

Appendix H A Chronology of Tropical Forest Planting

Southern Asia

During the 18th and 19th centuries, the British Empire's dependence on teak (*Tectona grandis*) for naval timbers led early to concern for future supplies and attempts to plant teak in India (Laurie 1937). Teak became scarce about 1830, and planting was attempted on sites with 300 cm of rainfall annually. It was then that the difficulty with teak seed germination was first reported. A technique finally worked out after 20 years (by an accountant) was used for nearly a full century thereafter. The earliest plantings were harvested at about 75 years of age.

Most tree planting in India is concentrated in dry zones, and fuelwood is an important product. An annotated list of shrub and tree species for dry and desert areas appeared in 1946 (Badhwar and Griffith 1946). Also included were 33 species for binding sand, 54 for arid zones, 12 for irrigated plantations, and 28 for canal banks.

Casuarina equisetifolia became popular as a fuelwood tree for beach areas in India more than a century ago (Kesarcodi 1951a, Sharma 1951). By the 1950s, 1,400 ha of this species had been planted in Orissa and 440 ha in Bombay. *Eucalyptus*, introduced into India some two centuries ago, developed a hybrid there referred to as "Mysore gum." By 1978, this and several other species had been planted on 394,000 ha (Lohani 1978).

Tree plantings began in what is now Bangladesh in 1873, and planting has been increasing ever since (Rahman and others 1982). In Chittagong alone, where planting began in 1921, some 17,300 ha had been planted by 1978. By 1982, there were 6,500 ha of plantations 30 years old or older and 47,500 ha older than 15 years.

While Pakistan was still part of India, an extensive irrigated fuelwood plantation was established at Changa Manga (Khan, M.I.R. 1961), mostly with *Dalbergia sissoo*. Located in a region of widespread fuelwood families, the plantation has produced an income that compares favorably with that of irrigated farming. By 1961, 50,000 ha of a total planned area of 218,000 ha had been planted. By 1980, the planted area had reached 160,000 ha (Anon. 1981g).

Africa

The introduction of teak in west Africa marks the beginning of reforestation efforts. Table H-1 summarizes progress to 1956.

Table H-1.—Teak (*Tectona grandis*) introduction and early planting in Africa

Country	Yr. of teak introduction	Hectares planted to 1956
Nigeria	1889	450
Togo	1905	4,500
Dahomey, now Benin	1916	950
Ivory Coast	1926	2,275
Senegal	1933	72
Guinea	1937	410

Source: Lanier 1959.

Tests of underplanting in francophone Africa, begun before 1940, showed promising results with *Swietenia macrophylla* and *Terminalia superba* (Aubreville 1953). By 1954, 3.6 million trees had been underplanted in the Ivory Coast, mostly *Tarrietia utilis* and several Meliaceae (Mensbrugge 1962). In Nigeria, in contrast, emphasis was on plantations of teak, using the taungya system. By 1955, a total of 480 ha of teak had been established (Ross and Moss 1957). Seventeen other exotic tree species had been introduced and were being tested. In Uganda, about 10,000 ha of plantations for construction materials, boxes, poles, and fuelwood had been established on grassland (Anon. 1957c).

In Nigeria, during the early 1960s, with the abandonment of shelterwood, the shift was toward agroforestry, but there remained 150,000 ha of planted pines and eucalypts in the savanna reserves (Lowe 1984). In total, the planted area of Nigeria in 1990 was 216,000 ha (Anon. 1993a).

In South Africa, 15 years of testing indigenous species began in 1912 and included large-scale *Juniperus procera* plantings (Pudden 1957b). Growth was slow, so exotics were substituted. By 1955, there were 18,000 ha of three species of *Cupressus*, 4,400 ha of *Pinus patula*, and 3,500 ha of *P. radiata*. Also under test were 22 other pine species, 6 *Araucaria*, 3 *Callitris*, 12 other conifers, 70 *Eucalyptus*, and 80 other broadleaf species.

In francophone Africa, plantings had been undertaken in all the colonies by 1960. Soil-conservation plantings in the French Cameroons used *Albizia lebbek*, *D. sissoo*, *Khaya senegalensis*, and *Senna siamea* (Guiscafre 1961).

On the coastal sands of what is now Benin, more than 700 ha of *Casuarina* had been planted for poles and firewood. In addition, 3,500 ha of teak had been planted by taungya farmers (Buffe 1961b). In Togo, there were 3,400 ha of teak and 400 of *Anacardium occidentale* (Sarlin 1961). In what is now Burkina Faso, *Azadirachta indica*, *S. siamea*, and *Tectona grandis* had been planted on 850 ha of savanna (Mulard 1961). Teak had been planted on 3,500 ha, using the taungya system (Buffe 1961b). In Chad, 400 ha of fuelwood plantations had been established, using the same species as in the Cameroons (Goudet 1961).

By 1963, eucalypt planting in Africa south of the Sahara was proceeding at an annual rate of 13,700 ha (Begue 1963). The areas planted annually were 9,000 ha in South Africa, 1,800 ha in what is now Zimbabwe, 1,200 ha in Mozambique, 600 ha in Angola, 400 ha in Uganda, and lesser areas in six other territories. By 1990, the total planted area in this region had reached 1.057 million ha (Anon. 1993a).

Between 1949 and 1965, the Benguela Railroad in Angola planted 94 million *Eucalyptus* trees, mostly *E. rostrata* and *E. saligna*, all for fuelwood (Sampaio and Carita Frade 1965).

In the region as a whole, a wave of industrial plantings took place following the Second World War (Lanly 1982). Between 1960 and 1980, another 1.35 million ha of industrial plantations were established, nearly all by national governments. By 1980, the total of all plantations in 37 countries was 1.78 million ha, of which 31 percent was softwoods and 36 percent, fast-growing hardwoods. By 1990, the total had reached 3 million ha and the planting rate was 129,500 ha/yr for the 1980–90 period (Anon. 1993a).

Southeast Asia and the Pacific

In Peninsular Malaysia, tree planting was tested beginning in 1927 and rejected because of good natural regeneration on most areas (Watson 1935). However, by 1990 the planted area in Malaysia had reached 116,000 ha, and the annual planting rate was 9,000 ha (Anon. 1993a).

In Java, teak planting began in the 1880s and had covered about 850,000 ha by 1940 (Sieverts 1958). By that time these plantations produced an abundance of excellent and rather cheap material for furniture, shipyards, railroads, and even fuelwood. The entire yield was mar-

ketable. By 1975, the planted area was 1.193 million ha in Indonesia, 430,000 ha in the Philippines, and 394,000 ha in Taiwan (Skoupy 1976). Planting rates in 1975 for the Philippines were 18,000 ha/yr. By 1990, the total area planted in Indonesia was 8.75 million ha and in the Philippines, 290,000 ha. The annual planting rates were 474,000 ha for Indonesia and none for the Philippines (Anon. 1993a).

Recent concern about sources for electrical energy have led to a wood fuel energy program in the Philippines. In 1985, this program operated four electric generation plants and expected to have five more that year, each requiring about 90,000 m³ of stacked wood per year (Durst 1985). More than 8,000 ha have been planted, mostly to *Leucaena*. The trees are owned by farmers who expect to profit when the wood is sold. Average yield is nearly 50 cubic meters per hectare per year, but plantation-produced wood falls short of demand, and further planting trials are in progress.

In Queensland, Australia, planting included 15,000 ha of *Araucaria cunninghamii* by 1937 and 12,000 ha of exotic pines, principally *P. elliotii* (Grenning 1957). By 1967, there were 25,000 ha of *A. cunninghamii* and 25,000 ha of exotic pines (Hawkins and Muir 1968).

In Fiji, there were more than 10,000 ha of *S. macrophylla* plantations by 1967 (Busby 1967). Between 1908 and 1960, nearly 1,100 tree species were introduced into the Hawaiian Islands, with as many as 10,000 trees of some species being planted (Nelson 1965).

Two countries, India and Indonesia, currently boast 93 percent of all the plantations in tropical Asia and the Pacific (Lanly 1982). The total planted area in 16 countries in 1980 was 5.111 million ha, of which 16 percent was softwoods and 45 percent fast-growing hardwoods. From 1975 to 1980, some 2.1 million ha were planted in this region. The planting rate is about one-fourth of the deforestation rate.

Tropical America

Tests of 83 Brazilian timber species in the early 1900s showed that most of them grew more slowly than eucalypts that had been introduced much earlier; therefore, by 1906, 72 species of eucalypts were under test in Brazil (Navarro de Andrade 1941). Planting progressed rapidly in the State of Sao Paulo with the appointment in 1903 of Edmundo Navarro de Andrade as director of forest planting for the Companhia Paulista de Estradas de

Ferro at Jundiá (Navarro de Andrade 1939). Another 120 species of eucalypts were introduced in 1913. By 1941, when Navarro died, nearly 100 million trees of 75 different species were growing in 17 plantations along the railroad despite vigorous public condemnation of eucalypts for alleged soil effects.

By 1951, Brazil's Companhia Siderurgica Belgo Mineira had planted 3.8 million *Eucalyptus* trees to be used in charcoal for steel production (Anon. 1951b). By 1970, charcoal production ranked in value just below rice and corn and far above coffee and sugar (Ayling and Martins 1981). By 1966, there were 450,000 ha of *Eucalyptus* plantations in the State of Sao Paulo alone and, by 1972, some 580,000 ha (Victor and others 1972). By 1970, the paper industry of the State of Sao Paulo consumed the production of 90,000 ha of plantations (Golfari 1970b). By 1976, there were also 40,000 ha of *Eucalyptus* plantations in the State of Parana (Stohr and de Hoogh 1980).

By 1983, the annual reforestation rate in Brazil had reached about 350,000 ha, and the total area planted was almost 4.5 million ha (Nock 1982), most of it by private enterprises. Rates of reforestation as high as 600,000 ha annually were being planned, with a goal of 8 million ha in total.

A large Brazilian *Eucalyptus* timber-plantation enterprise is Aracruz, in the State of Espirito Santo (Carbonnier and Lanner 1979). The project began in 1967 on 75,000 ha in response to Brazilian tax incentives. Experts were sent to acquire *Eucalyptus* seed in Australia, Papua New Guinea, Timor, and South Africa. Seed orchards of *E. grandis* and *E. urophylla* were established, to be followed by vegetative propagation. The plantations were laid out before the processing facilities were built. Yields on a 7-year rotation average 36 m³/ha/yr and total about 1.64 million m³/yr. In 1978, Aracruz inaugurated the world's largest single-line bleached-pulp operation, with an annual capacity of 460,000 t. By 1979, a total of 59,000 ha had been planted, using 1,044 provenances of 37 species of *Eucalyptus* and also 1.5 million trees of native species, mostly jacaranda (*Dalbergia nigra*) and pau Brasil (*Guilandina echinata*) (Kalish 1979a). By 1985, the genetic base included 54 species, 1,254 provenances, and some 5,000 selected clones from established plantations (Anon. 1985a).

The opposition to *Eucalyptus* as a cause for deserts and changing climate has been effectively answered by exposing such myths (Golfari 1975a); still, there has been a

trend toward *Pinus* in Brazil because of the greater versatility of wood, particularly for cellulose products. A native conifer, *A. angustifolia*, once covered 3 percent of Brazil's land area, but its regeneration has proved complex and its growth slower than that of exotic pines (Krug 1968). By 1970, some 90 percent of the native *A. angustifolia* forests had been exploited and were not regenerating (Stohr and de Hoogh 1980).

By 1948, Brazil's Instituto Nacional do Pinho had started pine reforestation projects with 3,500 ha planted in São Paulo, 990 ha in Parana, 680 in Santa Catarina, 650 in Rio Grande do Sul, and 80 in Minas Gerais (Anon. 1949b). Planting began with *P. radiata*, which failed (Krug 1968). By 1964, 106 million *P. elliotii* had been planted, nearly half of them by private landowners (Krug 1968). By 1968, many other gymnosperms were showing promise, including *Agathis*, *Cunninghamia*, *Cupressus*, *P. caribaea*, *P. kesiya*, *P. merkusii*, *P. oocarpa*, and *Podocarpus*. The annual planting rate exceeded 200 million trees.

By 1972, Sao Paulo had 176,000 ha of conifer plantations (Victor and others 1972). Of the conifers, 30,000 ha were *Pinus caribaea*, *P. oocarpa*, and *P. patula*; the rest were *A. angustifolia*, *P. elliotii*, and *P. taeda* (Golfari 1972). The area proving to be suitable for *P. caribaea* was vast, from Parana to the Amazon.

Brazil's 1966 legal reforestation incentive permitted an income tax reduction of up to 50 percent by an offsetting investment in reforestation (tax relief was reduced to 25 percent in 1972). This led to 38,000 ha of plantations in the first year (1967), 2.908 million ha by the end of 10 years (1977), and 5.189 million ha by 1983 (Romero Pastor 1983). From 1960 to 1970, Brazil's annual production of pulpwood rose from 300,000 to 800,000 t, and of paper from 470,000 to 1.08 million t.

In the Brazilian State of Parana, 295,000 ha of *P. elliotii* and *P. taeda* and 46,000 ha of *Araucaria angustifolia* plantations had been established by 1976 (Stohr and de Hoogh 1980). A typical successful pine-plantation enterprise in southern Brazil is that of Olinkraft, at Lages, Santa Catarina. By 1980, this company was producing kraft paper entirely for domestic markets from 400,000 ha of *P. elliotii* (Blackman 1980).

In 1968, the acquisition of 15,000 km² along the Rio Jari in Amapa began what was then Brazil's largest forestry venture (Anon. 1979c). By 1979, some 90,000 ha of

Gmelina arborea and *P. caribaea* had been planted, and 260,000 t of bleached kraft pulp were being produced per year. Some 3,000 km of plantation roads had been built, and employment had reached 10,000 workers at Monte Dourado. The wood residues from 4,000 ha of virgin forest have been used each year for energy for wood processing and for the adjacent isolated community (Kalish 1979b). This project now uses only a hybrid of eucalypts.

The study of native tree species in Brazil has not been abandoned. Silvical information on 64 species native to Sao Paulo can be found in Nogueira (1977). Standards for selecting superior trees for breeding have also been developed (Pires 1979). An excellent analysis of planting sites throughout northeastern Brazil was completed using Thornthwaite's water-balance studies (Golfari and Caser 1977). Tests of underplanting with both native and exotic species have been in progress in the Amazon Valley (Carvalho Filho and Marques 1979).

From 1965 to 1980, Brazil planted enough trees—some 4 million ha—to meet nearly 60 percent of its domestic requirement for industrial wood (Spears 1983). Within the foreseeable future, it could produce all of its industrial wood needs from plantations close to the population centers of the southern and eastern half of the country. Less than 10 percent of current production comes from the Amazon region. The expansion of plantations in Brazil has already taken pressure off the natural forests and increased prospects for setting aside large areas of natural forests as nature reserves, parks, and catchments. By 1983, the rates of return on 35 World Bank reforestation projects covering 1 million ha were all more than 10 percent and some were 25 to 30 percent (Spears 1983).

A landmark in the development of forestry in Trinidad was the introduction of teak from what is now Myanmar in 1913 (Brooks 1938). The teak was originally intended to provide boiler fuel for the sugar estates and for burning clay for road surfacing, among other uses. Only about 40 ha were planted in the following 10 years, but by 1956, plantations covered 4,100 ha (Ross 1959) and by 1979, 9,700 ha. *Pinus caribaea* was introduced in 1952.

In Suriname, the Gongrypp plantations were established at Zanderij from 1904 to 1924 (Swabey 1950). They covered 1,800 ha. Planted species included *Eperua falcata*, *Hymenaea courbaril*, *Goupia glabra*, *Manilkara bidentata*, *Mora excelsa*, *Vochysia* spp., and many others. In 1947, these plantations, long abandoned, were partly restored, and a more extensive planting program ensued using both native species and exotics (Schulz and Rodriguez 1966).

Plantings of *Eucalyptus globulus* in the Peruvian Andes were, by 1947, producing more than half that country's wood (Moulds 1947).

In Central America, planting was first undertaken in 1927 near Lancetilla, Honduras, by the United Fruit Company; the emphasis was on teak (Chable 1967). By 1953, the total area planted was 4,250 ha.

In Cuba, forest planting between 1940 and 1959 totaled 1,900 ha, mostly in Pinar del Rio Province (Gomez Ricano 1966). Between 1960 and 1964, an additional 60,000 ha were planted, nearly half of which was in Pinar del Rio. About 40 percent of the trees were eucalypts; another 12 percent were pines.

In the French Antilles, the introduction of *S. macrophylla* led to an active planting program beginning in 1924 (Chapuis 1955). By 1955, there were about 12,000 ha of plantations on Martinique, of which 5,000 ha were productive. Underplanting has been done extensively on Guadeloupe.

In Puerto Rico, timber-tree planting began in 1922, and more than 80 million trees have been produced since then. The current plantation area is about 6,000 ha.

In Venezuela, large-scale government forest planting of *P. caribaea* began in 1968 in the lower Orinoco Valley. By 1976, more than 50,000 ha of savannas had been planted (Lama Gutierrez 1976).

In 1979, Keogh listed the then-known teak plantation areas for tropical America; they included 9,700 ha in Trinidad, 800 ha in Puerto Rico, 560 ha in Colombia, 560 ha in Venezuela, 300 ha in Costa Rica, 230 ha in El Salvador, 200 ha in Cuba, 60 ha in Nicaragua, and 30 ha in Belize, or a total of 12,440 ha.