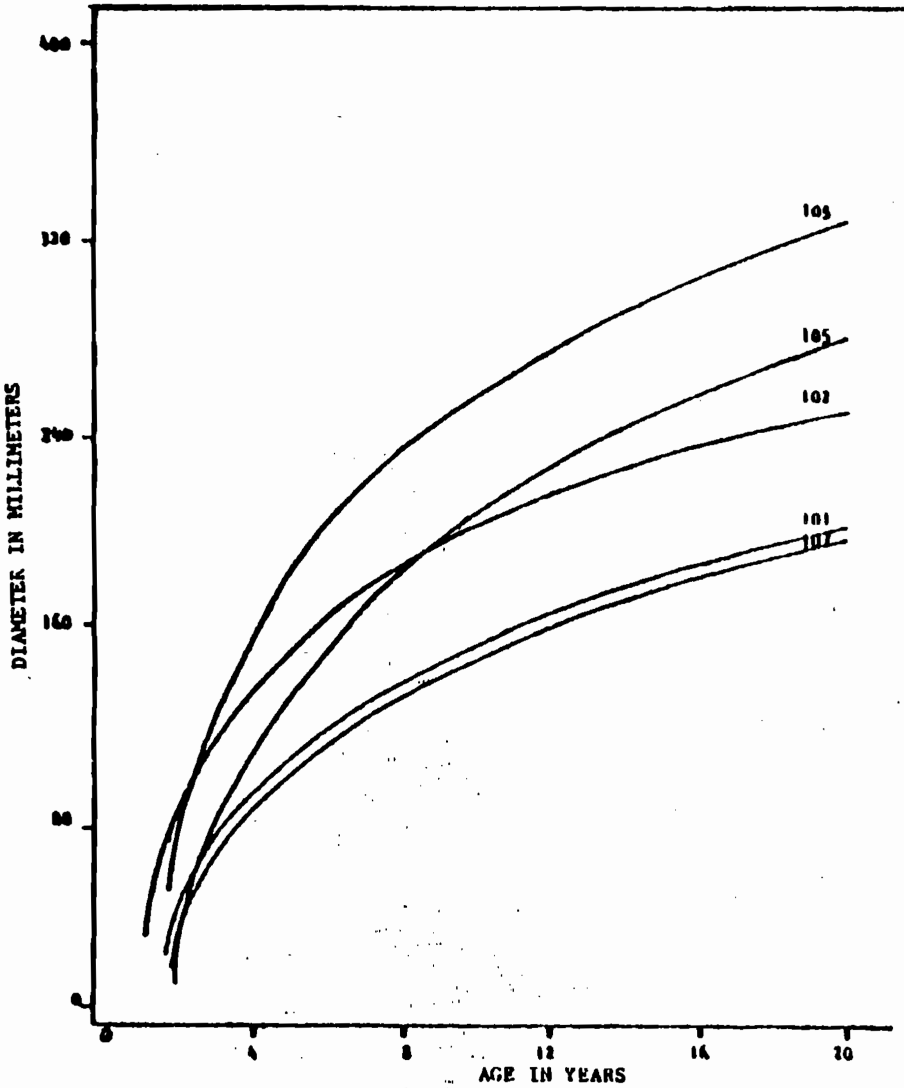

Fig. 6. Initial 10 years growth curves for different *Gmelina arborea* study sites in zone 1 of Costa Rica. Individual curve (number above the curve) is based on the mean of the 81 trees measured per plot.

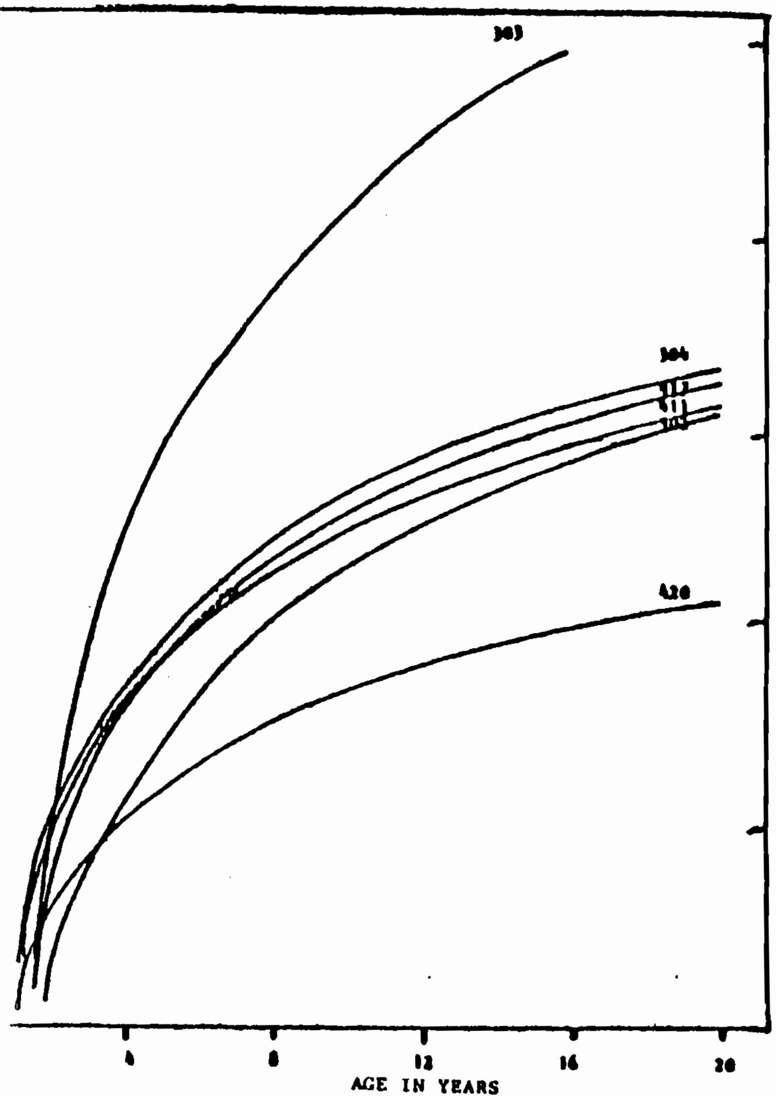

Fig. 7. Initial 10 years growth curves for different *Gmelina arborea* study sites in zones 3 and 4 of Costa Rica. Individual curve (number above the curve) is based on the mean of the 81 trees measured per plot.

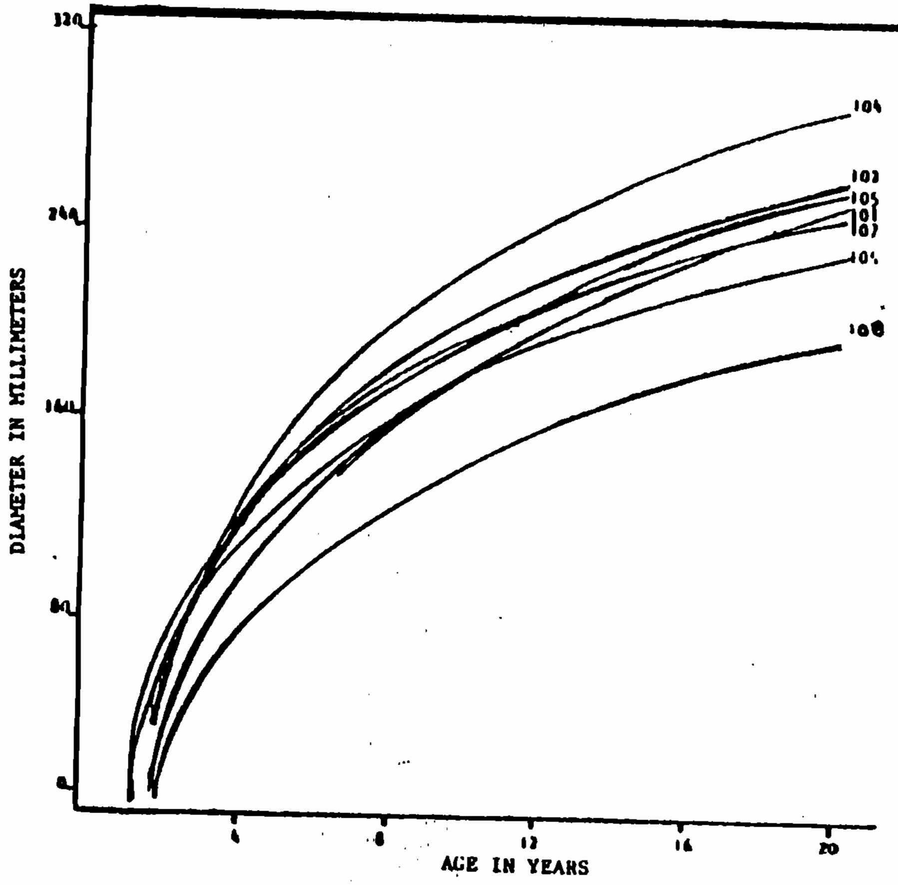

Fig. 8. Initial 10 years growth curves for different <u>Pinus caribaea</u> study sites in zone 1 of Costa Rica. Individual curve (number above the curve) is based on the mean of the 81 trees measured per plot.

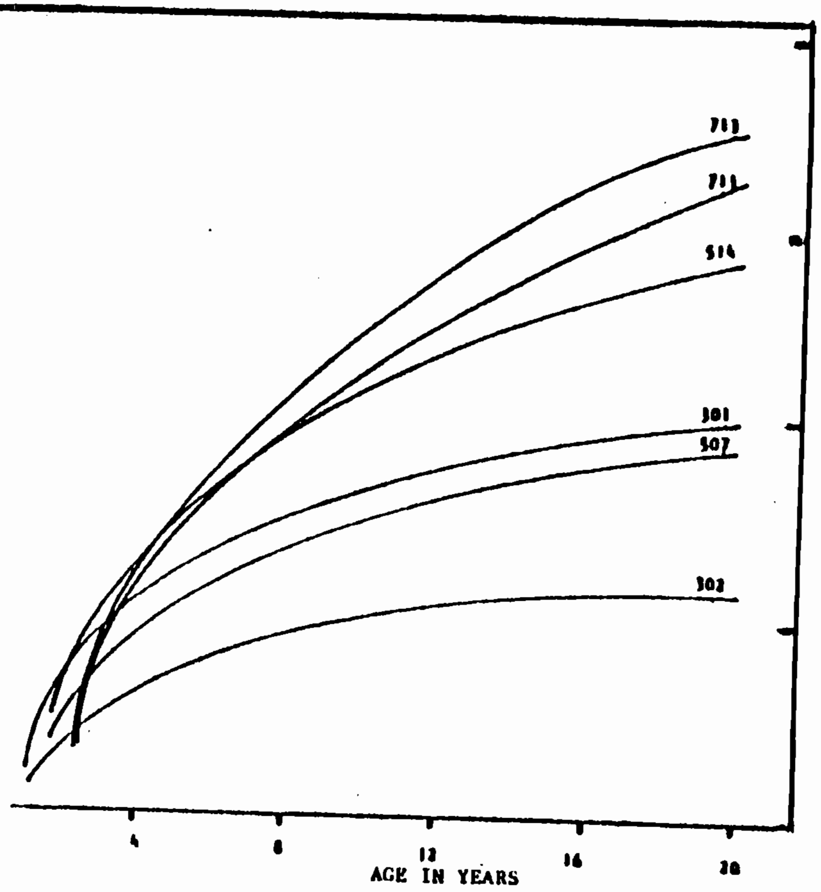

Fig. 9. Initial 10 years growth curves for different <u>Pinus caribaea</u> study sites in zones 3, 5, and 7 of Costa Rica. Individual curve (number above the curve) is based on the mean of the 81 trees measured per plot.

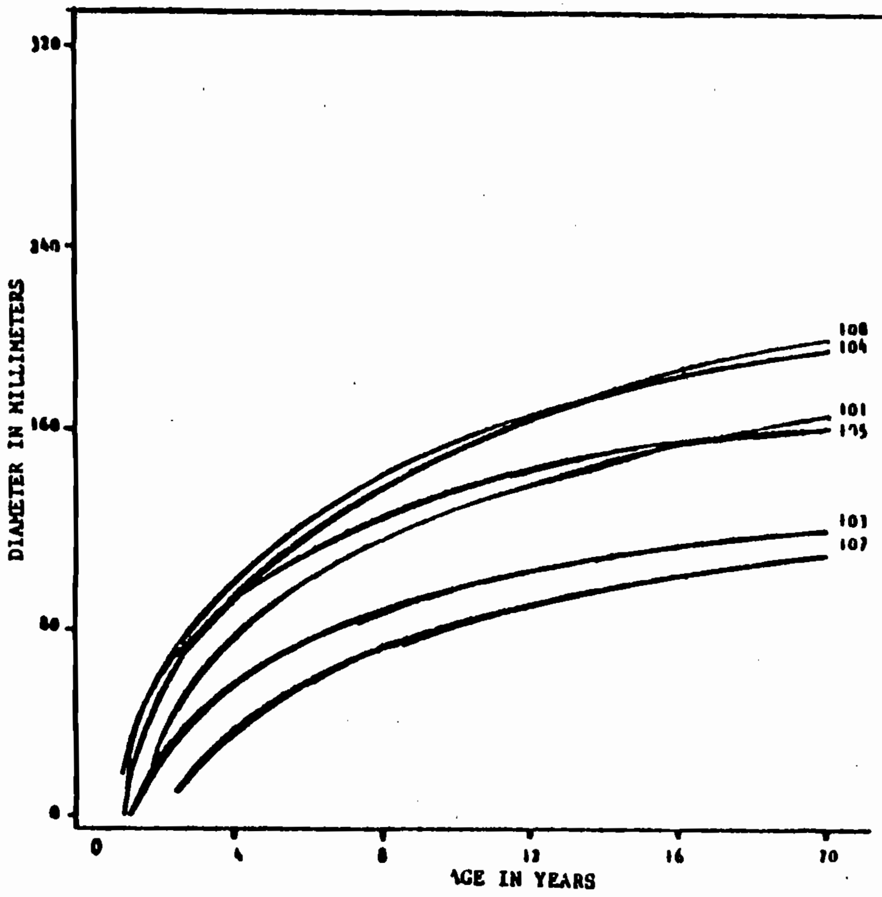

Fig. 10. Initial 10 years growth curves for different *Tectona grandis* study sites in zone 1 of Costa Rica. Individual curve (number above the curve) is based on the mean of the 81 trees measured per plot.

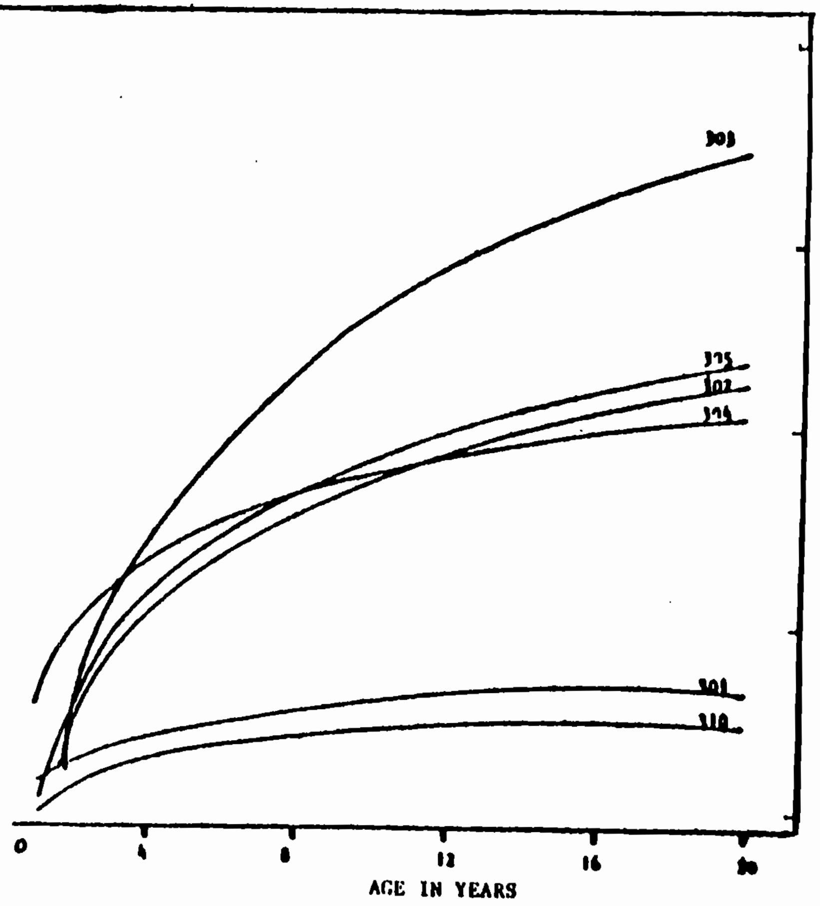

Fig. 11. Initial 10 years growth curves for different *Tectona grandis* study sites in zone 3 of Costa Rica. Individual curve (number above the curve) is based on the mean of the 81 trees measured per plot.