RECURSOS NATURALES TROPICALES S.A.

Teak (*Tectona grandis*) in Central America

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ACRONYMS

CCF	Costa Rican Forestry Chamber
FB	Forest Bonus
FONAFIFO	National Fund for Forest Financing
MAI	Mean Annual Increment
NPV	Net Present Value
PES	Payment for Environmental Services
PSP	Permanent Sample Plots

I. TEAK IN CENTRAL AMERICA

The first report on introduction of teak seed in Central America is from 1926, when it was planted in the Summit Botanical Garden of the former Channel Zone (Gutiérrez and Cordovéz, 1978, mentioned by Morán). According to the same authors, the seed came from Colombo, probably from the Paranaeniya Botanical Garden (Weidema, 1966).

This place of provenience, that has been called Ceylon - Panama or Sri Lanka - Panama, gave way to teak plantations located in farms dedicated to the banana production of the Chiriquí Land Company. Furthermore, the Good Year Company, dedicated to establish rubber plantations, also planted teak.

Gutiérrez and Cordovéz (1978), mentioned by Morán (1998), report the shipment of seeds from the Summit Botanical Garden to 11 Central and South American countries and the Caribbean during the period between 1936-1948. The United Fruit Company purchased the seed in February of 1943. Records from the Botanical Garden indicate a second shipment to R.A. Nichols, at the IICA, Turrialba, in April of 1943. By 1967, the Forest Development Project in select zones directed by FAO/UNDP/ITCO used seeds from five places of origin: Honduras, Panama, Trinidad and Tobago, Quepos (Costa Rica) and Nicoya (Costa Rica) (FAO 1967, mentioned by Keogh et al., 1979).

The date of introduction of the first teak seed in El Salvador is unknown. A more detailed reference mentioned by Keogh (1997) places the introduction of seeds in 1950, originally from Puerto Rico and Honduras. Reports do not specify if teak seeds actually came from both countries or from one of them. Other versions indicated that the first seeds came from Burma and Trinidad (Zambrana, 1998). Nevertheless, it is possible that the seed from Honduras came from the trees planted with seed from Panama and any other source between 1942 and 1943.

There are no reports, in Honduras and Nicaragua, of commercial teak plantation. Guatemala reports a planted area no bigger than 2,000 hectares (ha).

II. REFORESTED AREA IN THE REGION

In Central America, total planted area is approximately 224,896 ha, whereby 40,815 ha correspond to teak plantations (18.1% of the total planted area). The use of teak in planting projects increases at the beginning of the 1990s. As shown in **Table 1**, from the total area planted with teak, 57.5% has been planted in Costa Rica, 32.2% in Panama, 6.1% in El Salvador and 4.2% in Guatemala.

In most Central American countries the plantation process began at the end of the 1970s and was promoted by various international co-operation projects that did research during the 80s. For example, the MADELEÑA project did it with multiple use species. **Table 2** presents a list of the main species used in reforestation projects in Central America. **Appendix 1**.presents the total area planted in Guatemala, Panama and Costa Rica.

Table 1. Total Reforested Area in Central America and planted area with Teak (*Tectona grandis*). June, 1998. (hectares).

Country	Total Area (ha)	Total Reforested Area (ha)	Reforested Area with TEAK (ha)	Period (years)
Belize	2 143 500	2 245 [1]	Na	Na
Guatemala	10 889 000	12 444 [2]	1 717 [2]	1990-1995
El Salvador	2 097 000	6 584 [3]	2 488 [8]	Until 1996
Honduras	11 249 200	8 647 [4]	Na	Until 1995
Nicaragua	12 142 800	32 754 [5]	Na	1993-1996
Costa Rica	5 113 300	135 498 [6]	23,475 [6]	1979-1997
Panama	7 551 700	26 724 [7]	13 135 [7]	Until 1997
Total	**51 186 500**	**224 896**	**40,815**	

Source: [1] Toumasjukka (1996), [2] INAB (1998), [3] INCAE (1998), [4] SEGEPLAN et al (1996), [5] CAD et al (1997), [6] MINAE (1998), [7] INRENARE (1997), [8] Zambrana (1998).

NA = not available

Table 2. Main species used in reforestation projects in Central America. June 1998.

Country	Main Species
Guatemala	*Pinus caribaea, P. tenuifolia, P. oocarpa, P. Maximinoi, P. pseudostrobus, Cupressus lusitanica, Eucalyptus camaldulensis, Gmelina arborea, Tectona grandis, Cedrela odorata* [1]
El Salvador	*Tectona grandis, Pinus caribaea, Eucalyptus sp., Cupressus lusitanica*
Nicaragua	*Gmelina arborea, Eucalyptus camaldulensis, E. urophylla, Gliricidia sepiun, Lysiloma seemanii, Simarouba amara* [2]
Honduras	*Eucalyptus camaldulensis, E. grandis, E. teriticornis, Gliricidia sepium, Gmelina arborea, Leucaena leucocephala* [1]
Costa Rica	*Gmelina arborea, Tectona grandis, Cordia alliodora, Bombacopsis quinatum, Eucalyptus deglupta*, other natives.
Panama	*Tectona grandis, Pinus caribaea, Eucalyptus* spp.
Belize	Not available

Source: INCAE (1998), [1] INAB (1998), [2] Galloway (1997)

III. PHYSIOLOGICAL AND TECHNICAL ISSUES.

3.1. Bio-ecological requirements and growth.

Most of the data of the bio-ecological requirements of teak in Central America comes from the experience of, and the studies done, in Costa Rica, and a little from Panama and El Salvador.

Vásquez and Ugalde (1995) identified the following aspects in 14 sites located of the Guanacaste province, in the North Pacific region of Costa Rica,

- Teak best sites are located in areas with medium to flat slopes, at the base of a mountain or in valleys and, in areas where the soil's depth is 90 cm or more. These sites allow more space for root growth, and have more water and nutrients available, with a calcium content higher than 10 meq/100 ml of soil in the first stratum.
- Sites classified as highly productive have rainfalls higher than 2000 mm yearly. It is important to mention that the evaluated zone is the Dry Pacific of Costa Rica, with a 3-5 dry month period.
- Teak worst sites are those affected by strong winds, soils area shallower than 80 cm, with high iron and low calcium contents. These areas are generally located in summits, in over-pastured soils, with rainfalls lower than 1800 mm/ year.
- Plantations with a dominant height of 21.7 meters or more, at 10 years of age (base age), are classified as highly productive. Plantations with a dominant height lower than 18.1 m, at the same age, are classified as low productive.

Table 3 shows the increments in diameter, height, basal area and volume for high, middle and low productivity sites.

Table 3. Yields for *Tectona grandis* in Guanacaste, Costa Rica.

Range	MAI-dbh (cm/year)	MAI-Height (m/year)	G (m^2/ha)	MAI-G (m^2/ha/year)	MAI-Volume (m^3/ha/year)
High	2.0 or more	2.0 or more	20 or more	2.5 or more	18 or more
Middle	1.6-1.9	1.6-1.9	15.1-19.9	1.6-2.4	12.1-17.9
Low	1.5 or less	1.5 or less	15 or less	1.5 or less	12 or less

Source: Vásquez y Ugalde (1994).
MAI= Mean Annual Increment.

Vallejos (1996) in the same zone that Vásquez and Ugalde studied, determined that calcium content (0 - 20 cm of depth) influences significantly the yield of teak. He found that 18 cmol/l and more are adequate for good teak development. When soil present lower quantities, it is recommended to correct it with lime applications. He also determined that water deficit influences negatively the development of teak.

In this study, a Site Index prediction model was developed:

$$Ln(SI) = Ln(Hdom) + 1.8253 * ((1/Age^{0.5162}) - (1/Base\ Age^{0.5162}))$$

Where:

Ln= it is the natural logarithm

SI =is the Site Index

Hdom= it is the Dominant Height (meters)

Base age = 10 years

Furthermore, a model relates the SI to the soil calcium content (Ca) and water balance (DEFHID):

$$SI = (25.432112 - 2.695521 * DEFHID + 0.268667 * Ca)/0.794$$

Where:

SI is the Site Index

DEFHID is the number of months with less of 100 mm of rainfall.

Ca is the content of calcium (cmol/liter)

Vallejos (1996) developed a five classes production/yield index for that area. **Table 4** displays the information. **Table 5** summarizes the conditions for good teak growth in Costa Rica.

Table 4. Yield and production classes for *Tectona grandis* in Guanacaste, Costa Rica.

Variable	Unit	Marginal	Low	Middle	High	Excellent
MAI-dbh	cm/year	1.90 or less	1.91 - 2.49	2.50 – 3.01	3.02 - 3.8	3.81 or more
MAI-H	m/year	1.63 or less	1.64 - 2.32	2.33 – 3.14	3.15 - 4.05	4.06 or more
MAI-G	m^2/ha/year	0.97 or less	0.97 - 2.04	2.05 – 2.77	2.78 - 3.73	3.74 or more
MAI-Vol	m^3/ha/year	3.20 or less	3.21 - 11.83	11.84 – 18.00	18.01 - 26.57	26.58 or more

Source: Vallejos (1996).

Vol = total volume with bark in m^3

In Central America, teak has been planted in the dry forest zone as well as in the humid forest. Given the wide range of climatic, edaphic and topographic conditions in which it has been planted, there is enough experience to indicate the conditions under which it is more likely to obtain better growth and yields.

Ugalde (1997) indicates that, with the experience in Central America, the following aspects have to be considered:

- Temperature: The limits are an average of 25 and 28 degree Celsius, classified as good. Outside of those temperatures, the species does not grow well.
- Rainfall: Teak grows well between 1 250 and 2 500 mm/year. The species requires a 3 to 5 months dry period per year.
- Elevation: In Central America, the best yields have been obtained under 600 meters above sea level.
- Soils: Teak does well in sandy and slightly clay, fertile, deep, well drained soils, with a neutral or slightly acid pH.
- Limiting Factors: It is not recommended to plant teak in steep slopes; compacted or shallow soils and; heavy textures.

Table 5. Bio-climatic considerations for planting teak in Costa Rica.

Variable	Optimal Conditions	Observations **
Temperature (°C)	25 – 28	25
Rainfall (mm)	889 - 3 689	2 500
Rainfall Distribution	At least 3 dry months	
Elevation	0 – 600	Up to 800
Soil	Deep with high fertility	
Texture	Light	Heavy/drainage
Compaction*	Absent	Can be managed
Fertility *	High	High calcium content, neutral pH, low in aluminum
Topography	Flat *(to)* undulated	
Slope *	Under 20%	
Drainage *	Good	Superficial/Internal
Holdridge Life Zone's	Tropical Humid Forest Tropical Dry Forest	Under 800 m above sea level
Winds *	Absent	Limiting

Source: Picado (1997).
*Limiting condition or variable. **Detailed values or specifications.

The MADELEÑA Project established sample plots in all countries. The results are summarized below (Ugalde 1997):

- Honduras: There are reports of a diameter MAI of 2.29 cm/year in the Atlantic Coast and 1.05 cm/year in the north zone, coupled with height MAI's of 1.75 m and 1.0 m respectively.

Range	MAI-dbh (cm/year)	MAI-Height (m/year)
High	2.5 or more	2.5 or more
Middle	1.51-2.5	1.51-2.5
Low	1.5 or less	1.5 or less

- El Salvador: Some studies indicate an MAI in diameter between 1.6 and 2.5 cm/year and a MAI in height between 0.8 to 2.9 m/year.

Range	MAI-dbh (cm/year)	MAI-Height (m/year)
Excellent	na	2.5 or more
High	na	1.6-2.5
Middle	na	1.1-1.5
Low	na	1.0 or less

na = not available

- Nicaragua: The studies reported a maximum MAI in height of 1.9 m/year and a maximum MAI in diameter of 2.2 cm/year.

Range	MAI-dbh (cm/year)	MAI-Height (m/year)
High	na	2.0 or more
Middle	na	1.0-2.1
Low	na	1.0 or less

na = not available

- Panama: diameter increments of 1.2 and 3.2 cm/year and in height between 0.18 and 3.4 m/year have been reported.

Range	MAI-dbh (cm/year)	MAI-Height (m/year)
Excellent	3.1 or more	3.1 or more
High	2.1-3.0	2.1-3.0
Middle	1.1-2.0	1.1-2.0
Low	1.0 or less	1.0 or less

Flora y Fauna S.A. reported volume MAI increments between 9.3 and 22.9 m^3/ha/year in plantations located in the North Zone of Costa Rica (**Table 6**). The Flora y Fauna Company has a set of production tables for the different sites of their plantations.

Table 6. Summary of four production scenarios (total and commercial volume) established for Flor y Fauna S. A. (plantation for a 20-year rotation). San Carlos, Costa Rica.

Class site	Project	Trees (n/ha)	Diameter (cm)	Height (m)	MAI of Total volume (m^3/ha) MAI	MAI of Commercial Volume (m^3/ha) MAI
Low	Teakwood I	240	28.6	20.2	13.4	9.3
Medium	Teakwood III	240	31.8	22.5	19.8	14.2
High	Teakwood VIa	240	34.5	25.3	25.3	18.5
Maximum	Teakwood VIb	240	37.2	27.3	31.4	22.9

Source: Camacho (1998)

Annual increments in diameter, height and volume in Bosques de Puerto Carrillo were obtained from Permanent Sample Plots. The project information is presented in **Appendix 5.** Some average parameters obtained from the Permanent Sample Plots are summarized in **Table 7.**

Table 7. Technical information from Permanent Sample Plots (PSP) of Bosques de Puerto Carrillo's teak plantations. July, 1998.

Age (years)	Total Height H_{med} (m)	Average Diameter D_g (cm)	Number Trees N (trees/ha)	Total Volume V_{tot} (m^3/ha)	Commercial Volume V_{10} (m^3/ha)	Mean Annual Increment MAI V_{tot} (m^3/ha/year)	Mean Annual Increment MAI V_{10} (m^3/ha/year)
3	10.5	10.4	1 111	n.s.	n.s.	n.s.	n.s.
4	12.6	12.7	660	55.2	19.5	23.3	8.2
5	14.2	14.5	660	69.1	34.1	21.4	9.5
6	15.6	16.0	660	83.7	49.6	20.2	10.5
7	16.7	17.3	660	98.3	65.1	19.4	11.2
8	17.6	18.4	440	74.8	53.2	18.8	11.6
9	18.5	19.3	440	83.9	62.8	17.7	11.4
10	19.3	20.2	440	93.4	72.9	16.9	11.3
11	20.0	21.0	440	102.5	82.6	16.2	11.1
12	20.6	21.7	220	55.5	45.8	15.5	11.0

Source: Quirós (1998).

n.s. = non-significative.
V_{tot} = Total volume according to Keogh's formula (1987), $V_{tot} = 0.0359 + 0.000022\ D_g^2 * H_{med} * N$;
V_{10} = Useful volume up to a minimum diameter of 10 cm without bark.

Picado (1997) proposed a plantation management structure and possible yields to be obtained in Costa Rica. According to his projections, after 20 years, the MAI commercial volume will be 19.4 m^3/ha/year (**Table 8)**. Therefore, the structure can be considered representative of the average teak production conditions in the country.

Table 8. Expected teak growth and yield per hectare in a high quality site with minimal management in Costa Rica.

Age (years)	Trees (n/ha)	Harvested trees (n/ha)	Diameter (cm)	Commercial Height [a] (m)	Commercial Volume ($m^{3/}$/ha[b])
1	1 300				
4	700	600	12.0		
8	400	200	20.8	11.0	48.59
15	200	200	31.3	14.0	140.04
20	---	200	37.3	14.0	198.87
Total gross volume					387.50

Source: Picado (1997)
[a]: Commercial height up to a diameter of 10 cm with bark;
[b]: Gross commercial volume = $(dap/100)^2$ * 0.7854 * Commercial Height *ff; where: ff = estimated factor form of 0.65.

Zambrana (1998) reported preliminary data for young plantations from El Salvador, 214 m^3/ha of commercial log volume (8 cm top diameter) for 25 rotation period. **Table 9** shows the proposed thinning plan and commercial volume yields.

Table 9. Preliminary yields estimates for teak in El Salvador.

Parameters after thinning						Thinning			Total	
Age (years)	No. of (trees/ha)	Aver.. Height (m)	Averag. Dbh (cm)	Basal Area (m^2/ha)	Vol. (m^3/ha)	No. of trees/ha	Average Dbh (cm)	Vol (m^3/ha) diameter >8 cm	Basal Area (m^2/ha)	Vol (m^3/ha) >8 cm
0	2200	-	-	-	-	-	-	-	-	-
4	1000	8	10	8	13	1200	6	9	11	22
10	500	15	17	12	50	500	14	30	23	89
17	300	18	24	13	85	200	20	35	33	159
25	190	20	30	14	100	190	27	40	40	214

Source: Zambrana (1998)

3.2. Plantation Management System.

To produce timber for sawmills, Picado (1997) recommends planting 1,000 – 1,600 trees/ha.

In Costa Rica, in a high quality site, the first thinning must be performed between the third and fourth year. About 40 -50% of the total population has to be eliminated. Generally, this thinning does not yield any commercial product, but it is necessary to eliminate competing, malformed, sick or damaged trees.

Until now, Costa Rica's teak plantations management has been "poor and inadequate". Poor because the owner does not wish "to lose" 400 to 500 trees, that represented an investment during first three to four years, and inadequate because they don't have enough technical knowledge. The result damages the plantation productive potential, reduces the size of the logs and limits the timber supply of better quality logs in the short term.

Martínez et al (1994), indicate that 62 % of the forest plantations of small and medium size farmers, with economic support from the State and technical direction from organizations of forest producers, showed management problems (lack of pruning and thinning).

Table 10 presents examples of estimated teak rotation, based on diameter increments values of 1.5 and 2 cm/year. For a 20 years rotation, average diameter at the final cut will be 30 - 40 cm. For a 25 years rotation, will vary between 37.5 and 50.0 cm. However, it is important to clarify that it is tantamount a good site selection and timely management to reach the maximum productive potential of the site.

When the diameter increment is equal or bigger than 2 cm/year, the convenient rotation is 20 years, with trees of an average of 40 cm (dbh). Financial analysis shows that rotations of more than 25 years presented IRRs lower than 12%.

Table 10. Estimated rotation age for Teak plantations in Central America. June 1998.

Project	Country	Rotation (years)
Bosques de Puerto Carrillo [1]	Costa Rica	25
MACORI [2]	Costa Rica	25
Flor y Fauna [3]	Costa Rica	20
General [4]	Guatemala	20
General [5]	Panama	20
General [6]	El Salvador	25

Source: [1] Quirós (1998), [2] Víquez (1998), [3] Camacho (1998), [4] Becker (1998), [5] Morán (1998) and [6] Zambrana (1998).

The University of Wageningen is developing Yield Tables for three productivity index in the Dry Pacific and Atlantic Zone of Costa Rica (de Vriend, unpublished thesis 1998).

IV. POLITICAL, LEGAL AND INSTITUTIONAL ASPECTS.

4.1. Legal Framework.

There is a Central America Agreement for Management and Conservation of Natural Ecosystems and Development of Forest Plantations[1]. For our purposes, the convention has two relevant elements:

1. Article 2, states "*to promote national and regional mechanisms to avoid changes in the use of areas with forest coverage located in forest lands and to recover deforested areas*".

2. Article 3d indicates: "*to Guide national and regional reforestation programs to recover degraded lands preferably apt for forestry and that are currently under agricultural use.....”*

On the other hand, one of the objectives of the Central American Alliance for Sustainable Development is "to promote reforestation and the productive forest activity in Central America” (CCAD, 1994).

These documents show the growing political importance of timber production through forest plantations. It is obvious that, at regional level, the States are interested in promoting reforestation as an important environmental measure.

4.2. Forest plantations promotion policies.

Central American countries plantations forest policies have very particular characteristics. An important element is a reforestation Incentive Systems. Because most teak plantations are located in Costa Rica, Panama and El Salvador, reference is made of the legal framework of each of these countries.

Costa Rica

The first Forestry Law (No. 4465) of Costa Rica was promulgated on November, 1969. The present Forestry Law is No. 7575, approved in 1996. Together with its Rules and Regulations[2], constitutes the Costa Rican forest legal framework.

[1] Ratified by Costa Rica in 1996.
[2] La Gaceta No. 16, January 23rd, 1997

Costa Rica has a 29-year experience of regulating plantation and conservation activities. However, it is only in the last 10-12 years when private sector plantation activities attained relevance. Also, the private sector increased its participation in the decision-making process of sector.

New legislation defines the State intervention in forest plantations. Article 28 indicates that "*forest plantations, included the agroforestry systems and individually planted trees and their products, will not require harvesting, transportation, industrialization or export permit...*". Article 56 states that "*logs and rough sawnwood from forests or plantation, will not be transported, if it does not have the respective documentation*"). A Transportation Certificate is required as a form of control in highways.

The law establishes a new incentive system for forest plantations known as Payment for Environmental Services (PES), a payment or compensation for carbon sequestering, soil, water and bio-diversity protection and scenic beauty provided to society. Some of these services benefit not only the Costa Rican population, but also the global community, as is the case of carbon sequestering.

PES is a program under the responsibility of the National Fund for Forest Financing (FONAFIFO)[3], organization created to finance forest activities by granting credits or PES. Article 69 indicates that, from the total amount collected yearly by the Selective Consumption Tax on Fuels and other Hydrocarbons, a third will be allocated to the PES Program (approx. US$31 million/year).

Government dispositions detailed PES conditions. The yearly amount to be paid is update annually. For forest plantations is of US$600/ha for the first five years. The landowner endorses to the government the annual amount of carbon sequestered by the plantation, signing a contract for a maximum of 15-years.

Article 29 of the Forestry Law lists the incentives that the landowner can have access to:

- Exemption on real estate tax on planted areas.
- Exemption on payment of uncultivated lands tax.
- Exemption on payment of taxes of assets during the establishing, growth and thinning period, that will be considered pre-operative.
- Special protection against squatters.

Different articles permits that:

- If the landowner finance the plantation with its own resources, " *the profits obtained by the marketing of products from their plantations will be tax exempted"*.
- An investment of US$100.000 in forest plantations will allow the investor access to the category of "Resident Investor" (Art. 70).
- Forest plantations that were established without Forest Bonus (FB) can apply for PES, and will receive an amount of US$46/ha/year during 5 years.

FONAFIFO has incorporated new elements to facilitated landowner access to these credits. Payment schedule and interest rates area designed for long-term investments. They cover not only the establishment of the plantation, but also its management. Because FONAFIFO has limited financial resources, at present the maximum area to be financed is 100 ha/year/loan. Also is possible to use the plantation (trees) as collateral to guarantees the credits. The country's commercial banking system has no similar credit plan.

Landowners and industrial managers interested in the forestry sector development, have organized the Costa Rican Forestry Chamber (CCF), a union created in 1993 that represents the interests of the Costa Rican private forestry sector.

[3] Article 69: Support to Compensation Programs. Forestry Law No. 7575

Panama

Panama has a detailed legal framework that regulates reforestation activities: Forestry Law No. 1 (approved in 1994). Law No. 24, approved in 1992,deals with reforestation, and was amended in June 1993, adding specific Reforestation Incentives. It establish a 30 year period during which, all forms of private reforestation will receive priority and support. This Law indicated the country's political will to increase reforestation,

The most relevant economic aspect is in article 5, which states that "*100% of the Forestry Investments made by legal or natural persons is considered deductible expenses of Income Tax,"* This incentive applies to all incomes, excepted those from forestry activities. Furthermore, machinery, equipment and inputs imported for reforestation activities are exempt of taxes and fees (Panama, 1992).

The institution responsible for the implementation of the forestry policies is the National Institute of Renewable Natural Resources (INRENARE), that depends of the Planning and Economic Policy Ministry. The Finance and Treasury Ministry is responsible of registering and controlling the taxes invested in the reforestation activity.

There is a National Panamanian Association of Forest Farmer. It's members owns almost 70% of the teak plantations in the country.

TEAK IN PANAMA

Up to 1997, Panama had registered a total planted area of 26,724 hectares, using mainly *Pinus caribaea, Tectona grandis, Bombacopsis quinatum, Acacia mangiun* and African mahogany. The teak area was 12 936.4 ha, or 48.4% of the total reforested area.

Furthermore, they have a financing policy, promoted by the National Bank, that offers credits at 7.5% interest rate for a 10-year term. In addition, the Agricultural Development Bank has a credit line for timber production projects of medium-size growers, and for sawmills.

Teak plantations were established considering a 20 years rotation. Subsequent studies of INRENARE and CATIE proposed a 25 year rotation as a minimum. ANARAP and forestry technicians, estimate average increases of 1.3 cm/year in diameter, 2 m/year in height and 12 m^3/ha/year. The total volume at 25 years is estimated as 300 m^3/ha (thinning and final cut) and the commercial volume as 250 m^3/ha

Overall, teakwood has good acceptance on the national market. Ever since woodworkers have learned how to work it, its acceptance has been on the rise and is considered comparable to Mahogany and Cedar. Teakwood commercialized locally comes from isolated trees or second thinning of small areas. In the last 2 years a teakwood market for mature trees has opened. . Timber purchased from farmers is sold to Japanese and Chinese businessmen for export. As the amount of mature teak is very limited, this is a temporary business.

Teak plantation investment projects had a B/C relationship =1.38, and a NPV=US$19,380/ha, with production costs close to US$14,000/ha for a 25 years rotation, at an average price of US$600/$m^3$ for wood.

Source: Morán (1998).

El Salvador

El Salvador Forestry Law, approved in 1973, gives general guidelines for the reforestation process.

A Project to reform the actual Forestry Law is under consideration. Article 34, of this proposal specified that forest plantations in private properties will not require authorization for its establishment, maintenance, and thinning or final cut.

Reforestation is based on technical and financial criteria. For credits approval, banks request the technical opinion of the Forestry Service. The banks have funds for forest credits.

The institutions related with the Forestry Policy are:

- The Agriculture and Range Management Ministry through two organizations:
  - CENTA: promotes and provides technical assistance for the establishment of plantations with forest species (including teak), mainly to small farms and with agroforestry systems. The CENTA officers can not authorize harvesting of natural forest or forest plantations.
  - The Forest Service: offers technical assistance and controls the execution of the projects.
- The Banking System: finances reforestation projects with their own funds, and with funds from the Multisector Bank of Investments (BMI).
- The Environment Ministry was created in June 1997 and has little relationship with promoting forest plantations.
- Other institutions that finance forestry projects by way of different contributions are FIAES and FONAES. These organizations policy is not to include teak in their projects, or reduce the area planted with this specie to a minimum. This decision is based on the assumption, without further technical analysis, that teak provokes erosion. Nevertheless, in good site and with adequate management, teak does not have erosion problems.

From 1992 to 1995, an important source of capital was the SOCIAL INVESTMENT FUND.

One of the limitations to promote reforestation in the country, is the lack of enough trained professionals. Universities do not have a degree in Forestry Engineer and there is no association of forestry professionals'. Since the banks do not require that the person who implements the project has a Forestry degree or background, professionals of any field can prepare and managed forestry projects,

There is a Forest Farmers Association and the Association of Seed Producers that gather seeds and produce trees in commercial nurseries.

TEAK IN EL SALVADOR

Between 1950s and 1976, 230 hectares of teak were planted and from 1980 to 1986 about 1,200 ha were planted by the MAG-ISTA. Until 1996, the total area registered was 2,488 ha, distributed in 138 owners.

In rural area teak has great demand as round logs for housing. Farmers are using the sprouts for small diameter products. Depending on the site, landowners plant up to 2,500 trees/ha. First thinning is scheduled between 4 and 8 years, between 11 and 13 years the second, and between 16 and 18 years the third. An important aspect is that most plantations lack management. Some are being "ransacked" and are gradually degrading.

Estimated rotation age is approximately 25 years. A commercial production of 214 m^3/ha of logs (up to 8 cm diameter top end), is assumed, corresponding to a Mean Annual Increment (MAI) of 8.56 m^3/ha/year.

The financing plans of the Forest Promotion Programs are applied to all forest species, including teak. Some characteristics of these programs are: have no financing limit, the term is from 2 to 25 years, the interest rate is 6%/year, with a 10 years grace period. All cases require mortgage guarantee.

Teak markets are analyzed based on 3 products:

- Roundwood: used in generally for housing or rural constructions, pitchforks, beams, round plank and rods. Competition comes from eucalyptus, mangrove or other construction materials. Roundwood is also used for the construction of ranchos de plaza (recreation sites). The price is good, but the market is limited.
- As Timber: the sawmill industry demands the larger diameters. The main buyer is a company that manufactures export furniture. Prices depends on log diameter, they pay per cubic foot, without considering the form of the log.
- Roundwood for Export: In eventual cases there is an export market. Recently, some logs were sent to Australia and India.

Wood prices vary accord to log diameter and length.

It is not sure that the expansion of planted areas will be with teak. Is one of the most criticised species, for being foreign, and for assuming it erodes steep slopes. In spite of all, teak is currently the most planted specie in El Salvador.

Sites with long drought periods produce wood with a very attractive appearance, what is a plus.

Source: Zambrana (1998).

V. ECONOMIC ASPECTS.

5.1. Reforestation funding models.

There are two main funding models:

International investment.

Several foreign companies, dedicated to plant, manage and sale teak, began to invest in Costa Rica, either establishing operations by themselves or subscribing contracts with local forest companies, that provide forestry services. They are not interested in State incentives, but do inscribe their farms in the Forest Regime[4] so as to have land taxes exemption, and income tax exemption from sales of plantation products.

Their funds comes from selling the forest stands in parcels (and its maintenance) to the general public in Europe and North America through two main modes:

1. Sale of project's shares. It's value is equivalent to a determined area, or to a fraction of the value of the project.

2. Sale of planted areas that vary in size from ¼ ha to one or more hectares. Some sell not only the stand and its maintenance, but also the land, while others only sell the stand, and include the leasing of the land.

In the last years some foreign companies have purchased already established plantations from local growers who had used the incentives granted by the Costa Rican government. In these cases, the purchasing company assumes the liabilities contracted by the seller with the State.

State incentives.

The vast majority of the plantations established in Costa Rica have been totally, or partially, financed by State incentives. The first one was to allow landowners to deduct unlimited plantation expenses/ha from income tax (theirs or from other taxpayers). Later, to prevent over-expending, it was established a fixed amount/ha, adjusted yearly. Then followed a forest bonus (CAF), still in use, to pay Government taxes, credits etc (can be sold in the Stock Exchange at 99,9% of its face value). These two models did not require reimbursement on the part of the beneficiaries.

Presently, the National Fund for Forest Financing (FONAFIFO) finance the planters with credits. Loans are guaranteed with mortgage, collateral or fiduciary warranties (according to the conditions of the trust that funds it). Interests are cumulative, and payments are determined according to each project's cash flow which, that depends on the expected production program. Credits for the management of existing plantations have similar conditions. In general, credits for timber production projects area granted at the Basic Passive Rate (rate paid by the bank to private investors) minus 6 points (around 12-18%). The credit cannot exceed US$600/ha.

The same amount is also the maximum granted by the Payment for Environment Services (PES) incentive model. PES was created for the recovery and maintenance of forests, and includes all activities (protection, conservation and forest management) in natural forest and/or established forest plantations. In the later case, the US$600/ha is disbursed in the first five years, in tracks of 50, 20, 15, 10 and 5%. Since funds depends on the resources assigned by the government, and those raised by FONAFIFO by selling environmental services abroad, payments can be made with credit instruments or cash.

[4] Forest Regime, a set of legal and technical dispositions published by the government for the landowners who want to take advantage of forest incentives.

5.2. Establishment and maintenance costs.

Since plantation costs depend on factors such as prior use of the soil, size, slope, location, access, soil and climatic conditions, existing infrastructure and the modality of financing, they varied widely, planting can be done by the farmer or by a contracted company, who will be responsible for planting and the management of the farm as a whole. In the second case, costs related to farm maintenance (infrastructure and administration), and those, are charged to the plantation.

5.2.1. Plantations done by the landowner.

Case 1.

Cost studies of Costa Rica (GFA et al, 1998) (**Table 11)** plantations of 30 ha or more, 1,111 trees/ha, have reached US$863/ha for the first five years, and US$1,034/ha for a 20 years rotation, under the following conditions:

- An average of 100 meters of fences and 50 meters of roads per ha;
- Soil is prepared with agriculture tractor;
- Nursery stock produced in boxes;
- A 22% of social charges paid on salaries;
- Except fertilizer, no other chemical product is used;
- Technical supervision done by professionals, who visit it 3 visits during establishment (first year), 2 in the second year and 3 times for pruning and thinning. Each visit costs an average of US$ 117.40, including transportation and travel expenses.

The above data refers to plantations established in parts of farms where the following cost are beared by other farm activities or, in the feasibility analysis are assumed to be negligible:

- Foreman living permanently in the farm;
- Services, such as drinking water and electricity;
- Accounting;
- Administrative subdivision of the plantation;
- Basic equipment not provided by workers, such as hand pruning saws, shovels, etc;
- Construction and/or improvement of infrastructure, such as houses, stockrooms, culverts, bridges;
- Maintenance of infrastructure (fences and roads) after year 1;
- Transportation of personnel and inputs;
- Unforeseen expenses, such as materials and labour for fastening bowed trees and pests and diseases control.

Case 2.

Alfaro y Villamizar (1998) estimated a cost of US$ 1,054/ha for the first five years (US$ 1,707 for a 20 years rotation). It was a plantation of 1,111 trees/ha with genetic improved material (2% higher cost over not improved material). When plantations were established, as the landowners could not afford infrastructure investments, these items were excluded from the study, together with pre-investment costs (reforestation plan). Administration and technical assistance costs added US$ 20/ha/year, and the daily wage was estimated at US$6.8, including social charges (**Table 11**).

5.2.2. Plantations done by contractors.

Case 3.

In these plantations, in addition to planting and managing the stand, the companies have duties and activities (below detailed) that give this system especial characteristics;

1. As the main objective is to produce first quality material for international market, the management system is not limited by funds, as it happens with plantations established with local support.
2. The contractor built and/or improves the necessary infrastructure and maintains it. Does the paper work for the Environmental and Energy Ministry to include the farm in the Forest Regime. As a rule, the contractor must duly constituted, pays taxes and have the employer civil and environmental responsibilities.
3. A third company, or independent professional, is subcontracted as a verifier (regency) and, sometimes, as a certifier. This company prepares the reforestation plan, visit the project bimonthly during the first year, and at least twice during other years. The verifier has to report to the contracting party if management has been done properly.
4. Third company visit (RNT, 1988) costs US$ 240, including transport and travel expenses.
5. Subdivision of the planted area suitable for selling in parcels of 1 to 20 ha, done by surveyors.
6. Pre-investment costs include selection of the farm, verification of its area (surveying) and legal status, and soil analysis.
7. Soil preparation and fertilization according to site conditions. Where it is not possible to prepare the site with agricultural tractors, a more expensive method is used. Holes of 35 cm. depth by 30 cm. diameter are dug (manually or with motor-drills). Usually a soil specialist determinates the fertilization system. Fertilizer is applied every year, except when in thinning years. After year 4 (first thinning) 500 grams are applied to each tree.
8. The farm area acquired for teak planting. Farm improvements and maintenance costs are charged to the plantation. Normally, two to three permanent workers live in the farm.
9. North Region of Costa Rica projects general norms are:
    - 1,300 - 1,600 trees per ha;
    - 60 ha average area suitable for planting (average farm area 81 ha);
    - Average distance to paved roads; 5 km
    - 20% slope or less in 90% of the area. As they are small terraces, that rarely allow mechanization, holes are open with motor drills, and diameters are enlarged with a shovel;
    - Mean annual temperature of 26 ºC and mean annual rainfall of 2,700 mm;
    - A dry period of three months;
    - Deep, clayey soils of average fertility, no risk of floods;
    - Usually the farms have poor or non-existent infrastructure;
    - Between 10% and 25% of the area is covered by bushes, or abandoned orange plantations. There are isolated -trees

After four years of working under these conditions, a company has been able to reduce establishment and maintenance costs by 20%, and further reductions are expected (GFA et al, 1998). Major factors responsible for the cost reductions are: increase of the planted area reduced fixed and administrative costs; and assuming previously subcontracted activities (marking and drilling of holes),. Today, under the conditions described above, cost/ha amounts to US$ 2,194 for the first 5 years and to US$ 2,250

per/ha for the following 15 years (with a 500 grams fertilization applied to each remaining tree after year 5. For a 20 years rotation period, total cost is estimated at US$ 4,444 **(Table 11)** without contractor's profits.

Table 11. Comparative reforestation cost estimates under different conditions (US$/ ha).

Year	Case 1 GFA et al (1998)	Case 2 Alfaro y Villamizar (1998)	Case 3 Sage (1998)
1	656	442	1 191
2	80	195	415
3	11	166	238
4	11	217	200
5	105	34	150
6	9	34	150
7	9	34	150
8	21	109	150
9	9	34	150
10	9	34	150
11	9	34	150
12	9	34	150
13	9	62	150
14	21	34	150
15	9	34	150
16	9	34	150
17	9	34	150
18	9	74	150
19	9	34	150
20	21	34	150
Total	**1 034**	**1 707**	**4 444**

Sources: GFA-RNT 1998, Alfaro y Villamizar 1997 y Sage (Consultora S.A.) 1998.
Dollar exchange rates: Case 1 = 255.5, Case 2 and 3 = 250.

5.3. Markets and prices

Currently in Central America, the only country that is developing an important international and local market for teak is Costa Rica but, as local information is keep confidential, their is no reliable information on domestic prices. The majority of the plantations are just producing the first commercial thinning. There is not reliable data on prices of old plantation, since these were areas planted by foreign companies in Parrita decades ago, and teak was not managed technically.

Plantations:

Data of young plantation prices some landowners are asking is presented (**Table 12**). Though is what they ask to foreign investors, they provide a first approximation of the wood value during the first stages of development.

Table 12. Prices of the forest projection requested by local farmers to foreign investors.

Place	Age (years)	Price of the wood (US$/ha)
Península de Nicoya, Guanacaste	9	4 022
Península de Nicoya, Guanacaste	8	6 000
Parrita, Puntarenas	3	3 500 *
San Carlos, Alajuela	3	2 500

Source: Hernán Delgado (Parrita), Armando Campos (Guanacaste) and Mohamed Sandí (San Carlos).

*In 1998 the price increased to US$6 500 per hectare.

Standing timber for local consumption:

The most reliable information source on local market standing timber teak prices is the information bulletin of the Costa Rican Forestry Chamber (CCF). It registers mostly transaction prices of the South Pacific zone, where there are the oldest plantations. Bulletin number 20 present information on local market with a price average of US$ 117/m^3 at December, 1996. By January - February 1998 the average price decreased to US$ 91 and by March - April 1998 the price was US$ 110/m3.

Timber (logs)

The 1998 the CCF published data on sawmill yard transactions at US$260/$m^3$ for diameters between 15 and 24 cm, sold to European buyers. No other specification that diameter was supplied. This price is similar to plantation logs in the international market, since their average price for the March - June 1995 period was US$240 /$m^3$.

Sri Lanka's plantation logs reached 243 dollars m3 by the end of 1996 and Costa De Marfil's FOB price for plantation was 286 dollars per m^3 by the middle of 1997. In both cases were logs of 15 and 20 cm diameters. As a rule, the international market buys logs free of defects, such as twistings, knots, and rot. In 1996, this market quoted Sri Lanka plantation logs, diameters between 21 and 50 cm, at 304 and 426 dollars/m^3; while timber from Central and South America, with diameters of 31 to 50 cm., reached FOB prices between 190 and 200 dollars/m^3. This information is summarized in **Table 13**.

Table 13. Teak *(Tectona grandis*) Log Prices by diametric class, from Sri Lanka, Central and South America.

Mean diameter (cm)	Sri Lanka (US$/$m^3$)	Central and South America (US$/$m^3$)
15 – 20	243	Na
21 – 30	304	Na
31 – 40	386	190
41 – 50	426	200

Source: ITTO Market report, 1995; FAO and Phillips (1997)

Sawnwood

CCF, 1998b, reports a single local market transaction of rough boards for export (2"x2"x120", 50% sapwood, 50% heartwood and free of pitch) at US$500 per m^3 FOB.

The international grading includes a category "special quality scantlings", whose lengths range from 2.5 feet (short) and six feet (long), several widths and thickness. In 1995, natural forest lumber prices varied US$ 855 to US$ 1 950/m^3 for shorts and US$1 985 to US$3 095 for long. "Special and better" category, widths of 8" and lengths between 3-4 feet and varied thickness, reached prices between US$ 2 580 and US$ 4 055/m^3. "Planks-special and better 3.5 thick" varied between US$ 2 460 and US$ 3 395/m^3 and "decks-special and better" with lengths between 11 and 15 feet, several widths and thickness ranged from US$ 4 785 and US$ 5 235/m^3 (G. Gresham, Churchill M. Group, 1996). However, depending on the dimensions, plantation lumber reached prices of US$ 1.200 to US$ 1300/m^3 in 1995 the international market (ITTO Market Report, 1995).

Lumber from plantation was sold at prices of US$ 800 and US$ 1200/m^3 FOB in Lagos in 1996, and FOB Papua New Guinea in 1995, respectively. In 1997, a mixture of several lumber categories from plantations of Trinidad, Costa Rica and Panama was sold in US$ 600/m^3 CIF Miami. Currently in the United Kingdom, lumber from Central America and Trinidad plantations is quoted from US$ 800 to US$ 1200/m^3, of 1"x2.5"x2.5' and 1"x2.5"x6' (Gareth Phillips, consulting, Oxford, England).

5.4. Income expectations.

In cases 1 and 2 (**Table 11**), to calculate the internal return of the projects, local teak timber prices have been used. If a part of the total volume is selling to the international market, Internal Rate of Return (IRR) and Net Present Value (NPV) will be bigger.

Case 1 assumes income in years 8, 14 and 20, from the sales of 20, 40 and 180 m^3/ha, respectively. Standing timber prices are US$ 65, US$ 78 and US$ 91/m^3. The IRR is 23% and the NPV) (3%) is US$ 11 196 (GFA et al, 1998).

Case 2 assumes income in years 10, 15 and 20 from the sales of 25, 45 and 180 m3/ha, respectively. Standing timber prices are US$ 65, US$ 78 and US$ 91/m^3. The real internal rate of return is 22.7% and the NPV (3%) is US$ 11 882 (Alfaro y Villamizar, 1998).

In **Case 3** corresponds to plantations done by contractors. Therefore higher yields in volume and quality are expected, and most of the products will be sold in the international market. Also, as the contracting companies are supposed to engage in subsequent stages of the industrialization and commercialization process, other prices must be used to estimate profitability.

A commercial accumulated volume of 327 m^3/ha is used, and is the simple average of the high class sites reported by Camacho (1998) for Flora y Fauna S. A. and Picado (1997) (section Physiological and Technical base). Logging loses are estimated at 15%, so 85% will be actually sold.

Two commercial thinnings are programmed:

- The first one in year 8 produces 26 m^3/ha total volume and 22.2 m^3/ha of commercial volume will be sold at US$ 67/m3, generating a total income of US$ 1,467/ha. This income would make the plantation self-sustainable, as it will provide US$ 244.50/ha/year until the next commercial thinning.
- The second (year 15) produces 49 m^3/ha total volume and a total income of US$ 6,601/ha. Logs with diameters between 15 and 20 cm (50% of total commercial volume = 20.85 m^3) were priced at US$ 240/m^3, minus logging costs of US$20/$m^3$, will produce an income of US$ 4.587/ha. The rest of the commercial volume will be sold locally, as standing timber, at a price of US$ 96.60/m^3. These prices are the lowest local price reported for standing teak trees (CCF 1998a); and will produce an income of US$2 014/ha.

The final harvest (year 20) will produce a total volume of 252 m^3/ha. All timber will be converted into rough lumber at a 55% recovery factor (117.7 m^3). Only 50% (58.85 m^3) will be sold at US$ 800/m^3 (66% of price in the international market); minus logging, milling, drying and hauling costs (US$178/$m^3$), FOB port. Net income generated is US$ 36 605/ha. Another 30% of the lumber can be sold at US$ 600/m3 (50% of price in the international market), FOB port, generating a net income of US$ 14 900/ha/, after deducting logging, milling, drying and hauling costs. The remaining 20% can be sold at a price of US$ 400 (33% of the international market price) and generates a net income of US$ 5 226/ha. The final harvest income is US$ 56 731/ha. Logging, milling and transport costs includes the normal profits of these operations.

The expected total income of US$64 800/ha from plantations with first quality management, whose final product is rough sawn lumber (against standing timber of cases 1 and 2). The income comes from three different harvests, done in years 8 (US$1 467/ha), 15 (US$6 601/ha) and 20 (US$56 731).

Plantations established by foreign companies are sold to the general public of their home countries. Information about other components of the total cost (i.e. marketing costs) were not available to the consultants. The present study is limited to calculate the Net Present Value of the income generated by the different harvests at different discount rates **(Table 14).**

Table 14. Present Value of income at different discount rates (US$ 1998).

Discount Rate (%)	Present Value (US$/ha)
4	31 854
6	22 645
8	16 248
10	11 767
12	8 601
14	6 346
16	4 727

Source: The authors.

No real price increase is assumed.

Summarizing, the major limitation of the present study are:

i) local data on teak prices comes from a small market in the South Region of Costa Rica, where most of the timber comes form plantations that were not properly managed,

ii) data of plantation yields is based on projections of the growth of stands that are just undergoing their first commercial thinning.

Furthermore, in spite the availability of teak prices from other countries, there is not enough information on quality of local teak products to allow an objective price-product comparison.

To increase net income/ha, local producers and foreign investors should consider more elaborated products. Some of these foreign firms are already producing furniture and parquet flooring. Investments, costs and returns are not available.

Another particularly important factor is the future of the teak market. At a first glance, diminishing inventories of teak natural forests and restrictive policies enforced of these countries, will force future prices upwards but, given the uncertainty of prediction models, this factor is difficult to assess.

Costa Rica's Teak Marketing Experiences

In the 90's, Costa Rica's teak area increased from around 1.000 ha (1987) to more than 25.000 has in 1997. Before 1996, the only teak marketed came from plantations in Quepos, province of Puntarenas, established between 1943-1966 by the United Fruit Co.

This company began to harvest (1) in 1968-1969 plantations of 25 or more years. Teak use was limited to parquet, components, and accessories for yachts (Keogh, Fallas and Mora. 1979). Small areas of those plantations still remain.

Nowadays, companies like Hacienda El Tecal produces parquet. However, since there are only about 1 000 ha of teak 10 years old or more, reforestation companies have focused their efforts to find markets for young teak (baby teak) products, to identify adequate designs and the necessary technology to manufacture those products.

One company with great success in marketing young teak (ages between 6-7 years) is Flor y Fauna S.A.. They participated in several international fairs in the United States with a variety of prototypes. So far, they have consolidated, with great success, the following products: 1) bed sofa, 2) tables for lamps, 3) occasional table, 4) small trunk, 5) components for computer tables and 6) floorings (boards of 3"x1 m). These products are being marketed at prices higher than US$1 000/$m^3$ and, in cases, at the following prices:

- Products 1 to 4: US$1 500 and US$1 600/m^3.
- Products 5 and 6: US$1 200/$m^3$.

Also, this company has developed, in the United States, a market for garden implements, with very good results but, as these products have to be at low prices to make them competitive, they are consider marginal.

Another initiative, being developed by the CCF and the CACH (Centro Agrícola Cantonal de Hojancha), is to export teak lumber at US$ 655/m^3 with the following specifications: sound knots, healthy, free of the fungi and insects attacks, free of sapwood, with up to 50% white color and 50% golden color, without cracks, sawn four sides.

Aventuras Forestales S.A. has produced ashtrays, pocket humidors and women cabinets, which are marketed in small quantities in Costa Rica and in the United States.

In spite of being a very specific experiences, they confirm the great possibility that young teak can be accepted in Costa Rica and elsewhere.

Source: Zamora (1998).

VI. POTENTIAL FOR INCREASING TEAK PLANTATIONS.

This potential must be analyzed country by country. Statistics shows that, in some countries, teak planting is just beginning, while others have made important progress in the last decade.

First, teak availability must be analyzed. Up to 1995 there were 70.84 millions/has of plantations of approximately 100 forest species, in 90 countries (79 of them located in the tropic, and 11 in the sub-tropics). About 57.5% of the total area hardwoods, and 42.5% softwoods. Also, 79% of the total area was planted with white woods (eucalyptus, pines and others). Teak is the only specie of fine dark wood being planted massively (2.25 million/has). As the international market will face mainly a supply of white woods, a dark wood like teak will have little competition (Pandey, 1997).

All natural teak forests and 93.3% of the 2.1 million/has planted with teak are located in Asia and the Pacific, 4.5% in Africa and 2.2% in Latin America. Central America has 43 010 ha, or 1.9% of the total area planted in the world, and 86% of the area of Latin America. Furthermore, other species planted in quantities in the region are pines, eucalyptus and melina. Some dark wood native species are being planted in small scale or, in some instances, at the experimental level. In a market a customer to dark hardwoods, teak can be a substitute of valuable natural forests for furniture and decoration panels.

Wood price is another factor that determines the expansion of these plantations. Up to date, teak prices show growing trends in real terms and this motivates to continue expanding the planted areas.

Specialists predict a decrease of teak supply from Asian natural forests. Therefore consumption of teak from plantation will increase. Price of timber and lumber from plantations could rise steadily in the future (Keogh, 1997b). All this could increase the interest of the farmers and investors to plant teak.

Strong international critiques for the high deforestation rates in tropical countries, and the political clout of environmentalist movements, support the believe that well managed forest plantations are the alternative to native forest wood supply.

It has been estimated that at least 100 000 ha more could potential to be planted with teak in Central America: 25% is located in Guatemala, 25% in Nicaragua, 20% in Costa Rica and 15% in El Salvador and Panama. With a rotation period of 25 years, these countries could be harvesting 5 720 ha/year or, approximately 1.43 million/m3/ of roundwood.

Costa Rica

Costa Rica has developed technological packages for establishment and managing teak. In the best sites, under intensive management plans, in rotation from 20 to 25 years, the specie has an a MAI of 20 to 25 m^3/ha/year. It is foreseen that well managed plantations will produce a total volume of 15-20 m^3/ha/year, and 10-15 m^3/ha/year of commercial industrial volume. These results, obtained in the last decade, have stimulated large scale planting.

Teak expansion in Costa Rica will depend from the availability of financial resources that originate from two sources:

- PES (already explained)
- Foreign Investment.

The US$600/ha paid for the environmental services generated by forest plantations to society, in terms of carbon sequestering, soil protection, water cycle regulation and scenic beauty, permits the farmers to invest on this production system, where capital recovery comes in the long term.

Several facts affected foreign investments. First, the 1995 Bosques de Puerto Carrillo's bankruptcy. Although the main reasons was that the industrial investment was made before enough timber was available for the sawmill, it brought discouragement. In 1996 Flor y Fauna was the subject of a strong international critique for the data on stands growth and financial performance they reported to its investors in the Netherlands. Several authors considered it unrealistic data.

During 1997 the European stock exchange market had an attractive performance, reducing the interest in reforestation projects, that some considered of high risk. For these reasons, the yearly-planting rate between 1996-1998 decreased. Foreign companies that planted teak have reduced their expansion expectations to 2 000-3 000 ha during the next 2-3 years.

Also, as part of the public policies for resource conservation, the use of the natural forests for the sustainable wood harvest is being continually limited. Right or wrong, these guidelines tend to reduce the number of species, and many of the species permitted to be exploited can be classified as white woods.

In fact, the great question is if the national market will continue to appreciate teakwood. The answer is that as long as the supply of natural forests dark woods continues to be limited, local users will purchase teak. Today there are pilot experiences that show the buyers acceptance of teak products.

However, the determinant factor in present and future consumption of teak will be the price. At present, teak logs traded at local level reached prices of US$140 to US$165 per m3 at the mill yard. This price doubles the price of the woods classified as "*semi-duro*"[5], and it is below the price of fine species such as cristóbal (*Platismiscium pleiostachum*) and ron-ron (*Astronium graveolens*), both "precious hardwoods". Their timber is priced at sawmill yard between US$260 to US$290/m3 (CCF, 1998).

Although teak reached the highest price of all species used in construction, it is also true that the limited quantity of natural forest wood supply leaves, as principal alternative, teak for interior decoration and furniture.

At the international market level, the big question is how Costa Rica's wood will compete with Asia and African plantations. This leads to the necessity to produce a very high quality for the export market. Producers will have to locate market niches that pay for wood quality.

Panama

Panama is second in area planted with teak. Three areas have expansion potential: the South of Veraguas Province, the East of Panama Province (currently used for cattle-raising), and the south-west of the Darién Province (in national lands, or properties currently dedicated to cattle-raising). The principal problem for teak expansion is land price (US$ 1 000/ha). A policy that favored land prices increases is the reforestation incentive. As it covers 100% of the expenses, including land, it started a speculative price spiral, and nobody is interested in checking it (Morán, 1998).

El Salvador

In El Salvador the plantation expansion has good possibilities, there is area and domestic and international demand, who can motivate the farmers to plant. It is not guaranteed that the expansion will be with teak. Is one of the most criticized species for being exotic and its leafless appearance in the dry season. As it has been planted at 2m x 2m, no vegetation grows under the canopy, favoring erosion in steep slopes.

However, there are good reasons to use teak widely in reforestation programs (Zambrana 1998):

- It adapts very well to the climatic conditions of the country.
- There is an abundance of seeds.
- The greenhouses seedling production system is well known.
- It resists fire very well.

[5] In Costa Rica hardwoods are classified by hardness (hard, semi-hard and soft).

- It sprouts very well (mainly young plants).
- It has an acceptable performance, even in low productivity sites.
- Easy to plant.

Long drought periods causes very attractive wood streaking. In teak, this is a favorable element, as the specie to be used in those sites, which are difficult for other species that require a shorter dry season.

Guatemala

As they country still has vast areas of broad leaf and coniferous forests, reforestation moves at a very low pace. The only project that has anticipated the expansion of teak areas is ECOFOREST S.A. with its Atlantic Coast plantations, close to Puerto Barrios.

As Current natural forests timber supply the national markets, planting trees have little attraction for farmers or investors. But now, the Forest Law anticipates incentives for those who plant trees.

Nicaragua

The economic crisis does not favor reforestation as an economic land use alternative. Farmers do not have capital to invest in this long term, where most of the investment is in the first years. The lack of reforestation incentives does not favor the expansion of the planted areas in the near future.

The Forest Law is being revised by the different sectors, including incentives for reforestation. However, this law will not be approved before 1999 (Tellez, 1998). The Exchange of Cattle-Raising Debt for Forests, a program of the Ministry for Agriculture, could stimulate reforestation. This program is just beginning, but it is a good opportunity to plant teak.

Land prices and reforestation costs are lower than in other countries and opportunities to plant teak does exist.

Honduras

In Honduras reforestation is its infancy. The experience is with plantations of *Pinus caribaea*. Broadleaf has been planted at experimental level. It is estimated that, in the short and middle terms, there will not be interest to plant with teak.

In addition we recommend the following:

1. To create a Central American Teak Growers Association with the purpose to exchange experiences in the three main aspects of successful plantations: selecting sites, selecting vegetative material, select the best silvicultural program.

2. Top invest in a Central American genetic improvement programme, with the development of seed orchards, *clonal* orchards, seed production and clonal plant production.

3. To publish a bulletin of the Central American Teak Growers Association to inform themselves and the public in general.

4. To develop a portfolio of project profiles for joint ventures with foreign capital. The region would provide land, local technicians, labor and the foreign investors capital, technology and industry funding.

5. Associate the Central American Teak Growers Association with the Teak 2000 initiative in order to open a channel for technology transfer and joint ventures.

6. Training of people in the industrial aspects of teak production: sawmilling, drying, wood processing, marketing, etc.

7. To begin with the promotion of the product Central American Teak as a joint venture of the Central American Association of Teak Growers.

8. Interest the bilateral cooperation, CIFOR, foreign and national universities to develop and execute a research plan for teak cultivation, yield modeling, financial modeling, etc.

VII. REFERENCES

ALFARO, MARIELOS; JIMENEZ, VALENTIN (eds). 1997. Teca: Mitos y Realidades. Memorias del Seminario realizado el 31 de julio y 1 de agosto de 1997. Recursos Naturales Tropicales S. A. (RNT S.A.), San José, Costa Rica. 69 p.

ALFARO, MARIELOS; VILLAMIZAR, MARIO. 1998. Análisis de la oferta actual y la demanda potencial de semilla mejorada de melina y teca en Costa Rica y Centroamérica. En: Seminario Aumento de la Rentabilidad de las plantaciones forestales: Un reto ligado al uso de semilla de alta calidad. San José, Costa Rica. 1-36 p.

CCF. 1998a. Lista de precios de madera en pie, en patio de industria y aserrada de las especies más comercializadas en las distintas zonas de Costa Rica. Precios a enero-febrero de 1998. Revista Desde El Bosque, Año 1, Número 2. Cámara Costarricense Forestal (CCF), San José, Costa Rica.

CCF. 1998b. Estadísticas sobre área reforestada en Costa Rica. Base de datos de la Unidad de Comercialización de la Cámara Costarricense Forestal (CCF).

CAMACHO, PABLO. 1998. Programa de Reforestación de FLOR Y FAUNA S.A. Estudio de Caso. 9 p.

CAMPOS, ARMANDO. 1998. Comunicación Personal. Guanacaste, Costa Rica.

CESPEDES, RENZO. 1998. Comercialización de madera de plantaciones forestales. Comunicación Personal. Cámara Costarricense Forestal. San José, Costa Rica.

CHAVES, E. y W. FONSECA. 1991. Teca (Tectona grandis L.f.) árbol de uso múltiple en América Central. CATIE, Turrialba, Costa Rica. 60 p.

COMISIÓN CENTROAMERICANA DE AMBIENTE Y DESARROLLO (CCAD). 1994. Alianza Centroamericana para el Desarrollo Sostenible. San José, Costa Rica. pp. 39

CCAD; CCAB-AP; UICN/ORMA. 1997. Diagnóstico Forestal de Nicaragua. Versión Preliminar.

DE CAMINO, RONNIE. 1997. Oportunidades de Inversión en Plantaciones de Teca. El contexto nacional e internacional. En: Seminario sobre "Teca: Mitos y Realidades". RNT S.A., San José, Costa Rica. pp. 59-64.

DE VRIEND, JELGER. 1998. Teak: An Exploration of Market Prospects and the Outlook for Costa Rican plantations based on Indicative Growth Tables. DRAFT. Wageningen University, Netherlands.

DELGADO, HERNAN. 1998. Comunicación Personal. Parrita, Costa Rica.

GFA, RNT, GWB. 1998. Estudio de Factibilidad "Programa Forestal para la Región Huetar Norte, Costa Rica. Informe de Consultoría. 106 p + Anexos.

GUTIÉRREZ, R.; CORDOVEZ, D.E. 1978. Informe Anual del Jardín Botánico Summit, Zona del Canal. Ciudad de Panamá, Panamá.

GRESHAM, G. and CHURCHILL, M. Group. (1996). Prices for Teak 1995.

CRUZ, E.; GÓMEZ, L.. 1996. Actualización del Registro Nacional de Plantaciones Forestales y Cuantificación de Volumen. Proyecto Fortalecimiento a los Recursos Forestal, Agua y Suelo. Dirección General de Recursos Naturales Renovables. División de Recursos Naturales, Servicio Forestal y de Fauna, San Salvador. Mimeografiado.

GALLOWAY, GLENN. 1997. El Fomento de Plantaciones Forestales en Centroamérica. En: Resumen de Ponencias del III Congreso Forestal Centroamericano. 15-17 de setiembre de 1997, San José, Costa Rica. pp 66-85.

INCAE. 1998. Desarrollo de una Estrategia Centroamericana de Competitividad en los Mercados Internacionales de Carbono. Documentos elaborados por país sobre el Potencial de Carbono y Fijación de Dióxido de Carbono de la biomasa en pie por encMAI del suelo en los bosques. Proyecto BCIE-INCAE-HIID.

INAB. 1998. Estadísticas sobre Reforestación en Guatemala durante el período 1990-1995. Instituto Nacional de Bosques (INAB). 2 pág.

INSTITUTO DE RECURSOS NATURALES RENOVABLES (INRENARE). 1998. Estadísticas sobre reforestación en Panamá. Departamento de Plantaciones, INRENARE. Ciudad de Panamá, Panamá.

INRENARE. 1997. Memoria INRENARE 1996. Dirección de Planificación, Instituto Nacional de Recursos Naturales Renovables. Ciudad de Panamá, Panamá. 112 p.

ITTO. (1995). Market Report. Japón.

KEOGH, RAYMOND. 1997a. Teca 2000: Apoyo por alta calidad de plantaciones de madera dura tropical. En: Seminario Teca: Mitos y Realidades. Memorias. Recursos Naturales Tropicales S.A. San José, Costa Rica. p. 57-58.

KEOGH, RAYMOND. 1997b. La teca en el mercado internacional. Comunicación Personal. 1 de agosto de 1997, Complejo Kamakiri, San José, Costa Rica.

KEOGH, R. 1980. Teca(*Tectona grandis* LINN.F.). Procedencias del Caribe, Centro América, Venezuela y Colombia. In Producción de madera en los Neotrópicos por medio de plantaciones, Río Piedras, Puerto Rico, 8-12 setiembre 1980. PP 356-372.

KEOGH, RAYMOND; FALLAS, JORGE; MORA, FERNANDO. 1979. Teca (*Tectona grandis*) en Costa Rica. PNUD/FAO COS/72/013. Documento de trabajo 16. San José, Costa Rica. 22 p.

MARTINEZ, H.; SAGE, L.; BORGE, C.; PICADO,W. 1994. Evaluación técnica externa del Programa Desarrollo Forestal. Informe de los consultores. 121 p.

MINAE. 1998. Estadísticas Forestales. Sistema Nacional de Areas de Conservación. San José, Costa Rica.

MORÁN, BLAS. 1998. La Teca en Panamá. RNT S.A., San José, Costa Rica. 7 p. (sin publicar)

MORATAYA, R.; GALLOWAY, g. 1996. Relaciones entre follaje y albura en Tectona grandis L.F. y Gmelina arborea Roxb.: Aplicación de la teoría del Modelo Vascular e implicaciones en el manejo. Basado en Morataya (1996) Desarrollo de modelos de predicción para pesos de follaje y volumen de albura: Aplicación de la teoría del Modelo Vascular e implicaciones en el manejo en Tectona grandis L.F. y Gmelina arborea Roxb. Hojancha, Guanacaste, Costa Rica. CATIE, Tesis M.Sc.

PANAMÁ. 1994. Ley No. 1. Ley Forestal. Del 3 de febrero de 1994. Instituto Nacional de Recursos Naturales Renovables. Ciudad de Panamá, República de Panamá.

PANAMÁ. 1993. Decreto Ejecutivo No. 89. Reglamento a la Ley No. 24. Ministerio de Hacienda y Tesoro. Ciudad de Panamá, República de Panamá.

PANAMÁ. 1992. Ley No. 24. Ley de Incentivos a la Reforestación. Del 23 de noviembre de 1992. Asamblea Legislativa, Ciudad de Panamá, República de Panamá.

PANDEY, DEVENDRA. 1997. Tropical Forest Plantations areas 1995. FAO, Rome. Draft.

PHILLIPS, GARETH. (1997). Price by diametric class of teak logs *(Tectona grandis*) coming from Sri Lanka and Central and South America. Consulting, Oxford, England.

PICADO, WALTER. 1997. La Teca en Plantación. Memorias del Seminario realizado el 31 de julio y 1 de agosto de 1997. Recursos Naturales Tropicales S. A. (RNT S.A.), San José, Costa Rica. pp. 13-27.

PICADO, WALTER. 1998. Informes de evaluación de plantaciones de teca en Costa Rica. no publicados.

QUIROS, RODOLFO. 1998. El Programa de reforestación de Bosques de Puerto Carrillo S.A. Estudio de Caso. 9 p.

SAGE, LUIS FERNANDO. 1998. Modelos financieros para el establecimiento y manejo de plantaciones forestales en Costa Rica. Comunicación Personal. San José, Junio, 1998.

SANDI, MOHAMED. 1998. Comunicación Personal. San Carlos, Costa Rica.

SEGEPLAN, SRN, AFE-COHDEFOR. 1996. Plan de Acción Forestal PLANFOR 1996-2015. Tegucigalpa, Honduras. 3 volúmenes.

TELLEZ, OSCAR. 1998. La reforestación en Nicaragua. Comunicación Personal. 16 de abril de 1998. Hotel Camino Real, Managua, Nicaragua.

UGALDE, LUIS. (ed.). 1997. Teca (Tectona grandis): Resultados de investigación silvicultural del proyecto MADELEÑA en América Central. CATIE, Turrialba, Costa Rica. 63 p.

VALLEJOS, O. 1996. Productividad y relaciones del índice de sitio con variables fisiográficas, edáficas y foliares para Tectona grandis L.F., Bombacopsis quinatum (Jacq) Dugand y Gmelina arborea Roxb. en Costa Rica. CATIE, Tesis M.Sc. 147 p.

VIQUEZ, EDGAR. 1998. Programa de Reforestación de MADERAS PRECIOSAS DE COSTA RICA S.A. Estudio de Caso. 5 p.

WEIDEMA, W.J. 1966. An Information on Teak growth in Nicaragua. Turrialba Vol. 16, No. 4. Turrialba, Costa Rica. pp 387-389.

ZAMBRANA, HUGO. 1998. La Teca en El Salvador. RNT S.A., San José, Costa Rica. 9 p. (sin publicar)

ZAMORA, NANCY. 1998. Experiencias de comercialización de teca en Costa Rica. Unidad de Comercialización, Cámara Costarricense Forestal. San José, Costa Rica. 2 pp.