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# Tree Species for Planting in Forest, Rural, and Urban Areas of Puerto Rico

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# Tree Species for Planting in Forest, Rural, and Urban Areas of Puerto Rico

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## Abstract

Responding to near total deforestation in Puerto Rico, in the 1920's the U.S. Department of Agriculture, Forest Service, began to produce tree seedlings, reforest degraded lands, establish planting trials, and conduct silvicultural research. In 75 years an extensive body of knowledge has been accumulated. Advances in tree-seed handling, nursery practice, plantation establishment, and plantation management made in Puerto Rico are summarized. Tree species recommended by local research and experience for planting in wildland, farm, and urban forestry are detailed in this report. Site requirements, management techniques, growth rates, and benefits are given.

**Keywords:** Deforestation, plantation establishment, plantation management, Puerto Rico, reforest, silvicultural research

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## Introduction

Indigenous peoples were clearing land for crops and planting trees for fruit, fiber, and medicine well before Europeans arrived in Puerto Rico. For many decades, European colonization had only minor impacts on the environment. However, an expanding population eventually resulted in massive deforestation. A scarcity of wood, grinding rural poverty, and impending environmental disaster emphasized the need to plant trees for environmental protection, wood production, agroforestry benefits (Bates 1930), and ornamental purposes. Settlers planted fruit and ornamental trees early in the Spanish colonial era, but reforestation for environmental protection and timber production began in earnest under the leadership of the U.S. Department of Agriculture, Forest Service, during the 1920's (Brown and others 1983, Domínguez Cristobal 1989). Large areas that were or would become parts of national and State forests, as well as some private lands, were planted during the 1930's and 1940's (Birdsey and Jimenez 1985, Brown and others 1983, Domínguez 1989, Marrero 1950b). Planting continued at a fairly steady pace through the 1960's, after which time the areas planted were substantially reduced. Although much plantation area has been lost to the encroachment of secondary

forests, some has been harvested and a little converted to nonforest uses. By 1988, about 4,000 hectares (ha) were still identifiable as forest plantations (Francis 1995a).

As foresters worked to establish plantations of significant size and numbers, it became obvious that to succeed they needed to know a lot more about nursery practices and tree planting. They discovered that seeds of many species require special treatment, that different shade and irrigation regimes in the nursery are necessary, and that some species need specialized root symbiotes. They began to realize that the wide range of soil and site types required planting a number of different species, even from different seed sources within the same species, in order to obtain good survival and growth. To solve these problems, they conducted informal trials and structured research studies. With these efforts, forestry research had begun in Puerto Rico. Over the years, foresters and scientists conducted hundreds of studies and trials to acquire the knowledge needed to successfully establish tree species and thereby meet the perceived needs of the people of Puerto Rico (Wadsworth and Lugo 1989).

Seventy-five years of experience and experimental results gained by workers in Puerto Rico, both within and outside the Forest Service are distilled in this report. It covers seed handling, nursery practices, plantation establishment and management, species adaptability, and uses. As far as possible, the author has documented the publication source of each bit of knowledge. Information not referenced by published sources is from data that are on file at the International Institute of Tropical Forestry (IITF) and from the author's personal knowledge. Modern foresters recognize that much of the information and most of the skills associated with establishing trees in the tropics were acquired by persons unknown—and, perhaps, now long deceased. Nevertheless, the living results of their work still benefit both the astute observer and the careless user.

We can learn valuable lessons about tree planting from the forest history of Puerto Rico. From the number of seedlings reported to have been planted by 1980, some

38,000 ha of forest plantations should have been established (Birdsey and Weaver 1982, Food and Agriculture Organization 1988). Including the multipurpose trees that were planted on farms and the many ornamental trees planted throughout Puerto Rico, foresters, farmers, and landholders had planted more than 100 million trees. Why, then, are there so few trees and plantations today to show for these efforts? Of course, some decadent trees have been harvested or removed, but early seedling mortality has been the overwhelming cause of failure to successfully establish plantations. Although no data have been collected to quantify the loss, probably more than 90 percent of the trees planted will never yield the intended benefit. Possibly the single most important cause of early mortality over the years has been poor species selection for the site to be planted. The second most important cause of plantation failure likely has been weed encroachment and discontinued maintenance. By selecting the best species for the site to be planted, using the proper site preparation and planting techniques, and protecting newly established trees from weeds and encroaching secondary forest trees, landowners can successfully establish trees and plantations virtually anywhere in Puerto Rico. Local research findings on seed handling, nursery practices, site preparation, planting practices, and silviculture techniques, which have been shown to increase the chances of successful tree establishment for nearly 300 species, are summarized in this report.

## Seed Collection and Handling

Although some species, such as *Gliricidia sepium* (Jacq.) Walp., *Ficus citrifolia* P. Miller, and *Salix chilensis* Molina, are normally reproduced vegetatively from cuttings, most species grown for forestry purposes are reproduced from seeds. Seed problems often dictate whether a species is grown at all.

Availability is the most persistent seed problem. In the absence of commercial suppliers in Puerto Rico, growing trees in a nursery requires a nursery worker or a forester first to collect the seed. Because as many as half the tree species do not bear viable seeds every year, and many others bear seeds intermittently throughout the year, it is necessary to watch carefully for seed production on various parts of the island. When seeds are located, they must be collected in quantity (often difficult because of the heights of trees) and cleaned. Different cleaning techniques are employed, depending on the size of the

seeds and the type of enclosing fruit. Some species should be dried before storage; other species, called recalcitrants, will die if allowed to dry out. They may be stored in refrigerators for a short time in sealed containers but are usually planted immediately after cleaning. A few species, such as corozo (*Acrocomia media* O.F. Cook), require a period of afterripening before they will germinate. Hard-coated seeds may be stored for 1 to several years before planting. It is usually beneficial to store them in airtight containers in refrigerators at about 4 °C. Seeds of the majority of tree species may be planted without any treatment. However, the hard-coated seeds of many species must be treated in some way to perforate the seed coat, or germination will be slow and erratic. Methods include abrasion, cracking, treating with acid, and immersing briefly in boiling water. Often, to hasten and increase germination, seeds are soaked in water for a few to many hours before sowing.

Most seeds will germinate on the surface of wet soil. Often, to protect against desiccation, seeds are covered with compost, sand, soil, or artificial media. The chosen germination substrate can have a significant effect on the degree to which seeds of some species germinate. In a comparison of depth and kind of covering, compost and sand brought much better results than subsoil, and coverings of approximately 1 to 2 centimeters (cm) proved to be better than deeper or shallower coverings (Marrero 1947b). A serious problem in Puerto Rican nurseries has been germinant mortality caused by damping-off fungi. The fungi can be controlled with chemicals, steam pasteurization of germination media, or the use of newly purchased, sterile potting media in germination trays.

Obviously, there are innumerable details about handling the seed of so many tree species. Insofar as they are available in the literature or are known to me, the author will give a summary under the species descriptions or cite references where more detail may be obtained. In cases where facts are not available, the reader is encouraged to talk with nursery workers who specialize in growing trees and, if necessary, to develop methods for new species through informal trials.

## Nursery Practice

A number of nursery techniques are used to produce tree seedlings for planting. Sometimes there seems to be a "best" way; often, alternate approaches are equally

successful. One of the most common methods used today in the tropics is to germinate seeds in trays or germination beds and, after they reach from 2 to 5 cm in height, transplant the seedlings into plastic nursery bags filled with a mixture of soil, sand, and organic material such as peat or composted manure. Fertilizer may be added to the mixture, but more often is added once the seedlings are established in containers. Other types of containers used are paper pots, styroblocks, root trainers, and large plastic pots. Some nurseries are also producing seedlings in nursery beds that are periodically undercut. The types of bare-root planting stock produced in this manner are (1) unpruned and top pruned seedlings, (2) striplings (bare-root seedlings with the leaves removed), and (3) stump plants (bare-root seedlings with the entire top removed). Considerations in choosing a nursery system include (1) tolerance of the species to disturbance during transplanting, (2) drought hardiness, (3) the environment into which the seedlings will be transplanted, (4) size of seedlings required and/or time available to grow them, (5) problems of transport to and within the planting site, and (6) cost involved in seedling production. Generally, potted (containerized) seedlings are more expensive and bulkier to transport but give better survival than the various types of bare-root seedlings, especially in drought-prone environments and with sensitive species.

## **Plantation Establishment and Management**

Three methods of plantation establishment, with numerous variations, have been used extensively. Solid planting using the corona method is an adaptation of a method once used widely in the Puerto Rican hills to establish banana, coffee, and fruit trees. Planting positions are measured with a rod and laid out around the hills (sometimes up and down), sometimes haphazardly, to avoid rocks, stumps, and holes. Coronas ("crowns"), circles about 1 meter (m) in diameter, are cleared and tilled with a mattock hoe or a machete (Balmer and Zambrana 1977). Seedlings or seeds are inserted immediately or within days in the center of the corona. The area between coronas is usually slashed down but not cultivated. Weeds are controlled within the coronas with hoe or machete, as necessary, whereas the intervening area is slashed only occasionally to prevent brush from growing so tall as to shade the seedlings. When newly planted trees grow to or above grass and

brush height (usually about 2 m), weeding is suspended, except when control of vines is necessary. When hand labor is available, this method is probably still the best available for establishing plantations in old pastures or brush fields on rough terrain. Failures with the method using well adapted species have generally resulted from using coronas that were too small and from not weeding consistently.

In a few situations, planting without coronas or other forms of site preparation has been successful on disturbed sites that have little weed or grass cover. Some degree of weeding is usually necessary. On the other hand, complete site clearing and tillage have been employed in a few plantings. While effective, this method is expensive and usually results in excessive erosion on steep slopes during the first year. During the days of subsistence farming in Puerto Rico, *taungya*, a variation of solid planting, was practiced to a limited extent (Marrero 1939, Weaver 1989b). Under that system, trees were planted among agricultural crops and weeded along with them until the trees neared crown closure and shaded out the agricultural crops. A new site was then chosen and the process repeated.

A second major plantation establishment technique used in Puerto Rico was underplanting with release. In this method, seedlings or seeds were planted under stands of trees. After the seedlings became well established, the overstory was removed in one or more stages. Ideally, the stand was harvested commercially, but often the trees were of little value and therefore were girdled or poisoned. For underplanting to succeed, the overstory must be thin or have been thinned, the site must have a fairly open understory or be made so by weeding, the species planted must be at least midtolerant, and removal of the overstory must be timely. Because species planted were not tolerant enough, initial shade was too dense, or the overstory was never removed in underplanting operations, many failures occurred, although several small plantings have shown good results, and several plantings using this method are in progress. The method is sound, but the application under operational conditions is sometimes difficult.

A third method, formerly used and once again popular, is the line-planting method (Marrero 1950b). Swaths, or "lines" 2- to 5-m wide are cleared through low-value secondary forest. The lines are separated by 10 to 20 m, and the forest between is left intact. Spaced at about 3 m

along the lines, coronas are tilled, and seedlings of a moderately intolerant or midtolerant species are planted. Big-leaf and hybrid mahogany are the usual species planted in Puerto Rico (Southern Region 1991). One small-line planting of *Dipteryx panamensis* (Pittier) Record & Mell is progressing well and another with a variety of native species is showing mixed results, depending on the species planted. A number of other good candidate species, such as mahoe (*Hibiscus elatus* Sw.), remain untested. As the planted trees grow, the intervening stand is progressively removed, and whatever interspersed, high-value trees remain are retained. The result of this process is a mature stand that is a mixture of the planted species and other valuable, naturally regenerated species. The most frequent causes of failure, other than using species not adapted to the site, are planting very intolerant species or slow-growing species and failure to widen the lines as both the residual stand and the planted species grow.

## Species Selection

Over the years, several hundred timber, ornamental, and multipurpose species have been planted in Puerto Rico. Included in the following descriptions are species that the Forest Service has planted and a few other ornamental and multiple-purpose species that produce wood or nonwood products, have wildlife benefits, or may be employed for conservation plantings (to protect or restore the environment to former health). For convenience, very important and widely used species are divided into those that might be considered timber trees and multipurpose

trees without major timber potential. Following these categories, a larger group with briefer commentary includes species with less current importance but proven potential. A tabular summary of the properties of these species and their uses is given in Appendix, table 1. Appendix, table 2, summarizes the site requirements and recommended management practices for that group. An additional group of tree species that are either of minor importance, are recommended by only a few successful individuals, have given mixed results in trials, or have some serious drawback to consider are listed with a very brief description in Appendix, table 3. Finally, a large group of species were successfully grown in the nursery, but, for various known or unknown reasons, failed to survive or grow after outplanting (Appendix, table 4).

Most test plantings were made in the Caribbean National Forest/Luquillo Experimental Forest/El Yunque (hereafter referred to as CNF) and the Puerto Rico State forests, particularly Cambalache, Toro Negro, Carite, Río Abajo, Monte Guilarte, Vega, Susúa, Guánica, and Maricao. The Arboretum and El Verde (located in the CNF), the Woodlot (part of the University of Puerto Rico Botanic Garden), St. Just (former property of the USDA Forest Service in Carolina, Puerto Rico), and the Adaptability Trials (test areas widely dispersed on Government and private lands) are frequently cited. Exact locations can be obtained for nearly all the plantings referred to in this paper by searching IITF files or by consulting with the author and other IITF personnel. Forest types cited, such as dry, moist, or wet forest, are defined according to the Holdridge (1967) life-zone system.

# Commercial Timber Species Widely and Successfully Planted in Puerto Rico

***Bucida buceras* L.**  
**COMBRETACEAE**  
**Ucar**



*Ucar is a stately native species that is apparently climax in the dry forests, some of the moist forests in their drier extremity, and in some of the moist limestone-hills area.*

**Seed and Nursery**—Ucar seed is available throughout the year and can be collected from the ground or with a pruning pole. There are about 38,000 seeds per kilogram (seeds/kg). Germination is best in fine sand but is low (about 6 percent). Seedlings reach plantable size (40 to 50 cm) in about 6 months. Outplanting survival is usually high.

**Site Requirements**—Ucar grows naturally in areas of Puerto Rico that receive from 750 to 1600 millimeters (mm) of rainfall per year. Ucar will grow well when planted in well-drained sites that receive up to 2400 mm of mean annual precipitation (m.a.p.). Acid, calcareous, and mildly salty soils are tolerated, but the species does not appear to tolerate poorly drained conditions. It also grows reasonably well on eroded and compacted soils.

**Location of Plantings**—Two small plantations now nearing small sawlog size can be found in Cambalache. Ucar is planted as an ornamental and shade tree in every city in Puerto Rico.

**Management and Growth**—Initial spacings of 2.5 by 2.5 m to 3 by 3 m are recommended followed with 20-year thinnings for posts, poles, or charcoal. After a long, clear bole has been set, thinnings should increase spacing enough to allow the development of a full crown for rapid growth. Plantation trees in Puerto Rico gain about 0.5 m of height per year and add about 0.5 cm per year in diameter at breast height (d.b.h.). At that rate, sawlog rotations should be 80 to 100 years. Ucar trees are long-lived (probably exceeding 200 years) and can reach from 1 to 2 m d.b.h. on good sites.

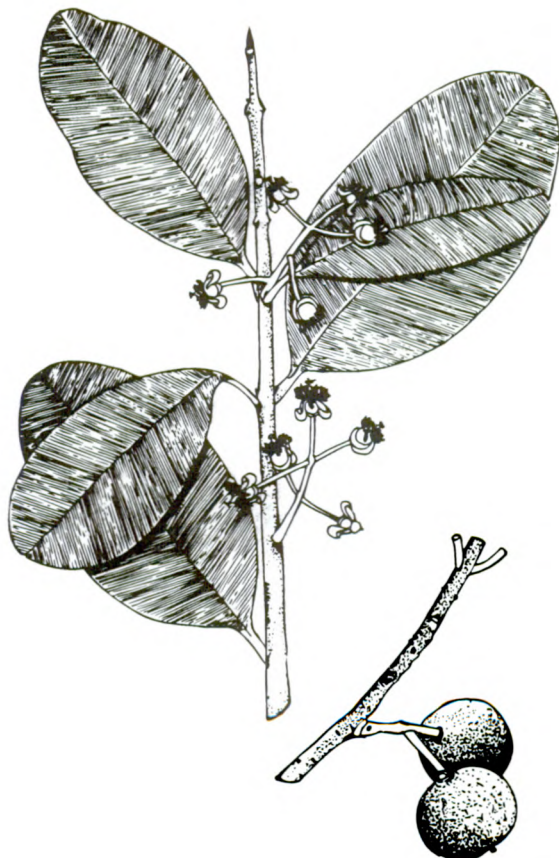
**Benefits**—Ucar is one of the most commonly planted ornamentals and urban shade trees in Puerto Rico. The wood makes good parquet flooring and construction beams and is a preferred wood for making charcoal. It is also recommended for reforestation in dry and moist, transition-to-dry forest areas.

**References:** Brush 1925b, Francis 1988c, Francis 1989a, Francis and Rodríguez 1993, Longwood 1961, Southern Region 1990, Tropical Forest Experiment Station 1949, Tropical Forest Experiment Station 1951, Wadsworth 1944b, Wadsworth 1947a, Wadsworth 1948, Wolcott 1940, Wolcott 1946.

***Calophyllum calaba* L.**

**GUTTIFERAE**

**Maria, maría**



*Maria, a native species that grows mainly along the North Coast in primary forest, is now widely scattered throughout moist secondary forests because of planting. Maria develops a thick crown of dark-green leaves and a gray trunk with distinctive, diamond-shaped lenticles.*

**Seed and Nursery**—In Puerto Rico, the fruits of maria mature mainly in the fall. They can be gathered in quantity under fruiting trees. There are about 300 seeds/kg. Germination takes from 4 to 16 weeks, and usually 90 percent or more of the seeds germinate. Seedlings will reach plantable height (0.5 m) 6 to 8 months after emergence. Seeds can be sown directly into the nursery bags or the seedlings can be pricked in

(inserted in a dibbled hole) later. Direct seeding with a dibble into prepared seedspots (best) or unprepared abandoned farmland was the usual means of establishing maria in the era of reforestation.

**Site Requirements**—Maria grows best in moist coastal sands and clays and in the moist foothills. The m.a.p. on favorable sites varies between 1500 and 2000 mm. Maria will grow on sites receiving up to 3000 mm of m.a.p. It prefers deep, fertile soils but tolerates acid and alkaline soils, eroded sites, and soils derived from serpentine rocks. A number of plantations on poor sites have produced scrubby trees useful only for fenceposts and fuel.

**Location of Plantings**—Fairly extensive plantations have been established on poor sites in Guajataca, Maricao, Río Abajo, and the CNF. There are many smaller plantations scattered across Puerto Rico.

**Management and Growth**—If direct seeding is used, it should be done densely (2 by 2 m), and the plantation should then be thinned for form and vigor to about 4 by 4 m after 3 or 4 years. Height growth may reach as much as 1 m/yr in young stands and then decrease until a maximum height of about 20 to 25 m is reached. On good sites, diameter growth of the dominants is usually about 1 cm/yr. Basal areas of 20 to 40 m<sup>2</sup>/ha are normal in unthinned stands. Thinning to the lower end of this range is advisable. Yields vary from about 5 to 15 m<sup>3</sup>/ha/yr, and rotations for sawlogs should be from 40 to 70 years.

**Benefits**—Maria wood is used for beams, posts, furniture, cabinetry, millwork, and crafts. It is an important landscape and conservation tree and a food source for fruit bats.

**References:** Brush 1925a, Brush 1925b, Chudnoff and Goytia 1972, Englerth 1960, Francis 1995a, Francis and Rodríguez 1993, Holdridge 1940b, Kramer 1924, Longwood 1961, Marrero 1947a, Marrero 1948, Marrero 1949a, Marrero 1950a, Marrero 1950b, Schubert 1979, Southern Region 1990, Tropical Forest Experiment Station 1949, Tropical Forest Experiment Station 1952, Tropical Forest Research Center 1958, Wadsworth 1943c, Wadsworth 1944a, Wadsworth 1949, Wadsworth 1960b, Wadsworth and Englerth 1959, Weaver 1989b, Weaver 1990a, Wolcott 1940, Wolcott 1945, Wolcott 1946, Zambrana and Balmer 1979.

***Cordia alliodora* (Ruiz & Pav.) Oken**

**BORAGINACEAE**

**Capa prieto**



*Capa prieto* is a ubiquitous, medium-sized native species principally of the moist forest. It invades secondary forests after the initial woody vegetative cover is established.

**Seed and Nursery**—Seeds are produced in large numbers by open-grown trees and can be collected by clipping fruiting branches or shaking the tree over tarps after fruits change from green to brown. There are from 42,000 to 100,000 seeds/kg and germination of 50 to 70 percent may be expected from fresh seeds, beginning in about 8 days. Seeds lose viability in 5 to 6 months if not sealed and refrigerated. From 5 to 10 months in the nursery are required to produce seedlings of plantable height. Potted seedlings are recommended, but stump plants are also suitable for plantation establishment.

**Site Requirements**—Capa prieto requires fertile sites with deep soils for good growth. The range includes areas with rainfall from 750 to 3000 mm, and areas with precipitation near the middle of this range are probably best. Elevation is not a limiting factor in Puerto Rico.

**Location of Plantings**—A test planting of capa prieto is located in the Arboretum. Remnants of early reforestation plantings may still be found in various locations in the CNF, Carite, Río Abajo, and Guilarte. A more recent successful plantation is located in Guajataca.

**Management and Growth**—Capa prieto may be underplanted if the shade is not too dense and seedlings are liberated within about 5 years. Probably the best growth will be obtained by planting in cleared sites at normal spacings (about 3 by 3 m). Careful weeding will be necessary for 4 or 5 years. Height growth ranges from 0.4 to 1 m/yr, depending on site quality. Diameter growth of trees given enough space to develop full crowns will average about 1 cm/yr. Trees in thinned plantations should reach harvestable size (0.5 m d.b.h.) in about 50 years. Maximum heights and diameters reached in Puerto Rico are about 22 m and 1.0 m, respectively.

**Benefits**—Capa prieto wood dries and machines easily. Its wood is used for furniture, cabinetry, turnery, carpentry, posts, pulp, and charcoal. The species is used to shade coffee and, to a limited extent, as an ornamental.

**References:** Bates 1939, Brush 1925b, Francis 1989f, Francis and Rodríguez 1993, Institute of Tropical Forestry 1963, Kramer 1925, Liegel and Stead 1990, Longwood 1961, Marrero 1974b, Marrero 1949a, Marrero 1949b, Marrero 1950, Martorell 1953, Tropical Forest Experiment Station 1949, Tropical Forest Experiment Station 1951, Tropical Forest Experiment Station 1952, Wadsworth 1949, Wadsworth 1960, Wadsworth and Englerth 1959, Wolcott 1946.

***Eucalyptus deglupta* Blume**

**MYRTACEAE**

**Deglupta**



*Deglupta* is a large, straight tree with a striking, multicolored bark. This native of several Southwest Pacific islands has been received enthusiastically in Puerto Rico as an ornamental and timber tree.

**Seed and Nursery**—Seed production is heavy in open-grown and dominant trees and often begins at age 3 or 4. Racemes of mature, green capsules are clipped from trees and packed in paper bags loosely to dry, and then shaken to separate the seed. There are 15,000 to 18,000 seeds/g. The seeds are germinated on wet peat. Seedlings should be pricked into containers when they are about 5 cm in

height and will be ready for outplanting within 3 or 4 months after sowing. If drought stress is avoided at outplanting, survival is good.

**Site Requirements**—For good growth, *deglupta* requires rich, friable soils below 200 m in elevation receiving between 1800 and 3500 mm of precipitation. Plantations usually fail on poor soils and at high elevations.

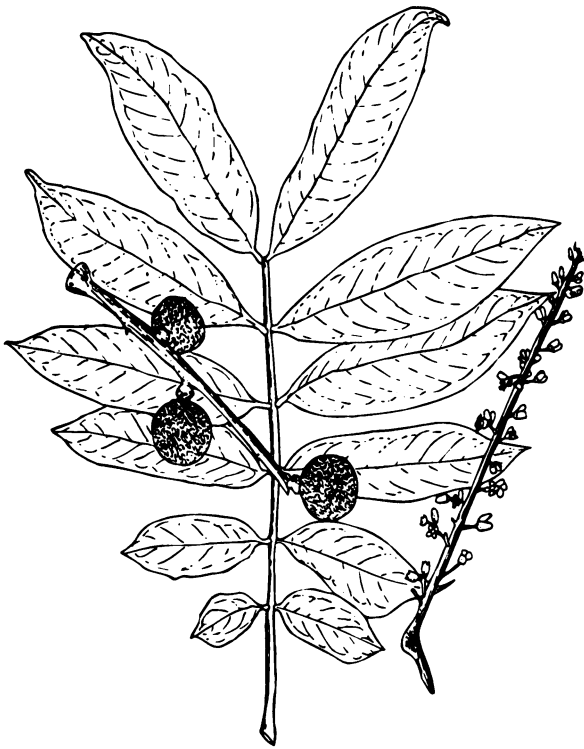
**Location of Plantings**—Provenance trials were installed on private property near Yabucoa, at Río Abajo, and on the Guzmán tract in the CNF. Small, pure plantings were installed at Bosque Vega, Cambalache, and on private property near Humacao.

**Management and Growth**—Initial plantation spacings of 2.5 by 2.5 to 3.5 by 3.5 m are recommended, followed by early thinnings to maintain 15 to 30 m<sup>2</sup>/ha. On good sites in Puerto Rico, one may expect between 16 and 25 m of height growth in 8 years and 25 to 35 m of height in 16 years. Mean diameters in closed stands will be between 20 and 30 cm in 16 years. Volume yields of 15 to 30 m<sup>3</sup>/ha/yr can be obtained on rotations of 15 years or longer. Rotations of 15 to 30 years are recommended.

**Benefits**—*Deglupta* yields pulpwood and furniture-grade lumber. It is also planted as an ornamental because of its attractive, multicolored bark.

**References:** Figueroa and Whitmore 1980, Francis [n.d.], Francis 1995a, Lugo and Francis 1990.

***Guarea guidonia* (L.) Sleumer**  
**MELIACEAE**  
**American muskwood, guaraguao**



*Puerto Rico's largest native Meliaceae species, American muskwood is very common in secondary moist and wet forests. Tiny amounts of red fruit around the seeds attract birds that disperse the seeds widely.*

**Seed and Nursery**—Fruiting of American muskwood is discontinuous throughout the year. Seeds may be picked off the ground under fruiting trees or removed from clipped branches when capsules are starting to open. Generally, seeds are difficult to collect in quantity. They lose viability quickly, and drying is fatal; so it is best to plant the seed immediately after collection. There are about 2,500 seeds/kg and about half may be expected to germinate. Older Forest Service plantings with bare-root seedlings and large, top-pruned wildlings were successful.

**Site Requirements**—American muskwood grows well on hillsides in moist and wet forests where rainfall ranges between 1500 and 3000 mm/yr. A wide variety of soil types are suitable. Because seedlings planted in the open usually die, planting should be under light to medium shade, as is provided under *Albizia procera*, *Spathodea campanulata*, and other pioneer species.

**Locations of Plantings**—A number of successful plantings have been documented in Carite, the CNF, Guilarte, Río Abajo, and Toro Negro forests. However, because of the difficulty in distinguishing planted trees from the common and widespread naturally regenerated trees, these plantations have not been located or measured in recent years.

**Management and Growth**—After underplanted American muskwood have become established and grown to sapling size, the overstory should be removed in at least 2 stages. The objective is to develop long boles before opening the crowns to full sunlight. Seedlings and saplings grow about 0.5 m/yr in height and 0.5 cm/yr in diameter. Diameter growth of American muskwood trees in secondary forests averaged 0.6 cm/yr with dominant trees adding 0.9 cm/yr.; plantations probably will grow as well or better. American muskwood trees are capable of reaching more than 1 m in d.b.h. and 27 m in height. It is generally a less robust tree than *Swietenia macrophylla* and should probably be harvested at about 0.5 m, which it can be expected to reach in 70 to 80 years.

**Benefits**—The heartwood of American muskwood is reddish brown and easily worked. This termite-resistant wood is used for furniture, cabinetry, veneer, turnery, and trim. Lower quality material is used for fenceposts, firewood, and charcoal. American muskwood is a common shade tree in coffee plantations and is occasionally planted as an ornamental.

**References:** Chudnoff and Goytia 1972, Englerth 1960, Longwood 1961, Marrero 1947b, Marrero 1949a, Marrero 1949b, Marrero 1950b, Martorell 1953, Tropical Forest Experiment Station 1950, Wadsworth 1943c, Wadsworth 1944c, Wadsworth 1949, Wadsworth and Englerth 1959, Weaver 1988, Wolcott 1940, Wolcott 1946.

***Hibiscus elatus* Sw.**

**MALVACEAE**

**Mahoe, majo**



*This native of Cuba and Jamaica is well adapted to Puerto Rico and has naturalized in most of the sites where it has been planted. Mahoe is distinctive for its clean, straight boles, heart-shaped leaves, and orange flowers.*

**Seed and Nursery**—Seed production begins at 3 or 4 years in plantations and proceeds throughout the year. Collection of seed is difficult because most of the green capsules are eaten by fruit bats, and the capsules, which generally grow high above the ground, open and release their seeds on maturity. The seeds, which average 54,000/kg, germinate at low to moderately high rates in fine sand. The seedlings are pricked into nursery bags, reach about 0.5 m in height, and are ready for outplanting

in about 1 year. Wildlings are also collected and grown to plantable height in nursery bags. Stem cuttings from seedlings and small saplings can be rooted in moist soil.

**Site Requirements**—Mahoe requires sites that receive at least 1500 mm of precipitation and an ample supply of exchangeable basic cations. Sites from near sea level to the beginning of the cloud forest will support mahoe. Deep soils on midslope, toe-slope, and along creek bottoms are best, whereas ridges and eroded sideslopes generally produce slow-growing and poorly formed trees.

**Location of Plantings**—There are plantations in Cambalache, Carite, the CNF, Guajataca, Río Abajo, and Toro Negro.

**Management and Growth**—An initial spacing of about 2 by 2 m is probably best with thinnings for poles or posts after 4 or 5 years to increase the spacing to about 4 by 4 m. In later years, basal areas should be maintained at 30 to 40 m<sup>2</sup>/ha. Height growth in the first 15 years averages a bit more than 1 m/yr and then slows gradually until the trees reach a maximum height of 25 to 35 m. Mean annual diameter increments range from 1.0 to 2.5 cm/yr; volume increments on good sites range from 15 to 24 m<sup>3</sup>/ha/yr. Mahoe trees should be considered for harvest after they reach 0.5 m d.b.h. at about 30 years.

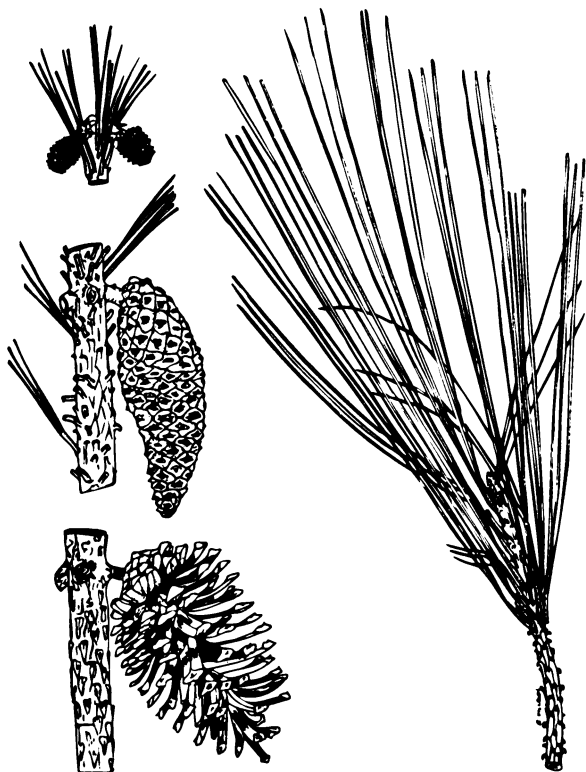
**Benefits**—Mahoe produces an unusually colored gray wood that is used in furniture, musical instruments, cabinetry, and interior trim. The tree is also planted as an ornamental.

**References:** Francis 1989c, Francis 1989f, Francis 1992d, Francis 1995a, Francis and Weaver 1988, Geary and Briscoe 1972, Institute of Tropical Forestry 1963, Longwood 1962, Lugo and others 1990a, Lugo and others 1993, Wadsworth 1960a, Wadsworth and Englreth 1959, Weaver and Francis [n.d.].

***Pinus caribaea* Morelet**

**PINACEAE**

**Caribbean pine, pino del Caribe**



*Caribbean pine is the pine species most completely adapted to the humid tropics. It is capable of producing more volume per acre than any other tree species in Puerto Rico. Three varieties of the species exist, of which the Central American variety, Pinus caribaea var. hondurensis, grows the most rapidly in Puerto Rico.*

**Seed and Nursery**—Seeds of Caribbean pine are collected by picking cones after they have begun turning from green to brown. The seeds are released as the cones dry and open. Seed yield is generally low in Puerto Rico; purchase of seed from foreign sources may be advisable. There are 50,000 to 80,000 seeds/kg. Fine sand or sandy soil is the best germination medium. After germination, seedlings are pricked into nursery bags or beds. Pine seedlings must be inoculated with mycorrhizal fungi. This may be done from cultures or by adding soil containing the spores. From 5 to 6 months are required

to grow seedlings to plantable size (15 to 25 cm). Containerized stock provides higher and more consistent survival than bare-root seedlings.

**Site Requirements**—Growth is remarkably consistent across a wide range of climates and sites in Puerto Rico. Planting in areas that receive less than 1200 mm of precipitation is not recommended nor in areas with limey soils or where the pH is > 7.0.

**Location of Plantings**—There are relatively large plantations in Carite, the CNF, around Toa Vaca reservoir, and on Department of Natural Resources property near Moca. Dozens of small plantings have been made on private and public lands across Puerto Rico.

**Management and Growth**—An initial spacing of 3 by 3 m is recommended with thinning after 8 to 15 years if sawlogs are the desired product. A somewhat closer spacing will yield a higher volume of posts or pulpwood. Height growth in the first 20 years averages between 0.75 and 1.5 m/yr. Diameter growth varies from 1 to 3 cm/yr depending on tree vigor. Maximum height in Puerto Rico is about 30 m. A few individual trees in Puerto Rico are approaching 1 m d.b.h. and are still growing rapidly. Small study plots at close spacing have shown increments as high as 50 m<sup>3</sup>/ha/yr. Yields on good sites over 15-year rotations ordinarily average 32 m<sup>3</sup>/ha/yr.

**Benefits**—Caribbean pine is useful as construction lumber, plywood, chipboard, millwork, and pulpwood. The species is planted for windbreaks, for reforestation of eroded sites and, to a limited extent, as an ornamental.

**References:** Balmer 1980, Barres 1964, Boone and Chudnoff 1972, Briscoe 1959, Briscoe 1960, Cuevas and others 1991, Francis 1992b, Francis 1992d, Geary and Briscoe 1972, Geary and Zambrana 1972, Hussain 1987, Institute of Tropical Forestry 1963, Lantz 1983, Ledig and Whitmore 1981, Liegel 1984a, Liegel 1984b, Liegel 1985, Liegel 1991, Liegel and others 1980, Liegel and others 1985a, Liegel and others 1985b, Liegel and Venator 1987, Lugo and others 1988, Lugo and Liegel 1987, Lugo and others 1990a, Marrero 1949b, Marrero 1961b, Marrero 1962a, Marrero 1962b, Marrero 1965a, Marrero 1965b, Muñoz and Hill 1967, Parresol and others 1987, Schubert and Zambrana 1982, Venator 1972, Venator 1976, Venator and others 1977a, Venator and others 1977b, Venator and Rodríguez 1977, Whitmore and Liegel 1980.

***Swietenia macrophylla* G. King**

**MELIACEAE**

**Big-leaf mahogany, caoba**



*Big-leaf mahogany, recognized as one of the best cabinet woods in the world, was introduced for timber production from Belize, Venezuela, and Panama. It has grown well and become naturalized almost everywhere it has been planted.*

**Seed and Nursery**—Dominant and codominant big-leaf mahogany trees produce seed annually, usually in early spring. There are about 1,800 seeds/kg. If possible, seeds should be used within 6 months of collection because by then they begin to lose viability. Seeds may be sown into germination trays or directly into nursery containers. A covering of about 1 cm of light soil or potting mix is adequate. Germination begins within

about 20 days and usually is complete within 50 days. When seedlings are about 50 to 100 cm tall, 6 to 12 months after sowing, they are ready for outplanting. They are usually grown in plastic nursery containers but also as bare-root stock, striplings, and as stump plants. Direct seeding has worked well on wet forest sites.

**Site Requirements**—Big-leaf mahogany can grow on sites in Puerto Rico that receive from 1000 to 3500 mm of m.a.p. Best growth is achieved in areas that receive about 1900 mm. Although alluvial and coluvial soils are best, a wide range of soils still provide good growth. Deeply eroded acid clays should be avoided. Big-leaf mahogany is susceptible to throw during high winds. Soils that offer shallow rooting, such as Ultisols with anaerobic subsoils, should be avoided.

**Location of Plantings**—Large plantations stocked with sawlog-sized trees are found in the CNF and Río Abajo. Smaller plantings may be found at Cambalache, Carite, Guajataca, Toro Negro, and the Boy Scout Camp near Guajataca.

**Management and Growth**—In Puerto Rico, early growth of about 1 m per year leads to maximum heights of 20 to 30 m. Diameter growth is around 1 cm through most of a tree's life, resulting in rotations of 40 to 80 years. Yields of about 8 to 12 m<sup>3</sup>/ha/yr are common in stands with basal areas of 18 to 25 m<sup>2</sup>/ha.

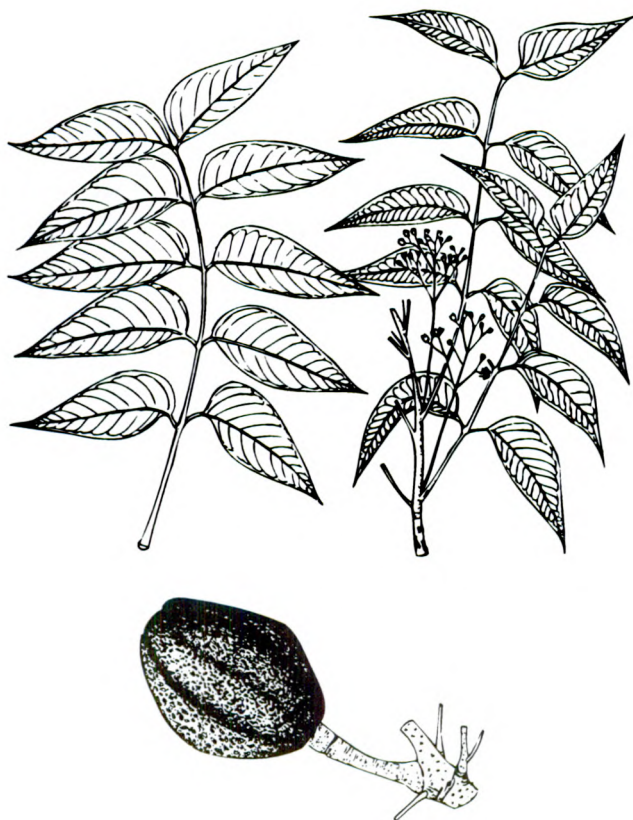
**Benefits**—Big-leaf mahogany is used to make furniture, interior trim, and plywood, as well as for construction, millwork, and arts and crafts. The tree is widely planted as an ornamental and avenue tree, although it breaks and raises sidewalks and curbs when its roots become large.

**References:** Bates 1939, Bauer 1987, Briscoe and others 1963, Brush 1925a, Ewel 1963, Francis 1992d, Francis and others 1996, Geary and others 1973, Glogiewicz 1986, Lugo and others 1990a, Lugo and others 1993, Marrero 1942b, Marrero 1943, Marrero 1947a, Marrero 1948, Marrero 1949a, Marrero 1950a, Martinez 1942, Scatena 1989, Southern Region 1991, Tropical Forest Experiment Station 1949, Tropical Forest Experiment Station 1951, Tropical Forest Experiment Station 1953, Tropical Forest Experiment Station 1954, Tropical Forest Research Center 1955, Tropical Forest Research Center 1957, Tropical Forest Research Center 1958, Wadsworth 1943c, Wadsworth 1949, Wadsworth and Englerth 1959, Wadsworth 1960a, Wolcott 1946.

***Swietenia mahagoni* Jacq.**

**MELIACEAE**

**West Indies mahogany, caoba dominicana**



*The West Indies mahogany is not native to Puerto Rico but grows and reproduces there very well. Its slower growth and smaller early stature make it a better choice as an ornamental than the big-leaf mahogany.*

**Seed and Nursery**—Open-grown, dominant, and codominant trees more than 12 or 13 years old produce seeds that are usually released between January and April. Ample seed can be collected by clipping capsules with a pruning pole when the first capsules on a tree begin to open. The collected capsules open after a few days of drying. There are about 7,000 air-dried seeds/kg. Seeds sown in moist potting mix or soil begin germinating in about 18 days and yield about 70 percent germination. Seedlings are maintained in the nursery for

9 to 12 months and planted as containerized stock or as top-pruned or stripling bare-root stock.

**Site Requirements**—West Indies mahogany is tolerant of drought, skeletal soils, free lime, high pH, and salt spray. No area in Puerto Rico receives too little rainfall to support this species. Wet areas (above 2000 mm precipitation) and low soil pH (< 6.0) are poor habitat for West Indies mahogany. It enjoys a competitive advantage in areas that are too dry or rocky for faster growing species.

**Location of Plantings**—West Indies mahogany was successfully used in an extensive reforestation of the Guajataca and Susúa State Forests. Significant plantations also grow in the Guánica State Forest, on private property near Peñuelas, in Vieques, and near Ponce. Mortality has claimed most of the trees in plantations established in the CNF.

**Management and Growth**—Initial spacing of 3 by 3 m is recommended, and thinning from below is effective when crowns begin to meet at 10 to 15 years. If not thinned, the more vigorous trees will dominate and suppress the rest. Height is strongly determined by site, and growth usually does not exceed 0.5 m/yr until stands reach a maximum of 15 to 30 m. The diameter growth of dominants varies by site from 0.3 to over 1.0 cm/yr and remains constant for as long as 200 years. Because of its constant growth over a long life, the West Indies mahogany can become an enormous tree.

**Benefits**—West Indies mahogany heartwood is expensive and is used for simulating and restoring classic furniture as well as for crafts. The species is also important for reforestation of dry sites and as an urban shade tree.

**References:** Bates 1939, Brush 1925b, Briscoe 1962, Francis 1991e, Francis 1992d, Francis and Liogier 1991, Francis and others 1996, Geary and others 1973, Glogiewicz 1986, Longwood 1962, Marrero 1947a, Marrero 1949a, Marrero 1950a, Marrero 1950b, Schubert 1979, Schubert and Zambrana 1978, Southern Region 1991, Tropical Forest Experiment Station 1949, Tropical Forest Experiment Station 1951, Tropical Forest Experiment Station 1954, Tropical Forest Research Center 1958, Wadsworth 1944b, Wadsworth 1947a, Wadsworth 1947b, Wadsworth 1948, Wadsworth 1949, Wadsworth 1960a, Wadsworth 1990, Wadsworth and Englerth 1959, Wolcott 1940, Wolcott 1946, Woodbury and others 1977.

***Swietenia mahagoni* x *macrophylla***

**MELIACEAE**

**Hybrid mahogany, caoba hibrida**



Wherever big-leaf and West Indies mahoganies grow near one another, hybrid seeds result. Because of their variability, hybrid mahogany can "custom fit" sites with variable conditions.

**Seed and Nursery**—The seeds of hybrid mahogany average 2,500/kg and yield over 80 percent germination. Hybrid seeds are handled similarly and behave in every respect like the seeds of *Swietenia macrophylla*. In the nursery, seedlings may be cultured and handled like *S. macrophylla*, although some of these seedlings with *S. mahagoni*-like traits will be smaller than the average seedlings at outplanting.

**Site Requirements**—Theoretically, hybrid mahogany are a 1:2:1 mixture of *S. mahagoni*, actual hybrid mahogany, and *S. macrophylla*. In reality, the progeny form a

continuum from the traits of one parent species to those of the other. This mixture of individuals with a wide range of traits imparts a great deal of site tolerance to a plantation. As a result, individuals not adapted to the particular site planted die or fall behind, leaving the adapted, individual trees to dominate the plantation. Hybrid mahogany is best planted in sites with a lot of variability and in areas between those ideal for West Indies mahogany and big-leaf mahogany. More specifically, hybrid mahogany should be planted in alluvial soils and deep, rich soils in the dry forest (less than 1000 mm precipitation), in the drier half of the moist forest (1000 to 1500 mm precipitation), and in sandy or shallow, rocky sites in the rest of the moist forest (1500 to 2000 mm precipitation).

**Location of Plantings**—Plantings of hybrid mahogany have been made on the CNF, in Cambalache, and along many highways and streets. There is a particularly nice group of hybrids in an urban setting at Camp Santiago, Salinas.

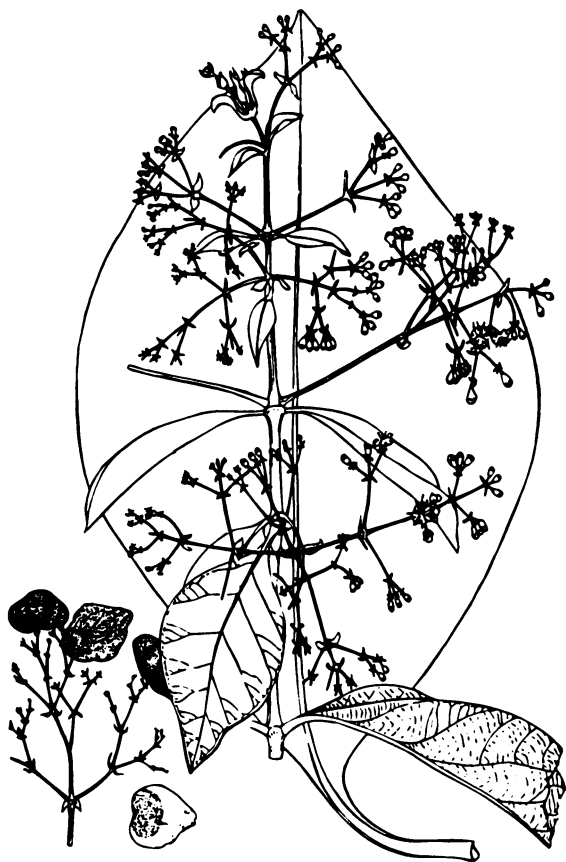
**Management and Growth**—Little is known about the best management and yield of hybrid mahogany in Puerto Rico. The hybrids will probably respond well to the same management schemes applied to big-leaf mahogany. Growth and yield will probably not differ markedly from big-leaf mahogany through most of the moist forest with the exception of shallow, rocky sites where the hybrids would probably have an advantage. In the dry forest, the growth and yield of hybrid mahogany would likely exceed that of West Indies mahogany. In the largest individuals on the CNF's Harvey plantation, hybrid mahoganys grow to at least 1 m d.b.h. and to heights of 30 m.

**Benefits**—The wood produced by hybrid mahogany appears to possess properties midway between those of the two parent species. A sampling of wood density (dry weight/green volume) from plantation-grown hybrids averaged 0.56 g/cm, between the values found for big-leaf and West Indies mahoganies. So far, relatively little of the wood has been available and has typically been sold as "caoba" (mahogany). Presumably, it can be used for furniture, turnery, trim, and crafts. Hybrid mahogany

are frequently planted along highways and for farm and city shade. Because of the tendency of its roots to raise and crack sidewalks and curbs, the hybrid, as well as other mahoganies, are not recommended for planting in confined spaces.

**References:** Bauer and Gillespie 1990, Francis and others 1996, Francis and Rodríguez 1993, Southern Region 1991, Weaver and Bauer 1986, Whitmore and Hinojosa 1977.

***Tectona grandis* L. f.**  
**COMBRETACEAE**  
**Teak, teca**



*This large-leafed native of Southeast Asia produces a very valuable wood. Reproduction has been seen in several areas in the understory of old teak plantations.*

**Seed and Nursery**—Seed production begins at 8 to 10 years and continues annually. Seeds are easily collected from logged trees or from the ground under plantation trees. There are about 2,000 seeds/kg. Germination is variable; cycles of soaking and drying are often used to improve it. Seedlings are grown in containers or planted as stump plants. Between 4 and 6 months are required to grow bagged seedlings, and stump plants take a year to develop.

**Site Requirements**—Elevation is not a limiting factor in Puerto Rico except in areas of high rainfall. In upland positions, teak in Puerto Rico grow between the high and low extremes of 1200 and 2500 mm of rainfall. Drier climates are tolerated along rivers or where extra moisture is available. Sites rich in exchangeable bases are best.

**Location of Plantings**—Plantations of significant size may be found in Río Abajo, Cambalache, and the CNF.

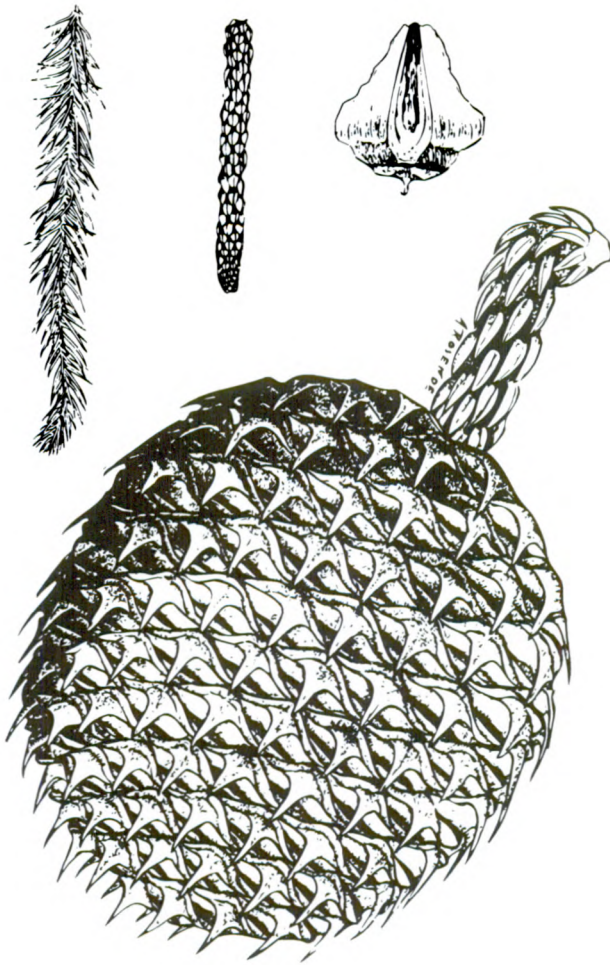
**Management and Growth**—Initial spacing of about 3 by 3 m is appropriate. A commercial thinning for posts, conducted from below to improve the form and mean vigor of the plantation, should follow at about 10 years. At least one intermediate thinning for small sawlogs should be conducted before final harvest at 70 to 80 years. Height growth of teak plantations is about 1.5 m/yr in the first 10 years, decreasing until a maximum height of 20 to 28 m is reached. Diameter growth varies from 0.5 to 1.0 cm/yr. Mean annual volume growth varies from 8 to 12 m<sup>3</sup>/ha/yr.

**Benefits**—Teak is the most expensive commercial wood produced in Puerto Rico. It is used for construction of pleasure boats, and for furniture, trim, and novelties. It is occasionally planted as a shade tree.

**References:** Bates 1939, Briscoe and Ybarra-Coronado 1971, Chudnoff and Goytia 1972, Englerth 1960, Francis 1992d; Francis 1995a, Friday 1987, Geary and Briscoe 1972, Marrero 1947b, Marrero 1949a, Marrero 1949b, Marrero 1950b, Tropical Forest Experiment Station 1950, Tropical Forest Experiment Station 1952, Tropical Forest Research Center 1958, Wadsworth 1949, Wadsworth 1960a, Wadsworth and Englerth 1959, Weaver 1993b, Weaver and Francis 1990, Wolcott 1946.

## Tree Species Widely and Successfully Planted for Purposes Other Than the Production of Sawlogs

*Araucaria heterophylla* (Salisb.) Franco  
ARAUCARIACEAE  
Norfolk-Island-pine



*Norfolk-Island-pine*, native only to Norfolk Island in the South Pacific, is a tall, stately conifer usually planted as an ornamental, although it possesses superior wood qualities. These trees rise above all other species on the skyline of Puerto Rican cities.

**Seed and Nursery**—Because local trees do not produce them, seeds are usually purchased from Australian

sources. They lose their viability quickly and must be planted in fine sand or potting mix upon receipt. There are about 1,200 seeds/kg. They germinate quickly with about 70 percent viability. New seedlings should be pricked into containers after the initial flush of growth. Partial shade is beneficial. If properly managed, seedlings reach 15 to 20 cm in one year and 60 to 75 cm by the end of the second.

**Site Requirements**—Norfolk-Island-pine is tolerant of a wide range of soil and climatic conditions. At least 1000 mm of well-distributed precipitation is required, but supplemental irrigation or runoff from roads enable growth as an ornamental throughout the island. The species will tolerate at least 3000 mm of annual rainfall, salt spray, a pH of 5.0 to 8.0, and poor, eroded soils. Most trees older than 25 years in metropolitan San Juan gradually lose vigor and eventually die, probably because of air pollution.

**Location of Plantings**—Small groves have been planted at the University of Puerto Rico Botanic Garden, Corozal Agricultural Experiment Station, and around homes near Aibonito and Coamo. Thousands of individual trees have been planted as ornamentals across the island.

**Management and Growth**—Initial spacings of 2.5 by 2.5 m to 3 by 3 m should suffice if trees are to be grown in solid blocks. Most Norfolk-Island-pines in Puerto Rico are planted individually, in rows, or in small groves. Growth is somewhat slow at first, but after 6 or 7 years accelerates to a fairly constant 1.0 m/year in height and 2 cm/yr d.b.h. The largest Norfolk-Island-pine reported in Puerto Rico measures 31 m high and 62 cm d.b.h. (1992) at about 33 years.

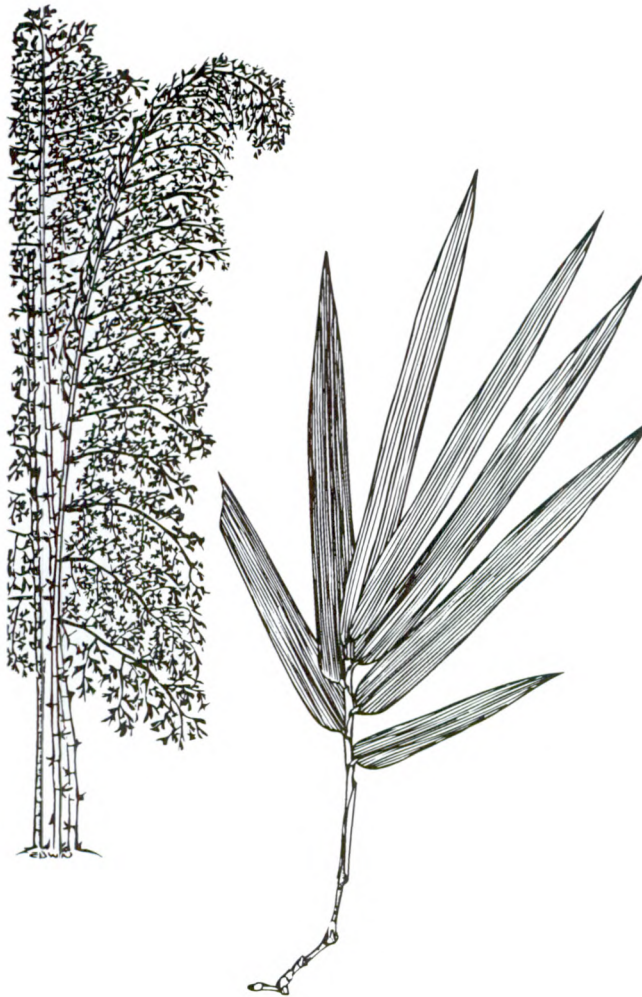
**Benefits**—Norfolk-Island-pine wood looks like a high-quality knotty pine lumber. However, its principal use is as an ornamental.

**References:** Francis [n.d.], Francis 1988a, Schubert 1979, Schubert and Zambrana 1982.

***Bambusa vulgaris* Schrad. ex Wendl.**

**GRAMINEAE**

**Common bamboo, bambú**



*Common bamboo, native of an unknown area in southern Asia, is a familiar sight along roads and streams in Puerto Rico. It has many ornamental and conservation uses.*

**Seed and Nursery**—Common bamboo rarely bears seed anywhere and has never done so in Puerto Rico. However, through a variety of vegetative propagation techniques, any number of new clumps of common bamboo can be started. Excavated rhizomes, the crown of rhizomes with a section of culm attached, and culms or culm sections can be planted directly in the field and

will root and grow. Branch cuttings should be grown in the nursery for about 2 years before moving to the field. Mulching around new plantings and watering during the first year are recommended.

**Site Requirements**—Cleared areas in moist and wet forests and along streams in dry forest are suitable sites. Clay soils are best, but common bamboo will grow on soils of any texture if they remain continuously moist. It will tolerate light salt spray and neutral soils. All elevations in Puerto Rico are acceptable.

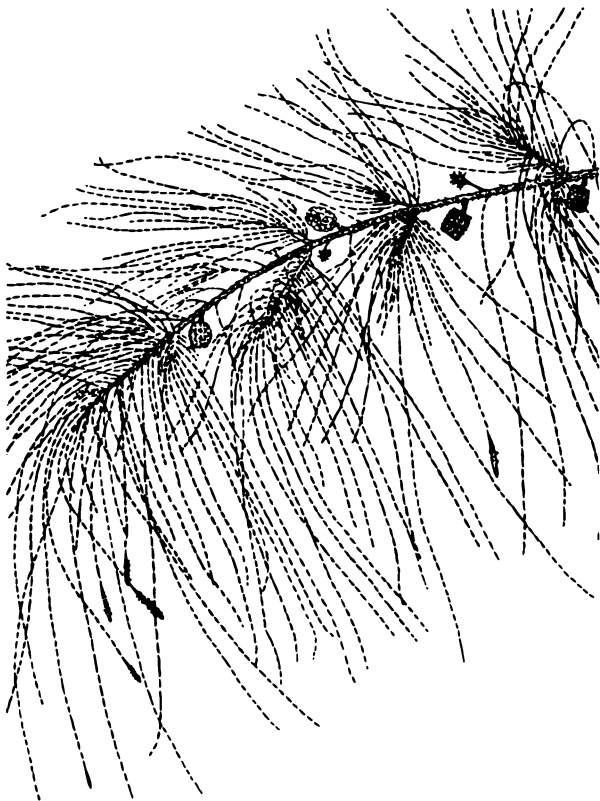
**Location of Plantings**—Common bamboo has been planted throughout the moist and wet parts of the island for over 100 years. Plantings are especially common along the banks of streams and reservoirs and on the fill side of road cuts in mountainous areas.

**Management and Growth**—Culms in established clumps develop very rapidly. They attain their full height of 10 to 20 m in about 3 months. In Puerto Rico, individual culms averaging about 8 cm d.b.h. may live for at least 4 years and sometimes as long as 12 years. Clumps develop slowly. It takes 7 to 9 years before new culms within clumps reach maximum height and diameter. Clumps more than 60 years old containing several hundred culms are present in Puerto Rico. Clumps can probably persist for hundreds of years if undisturbed and would expand continuously during that time. Yields of dry culms range from about 2 to 10 dry tons/ha/yr.

**Benefits**—Common bamboo culms have a multitude of uses, including the production of construction materials, pulp, crafts, and fuel. Harvested bamboo in Puerto Rico finds limited use for posts and fences, construction props, and crafts. Its principle benefits are soil stabilization on road fill, denuded sloped, and along river and reservoir banks. Clumps provide living fences and shade for cattle.

**References:** Chudnoff and Goytia 1972, Cruzado and others 1961, Englerth 1960, Francis 1993c, Francis and Liogier 1991, White 1948, Wolcott 1946.

***Casuarina equisetifolia* L. ex J.R. & G. Forst.**  
**CASUARINACEAE**  
**Casuarina, Australian pine**



*This tall tree with needle-like leaves (actually modified branches) is often called a pine, although it is, in fact, a hardwood. Native to Northern Australia and nearby islands, it has naturalized on disturbed areas in coastal sands and limestone hills in Puerto Rico.*

**Seed and Nursery**—When they change from green to brown, the cones are collected by clipping fruiting branches. Sun-dried, the cones open and release small, winged seeds. There are about 700,000 seeds/kg. Seeds should be used relatively quickly because they lose most of their viability within 1 year, even when refrigerated. Germination of fresh seed is normally between 40 and 90 percent on moist, well-lighted substrate. Seedlings can be pricked into pots after about 8 weeks when they reach 10 to 15 cm. Bareroot planting stock can also be produced. Care should be taken that new seedlings are exposed to nitrogen-fixing *Frankia* actinorhizal root

symbiotes. Usually, mixing some soil in which casuarina roots have grown into the germinating or potting medium is enough, although inoculation with cultured *Frankia* in solution is recommended for best results. Seedlings reach plantable size (20 to 50 cm) in 4 to 8 months.

**Site Requirements**—Casuarina is most competitive on sites in the moist coastal plain. It also grows well on upland sites if they are not too cool and wet. The soils should be at least moderately well drained. Casuarina does not prosper in the driest areas of Puerto Rico except where runoff or groundwater is available. Generally, rainfall should exceed 1000 mm/yr but not exceed 2500 mm/yr.

**Location of Plantings**—Casuarina has been planted around the coast and through the mountains of Puerto Rico, including almost all public forests of the island. Nearly all the trees have died in Guánica; remaining trees in the mountain forests are old and not regenerating. Casuarina has naturalized in Piñones and probably in other forests with moist coastal sands. It also reproduces naturally on excavated and cleared areas in the moist limestone hills when seed reaches them.

**Management and Growth**—Seedlings should be planted at 2-by 2-m to 3-by 3-m spacing. Managers should conduct the first thinning sometime between 5 and 10 years and should remove about half the stems. Wide spacing (6 by 6 m or more) will produce bushy, wide-crowned trees that may be more wind-firm and desirable as ornamentals. Four-year-old plantations on the Toa Baja Experimental Farm averaged 9.7 m in height and 7.7 cm d.b.h. Height growth may be as much as 3.5 m/yr in the first 1 to 3 years, gradually decreasing until a maximum height of 30 to 40 m is reached. Diameter growth of young free-to-grow trees usually exceeds 1.0 cm/yr and sometimes reaches 2.5 cm/yr. Older trees grow more slowly. Maximum diameter depends on how much buttress develops but rarely measures more than 1 meter. Trees older than 50 years generally show signs of senescence. Rotations for wood, charcoal, and pole production generally should be from 10 to 20 years. Casuarina is very sensitive to fire. Good protection against forest fires is essential.

**Benefits**—Casuarina is used in Puerto Rico for coastal dune stabilization, shade, wind- and soundbreaks, and as an ornamental. To a lesser extent, it is planted for firewood, fenceposts, and building poles.

**References:** Bates 1939, Brush 1925a, Brush 1925b, Chudnoff and Goytia 1972, Englerth 1960, Francis 1992d, Institute of Tropical Forestry 1963, Kramer 1925, Lugo and others 1993, Lugo and others 1990b, Marrero 1947b, Marrero 1949a, Marrero 1949b, Marrero 1950a, Marrero 1950b, Martorell 1953, Parrotta 1990a, Parrotta 1991a, Parrotta 1991b, Parrotta 1993a, Parrotta 1995, Parrotta and others 1996, Pennock 1967, Schubert 1979, Tropical Forest Experiment Station 1949, Tropical Forest Experiment Station 1953, Tropical Forest Experiment Station 1954, Tropical Forest Research Center 1958, Wadsworth 1943c, Wadsworth 1949, Wadsworth 1960a, Wadsworth 1990, Wadsworth and Englerth 1959, Wolcott 1946, Woodbury and others 1977.

## ***Cocos nucifera* L.**

### **PALMACEAE**

#### **Coconut palm, palma de coco**



*The stately and useful coconut palm is so familiar that most Puerto Ricans think it is native. It actually originated in the Asian-Pacific area.*

**Seed and Nursery**—Coconut palms are easily established by planting the nuts (buried to half their depth) or by transplanting small to tree-sized palms. The large fruits are variable in the time required to germinate but average about 4 months. The percentage of germination depends on variety. Because of the threat of lethal yellows disease that has been reported in adjacent islands, it is advisable to plant one of the "Philippine dwarf" varieties that have considerable resistance to the disease.

**Site Requirements**—Coconut palm grows best on sandy coastal or alluvial soils. It tolerates most other soil types, although it may grow slowly and bear few fruits. Waterlogged soils are not suitable. In Puerto Rico, the species grows in areas receiving from 700 to 2500 mm of precipitation, but areas receiving from 1200 to 2300 mm support the most productive trees.

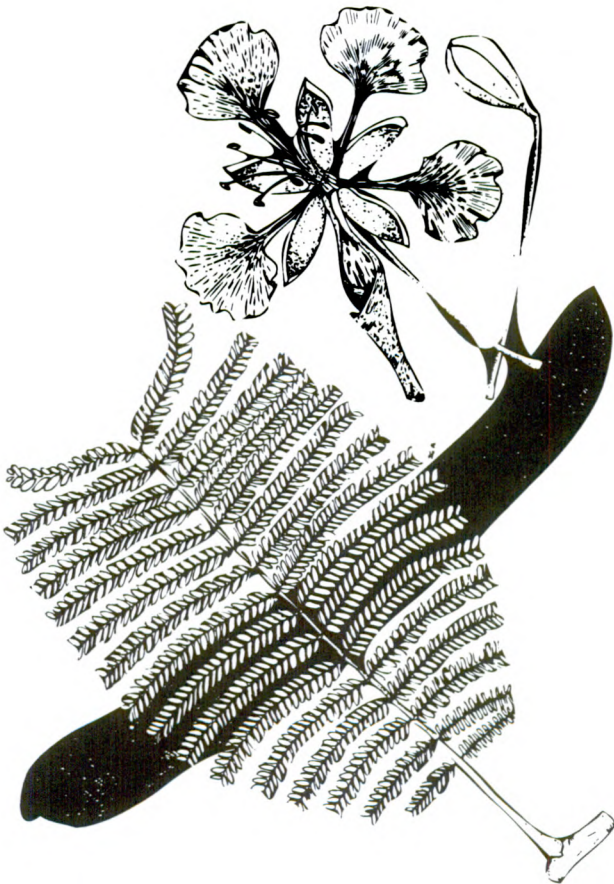
**Location of Plantings**—Coconut palm has been planted along all sandy shorelines in Puerto Rico and throughout the island in both urban and rural areas. It has naturalized in many areas, particularly on moist, sandy coastal soils that are not used as pasture. Although most of the plantings have been made to produce coconuts, many have been planted as ornamentals. In a few cases, they have been planted to stabilize beaches and revegetate the coastal strand.

**Management and Growth**—If coconut palms are to be planted in solid blocks or rows, a 9-m spacing is recommended. It takes about 5 years for the trunk base to form; growth rate depends on site conditions. Fertilization, cultivation, mulching, and irrigation are helpful. Under good conditions, coconut palm begins flowering at about 5 or 6 years when the tree is 2.5 to 4.5 m tall. In Puerto Rico, it reaches a maximum height of 15 to 28 m.

**Benefits**—The coconut was first cultivated for food in Puerto Rico. The large old groves were planted to create a copra industry for coconut oil. Although, for safety reasons, the planting of coconut is now prohibited along city streets and rural roads, the coconut palm remains an important ornamental in private yards, estates, and beachfront parks. The trunk is occasionally used for posts, and the fronds, for screens and shade canopies.

**References:** Calderón 1951, Francis and Liogier 1991, Little and Wadsworth 1964, Parrotta 1993b, Saavedra 1930, Schubert 1979, Winters and Almeyda 1953.

***Delonix regia* (Sojer) Raf.**  
**LEGUMINOSAE (CAESALPINIOIDEAE)**  
**Flamboyant tree, flamboyán**



*Flamboyant tree, a native of Madagascar, is one of the most familiar and loved trees in Puerto Rico. For its spectacular red-orange annual floral displays, this species is planted in every municipality on the island.*

**Seed and Nursery**—Flamboyant trees produce annual seed crops. There are about 2,050 seeds/kg. Seeds can be stored for several years but need to be scarified to ensure rapid and uniform germination. Germination begins about 8 days after sowing. One Puerto Rican trial documented a 76-percent germination. Seedlings are ready for outplanting in 5 to 6 months. Planting seedlings that have been grown in pots or plastic nursery bags is probably best.

**Site Requirements**—Flamboyant tree adapts to a wide range of soil and climatic conditions. It will grow in the driest parts of the island and in all but the wettest areas (up to about 3500 mm/yr precipitation). Poorly drained soils and the poorest exposed subsoils may not sustain flamboyant trees.

**Location of Plantings**—Flamboyant tree is planted as an ornamental throughout the island. It is probably the most common ornamental tree in Puerto Rico. It has naturalized in the moist limestone hills and, to a lesser extent, in moist volcanic areas. A small, direct seeding (30 seed spots) on very poor ground was conducted at St. Just. After 8 years, 17 spots were still occupied. Maximum height and d.b.h. were 7 m and 13 cm, respectively.

**Management and Growth**—Flamboyant trees may grow 1 m in their first year, up to 2 m in the second, and then height growth will slow until 6 to 20 m is reached. Diameter growth may vary from 1 to 2.5 cm/yr, depending on site quality and age of the tree. Old flamboyant trees tend to become rotten or hollow in the center.

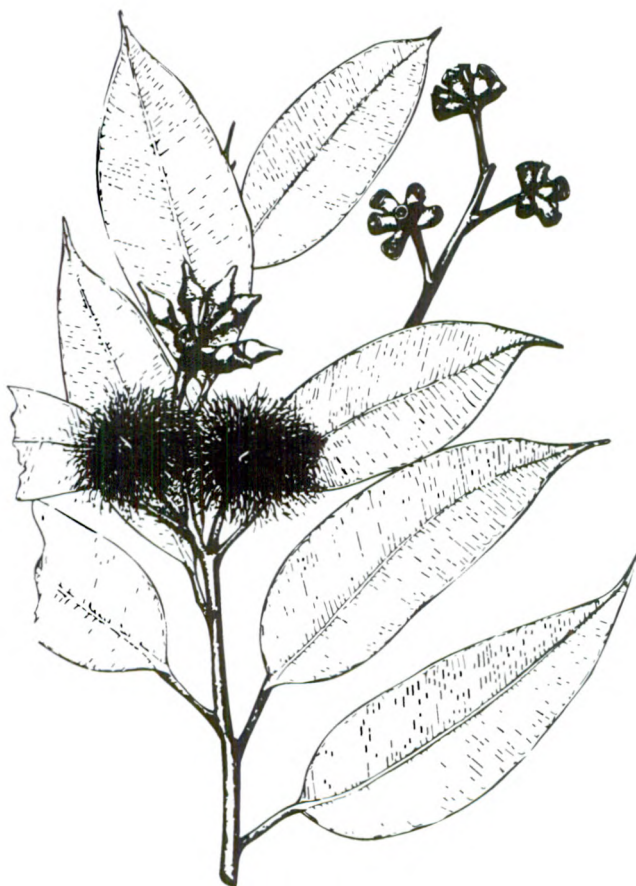
**Benefits**—Flamboyant tree is one of the most important ornamental trees in the world, and the beauty of its blossoms alone would justify its cultivation. Other incidental benefits include urban and farm shade, living fenceposts, and low-quality fuel. Flamboyant seeds are used in making jewelry.

**References:** Little and Wadsworth 1964, Marrero 1949a, Martorell 1953, Schubert 1979, Southern Region 1990, Wolcott 1940, Wolcott 1945, Wolcott 1946.

***Eucalyptus robusta* J.E. Smith**

**MYRTACEAE**

**Swamp mahogany, *robusta***



*Swamp mahogany, a native of Australia, has been the most aggressive and persistent of the eucalypts in wet upland areas of Puerto Rico. It has reproduced where mineral soil has been exposed by fire or heavy machinery.*

**Seed and Nursery**—Swamp mahogany produces seeds heavily and annually in Puerto Rico. Good seed can usually be obtained from open-grown trees by clipping capsule-bearing branches or by collecting them when the trees are felled. Capsules are placed in screen boxes to air-dry and open, and the boxes are shaken to extract the seeds. There are 400,000 to 600,000 viable seeds/kg of extracted (impure) seeds. The seeds are germinated on

the surface of wet peat. Germination begins in about 4 days. When the seedlings are 6 to 8 cm in height, they are pricked into plastic nursery bags. Plantable size (0.5 m) is reached in 4 to 6 months.

**Site Requirements**—Most swamp mahogany in Puerto Rico is planted on clay soils. However, the species is not site sensitive and even has been used to rehabilitate eroded sites. For good growth, rainfall should be at least 1500 mm/yr; rainfall up to 3500 mm/yr is tolerated.

**Location of Plantings**—Extensive plantations remain in Carite, Toro Negro, Maricao, and Monte Guilarte. Lesser areas of plantation grow in the CNF and on the Toa Baja experimental farm.

**Management and Growth**—Initial planting should be at about 3 by 3 m and thinning accomplished as soon as the crowns near closure. Areas within about a 2-m radius should be kept weeded for about 1 year, or until the seedlings are well above the weeds. Then, vines should be periodically controlled for about 1 year. Four-year-old trees in the Toa Baja Experimental Farm averaged 9.4 m in height and 10 cm d.b.h. on sandy soil. Basal areas of intermediate age stands are from 40 to 70 m<sup>2</sup>/ha. Thinnings should be designed to reduce basal areas to the lower end of this range. Usual yields on better-than-average sites are 10 to 25 m<sup>3</sup>/ha/yr on rotations of 25 to 50 years.

**Benefits**—Swamp mahogany produces a beautiful wood, but because of physical problems (hardness, difficulty in seasoning, and tendency to warp afterwards), it is not often used for furniture and interior decorations. The principal use in Puerto Rico is for treated fenceposts. The wood also makes good-quality fuel and charcoal. Swamp mahogany is planted for reforestation and as a roadside ornamental.

**References:** Birdsey and Jimenez 1985, Brush 1925b, Chudnoff and Goytia 1972, Englerth 1960, Francis 1992d, Francis 1995a, Marrero 1949a, Marrero 1949b, Marrero 1950a, Marrero 1950b, Parrotta 1995, Pennock 1967, Tropical Forest Experiment Station 1949, Tropical Forest Experiment Station 1950, Tropical Forest Experiment Station 1951, Tropical Forest Experiment Station 1952, Tropical Forest Experiment Station 1953, Tropical Forest Experiment Station 1954, Tropical Forest Research Center 1958, Wadsworth 1943c, Wadsworth 1949, Wadsworth 1953, Wadsworth and Englerth 1959.

***Gliricidia sepium* (Jacq.) Walp.**  
**LEGUMINOSAE (PAPILIONOIDEAE)**  
**Mother of cocoa, mata-ratón**



*Mother of cocoa is a small exotic tree widely planted in Puerto Rico as a living fencepost and for cattle forage. It also graces the fence rows and roadsides with an annual pink floral display.*

**Seed and Nursery**—Mother of cocoa bears seed in moderate quantities in the drier portions of Puerto Rico but rarely in moist or wet areas. The pods are picked by hand or clipped from low trees as they turn from yellow to brown. The pods open after drying, and the seeds can be shaken out. There are about 8,000 seeds/kg in the types found in Puerto Rico. Seeds germinate readily and reach plantable size in 2 to 3 months. Normally, mother

of cocoa is established for living fenceposts using cuttings 1.5 to 2.0 m long and 5 cm or more in diameter at the large end. The cutting is planted as a post and fencing wire stapled to it. Cuttings 10 cm or more in diameter root and grow best.

**Site Requirements**—Excluding water logged, very salty, and very acidic soils (lower than pH 5.0), mother of cocoa grows on almost all Puerto Rican sites. Establishment by cuttings becomes more difficult on dry sites; the use of seedlings planted during the wet season is recommended.

**Location of Plantings**—Mother of cocoa is planted as a living fence and as an ornamental throughout Puerto Rico. The species was included in a comparative growth test at the Toa Baja Experimental Farm.

**Management and Growth**—Mother of cocoa seedlings planted at Toa Baja had 72 percent survival and reached 3.8 m of height after 28 months. Diameter growth is about 2 cm/yr in Puerto Rico. Trees established from cuttings grow about 2 m in the first year on favorable sites. Mother of cocoa trees occasionally exceed 0.5 m d.b.h., but old trees are very rough and usually hollow.

**Benefits**—Again, the principal use of mother of cocoa in Puerto Rico is for living fence posts. The species is also planted as an ornamental because of its showy pink flowers.

**References:** Hernandez 1930, Marrero 1949b, Marrero 1961a, Martorell 1953, Parrotta 1990a, Parrotta 1991b, Parrotta 1992a.

***Inga vera* Willd.**  
**LEGUMINOSAE (MIMOSOIDEAE)**  
**Guaba**



*The native guaba is the preferred coffee-shade species in Puerto Rico. Most of the guaba in secondary forests owes its origin to the cultivation of shaded coffee.*

**Seed and Nursery**—The seeds are borne in a cylindrical pod containing a sweet, white pulp. Seed weights have not been documented but are estimated at around 2,000 or 3,000/kg. The seeds will not withstand drying (recalcitrant) and begin germination in the pod just before or after it falls. Pods should be clipped from fruiting trees with pruning poles. Seeds are separated from the pods by hand and should be planted immediately.

Germination of undamaged seed approaches 100 percent, and seedlings emerge within 2 weeks. They are typically ready for outplanting as containerized seedlings in 3 or 4 months.

**Site Requirements**—Guaba usually requires from 1200 to 4000 mm of precipitation. It grows well in a wide range of soil types on the moist coastal plain and through the mountains. Soils with a pH of 5.0 to 7.5 support guaba trees. Droughty, deep sands and shallow, rocky sites should be avoided when establishing plantations. Slope and aspect do not seem to affect survival and growth.

**Location of Plantings**—Guaba is common on nearly all secondary forest sites that have been coffee plantations. It is also managed in a few active, shaded coffee plantations. An Arboretum plot planted with guaba 30 years ago is still vigorous.

**Management and Growth**—A guaba plantation established below *Casuarina equisetifolia* on a moist forest site at Río Abajo reached a height of 0.9 m in 1 year, 1.2 in 2 years, 1.8 m at the end of 3 years, and 6 m at the end of 5 years. Growth is fastest in full sunlight. At 24 years, trees in the Arboretum plot averaged 78 percent survival, 14 m in height, and 11.2 cm d.b.h. Diameter growth in closed stands may be as low as 0.33 cm/yr, but open-grown trees may reach 2.5 cm/yr.

**Benefits**—The principal use for guaba has been coffee shade. To a limited extent, the wood is used for charcoal and for fenceposts. Its fruit is eaten by birds and other wildlife, and its flowers attract honeybees.

**References:** Birdsey and Weaver 1982, Chudnoff and Goytia 1972, Englerth 1960, Marrero 1949b, Marrero 1954, Rodríguez 1990, Tropical Forest Experiment Station 1951, Wadsworth 1944c, Wadsworth and Englerth 1959, Wolcott 1946.

***Lagerstroemia speciosa* (L.) Pers.**  
**LYTHRACEAE**  
**Queen-of-flowers, reina de las flores**



*Queen-of-flowers* is one of the most spectacular flowering trees in the tropics. It is native to Southeast Asia.

**Seed and Nursery**—Annual seed production is abundant, although germination in Puerto Rico is only 14 percent.

**Site Requirements**—Growth is reasonably good in most of Puerto Rico. Trees in dry areas, which receive run-off from roads or roofs or are irrigated, do well. Apparently, rainfall between 1000 and 2000 mm/yr is optimal. There is some indication that the species is not as healthy in high-rainfall areas. A wide range of soil types are tolerated, including partially compacted fill dirt. Planting in poorly drained sites should be avoided.

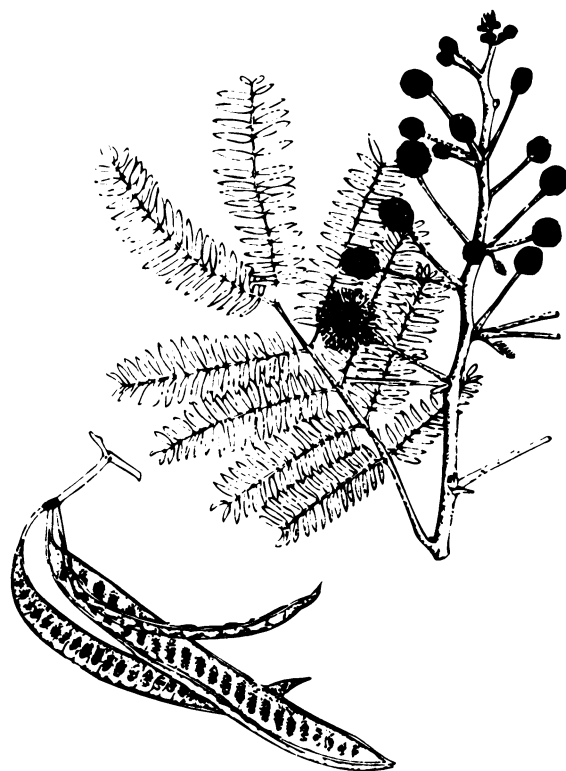
**Location of Plantings**—Queen-of-flowers is planted throughout Puerto Rico along streets and in yards and parks. No forestry plantations are known.

**Management and Growth**—Early height growth is about 0.5 m/yr until the tree reaches a height of about 20 m. Diameter growth of open-grown trees is a little over 1 cm/yr. There is no indication as to how old or large Queen-of-flowers can get, but the largest in Puerto Rico is approaching 1 m d.b.h.

**Benefits**—Queen-of-flowers is a spectacularly beautiful ornamental. Large, lacy lavender-to-pink flowers cover the tree when in full bloom. Although not yet harvested commercially in Puerto Rico, the species produces furniture-quality wood.

**References:** Francis and others 1996, Little and Wadsworth 1964, Pennock 1967, Schubert 1979.

***Leucaena leucocephala* (Lam.) de Wit**  
**LEGUMINOSAE (MIMOSOIDEAE)**  
**Leucaena, zarcilla**



*The shrubby strain of leucaena has been naturalized in Puerto Rico for 200 years or more. A Mexican variety known as K-8, which was introduced for agroforestry and conservation purposes, grows very rapidly and becomes a medium-sized tree.*

**Seed and Nursery**—*Leucaena* seeds can be collected in quantity by clipping the pods from the trees after they turn brown and then shelling the seeds from the dried and partially opened pods. There are 17,000 to 21,000 seeds/kg. The seeds will germinate erratically without scarification. Hot-water or acid treatments will bring speedy and uniform germination. Seedlings should be grown in containers and will be ready to outplant in 10 weeks when they are about 20 to 40 cm. Alternatively, direct seeding in prepared seedspots works well.

**Site Requirements**—*Leucaena* grows well in a wide range of soils, including ones that are calcareous, rocky, and eroded. Acid soils (lower than pH 5.0) with low exchangeable calcium give poor results. It does not do well in poorly drained soils or in areas that receive more than 2000 mm m.a.p.

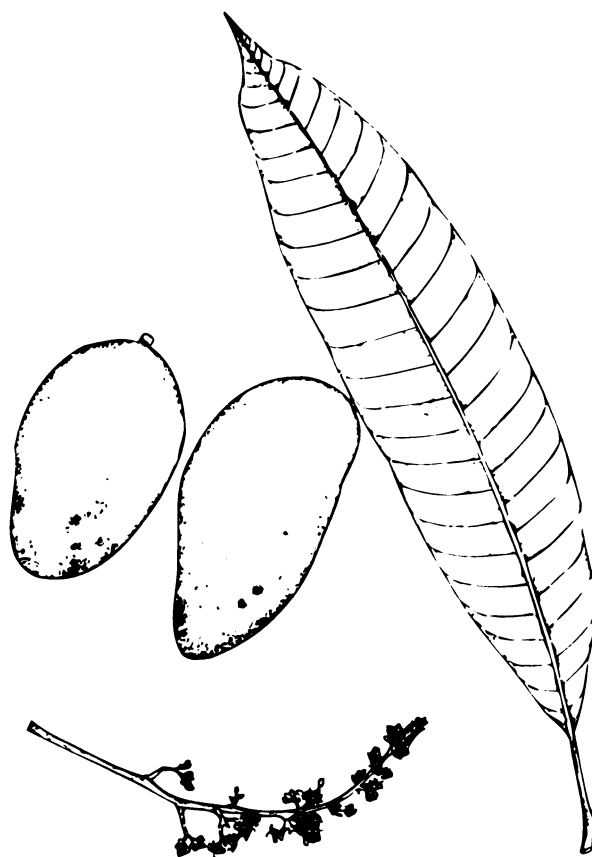
**Location of Plantings**—The shrubby variety of *leucaena* can be found in all moist and dry parts of Puerto Rico. Plantations of the giant variety of *leucaena* have been established at Cambalache, Guánica, Toa Baja Experimental Farm, Camp Santiago in Salinas, and the Vieques Ammunition Storage Facility. The latter variety has naturalized at all these locations and on other sites where the shrubby variety has been planted.

**Management and Growth**—For the purpose of this discussion, we assumed that only the giant variety will be planted. Spacing requirements depend on the objective for planting *leucaena*. For soil stabilization, spacing should be narrow, perhaps 1 by 1 m, for small-diameter fuelwood, about 2 by 2 m, and for small diameter sawlogs, about 3 by 3 m. The site should be weeded 2 or more times during the first year. Height growth in Puerto Rico during the first 5 years is usually about 2 m/yr, although it may be as low as 1 m/yr on difficult sites. Height growth slows after the fifth year until a maximum height of about 20 m is reached. Diameter growth ranges from about 1.0 to 3.0 cm/yr. Three replicates of a 4-year-old plantation averaged 8.4 m in height and 7 cm d.b.h. One plantation collected a 7.7 t/ha/yr accumulation of stem and large-branch biomass. Rotation ages and diameters have not yet been reached for this species in Puerto Rico. It will probably be difficult to grow *leucaena* older than 20 to 25 years, at which time it will probably measure 25 to 45 cm d.b.h.

**Benefits**—*Leucaena* is used for wood products, forage, and agroforestry elsewhere, but, in Puerto Rico, it is used mainly to revegetate disturbed sites and, to a lesser extent, to make charcoal or as an ornamental.

**References:** Francis 1993g, Francis and Liogier 1991, Lugo and others 1990b, Lugo and others 1993, Marrero 1949a, Parrotta 1990a, Parrotta 1991a, Parrotta 1991b, Parrotta 1992b, Parrotta 1995, Parrotta and others 1996, Wadsworth 1990, Wang and others 1991.

***Mangifera indica* L.**  
**ANACARDIACEAE**  
**Mango**



*Mango* is a much appreciated fruit tree grown in all parts of Puerto Rico. Although it originated in southern Asia, it has naturalized in many secondary forests that were formerly farm land.

***Melicoccus bijugatus* Jacq.**  
**SAPINDACEAE**  
**Genip, quenepa**

**Seed and Nursery**—Mango seeds should be cleaned and air-dried before planting but lose their viability within 80 to 100 days. They weigh about 25 g each and germinate within about 1 month of sowing. The seedlings will be about 45 to 60 cm in height and ready for outplanting in about 6 months. If mango trees are being planted exclusively for fruit production, improved varieties and grafted stock are desirable. Mango seeds are dispersed by humans and cattle and will germinate well on moist ground.

**Site Requirements**—Mango trees grow on a wide range of soils within the 1000 to 2600 mm/yr rainfall zone. However, growth is very slow on eroded clays. Mango seedlings have an intermediate tolerance to shade and are very competitive with brush but not with grass.

**Location of Plantings**—Mango has not been cultivated in forestry plantations but is included in this discussion because it is widely planted as a fruit or shade tree in cities and on farms. To some extent, it has naturalized in nearly all of the moist secondary forests of Puerto Rico.

**Management and Growth**—Height growth may be as much as 1 m/yr in early years and diameter growth varies from 1 to 2 cm/yr. Old mango trees often exceed 1 m in diameter and 30 m in height.

**Benefits**—Mango is planted almost exclusively as a fruit tree but also serves as a pasture and roadside shade tree and living fencepost. It can make a handsome ornamental, but the rotting fruit can be offensive if trees are planted near dwellings and along walkways. Mango wood is used in places other than Puerto Rico for construction, furniture, and fuel.

**References:** Francis 1995a, Francis and Liogier 1991, Gregory and Velez 1946, Little and Wadsworth 1964, Parrotta 1993d, Schubert 1979, Wolcott 1940.



*Genip is a native of Venezuela but has naturalized in many areas of Puerto Rico. Its fruits are harvested from trees in dooryards and secondary forests and are sold locally.*

**Seed and Nursery**—The fruits are harvested with pruning poles and can be purchased on the roadside in season. Seeds are usually saved after eating the fruit. There are about 400 seeds/kg, and they will germinate at a relatively high rate beginning about 28 days after sowing. Seedlings may be grown in plastic nursery bags and take about 18 months to reach plantable size (40 cm in height).

**Site Requirements**—Genip grows best along streams and rivers in drier portions of the island. However, the species can be grown on most soils in areas of Puerto Rico that receive less than 2000 mm m.a.p.

**Location of Plantings**—Genip has not been cultivated in forestry plantations but is widely planted or nurtured after natural reproduction for yard and fencerow fruit trees.

**Management and Growth**—Because growth is slow, protection from weed encroachment must be maintained for at least 2 years following outplanting. Little growth information is available, although height growth for open-grown trees is probably about 0.5 m/yr and diameter growth, about 1 cm/yr. Genip trees up to 24 m in height and over 1 m d.b.h. have been documented.

**Benefits**—The tasty fruit is the principal benefit of the genip. The tree is attractive enough that it is planted to some extent as an ornamental. Genip wood is useful for furniture, fenceposts, and fuel. Presumably, wildlife as well as people consume the fruits.

**References:** Francis 1992a, Francis and Liogier 1991, Francis and Rodríguez 1993.

***Pterocarpus macrocarpus* Kurz**  
**LEGUMINOSAE (PAPILIONOIDEAE)**  
**Burma padauk, terocarpus**



*Burma padauk, a native of southeastern Asia, is one of the most common shade and ornamental trees in urban areas of Puerto Rico. It produces a furniture-quality hardwood, although it has not been exploited yet in Puerto Rico.*

**Seed and Nursery**—Seeds are produced in abundance and are available all year. They can be picked up under large trees or cut with pruning poles. There are about 1,000 pods/kg, each of which contains 2 or 3 seeds. Usually germinated through the pods, seedlings must be thinned to one per pod or separated as they are pricked into nursery containers. They are ready for outplanting in about 6 months.

**Site Requirements**—Burma padauk grows best in areas that receive 1000 to 2000 mm/yr of rainfall. It tolerates a wide array of soil conditions including calcareous soils and eroded sites.

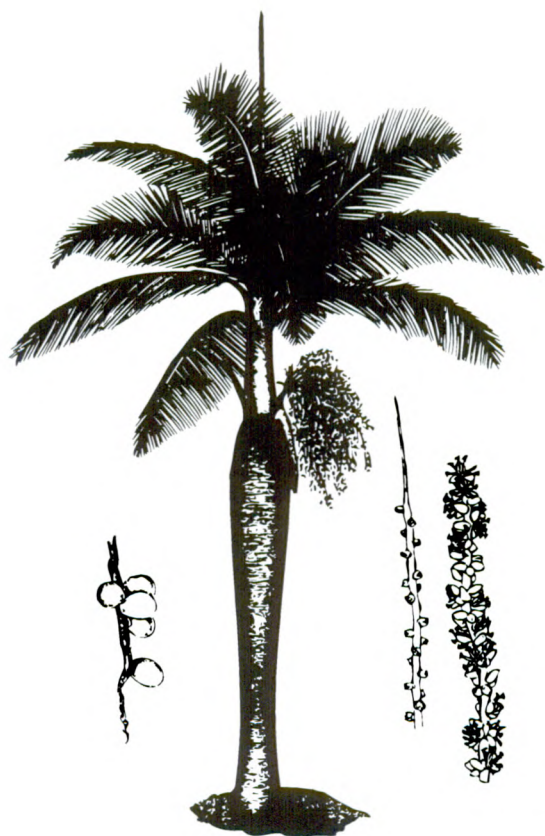
**Location of Plantings**—Limited test plantings have been made within the Arboretum and in the adaptability trials. This species is one of the most commonly planted urban trees in Puerto Rico and has naturalized in a few moist areas.

**Management and Growth**—An initial spacing of 3 by 3 m is probably suitable, followed by thinnings after a few years. Because the sapwood is thick, fairly large trees (1 m d.b.h.) are necessary to develop high-quality sawlogs. Cultivation for that purpose requires wide spacing after the commercial bole length is set as well as moderately long rotations (40 to 70 years). On good sites, the first year's growth is about 1 m, after which height growth increases to 1.5 to 2.0 m/yr, gradually slowing until a maximum height of 25 to 35 m is reached. Diameter increments vary from 0.8 to 2.0 cm, depending on site and freedom of crowns from competition. Burma padauk is one of the worst species for breaking and raising sidewalks and curbs. It should be planted at least 3 m from sidewalks, curbs, and foundations.

**Benefits**—The principal use of Burma padauk is as an ornamental and shade tree. The wood is similar to, but lower in quality than, teak, its forest associate in Indochina. Its wood is used for furniture, carpentry, and posts. The heartwood is resistant to rot and termites.

**References:** Francis 1989d, Francis 1989f, Francis 1992d, Francis and Liogier 1991, Francis and Rodríguez 1993, Steele 1981.

***Roystonea borinquena* O.F. Cook**  
**PALMACEAE**  
**Puerto Rico royal palm, palma real**



*Puerto Rico royal palm is a familiar and stately feature of the Puerto Rican urban landscape as well as secondary forests.*

**Seed and Nursery**—This palm is used in landscaping, principally by transplanting trees of advanced size from farms and forests to urban areas. Nursery seedlings are produced from seeds gathered under fruiting palms. There are about 3,000 seeds/kg. Germination in fine sand, the best medium, begins in about 14 days and can reach as high as 80 percent. Seedlings grown in plastic nursery bags reached 30 cm in 6 months, 40 cm in 8 months, and 90 cm in 15 months. Palms for commercial sale are propagated from seed and grown to a height of about 6 m.

**Site Requirements**—Puerto Rico royal palm grows naturally in a wide variety of soil types in areas that receive from 1200 to 2500 mm of m.a.p. Planted trees grow well in areas with up to 3000 mm of m.a.p. It is tolerant of poorly drained soils.

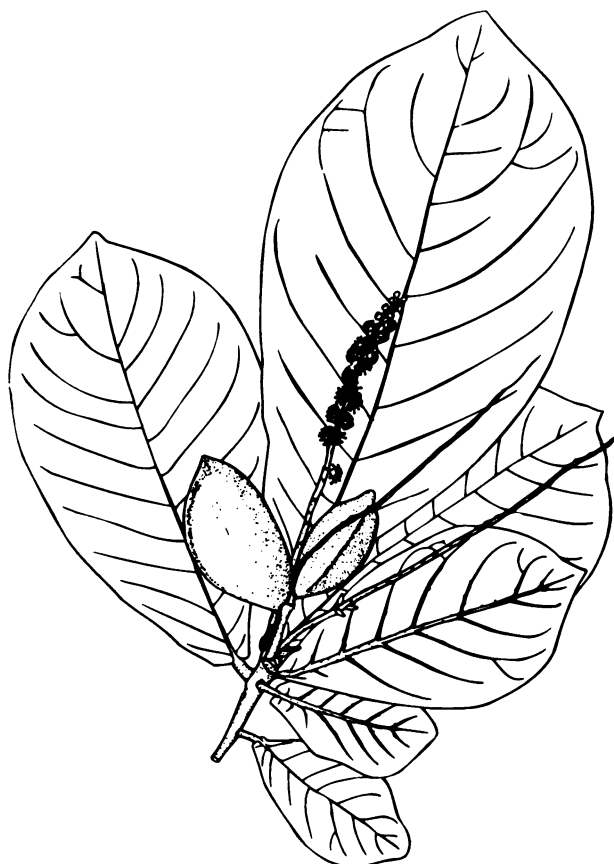
**Location of Plantings**—The Puerto Rico royal palm is planted throughout the island as an ornamental. On farms, it was once widely protected after reproducing naturally. Many farm groves still remain. No plantations established for forestry purposes have been documented.

**Management and Growth**—Up until fruit production begins at 7 to 14 years, Puerto Rico royal palm grows about 1 m/yr, after which time growth is slow. The tree reaches a maximum height of 18 to 26 m. Once set, diameters of 30 to 70 cm are stable.

**Benefits**—Puerto Rico royal palm is a very important ornamental species and produces an oil-rich fruit that is important to wildlife, particularly birds. Puerto Rico royal palm was once very important to subsistence farmers. The fruits were food for pigs and chickens, leaves were used for thatch, trunks were hewn into house boards, the heart was eaten as a vegetable, and, when forage was scarce, the interior of the trunk was fed to cattle.

**References:** Brush 1925b, Domínguez 1989, Francis 1992c, Francis and Rodríguez 1993, Schubert 1979, Wolcott 1940, Wolcott 1946.

***Terminalia catappa* L.**  
**COMBRETACEAE**  
**Indian almond, almendra**



*Indian almond is a relatively fast-growing exotic adapted to urban and forest plantings in coastal areas, especially on sandy soils. It is easily recognized by its large leaves, which turn yellow and red at senescence, and even tiers of branches.*

**Seed and Nursery**—There are about 24 fresh fruits/kg and about 160 nuts/kg. The nuts are gathered from under fruiting trees after the paricarp has been eaten or rotted off. They are sown in moist sand or potting mix and begin germination in about 20 days. Seventy percent germinated in one Puerto Rican test. Seedlings grown in plastic nursery bags under light shade can be ready to outplant within 3 months after emergence.

**Site Requirements**—Indian almond grows best in coastal sandy soils and in the loams of river floodplains in the moist forest type (1000 to 2000 mm m.a.p.). Most soil types are tolerated. In drier sites on the island, the tree only grows along watercourses or where supplemental water is available. In high rainfall areas (> 2500 mm/yr m.a.p.), Indian almond tends to poorer health and higher mortality than elsewhere.

**Location of Plantings**—Indian almond is planted in every Puerto Rican municipality and is especially common in coastal areas. The species has naturalized and become a component of secondary forests in coastal areas, especially on sandy soils. Only one forest planting (the Arboretum) is known. It grows reasonably well there but still below the species' potential.

**Management and Growth**—On good coastal sites, early height growth is about 1 m/yr, and diameter throughout the life of the tree will average about 1 cm/yr. Indian almond occasionally reaches 23 m in height and exceeds 1 m d.b.h.

**Benefits**—Indian almond is important as an ornamental. It produces a furniture-quality wood with a pleasing light-brown color and soft grain pattern. The seeds have an almond-like flavor. Their use is limited by the difficulty in extracting them. The fleshy fruit surrounding the nut is a favorite food of fruit bats and naturalized parrots.

**References:** Francis 1989e, Francis 1989f, Longwood 1961, Marrero 1949a, Martorell 1953, Pennock 1967, Schubert 1979, Southern Region 1990, Winters and Almeyda 1953, Wolcott 1940, Wolcott 1945, Wolcott 1946.

# Trees, Including Timber, Agroforestry, Conservation, and Ornamental Species, That Have Shown Promise in Institutional Tests and Private Plantings in Puerto Rico

## ***Acacia auriculiformis* A. Cunn. ex Benth.**

**LEGUMINOSAE (MIMOSOIDEAE)**

**Ear-pod wattle, auriculiformis**

Ear-pod wattle is a very attractive and hardy legume recently introduced in Puerto Rico. On a moist, sandy site at Toa Baja, individuals in a test planting grew to a height of 5.8 m in 28 months and to 9 m in height and 10 cm d.b.h. in 4 years. On shallow, eroded soil that covers volcanic rock at Albergue Olimpico (900 mm rainfall), tree seedlings grew 2.6 m in 2 years. The species produces annual seed crops that can be collected by clipping dry pods from the trees. A brief hot water treatment or overnight soaking is useful before the seed is sown. Samples of seed collected in Puerto Rico averaged 48,000 /kg and germinated at rates of 47 to 65 percent. Seedlings grow well in plastic nursery bags in light shade or full sun. The species is probably most useful as an ornamental and to rehabilitate disturbed areas in zones that receive less than 1800 mm of precipitation.

**References:** Parrotta 1990a, Parrotta 1991b.

## ***Adenanthera pavonina* L.**

**LEGUMINOSAE (MIMOSOIDEAE)**

**Jubie-beads, peronías**

Jubie-beads is a medium-sized tree from tropical Asia that has naturalized in several areas of the island. Trees were planted along trails and roads of public forests during reforestation efforts throughout the late 1930's and 1940's. Today, some of the original trees and much reproduction is found in Río Abajo, Cambalache, Guajataca, and St. Just. The largest of these is 45 cm d.b.h. and 24 m tall. Jubie-beads produces abundant annual crops of bright red seeds that number about 3,500 /kg. Germination occurs rapidly and at a high percentage. Seedlings develop quickly. The wood is hard and heavy and may be employed in crafts and as fuel. Seeds are used to make necklaces and novelties. To a limited extent, the jubie-beads tree has been used as an

ornamental and in agroforestry. Because of its aggressive reproduction, jubie-beads is not recommended for reforestation in the moist limestone hills.

**References:** Francis and Liogier 1991, Little and Wadsworth 1964.

## ***Agathis robusta* (C. Moore) F.M. Bailey**

**ARAUCARIACEAE**

**Queensland kauri**

Queensland kauri possesses beautiful dark-green foliage and a smooth gray bole. Although it is a conifer, its broad leaves resemble those of hardwoods. It produces high-quality lumber, which is suitable for construction and molding. The plant also is used as an ornamental in parks and on estates. Seed is not produced often, but wildlings can sometimes be collected in the Maricao forest. A year in the nursery is required to obtain modest-sized seedlings, which should then be planted at about 3 x 3 m. Height growth is slow in the first year following outplanting, but, after 2 or 3 years, the seedlings grow 0.5 to 1.0 m/yr. Fully stocked stands eventually form a dense canopy. Queensland kauri trees in Puerto Rico reach a height of 20 to 25 m in 25 to 30 years, after which they become round-topped and grow slowly. Diameter growth of individual trees is 1 to 2 cm/yr, depending on crown position. The largest tree in Puerto Rico measured 115 cm d.b.h. and was 22.5 m in height at 53 years. The species can be planted in areas ranging from sea level to 600 m or more. Sites should receive rainfall of at least 1600 mm/yr. Queensland kauri is tolerant of a wide range of soil pH and fertility. Plantations have been established successfully in Maricao, Toro Negro, and the CNF. The species is resistant to hurricanes and suffers no known insect or disease problems.

**References:** Francis [n.d.], Francis 1988a, Little and others 1974, Marrero 1950b, Tropical Forest Research Center 1958, Wadsworth 1960a.

***Albizia carbonaria* Britton**  
**LEGUMINOSAE (MIMOSACEAE)**  
**Carbonero**

Descendants of carbonero plants raised from seed imported from Colombia by the Forest Service in 1921 have spread over about 100 acres along the Adjuntas bypass. They are also said to be common on a farm near Coamo. Most of the trees observed by the author have many spreading branches and a thin crown of feathery leaves. Diameters and heights range up to 59 cm and 20 m, respectively. The trees in Adjuntas produce seed in abundance but only reproduce on bare ground. However, growth appears good on road cuts that offer low nutrient levels and poor physical conditions. Carbonero wood is light weight and light brown in color. Possibly the best uses for this species are for reclaiming disturbed sites, providing coffee and farm shade, and as an ornamental.

**References:** Little and others 1974 .

***Albizia lebbek* (L.) Benth.**  
**LEGUMINOSAE (MIMOSOIDEAE)**  
**Woman's tongue, acacia amarilla**

Woman's tongue is a legume with medium-to-fast growth, which has naturalized extensively along roads, in untended areas and, to some extent, in early secondary dry forests. Early height growth in moist habitat is a little over 1 m/year, and diameter growth may reach 3 cm/yr. However, in dry habitat and later in the tree's life within moister habitats, growth is much slower. The largest woman's tongue known in Puerto Rico is 70 cm d.b.h. and 10 m height. The species was cultivated in early reforestation efforts, but selected sites chosen were too wet, and failure was universal. Research and conservation plantings at Toa Baja and Albergue Olimpico have been fairly successful. Woman's tongue is occasionally planted as an ornamental and is also used in making charcoal.

**References:** Kramer 1925, Marrero 1947a, Parrotta 1987, Parrotta 1992c, Parrotta 1993e, Parrotta 1993f, Parrotta [n.d.]a.

***Albizia procera* (Roxb.) Benth.**  
**LEGUMINOSAE (MIMOSACEAE)**  
**White siris, albizia**

White siris, a native of tropical Asia and Australia, was once planted widely for reforestation, farm shade, and fuelwood. Because these trees live no longer than 15 to 25 years in Puerto Rico, none of the original plantations remain. Although farmers and cattlemen regard it as a pest because it so aggressively invades pastures, white siris yields some benefit to farmers by providing shade, forage, and erosion protection. Although it is not used for such purposes in Puerto Rico, the species produces a good-quality furniture wood that is resistant to dry-wood termites. There is a very abundant annual production of seeds, which can be harvested by clipping the pods from trees as they begin to dry. There are about 20,000 seeds/kg. A high percentage of seeds will germinate within a few days on almost any medium. Under full sun, seedlings will reach plantable size (30 to 50 cm) within 3 months. White siris grows well on good soils that receive from 1000 mm to 2400 mm of rainfall. Soil fertility requirements are not high. Early growth is typically 2 m/yr, which gradually slows until the white siris reaches 20 to 25 m. Diameter growth of dominants is 2 to 3.5 cm/yr. A timber management strategy for the species involves direct sowing or planting at fairly close spacing, followed by precommercial thinning to improve form and eliminate diseased trees. Such a strategy would result in rotations of 15 to 20 years.

**References:** Bates 1939, Brush 1925b, Chinea-Rivera 1992, Francis and Rodríguez 1993, Lugo and others 1990b, Marrero 1947b, Marrero 1949a, Parrotta [n.d.]b, Wadsworth 1943c.

***Aleurites moluccana* (L.) Willd.**  
**EUPHORBIACEAE**  
**Candle-nut, nuez de vela**

This stately tree was imported for the drying oil its seeds yield. The hard-shelled nuts are slow to germinate, but candle-nut seedlings are easily grown. Growth is rapid on moist and fertile sites. Candle-nut trees from a Queensland source planted in the Arboretum demonstrate good form and have reached more than 0.5 m d.b.h. The wood is soft, susceptible to stain and rot, and is not commercially valuable. The species is occasionally planted as an ornamental.

**References:** Francis 1989f, Francis and Liogier 1991, Moulaert and Francis 1993.

***Andira inermis* (W. Wright) DC.**  
**LEGUMINOSAE (PAPILIONOIDEAE)**  
**Cabbage angelin, moca**

Cabbage angelin is one of the most important native timber species. The large seeds (30/kg) are easily collected from the ground after fruit bats have eaten the rind. If planted fresh, they may yield 100 percent germination and, in one test, storage at room temperature for 6 weeks resulted in a loss of only 20 percent. Because the seed is large, seedlings develop a root system and add roughly 15 cm of height very quickly. Cabbage angelin was used to direct-seed a number of deforested areas during the 1930's and 1940's. However, because growth is relatively slow, high mortality or complete failure generally resulted when the seedlings were smothered by weeds and secondary forest trees. At Guajataca, annual height growth in the first 9 years averaged only about 0.3 m/yr. Cabbage angelin planted in partial shade in Cambalache attained a maximum height of only 1.5 m at 10 years. Cabbage angelin planted as an ornamental grows about 0.5 m/yr. If the species is to be grown in plantations, it should be planted on moist, fertile sites and given good protection from weeds for at least 3 years. Because of its slow growth, faster growing alternative species such as *Swietenia macrophylla* may be better choices for plantations. Cabbage angelin produces pink flowers and makes a good ornamental and shade tree.

**References:** Bates 1939, Chudnoff and Goytia 1972, Englerth 1960, Francis and Rodríguez 1993, Marrero 1947a, Marrero 1949a, Marrero 1950b, Pennock 1967, Wadsworth and Englerth 1959, Weaver 1989a, Wolcott 1946.

***Anthocephalus chinensis* (Lam.) A. Rich. ex Walp.**  
**RUBIACEAE**  
**Kadam**

The flowering of kadam usually begins when trees are 4 or 5 years old. Ripe fruit can be gathered from the ground. To clean the seeds, which total about 20,000/g, the fruits are macerated and wet sieved. They store well refrigerated in air-tight containers and may be germinated on moist peat, soil, or fine sand under a moisture barrier cover. Kadam seedlings should be pricked-out after 3 or 4 weeks and will be ready for out planting about 3

months later. Kadam requires high fertility soils with good structure. Alluvial soils are best. On non-riparian sites, rainfall should be at least 1500 mm/yr. All elevations in Puerto Rico are suitable for the species. Height growth may exceed 3 m/yr in the first 2 years but decreases rapidly to about 1 m/yr. Typically, diameter growth of dominant and codominant trees ranges from 1 to 2 cm/yr for 25 to 50 years. The largest kadam trees in Puerto Rico have reached 90 cm d.b.h. and have attained heights of 31 m. Depending on the desired products, rotations are between 15 and 40 years. Kadam wood is used elsewhere for interior construction lumber, utility plywood, match blocks, mill stock, and pulpwood. Small plantings of kadam are widely scattered across Puerto Rico, and several hectares of the species have been cultivated in the CNF and within well-developed stands with natural reproduction in Río Abajo.

**References:** Francis 1989f, Francis 1992d, Francis and Liogier 1991, Geary and Briscoe 1972, Institute of Tropical Forestry 1962, Institute of Tropical Forestry 1963, Lugo and Figueroa 1985, Lugo and Figueroa [n.d.], Lugo and others 1990a, Marrero 1965b, Venator and Zambrana 1975.

***Araucaria bidwillii* Hook.**  
**ARAUCARIACEAE**  
**Bunya-pine**

As with other members of the genus, bunya-pine grows slowly at first. Seedlings add only about 0.3 m/yr in the first 2 years. Height growth then increases to 0.5 to 1.0 m/yr. There are about 50 small trees scattered in several small groups (including the Arboretum) along with single-specimen plantings. These remain generally healthy, and few have died. This species might be used to produce timber in moist forests if the growth rate does not taper off after a few years. Bunya-pine is most often planted as a curiosity on estates and in gardens that have ample room for a wide-crowned, spiny plant. To date, seeds have been imported from Australia.

**References:** Francis 1988a, Pennock 1967.

***Araucaria columnaris* (Forst.) Hook.**

**ARAUCARIACEAE**

**Columnar-pine**

Seeds of columnar-pine were brought from Hawaii and immediately planted. More than 100 seedlings reached plantable height (about 20 cm) in about 1 year. A plot of 49 was established under a heavily thinned overstory. After 1 year in the field, about 44 were alive and averaged about 40 cm tall. After 7 years, their height ranged from 1 to 4 m. The rest of the seedlings were dispersed as ornamentals. Two planted on the grounds of IITF are very healthy and have grown to 5 and 6.5 m, respectively, in 7 years. As a young tree, columnar-pine is almost identical to the Norfolk-Island-pine, and it appears as suitable for ornamental purposes.

***Artocarpus altilis* (S. Park.) Fosb.**

**MORACEAE**

**Breadfruit, pana**

Breadfruit was imported long ago and widely cultivated for the starchy fruit it produces. Another variety is cultivated for its edible seeds. The seedless variety reproduces from root suckers and aggressively maintains its position in the secondary forest stands that arose following the abandonment of subsistence farms. Therefore, breadfruit is a common feature of secondary forests in the moist-to-wet portions of Puerto Rico. Both height and diameter growth are rapid. Heights of nearly 30 meters are reached on favorable sites, and diameters of more than 0.5 m are not uncommon; but the wood is currently of little value. Breadfruit is widely planted as a dooryard fruit tree, and it has a potential for commercial cultivation.

**References:** Parrotta 1994a.

***Bambusa glaucescens* (Willd.) Siebold & Holt**

**GRAMINEAE**

**Pigmy bamboo, bambu enana**

Pigmy bamboo is native to China. Although culm diameters (1 to 2.5 cm) are smaller and the clumps shorter than those of the common bamboo, the culm wood is very strong and resilient. The smaller culm size also makes pigmy bamboo strikingly different from the

larger-culmed bamboos. Fairly extensive and very healthy plantings are present in the Botanic Garden and in Toro Negro above Lago Guineo. Pigmy bamboo can be established by the same means described for common bamboo.

***Bambusa longispiculata* Gamble ex Brandis**

**GRAMINEAE**

This bamboo, a native of India, was introduced in 1932 and tested in Mayaguez, Río Piedras, the CNF, St. Just, and Toro Negro. The species is not easily distinguished from other bamboos planted in Puerto Rico. Management is similar to *Bambusa vulgaris*.

**References:** Tropical Forest Experiment Station 1949, Tropical Forest Experiment Station 1951, Tropical Forest Research Center 1955, White 1948.

***Bambusa tulda* Roxb.**

**GRAMINEAE**

This large bamboo species was brought from India in 1903. It is similar in size, appearance, and vigor to *Bambusa vulgaris*. However, it is much more resistant to bamboo powder-post beetle (*Dinoderus minutus* (F.)) attack and, for that fact, should be favored when seeking material for manufacturing purposes. It is also known for its very straight culms. Test plantings were made in Mayaguez, Río Piedras, Toro Negro, the CNF, and Cambalache. A number of clumps in one area of the CNF flowered in 1995 and 1996 and have produced numerous seedlings. Planting of cuttings is still recommended, as is management similar to that used in the cultivation of *B. vulgaris*.

**References:** Tropical Forest Experiment Station 1949, Tropical Forest Experiment Station 1954, White 1948, Winters and Almeyda 1953.

***Bambusa tuldoidea* Munro**

**GRAMINEAE**

Brought from China, this bamboo is similar in appearance to *Bambusa tulda*, although it is somewhat inferior in form and powder-post beetle resistance. The species has been tested successfully in Mayaguez, Río

Piedras, Toro Negro, the CNF, and St. Just. Although there is some degree of uncertainty about location of the various species in these tests, this bamboo, with the other species, continues in large, healthy clumps. Management should be essentially the same as used with *B. vulgaris*.

**References:** Tropical Forest Experiment Station 1949, Tropical Forest Research Center 1955, White 1948.

***Buchenavia tetraphylla* (Aublet) R. Howard**  
**COMBRETACEAE**  
**Granadillo**

Granadillo is a large native tree common in moist and wet forests. Although individual trees bear fruits at long intervals, when a fruiting tree is found, a large quantity of seed can be collected from the ground. Seeds germinate well and are ready to outplant in 6 to 7 months. Small plantings have been made at St. Just, Toro Negro, and Catalina. Early survival was good, and height growth was between 20 and 60 cm/yr. However, mortality continued until the St. Just and Catalina plantings were considered failures. A few trees probably remain in Toro Negro, but it has not been possible to differentiate them from naturally reproduced trees. Recent conservation plantings have been made in Baranquitas, Bosque Vega, the CNF, and Aguas Buenas. First-year survival has been good. Although native trees do grow on eroded ridges, growth rates in plantations indicate that the only chance for success will be on deep, relatively fertile soils.

**References:** Chudnoff and Goytia 1972, Englerth 1960, Francis and Rodríguez 1993, Marrero 1947a, Marrero 1949a, Weaver 1991, Wolcott 1946.

***Byrsonima spicata* (Cav.) H.B.K.**  
**MALPIGHIACEAE**  
**Maricao**

Maricao is a native species that grows in moist and wet forests. It produces a wood suitable for fine furniture, cabinetry, and flooring. However, its growth has proved too slow to justify investing in plantations for wood production. Test plantings were made at Río Abajo, Cambalache, and Maricao. In the plantings at Río Abajo, heights of dominants and codominants in 15 years were about 12 m and d.b.h.'s, about 10 to 17 cm. The plantation at Bosque Maricao stagnated. Maricao makes

a pretty ornamental and has been planted to a limited extent for that purpose. The fruits it produces are eaten by wildlife.

**References:** Chudnoff and Goytia 1972, Englerth 1960, Francis 1990a, Longwood 1961, Marrero 1947a, Marrero 1949a, Marrero 1950a, Marrero 1950b, Sposta 1960, Wadsworth 1943c, Wolcott 1946.

***Cariniana legalis* (Mart.) O. Ktze.**  
**LECYTHIDACEAE**  
**Jaquitiba-branco**

Jaquitiba-branco is a large tree native to Brazil that produces a valuable wood used for furniture, paneling, carpentry, and millwork. A 49-tree plantation at the Arboretum had a 96-percent survival at 4 years and averaged 2.9 m in height. The trees were very healthy and had good form. A single tree planted at IITF headquarters at the same time was 5 m tall. Early indications are that this will be an excellent plantation species. Seed must be imported from Brazil.

**References:** Moulaert and Francis 1993.

***Casuarina cristata* Miq.**  
**CASUARINACEAE**  
**Scalybark casuarina, pino australiano**

Plantings of scalybark casuarina (thought to be *Casuarina lepidophloia* at planting) were made at St. Just and Cambalache in 1944. A row had already been planted at the experiment station in Río Piedras and probably elsewhere on the island. Initial survival at St. Just was about 50 percent. Growth in both forests was very fast. First-year height growth was from 2 to 3 m. Year-3 heights ranged from 6 to 11 m. By year 10, maximum heights were 25 m and maximum d.b.h.'s approached 25 cm. At year 12, most of the plantation at Cambalache was lost to Hurricane Betsy, although the scalybark casuarina continued to grow from sprouts. In St. Just, maximum heights at 15 years were 27 m, and maximum d.b.h.'s were 31 cm (average of 24 cm). At least 5 old trees are still present at the picnic area in Cambalache, and they range from 16 to 21 m tall and between 30 and 45 cm d.b.h. A number of pole-sized root sprouts are also present. The Río Piedras trees have all disappeared. Although production of cones and seed is common in Puerto Rico, there appears to have been no

reproduction from seed. Local seed tests described about 100,000 seeds/kg and only 4 percent germination. Root cuttings were used with high success to produce seedlings in the nursery.

**References:** Little and others 1974.

***Catalpa longissima* (Jacq.) Dum. Cours.**

**BIGNONIACEAE**

**Yokewood, catalpa, roble dominicano**

Yokewood is a beautiful tree native to Hispaniola and Jamaica. It produces a beautiful and very workable wood that is used for furniture, trim, millwork, flooring, and general carpentry. It is sometimes planted as an ornamental and for agricultural shade. A 2-ha plantation of yokewood now approaching sawlog size is growing well at Cambalache. Large individual trees are present on sites at the University of Puerto Rico at Mayaguez, the Navy ammunition storage facility in Viequez, the Botanic Garden, and the Albergue Olimpico. The species can be propagated from seed and cuttings. Long, wire-like pods produce winged seeds (about 600,000 seeds/kg). Sown on wet soil or dusted lightly with moist sand, the seeds begin to germinate in about 10 days. Seedlings grown in plastic nursery bags under full sun are ready to outplant in 10 to 14 weeks. Yokewood grows in areas receiving between 500 and 2000 mm of rainfall. Best growth on upland sites occurs in areas receiving more than 1400 mm. Solid planting at 3-by 3-m spacing is recommended. On marginal sites, height and diameter growth may be as little as 0.5 m/yr and 0.5 cm/yr, respectively. On the best sites and in the early years, outstanding individual trees may grow nearly 2 m/year in height and 5 cm/yr in diameter. Trees averaging 0.5 m d.b.h. could be expected on reasonably good sites in 50-year rotations. Puerto Rican yokewood trees have reached nearly 30 m tall and 1 m in diameter.

**References:** Francis 1990b, Francis and Rodríguez 1993, Marrero 1950b, Tropical Forest Experiment Station 1953, Wolcott 1946.

***Cavanillesia platanifolia* H.B.K.**

**BOMBICACEAE**

**Quipo**

Quipo is native to Panama and Colombia. Single trees were test-planted in Casa María, San German, and on the University of Puerto Rico campus at Río Piedras. In

addition, about 6 trees are growing at the Mayaguez station grounds. All are large, robust, and healthy. Quipo trees grow up to 1 m in height annually in early years. Diameter growth depends on site and may vary from 1.1 to 3.8 cm/yr. The largest quipo, growing at the Mayaguez Station, measures 2.28 m d.b.h. and is 28 m tall. Large winged seeds are born during the dry season (March-April) and germinate on the ground. Nursery propagation is likely to be easy. This species makes a beautiful specimen tree for parks and estates. The wood is soft and currently worthless.

***Cecropia schreberiana* Miq.**

**MORACEAE**

**Trumpet tree, yagrumo**

Trumpet tree is a fast-growing pioneer tree found in disturbed areas of moist and wet forests. There are about 5,000,000 seeds/kg, which germinate at about 80 percent in moist, shaded beds. However, seed quality is not consistent. Containerized seedlings are most successful, but plantations have been successfully established using bare-root stock. Planting-stock height reaches 25 to 60 cm in about 4 months and seedlings are then ready for outplanting. Seedlings should be grown in full sunlight and outplanted into completely cleared areas. Survival of planted stock is usually high and growth is rapid. The best saplings in a stand may reach 1.8 m in 7 months and 2.1 m in a year. Height growth slows as trees reach maximum heights (20 to 25 m). Diameter growth varies from 0.26 to 3 cm/yr, depending on stand density. Trumpet trees live 30 to 40 years; therefore, rotations should be from 25 to 35 years. At rotation age, the diameter of well-managed trumpet trees should be at least 30 cm but may be 50 cm or more. Several plantations were established during the 1950's but are no longer identifiable. Trumpet tree wood can be used for pulp, excelsior, and matches; but, in Puerto Rico, it is used for musical instruments, crafts, and as chips for animal bedding. The species is sometimes maintained for coffee shade. Naturally regenerated trumpet trees help rehabilitate disturbed areas and furnish soft mast for wildlife.

**References:** Chudnoff and Goytia 1972, Englerth 1960, Institute of Tropical Forestry 1962, Silander and Lugo 1990, Tropical Forest Research Center 1959.

***Cedrela odorata* L.**

**MELIACEAE**

**Spanish-cedar, cedrela**

Spanish-cedar is a magnificent native timber tree. It grows rapidly with excellent form and produces a beautiful, expensive, and very easily worked wood. Plantations of the species in Puerto Rico are subject to heavy attack by the mahogany shoot borer, *Hypsipyla grandella* Zeller. As a result, not one of the dozens of plantations has retained a continuous stand. Many plantations have died out entirely; most of them have only scattered individuals left. Although somewhat smaller than mahogany seeds (20,000 to 50,000/kg), Spanish-cedar seeds are handled similarly. Seedlings generally are grown in plastic nursery bags in full sun or light shade and are ready to outplant in 6 to 8 months. It is advisable to spray periodically with insecticide to avoid shoot borer attack in the nursery. Native Spanish-cedar is found in upland areas receiving from 1500 to 2500 mm of rainfall, and planting should probably be confined to this zone. It may be advisable to plant seedlings in wide dispersion in new plantations of non-*Hypsipyla* host trees or in scattered openings of natural forest. In the absence of shoot borer attack, seedlings will add up to 1 m to their heights annually.

**References:** Belanger and Briscoe 1963, Brush 1925a, Brush 1925b, Cintrón 1990, Francis 1992d, Holdridge 1943, Kramer 1925, Little and Wadsworth 1964, Marrero 1943, Marrero 1948, Marrero 1949a, Marrero 1950b, Tropical Forest Experiment Station 1949, Tropical Forest Experiment Station 1950, Tropical Forest Experiment Station 1952, Tropical Forest Experiment Station 1954, Wadsworth 1960a, Whitmore 1971, Whitmore 1978, Wolcott 1940, Wolcott 1946.

***Ceiba pentandra* (L.) Gaertn.**

**BOMBACACEAE**

**Silk cotton tree, ceiba**

Silk cotton tree is a native species that grows along rivers and streams and occasionally in the moist uplands. The wood is used elsewhere for plywood core stock. The seed fluff, the source of its name, was formerly collected for kapok. Today, cotton silk tree is used only as an ornamental and shade tree in parks and on estates. Although no forest plantations have been established in Puerto Rico, individual trees have been planted widely across the island. Seedlings are easily grown from seed

in the nursery, usually in large containers. Early height growth of about 1 m/yr may be expected on good sites. Because the tree becomes so large and the buttress and surface lateral roots so extensive, at least 8 m must be allowed between planted trees and structures such as sidewalks.

**References:** Chinea-Rivera 1990, Schubert 1979.

***Citharexylum fruticosum* L.**

**VERBENACEAE**

**Fiddlewood, pendula**

Fiddlewood is a medium-sized tree of moist secondary forests. It is an aggressive colonizer of pastures and plantations. In Cambalache, the trees in one test were heavily attacked by insects, but the species is actually seldom attacked. Fiddlewood is easily propagated from seed, and growth in the nursery is rapid. Growth in pole and small sawlog sizes is much slower than early growth. The species is favored for fenceposts because of its moderate size, straightness, and rot resistance. Fiddlewood is a honey plant and a heavy producer of fruits that are eaten by birds.

**References:** Chudnoff and Goytia 1972, Englerth 1960, Francis 1990c, Francis and Rodríguez 1993, Wadsworth 1947a, Wadsworth 1947b, Wadsworth 1948, Wolcott 1945, Wolcott 1946.

***Clitoria fairchildiana* R. Howard**

**LEGUMINOSAE (PAPILIONOIDEAE)**

**Clitoria**

Clitoria is a fast-growing ornamental from Brazil that is now widely planted in Puerto Rico. It is favored for its clean appearance and the violet flowers it produces one or more times annually. The species is easy to reproduce from seed and by air layering. Although of medium size, clitoria should not be planted in confined spaces because its near-surface roots are likely to damage sidewalks and curbs. A forest planting in the Arboretum has reproduced profusely. Hurricane Hugo tipped all trees in the Arboretum planting, but all survived and formed a thicket of new crowns that sprouted from the trunks and branches. Its wood properties are unknown.

**References:** Francis 1989f, Francis and Liogier 1991.

***Coccoloba uvifera* (L.) L.**

**POLYGONACEAE**

**Sea grape, uva de playa**

Sea grape is a small native tree that forms thickets in dune areas and rocky headlands along the coast. Formerly important for fuel and fruit, it now is used widely in coastal areas as an ornamental. It is also important as a wildlife food plant and can be useful in dune stabilization. Sea grape is propagated from seed as potted seedlings and from rooted cuttings of selected cultivars. Newly planted trees in moist areas may grow almost 1 m/yr during the first 3 years. The wood is very hard and heavy.

**References:** Marrero 1949a, Parrotta 1994c, Southern Region 1990, Wolcott 1946.

***Cunninghamia lanceolata* (Lamb.) Hook.**

**TAXODIACEAE**

**Chinese fir**

Chinese fir has been planted in two small groups (total of 29 trees) within the Arboretum. They averaged 12 m in height and 19 cm d.b.h. at 25 years. The trees are healthy and have had good survival. Although this conifer produces a valuable timber, its growth in Puerto Rico appears too slow for commercial wood production. Chinese fir is attractive and, despite its spiny leaves, could be used effectively as an ornamental in Puerto Rico's cool, wet areas.

**References:** Francis 1989f.

***Dacryodes excelsa* Vahl**

**BURSERACEAE**

**Tabonuco**

Tabonuco is one of the most stately trees of the wet forests of Puerto Rico. Its wood, which has been compared to mahogany, is used for furniture, cabinetry, trim, and construction. Seeds totalling 500/kg are easily collected in season under dominant trees. They are recalcitrant and, if sown soon after collection, germinate at a high rate. In the nursery, seedlings develop well under shade and reach plantable size in 6 to 10 months. To date, however, no planting of nursery-grown seedlings has succeeded. The majority of plantings, including

some recent ones, have failed completely. The most successful planting (using wildlings) in Toro Negro reportedly had "rather low" survival. However, vigorous saplings 2.5 to 5.0 cm d.b.h. and 2.5 to 3.5 m in height were reported at 9 years. Apparently, planting in light shade and effective inoculation with micorrhizae are necessary, but much remains to be learned before this species can be consistently regenerated artificially.

**References:** Chudnoff and Goytia 1972, Englerth 1960, Francis and Rodríguez 1993, Lugo and Wadsworth 1990, Marrero 1947a, Marrero 1949a, Wolcott 1940, Wolcott 1946.

***Dalbergia sissoo* Roxb.**

**LEGUMINOSAE (PAPILIONOIDEAE)**

**Sissoo, Indian rosewood**

Sissoo is a handsome, medium-sized tree adapted to drier, southern areas in Puerto Rico. The species is easily propagated from seed or root suckers. The wood is valuable for fine furniture, carvings, and many other uses. It is pretty enough to be used as an ornamental, but root suckering could be problematic in some situations. A small planting was established at the Toa Baja Experimental Farm. Clumps of saplings and poles reproduced from planted trees may be found near Lajas and Villa Alba.

**References:** Marrero 1950b, Parrotta 1989, Parrotta 1991b.

***Enterolobium cyclocarpum* (Jacq.) Griseb.**

**LEGUMINOSAE (MIMOSIOIDEAE)**

**Earpod-tree, guanacaste**

Earpod-tree is a large-to-very-large tree adapted to a wide variety of soils in moist and dry forests. From scarified seed, containerized seedlings are easily produced in the nursery. Plantations require good weed control in early years and periodic thinning to ensure rapid development of crop trees. Height growth is 1.0 to 1.5 m/yr, and maximum heights of 25 to 30 m may be expected. Diameter growth of free-to-grow trees will be between 2 and 3 cm/yr. The heartwood is a beautiful milk-chocolate brown and has many uses but has not been milled commercially in Puerto Rico. An adaptability planting in

Cambalache and a direct seeding in Vieques contain a few forest-grown trees. The species is widely planted, both as a shade and an ornamental tree.

**References:** Francis 1988b, Francis 1992d, Francis and Liogier 1991, Francis and Rodríguez 1993, Geary and Briscoe 1972, Institute of Tropical Forestry 1962, Kramer 1925, Little and Wadsworth 1964, Martorell 1953.

***Erythrina poeppigiana* (Walp.) O.F. Cook**  
**LEGUMINOSAE (PAPILIONOIDEAE)**  
**Mountain immortelle, bucayo gigante**

This giant coffee-shade tree is native to Panama and northern South America. It has naturalized in the moist secondary forests of Puerto Rico. Beautiful orange flowers that appear in early spring make it an interesting ornamental in parks and on large estates. Its nitrogen-fixing ability suggests wider use in agroforestry and conservation plantings. Mountain immortelle may be propagated from large cuttings and from nursery-grown seedlings. Seeds are collected in the late summer and total 4,200/kg. Germination proceeds quickly and, in Puerto Rican tests, has averaged 92 percent. Growth at all stages is rapid. The species was the most successful rooter in a study of rooting living fenceposts in the CNF. The wood is soft and susceptible to rot and termites.

**References:** Little and Wadsworth 1964, Marrero 1949a, Tropical Forestry Research Center 1958, Wadsworth 1944c.

***Eucalyptus citriodora* Hook.**  
**MYRTACEAE**  
**Lemon-scented gum**

The lemon-scented gum, native to Queensland, Australia, has a smooth, spotted bark, and narrow lanciolate leaves. The wood is heavy, hard, and useful for bridge construction, beams, and tool handles. The species was planted in a number of trials in wet upland clay sites on the CNF and in Toro Negro, where long-term survival was generally good. Early height growth was 1 to 3 m/yr, but areas within the stands stagnated. The best stand, located at Catalina in the CNF, averaged 35 m in height and 44 cm d.b.h. at 44 years. Yields of all stands

ranged from about 8 to 14 m<sup>3</sup>/ha/yr. Much of the lemon-scented gum in Puerto Rico was incorrectly thought to be *Eucalyptus maculata* Hook. when it was planted.

**References:** Francis 1989f, Tropical Forestry Experiment Station 1953, Wolcott 1946.

***Eucalyptus grandis* W. Hill ex Maiden**  
**MYRTACEAE**  
**Rose gum**

Rose gum is one of the most important eucalypts grown in the tropics for paper-making, plywood, carpentry, and flooring. In its native Australia, rose gum grows large and seems capable of the same in most Puerto Rican upland sites. One individual rose gum tree in the Arboretum reached 1 m d.b.h. in 30 years. Numerous other gum trees known locally as "hibrido" are practically identical to rose gum, but their capsule form differs slightly. They were planted in the 1940's across the island along roads and in other eucalypt plantations in insular forests, particularly Toro Negro, Carite, Monte Guilarte, the CNF, and Río Abajo. Hibridos are probably genetically impure forms of rose gum. Although there is little economic justification for planting rose gum in Puerto Rico, it probably would provide yields equaling to, or exceeding those of, swamp mahogany (*Eucalyptus robusta*).

**References:** Francis 1989f, Francis 1992d, Meskimen and Francis 1990.

***Eucalyptus pellita* F. Muell.**  
**MYRTACEAE**  
**Large-fruited red mahogany**

Large-fruited red mahogany is a medium-sized eucalypt that may reach 40 m in height. The wood is heavy, hard, and used in Australia for flooring and carpentry. Trees planted in an Arboretum plot averaged 67 percent survival, 5.2 m in height and 3.8 cm d.b.h. at 3 years. Seed for this test were collected from a group of 5 trees of unknown provenance, which were about 25 years old and averaged 31 m in height and 25 cm d.b.h. Trees in both the young and old plantations have good vigor and very good form.

**References:** Moulart and Francis 1993.

***Eucalyptus resinifera* Smith**

**MYRTACEAE**

**Red messmate**

Red messmate is a medium to large eucalypt with a heavy, hard, dark-red wood. It is similar to swamp mahogany but has a more fibrous bark and small capsules. It was represented in Toro Negro in two trials and one at Catalina where its growth rate was similar to or slightly better than swamp mahogany. Red messmate is probably only suitable in mountain areas.

**References:** Tropical Forest Experiment Station 1953.

***Eucalyptus tereticornis* Smith**

**MYRTACEAE**

**Blue gum**

A eucalypt known as *Eucalyptus Mysore x Bangalore*, which has since been identified as blue gum, was tested in the Arboretum and the Adaptability Trials on moist and wet upland sites. More recent trials with a new Queensland seed accession are under way on the Toa Baja Experimental Farm and at the Arboretum. Early height growth of the species has been very good, ranging from 1.8 to 6.0 m/yr. Long-term survival has been good, with maximum heights above 30 m and diameters up to 0.5 m in 30 years. Although not yet used in Puerto Rico, the wood is useful in heavy construction and for producing railroad ties, poles, and posts.

**References:** Francis 1989f, Francis 1992d, Institute of Tropical Forestry 1963, Parrotta 1990a, Parrotta 1991a, Parrotta 1991b, Tropical Forest Experiment Station 1949.

***Eucalyptus torelliana* F. Muell.**

**MYRTACEAE**

**Cadaghi, torelliana**

This eucalypt is striking because of its smooth, bright-green bark above the "stocking" (rough bark at the base of the tree). It has survived and grown well in moist and wet upland sites in Río Abajo and Toro Negro. Early height growth ranged from 2 to 3 m/yr on one site. Diameters and heights (of 8 trees) at 36 years averaged 64 cm and 26 m, respectively. Cadaghi could be an

excellent ornamental in mountain areas and probably within coastal areas if new seed collections could be made from lowland areas of Queensland.

***Eucalyptus urophylla* Blake**

**MYRTACEAE**

**Urophylla**

Urophylla, native to Indonesia, is one of the fully tropical eucalypts. It is valued mainly for its pulpwood. A Puerto Rican test evaluated 5 provenances on 2 sites. Urophylla grew well at the lower, drier site (Yabucoa), not significantly different than *Eucalyptus deglupta* provenances in the same test. In 15 years, height averaged about 23 m and d.b.h., about 28 cm. Growth was slower, and the incidence of canker and mortality were much higher in the cooler, wetter site at Río Abajo.

**References:** Figueroa and Whitmore 1980, Lugo and Francis 1990.

***Eucalyptus x kirtoniana* F. Muell.**

**MYRTACEAE**

**Kirtoniana**

The eucalypt tentatively identified as "kirtoniana," a hybrid between *Eucalyptus robusta* and *E. tereticornis*, was stocked in many plantations on public and private lands during the 1940's, and 1950's. It may still be found in Maricao, Carite, and Toro Negro. Its growth rate and survival are similar to swamp mahogany. Its wood properties are not known but probably are not superior enough to other eucalypts to justify planting it.

**References:** Institute of Tropical Forestry 1962, Institute of Tropical Forestry 1963, Marrero 1950a, Tropical Forest Experiment Station 1953, Tropical Forest Research Center 1958, Wadsworth 1953.

***Fraxinus uhdei* (Wenzig) Lingelsh.**

**OLEACEAE**

**Fresno**

Fresno is a handsome tree native to Mexico and Guatemala. It is planted as an ornamental in mountain areas near the first forestry plantations in Toro Negro,

Maricao, and Monte Guilarte, and it has naturalized in those areas. The forestry plantations in those forests and on the CNF have produced trees of sawlog size but relatively poor form. Fresno wood is useful for furniture, trim, turnery, and sporting goods. Seed is produced in old plantations and can be collected with pruning poles or from the ground. There are about 45,000 seeds/kg. Production in containers is recommended to ensure high survival, but bare-root seedlings will probably survive well if planted during the rainy season. Cuttings can also be rooted. Fresno is adapted to cool, moist areas that have relatively deep, fertile soils. Initial spacing of 3 by 3 m and thinnings to enhance form and vigor after the commercial bole length is set are recommended. Height growth is about 1 m/yr in early years, gradually decreasing. Diameter growth of dominants and codominants within stands is a fairly constant 1 cm/yr. The Puerto Rico champion tree measured 31 m high and 123 cm d.b.h. at about 58 years (1992).

**References:** Francis 1989f, Francis 1990e, Francis 1992d, Francis and Liogier 1991, Little and Wadsworth 1964, Marrero 1950b, Tropical Forest Experiment Station 1949, Tropical Forest Experiment Station 1951, Tropical Forest Experiment Station 1954.

### ***Genipa americana* L.**

#### **RUBIACEAE**

#### **Genipa, jagua**

Genipa is a fruit and potential timber tree probably introduced in pre-Columbian times. It is fairly common in moist-to-wet secondary forests. Seedlings are easily produced if care is taken to maintain an acid pH in the potting mix and alkaline irrigation water is not used. A few survivors remain in a single forestry planting at El Verde. Two genipa in the Botanic Garden were also planted at the same time. Growth rate is moderate, and, in Puerto Rico, the species' maximum size ranges from 20 to 30 m tall and a little over 0.5 m d.b.h. Genipa was widely planted as a fruit tree, but now the fruit is rarely eaten in Puerto Rico. The wood is valuable and is used commercially elsewhere for millwork, handles, furniture, and plywood.

**References:** Francis 1993e, Francis and Rodríguez 1993, Pennock 1967, Wolcott 1940, Wolcott 1946.

### ***Gmelina arborea* Roxb.**

#### **VERBENACEAE**

#### **Melina**

Melina, a native of the East Indies, has survived and grown at a moderate rate in several sites on the CNF, in Bosque Vega, and in the Botanic Garden. It produces abundant seed annually and has naturalized in Bosque Vega. Seedlings also have been observed in the Botanic Garden. The Arboretum planting had 94 percent survival at 14 years, and trees averaged 13.5 m in height and 19.5 cm d.b.h. The Bosque Vega trees are nearly twice as large. The form of local trees is open and branchy. Lack of a market for melina wood prohibits a search for provenances offering a better form and a higher growth rate.

**References:** Francis 1989f.

### ***Guaiacum officinale* L.**

#### **ZYGOPHYLLACEAE**

#### **Lignumvitae, guayacán**

Lignumvitae produces seeds in quantity, and they can be picked from fruiting trees. There are about 3,500 seeds/kg, and, in sandy soil, about 50 percent will germinate over a 6-month period. In the nursery, seedlings take 1 to 2 years to reach 25 cm in height. Survival is fairly good when potted seedlings are used but very poor with direct seeding or bare-root seedlings. Trees in a 13-year-old plantation in Guánica averaged 1.2 m high and had a maximum height of 2.4 m. Trees planted 41 to 49 years ago at Guánica averaged 4 and 3 m tall and 13 and 9 cm d.b.h. Where seed sources are available in dry forests, natural seedlings will probably provide enough stocking to manage. In areas with no regeneration, potted seedlings are recommended. Lignumvitae is sensitive to fire but will benefit from grazing.

**References:** Francis 1993f, Francis and Rodríguez 1993, Marrero 1949a, Marrero 1950b, Southern Region 1990, Wadsworth 1990, Wolcott 1940, Wolcott 1946.

***Haematoxylum campechianum* L.**

**LEGUMINOSAE (CAESALPINIOIDEAE)**

**Logwood, campeche**

Logwood is a very hardy, dry-forest species from Mexico and Central America, which was introduced in the 1920's to produce dyewood. It is now useful for site reclamation, forage, fuelwood, and carving. Logwood is used to a limited extent as an ornamental in dry areas.

Although it is very hardy, the tree is thorny and not particularly attractive. Two plantings on difficult sites at Guánica and the Albergue Olimpico have shown good survival and good early growth. The Guánica plantation (about 1 ha) established in 1924 has coppiced after being cut and the surrounding area is now thickly populated with logwood saplings. In Albergue Olimpico on 20-30 cm of soil over fractured igneous rock, 13 of 22 trees planted were growing after 4 years and averaged 2.7 m in height. Other individual trees and groups are scattered throughout the island. The largest logwood in Puerto Rico measured 79 cm in diameter (1992).

**References:** Brush 1925a, Francis and Liogier 1991, Marrero 1947b, Marrero 1950b, Wadsworth 1943d, Wadsworth 1990.

***Hernandia sonora* L.**

**HERNANDIACEAE**

**Mago**

Mago is easy to propagate and adapts well to plantations. The wood is not used commercially but probably would be suitable for plywood corestock, chipboard, and matches. Its best current use may be in conservation plantings along stream bottoms and in poorly drained fresh water areas. Small plantations are established in Cambalache, in the CNF near Savanna, and in the Luquillo Experimental Forest arboretum. The species fruits annually, usually during the winter. Its seeds, which can be gathered under fruiting trees, total about 360/kg and give a 40- to 50-percent germination on wet peat or soil. About a year is required to produce 45-cm seedlings. Planting containerized seedlings during the wet season has been shown to give good survival. Mago develops best on alluvial soils along rivers and streams but also can grow well on fertile upland sites in wet forests or other moist areas (>1500 mm precipitation). Full sunlight is essential for seedling survival. Initial

spacing should be about 3 by 3 m, and the plantation thinned as the crowns begin to close. Seedlings grow about 0.5 m the first year, about 1 m the second, and about 1.5 m thereafter for a few years, gradually slowing until the trees reach a maximum height of 25 to 35 m. A small, 26-year-old plantation averaged 1.0 cm/yr of d.b.h. growth and 12 m<sup>3</sup>/ha/yr of mean annual wood increment. Old trees measuring 40 m high and more than 1 m d.b.h. have been documented in Puerto Rico.

**References:** Francis 1989f, Francis [n.d.]d, Francis 1992d, Francis and Rodríguez 1993, Longwood 1961, Lugo and others 1990a, Marrero 1949a, Tropical Forest Experiment Station 1953, Tropical Forest Research Center 1955, Wolcott 1945.

***Hura crepitans* L.**

**EUPHORBIACEAE**

**Sandbox, molinillo**

Sandbox trees are a common occupant of fence rows and pastures on the coastal plain and foothills of Puerto Rico. Sandbox is easily raised in nurseries from seed in containers. Large cuttings have been used to establish living fenceposts. Sandbox was tested at St. Just on shallow, rocky soil but grew slowly. Along fencerows on moist coastal plain clays, height growth is moderate, and maximum height of open-grown trees usually does not exceed 20 m. Diameter growth is usually less than, but may exceed, 1 cm/yr. The largest sandbox known in Puerto Rico measured 1.8 m d.b.h. Although the wood is useful in the manufacture of plywood, utility lumber, posts, and charcoal, it is not put to those uses in Puerto Rico. Because it is spiny and has an irritating sap, sandbox is generally not used near dwellings as an ornamental or shade tree.

**References:** Francis 1990f, Francis and Rodríguez 1993, Winters and Almeyda 1953, Wolcott 1946.

***Hyeronima clusioides* (Tul.) Muell-Arg.**

**EUPHORBIACEAE**

**Cedro macho**

Cedro macho is a promising endemic timber tree that is not widely known, even in Puerto Rico. It produces a beautiful, rich brown wood suitable for fine furniture and

interior trim. Cedro macho grows in relatively fertile soils in moist areas (1600 to 3000 mm m.a.p.) and at elevations up to 600 m. The soils are mostly well drained loams and clays with pHs between 5.0 and 6.0. The species is only common in primary and advanced secondary forests in the moist limestone hills. Several hundred trees remain from 1952 plantings in Río Abajo. Remnants of small plantations also survive in Guajataca. Planting stock can be produced in the nursery from seed that is gathered in small quantities under fruiting trees in late summer and throughout the winter. Felling or climbing trees may be the only practical way of collecting large quantities of seed. There are about 200,000 seeds/kg and seeds may be germinated on the surface or under a light covering of potting mix. Seedlings reached plantable size (32 cm) 11 months after germination. At 37 years, trees surviving from early plantations have been straight and thrifty, ranging from 18 to 29 m in height and 12 to 36 cm d.b.h. However, because they were underplanted and never released, these are probably not good indicators of the species' growth potential. The largest cedro macho recorded (1990) was 163 cm d.b.h. and 27 m tall.

**References:** Francis 1991c, Francis and Rodríguez 1993, Little and Wadsworth 1964, Longwood 1962, Marrero 1947b, Marrero 1950b, Tropical Forest Experiment Station 1953, Tropical Forest Experiment Station 1954, Wadsworth and Englerth 1959, Wolcott 1940, Wolcott 1945, Wolcott 1946.

### ***Hymenaea courbaril* L.**

#### **LEGUMINOSAE (CAESALPINIOIDEAE)**

#### **West Indian locust, algarrobo**

West Indian locust is a large, native forest tree with a straight, cylindrical, but often short bole. The reddish brown wood is used for high-quality flooring, furniture, turnery, and tool handles. Children often eat the white powdery pulp within the large seed pods. Growth is moderate and sustained over long periods. Because height growth is only about 0.5 m/yr, lack of careful weed control usually results in poor survival. Diameter growth is about 0.5 cm/yr for trees in forest stands. The species is tolerant of a variety of moist forest site types and is fairly common in secondary forests. One small plantation stands in the woodlot behind the Botanic Garden.

**References:** Brush 1925b, Francis 1990g, Marrero 1943, Marrero 1950b, Wadsworth 1943c, Wadsworth and Englerth 1959, Wolcott 1946.

### ***Juglans jamaicensis* C. DC.**

#### **JUGLANDACEAE**

#### **Nogal**

Nogal is an endangered native species. Only 14 naturally regenerated individuals have been found in Puerto Rico, all at one site on Silla de Calderón mountain, near Monte Guilarte. Seed collections have been made by the Puerto Rican Department of Natural Resources (DNR), IITF, and Fidecomiso de Conservación, which together have grown several hundred seedlings. These have been dispersed widely on State, Federal, and private lands. A planting of 9 trees in the La Condesa tract of the CNF grew an average of 0.6 m in the first 14 months, and they were healthy and about 2 m tall after 4 years in the field. A single seedling on the IITF grounds grew 2.0 m during its first year in the field. Two plantings at a 600- to 1000-m elevation in a high-rainfall area are known to have failed. The species is probably limited by rainfall rather than elevation. Annual rainfall between 1500 and 2000 mm/yr is recommended, as well as fertile soils and sites with full sunlight. The wood of nogal is of the same excellent quality as American black walnut, and the nut is edible.

**References:** Francis and Alemañy 1994, Francis and Rodríguez 1993, Little and others 1974.

### ***Khaya grandifoliola* C. DC.**

#### **MELIACEAE**

#### **African mahogany**

African mahogany produces a quality furniture wood comparable to that of *Swietenia macrophylla*. In the arboretum and adaptability tests, its height growth exceeded *S. macrophylla*, and the bole form was excellent. Hurricane damage was comparable to that suffered by *S. macrophylla* and lower than for other *Khaya* species. African mahogany should be tested further in plantations.

**References:** Francis 1989f, Francis 1992d.

***Khaya nyasica* Stapf. ex Baker f.**

**MELIACEAE**

**East African mahogany**

East African mahogany produces a high-quality wood similar to, and is sometimes sold as, African mahogany. A very high percentage survived outplanting and competition in Puerto Rican plantations and grew as well as, or better than, *Swietenia macrophylla*. However, in the Arboretum plot, windthrow was severe during Hurricane Hugo.

**References:** Francis 1989f, Francis 1992d, Francis and Bokkestijn [n.d.], Geary and Briscoe 1972, Lugo and others 1990a.

***Khaya senegalensis* Juss.**

**MELIACEAE**

**Dry-zone mahogany**

Dry-zone mahogany produces the best quality African mahogany wood and is comparable to *Swietenia mahagoni*. Growth in the Arboretum was comparable to that of *S. macrophylla*. Growth at two low-elevation sites has been phenomenal. One ornamental tree reached 13 m in height and 23 cm d.b.h. in 4 years. However, dry-zone mahogany trees suffered severe windthrow and breakage during Hurricane Hugo.

**References:** Bokkestijn and Francis [n.d.], Francis 1989f, Francis 1992d, Geary and Briscoe 1972.

***Laguncularia racimosa* (L.) Gaertn. f.**

**COMBRETACEAE**

**White mangrove, mangle blanco**

Although white mangrove bolts are useful for posts and charcoal, the species is valued because it provides forest cover and wildlife habitat on tidal flats. White mangrove can be grown and planted as nursery seedlings or direct seeded. Planting information is only available for transplanted wildlings. Planted in Piñones, these seedlings averaged about 60 cm in height. Early survival was high, and the tallest seedlings were 1.3 m in 10 months. By 8 years, survival was fair, and average d.b.h. was 8 cm. Silt and clay sites are best; sites subject to sand deposition should be avoided.

**References:** Chudnoff and Goytia 1972, Englerth 1960, Holdridge 1940c, Jinenez [n.d.], Marrero 1949a, Marrero 1950b, Wolcott 1946.

***Lysiloma latisiliqua* Gray ex Sauv.**

**LEGUMINOSAE (MIMOSIODEAE)**

**Dormido**

Dormido, a legume from Cuba, Florida, the Bahamas, and Yucatán, was planted in Cambalache and St. Just in 1947 and 1948. Growth was around 1.5 m/yr in the first 7 to 10 years. In Cambalache, at 43 years, the dominants and codominants in a small plantation averaged 15.9 m in height and 18.1 cm d.b.h. Dominants and codominants in a direct-seeded plantation in the same area averaged 12.3 m in height and 20.7 cm d.b.h. at 41 years. Both plantations have shown abundant reproduction. The species is probably suitable for site rehabilitation in moist and dry forests, although there may be a danger of unchecked spreading after establishment. Dormido produces a beautiful wood that is prized for furniture and trim.

**References:** Francis and Liogier 1991, Tropical Forest Experiment Station 1949, Wadsworth 1948.

***Maesopsis eminii* Engl.**

**RHAMNACEAE**

**Musizi**

Musizi is a very fast-growing hardwood from Africa that aggressively colonizes disturbed areas. Natural reproduction is abundant at the Arboretum and on at least two of the other sites where it has been planted. Most openings within 400 m of the Arboretum contain musizi. Musizi produces a medium-density, brown heartwood that is similar in appearance and texture to leuan (Philippine mahogany). In Puerto Rico, these trees produce large quantities of fruit that is eaten by wildlife, particularly pigeons. Musizi begin bearing seed at about age 8. The fruits, small drupes, are borne in abundance each summer and may be gathered from under musizi stands. Any fruit still clinging to seeds should be removed and, because they lose germinability within 3 months, the seeds should be planted as soon as possible. There are from 700 to 1000 seeds/kg. Containerized seedlings, direct sowing, and stump plants have all been used successfully. Nursery seedlings grown under full

sunlight or in light shade should be ready to out plant in about 4 months. Musizi requires sites with deep soil, moderate fertility, and at least 1500 mm of precipitation. Clay Ultisols soils with a pH as low as 5.0 have shown good growth. Musizi has grown well in plantings at the Arboretum and on at least four moist sites on private land in the interior of the island. An initial spacing of 3 by 3 m is adequate, followed by one or more thinnings as crowns close. The early height growth of about 2 m/year tapers off as the species reaches a maximum height of 20 to 25 m. Boles prune clean to 8 m or more. Harvest diameters of about 50 cm may be reached in 25 to 30 years. Because the species is susceptible to breakage and throw in hurricanes, short rotations are recommended.

**References:** Francis [n.d.], Francis 1989f, Francis 1992d, Francis and Liogier 1991, Geary and Briscoe 1972, Institute of Tropical Forestry 1963.

### ***Mammea americana* L.**

#### **GUTTIFERAE**

#### **Mammee-apple, mamey**

Mammee-apple is a native fruit tree that produces a heavy, dark reddish-brown wood useful for novelties, turnery, and beams. Germination of the large seeds is high, although somewhat slow. Establishment does not appear to be difficult if good weed control is given for about 3 years. Two plantings in the 1950's were marginally successful. The best of the survivors have grown about 1 cm d.b.h. per year, a rate comparable to farmstead trees. Mammee-apple is long lived and can become large—up to 1.7 m d.b.h. It produces heavy crops of a large fruit that is consumed in rural areas and sometimes sold in fruit stands. Although only occasionally planted as an ornamental with its large, dark-green leaves and thick crown, mammee-apple deserves much more attention.

**References:** Francis 1989b, Francis and Rodríguez 1993, Longwood 1961, Schubert 1979, Wolcott 1940, Wolcott 1945, Wolcott 1946.

### ***Manilkara bidentata* (A. DC.) A. Chev.**

#### **SAPOTACEAE**

#### **Bullet-wood, ausubo**

Although bullet-wood produces one of the premier native woods, early efforts in establishing the species in

plantations were not very successful. Seed production is not consistent, and, so far, plantations established on high rainfall sites have been slow growing with high mortality brought by suppression, hurricanes, and other causes. The remnants of one plantation still survives in the CNF. Future plantations would have a better chance of surviving and growing well on foothill and coastal sites where the species was once common. Indeed, two planted trees near IITF measured 64 and 32 cm d.b.h. and 31 and 23 m in height at 52 years. A tree planted at the Conservation Trust nursery in Río Piedras was about 4 m in height at 5 years. First-year survival in three enrichment plantings in Baranquitas, Bosque Vega, and the La Condesa tract (CNF) was near 100 percent.

**References:** Brush 1925b, Chudnoff and Goytia 1972, Englerth 1960, Longwood 1962, Marrero 1947a, Marrero 1949a, Weaver 1990b, Wolcott 1946.

### ***Ochroma pyramidale* Cav.**

#### **BOMBACACEAE**

#### **Balsa**

Balsa is a common native species found throughout most of Central America, northern South America, and the Caribbean islands. Although balsa can be successfully established in plantations in Puerto Rico, the density of the wood produced is too high for traditional markets, and no commercial uses have been found. There are from 100,000 to 160,000 seeds per/kg, and they can be stored for up to 6 years. Seedlings must be transplanted with great care from germination trays to nursery containers or may be sown directly into pots or nursery bags. The use of any form of bare-root seedlings has not been successful. Seedlings are ready to outplant in 4 months when they are 20 cm in height. Planting at 2 by 2 m to 4 by 4 m should be followed by 2 or 3 heavy thinnings to a final density of about 75 to 100 trees/ha. The d.b.h. range under this regime will be 30 to 40 cm in 5 or 6 years.

**References:** Francis 1991d, Holdridge 1940a, Little and Wadsworth 1964, Longwood 1962, Marrero 1949b, Wadsworth and Englerth 1959, Wolcott 1946.

***Ocotea moschata* (Meissn.) Mez**

**LAURACEAE**

**Nuez moscada**

Nuez moscada is an endemic tree of moist and wet forests. It produces a high-quality wood used in furniture and musical instruments. The tree may also be used as an ornamental. Seeds are produced annually and, within 25 to 50 days, will germinate at 50 to 60 percent. In Puerto Rico, a number of direct seedlings were made in the 1930's and 1940's. Generally, good germination and early survival were reported, but growth was slow. High mortality resulting from competition has only left scattered trees and small patches of the original plantations. Trees in these plantations are now around 30 to 50 cm d.b.h.

**References:** Marrero 1950b, Wolcott 1946.

***Parkia timoriana* (DC.) Merrill**

**LEGUMINOSAE (MIMOSOIDEAE)**

**Parkia**

Parkia is an ornamental and medicinal tree in southern Asia. The wood is soft and has little commercial value. In 1988, 44 wildlings that had been collected at the Botanic Garden were planted in the Arboretum. At 5 years, they had 84 percent survival and averaged 5.5 m in height and 6.1 cm d.b.h. Parkia would probably be an excellent shade and ornamental tree within moist and wet areas of Puerto Rico.

**References:** Francis and Liogier 1991, Moulaert and Francis 1993.

***Peltophorum pterocarpum* (DC.) Black. & Heyne**

**LEGUMINOSAE (CAESALPINIOIDEAE)**

**Yellow flamboyant, flamboyán amarillo**

Yellow flamboyant is a native of Asia and Australia. Planted widely in Puerto Rico as an ornamental, it has naturalized within a few places in moist forests. A roadside planting in Río Abajo was very successful. An attempt to reforest a shallow, rocky area at Albergue Olimpico resulted in slow growth and high mortality. The species is hardy in moist forest areas (1000 to 2000 mm m.a.p.) and in dry forest areas (<1000 mm m.a.p.), if

soils are deep and fertile. It is capable of a meter or more of height growth per year and may reach 1 m or more d.b.h.

**References:** Francis and Rodríguez 1993, Francis and Liogier 1991, Marrero 1949a, Schubert 1979.

***Petitia domingensis* Jacq.**

**VERBENACEAE**

**Capá blanco**

Capá blanco is a familiar, native fencerow tree in rural areas. Its beautiful wood is suitable for furniture and many other uses. It grows in early secondary forest, but because of its short stature and intolerance, capá blanco does not persist for more than one generation. A number of plantings were made during reforestation efforts in the late 1930's. Plantations on ridges and badly eroded sites usually failed. On good sites, early growth up to 1 m per year was recorded. With the exception of one plantation in the CNF, none of the plantations retained a solid stand after 10 to 15 years. Today, plantation trees are 30 to 50 cm d.b.h. and have begun to be senescent.

**References:** Bush 1925b, Chudnoff and Goytia 1972, Englerth 1960, Francis and Rodríguez 1993, Marrero 1947b, Marrero 1949a, Marrero 1949b, Marrero 1950b, Rodríguez 1993, Tropical Forest Experiment Station 1951, Tropical Forest Experiment Station 1952, Wadsworth and Englerth 1959, Wolcott 1946.

***Pimenta racimosa* (Miller) J.W. Moore**

**var. *racemosa***

**MYRTACEAE**

**Bay-rum, malagueta**

Bay-rum is a small- to medium-sized tree found particularly on rocky soils of the moist forests and in the dry forest. Its wood is very heavy and hard and is used for posts and fuel. Its leaves are the source of bay oil, which is used as flavoring or scent in rum, cosmetics, and medicine. Commercial plantations now supply leaves for distillation. Bay-rum trees have also become a popular landscaping tree throughout the West Indies and in Florida. It is probably an important contributor of soft mast for birds. Planting stock is easily produced from seed. There were 35,000 seeds/kg in one sample from

Puerto Rico that yielded 25 percent germination. The seedlings should be grown in containers under light shade and will be ready for outplanting when they reach 25-30 cm. Planted at 16,000 plants per ha, the trees' leaves are ready for harvest in about 4 years.

**References:** Francis and Rodríguez 1993, Little and Wadsworth 1964, Rivera 1940, Schubert 1979, Southern Region 1990, Winters and Almeyda 1953.

***Pinus patula* Schiede & Deppe ssp.  
*tecunumanii* (Eguiluz & Perry) Styles  
PINACEAE  
Patula pine, pino patula**

Patula pine of Guatemalan seed sources is second only to Honduras pine of the pine species tested in Puerto Rico. Its wood is similar in quality to Honduras pine. In tests in Moca and the Arboretum, growth has been slightly slower than Honduras pine. Although a successful species in trials, unless new diseases or insects develop in Honduras pine, there seems to be little reason to plant Patula pine.

**References:** Francis 1989f, Gillespie 1992.

***Piptadenia peregrina* (L.) Benth.  
LEGUMINOSAE (MIMOSOIDEAE)  
Cojobana**

Cojobana is a native legume, although probably brought here by pre-Columbian peoples for the use of its seeds as a narcotic snuff. This small tree is found growing on foothills that are underlain by igneous rocks in the south of Puerto Rico. Test plantings were made in St. Just and Cambalache. The trees first planted there were not found in St. Just, but natural progeny from that planting was found on the area's rocky hillsides and bluffs. Five trees still living in Cambalache averaged 28 cm d.b.h. and 15 m in height after 45 years. The species may be useful in revegetating disturbed areas and for making charcoal and fenceposts.

**References:** Bush 1925b, Francis and Rodríguez 1993, Kramer 1925, Little and Wadsworth 1964, Marrero 1949a, Wadsworth 1944b.

***Pithecellobium arboreum* (L.) Urban  
LEGUMINOSAE (MIMOSOIDEAE)  
Cojoba**

Cojoba is a medium-sized tree from the serpentine and moist limestone hill areas of Puerto Rico. Although it grows at a moderate rate, it produces an excellent timber for furniture and interior construction. Its seeds are recalcitrant but easily germinated on moist soil if planted immediately after collecting. There were 1,400 seeds/kg in one collection, which gave 90 percent germination. It takes about 1 year for seedlings to reach 40 cm in height when grown under partial shade. A planting of 200 seedlings in 1949 on a hillside at Cambalache resulted in height growth of about 30 cm/yr and reasonable survival until the trees were smothered by vines. Three trees in the Cambalache forest about 20 to 30 cm d.b.h. and 15 m tall probably originated from that group of seedlings. Thirty-nine seedlings remaining from an unknown number planted under the shade along trails in the Guajataca Forest were found 5 years after planting. They averaged 1.9 m. The largest cojoba found in Puerto Rico measures 75 cm d.b.h. and 31 m tall. It would be difficult to justify commercial planting of this species, but if plantings were to be made, they should be confined to deep, fertile soils in moist forests. It has been recommended as an ornamental species.

**References:** Francis and Rodríguez 1993, Marrero 1949a, Schubert 1979.

***Pithecellobium dulce* (Roxb.) Benth.  
LEGUMINOSAE (MIMOSOIDEAE)  
Madras thorn, guamuchil**

Madras thorn is an exotic firewood and forage species that has naturalized widely in moist and dry coastal areas of Puerto Rico. There are about 6,000 seeds/kg. Seedlings are easily grown in the nursery and are ready for outplanting in about 3 months. Wildlings are also easy to collect and establish in pots. Individuals in a 6-tree test planting in Toa Baja averaged 4 m in height in 28 months. The species can grow to well over 1 m d.b.h. if allowed to live long enough. Madras thorn is used occasionally as an ornamental, although the thorns make it objectionable in some instances. It should be very effective rehabilitating degraded sites in coastal areas.

**References:** Francis and Liogier 1991, Francis and Rodríguez 1993, Parrotta 1991b, Parrotta 1991c.

***Platysmiscium pinnatum* (Jacq.) Dugand**  
**LEGUMINOSAE (FABOIDEAE)**  
**Macawood, cachimbo**

Macawood is native of Central America and northern South America. Small plantings were made in 1946 in St. Just and in 1955 in Cambalache. Of the 28 seedlings planted bare-root in St. Just, 8 survived to the second year and are still living. It was unclear how many of the earth-ball seedlings were planted at Cambalache, but researchers found 18 trees in 1988. Early height growth was about 1 m/yr. Macawood trees at St. Just average 19.1 m tall and 31.6 cm d.b.h. at 47 years. Those at Cambalache average 13.8 m tall and 13.9 cm d.b.h. Abundant regeneration up to 12 m in height and 23 cm d.b.h., is present on 1 ha or more in St. Just. Smaller reproduction is present near the parent trees in Cambalache. The wood is reddish brown to red and very valuable for furniture, flooring, cabinetry, and musical instruments. In Puerto Rico, poor form and slow growth probably preclude growing this species commercially. However, with its dark-green leaves and reddish-brown bark, the tree is very attractive and could be used as an ornamental.

***Pouteria multiflora* (A. DC.) Eyma**  
**SAPOTACEAE**  
**Bully-tree, jácana**

Bully-tree is a fruit and timber tree of minor importance today, but it was once quite important to rural people. The wood is hard and heavy, useful for furniture and house beams. A number of timber and reforestation plantings were made by direct seeding during the 1930's and 1940's. Although germination is usually fairly high, slow growth and weed competition have usually allowed only scattered trees from those early plantations to survive. Many of the survivors are now approaching sawlog size. Seeds can be collected under fruiting trees. Because they lose their viability very quickly at ambient temperatures, they should be planted within a few days. Both direct seeding and container-grown seedlings should give good results if weeds are controlled until the seedlings reach about 2 m tall. The species is fairly shade tolerant when young; therefore, underplanting thinned stands with release and line planting would likely yield good results.

**References:** Brush 1925b, Francis and Rodríguez 1993, Marrero 1950b, Parrotta and Francis 1993, Wadsworth 1943c, Wadsworth and Englerth 1959, Wolcott 1940, Wolcott 1946.

***Prosopis juliflora* (Sw.) DC.**  
**LEGUMINOSAE (MIMOSOIDEAE)**  
**Mesquite, bayahonda**

Mesquite is a thorny, exotic species that invaded dry parts of Puerto Rico from South America more than 200 years ago. It is used for charcoal, firewood, forage, and, to a limited extent, for shade in dry areas. Elsewhere, mesquite is made into novelties and fine custom furniture. The species helps stabilize and protect soil in disturbed areas. However, landowners often invest large amounts of money clearing away mesquite to increase forage yield. Mesquite produces seeds in abundance, which are generally available all year, although at times only on widely scattered sites and trees. The pods may be picked from trees or the ground. Tiny envelopes within the pods contain the seeds and are difficult to separate. It may be best to crush, screen, acid scarify, rinse, and dry, and then screen again. The seeds will store for several years without losing viability. There are about 37,000 seeds/kg. Germination depends, to a great extent, on how free the seed has been from insect attack. Usually around half germinate. Although data are not available, nursery production of seedlings appears not to be difficult. Potted seedlings give good survival. Spacing seedlings at 1 by 1 m may be advisable for site protection purposes; plantings for fuel should be wider, perhaps 2 by 2 m. For fuelwood production, coppicing is recommended when diameters reach merchantable size. Mesquite is one of the fastest-growing species in dry forests. Growth will range from 0.5 to 1.0 m per year up to a maximum height of 5 to 20 m, depending on site quality. Free-to-grow mesquite trees may grow from 0.5 to more than 1.0 cm/yr and can sustain that growth rate for as long as 100 years. Trees in crowded stands increase their diameters much more slowly. Mesquite tolerates rocky limestone and igneous hillsides, clay and sandy coastal plains, and salty, poorly drained flats just inland from the mangroves. However, the species is rarely found in areas that receive more than 1200 mm of precipitation. Plantings failed in Cambalache and St. Just but succeeded in Guánica. A few trees are still growing in two locations there.

**References:** Brush 1925a, Brush 1925b, Francis and Liogier 1991, Francis and Rodríguez 1993, Marrero 1949a, Marrero 1949b, Marrero 1950b, Tropical Forest Experiment Station 1949, Wadsworth 1949, Wadsworth 1990, Wolcott 1946.

***Prunus occidentalis* Sw.**

**ROSACEAE**

**Almendrón**

Almendrón is an uncommon native tree that may reach more than 1 m d.b.h. Wildlife eat its fruits, and the tree produces a hard and very beautiful wood. It produces seeds annually, which can be gathered from under dominant and codominant trees. There are 702 seeds/kg and up to 80 percent will germinate, beginning in about 13 days after sowing.<sup>1</sup> Seedlings raised in containers will be ready to outplant (at around 0.5 m) after 6 to 8 months in the nursery under light shade. Almendrón seedlings survive and grow best when planted under light shade as is provided by shelterwood stands or in lines cut in secondary forest. Early height growth may reach 1 m/yr under good conditions. Two small 40-year-old plantations in the CNF gave average diameter increments of 0.79 cm/yr.

**References:** Little and Wadsworth 1964, Marrero 1949a, Tropical Forest Research Center 1957, Wadsworth 1960a.

***Pterocarpus indicus* Willd.**

**LEGUMINOSAE (PAPILIONOIDEAE)**

**India padauk, terocarpus**

Despite reports misidentifying the widely planted ornamental Burma padauk (*Pterocarpus macrocarpus*), the only plantings of India padauk are in the Arboretum, the Adaptability Study, the Botanic Garden and, more recently, at Toro Negro. The only practical way of distinguishing the two species is by its seeds. The seeds of India padauk are smaller, lighter colored, and sometimes spiny. India padauk shows a better growth rate in high rainfall areas (> 2000 mm/yr) than *P. macrocarpus*. The wood is dark brown to red and very valuable, but boles tend to be short and crowns wide. India padauk produces the same annual yellow floral display as Burma padauk and is highly recommended as an ornamental in high rainfall areas of Puerto Rico. It also shares with *P. macrocarpus* a tendency to crack and raise sidewalks and curbs. It therefore should be planted at least 3 m away from such structures.

**References:** Francis 1989f, Francis 1992d, Francis and Liogier 1991, Little and Wadsworth 1964, Schubert 1979, Southern Region 1990.

<sup>1</sup> Personal communication with Salvador Alemañy, International Institute of Tropical Forestry.

***Rhizophora mangle* L.**

**RHIZOPHORACEAE**

**Red mangrove, mangle roja**

Red mangrove produces a pencil-like fruit that can be collected from the trees by boat. The plant is normally direct-seeded by pushing fruits part way into the mud. Germination and early survival are over 90 percent. Successful plantations have been established in Piñones, Cayo Santiago, and elsewhere. Early growth (up to 8 years) at Piñones was about 40 cm/yr of height growth and 0.6 cm d.b.h. Brackish mud flats are the species' favored sites. Planting red mangrove is recommended for environmental protection, although the wood may also be used to produce charcoal.

**References:** Chudnoff and Goytia 1972, Englerth 1960, Holdridge 1940c, Jimenez [n.d.]b, Marrero 1950b, Wadsworth and Englerth 1959, Wolcott 1946.

***Sabal causiarum* (O.F. Cook) Becc.**

**PALMACEAE**

**Palma de sombrero**

Palma de sombrero is a medium-sized palmetto of moist and dry limestone areas, especially near the coast. It once was an important source of straw for hat weaving. Many large palms are transplanted to urban areas for landscaping. Seeds, which are produced in abundance, germinate well, although growth is very slow. Height growth is only about 30 cm/yr, and growth is considerably reduced by competing weeds and trees. Maximum heights range from 10 to 24 m, depending on site. Two small plantings in Cambalache were established from nursery seedlings in 1946.

**References:** Francis and Rodríguez 1993, Marrero 1949a.

***Samanea saman* (Jacq.) Merrill**  
**LEGUMINOSAE (MIMOSOIDEAE)**  
**Rain tree, samán**

Rain tree is a large, spreading tree from Mexico, Central America, and northern South America that has naturalized in the drier parts of the moist forest area of Puerto Rico. Even though rain tree is widely planted as a cattle and farmyard shade tree, two of three forestry tests have shown failure or slow growth. Rain tree wood is valuable for furniture and carving. Cattle love the sweet pods that are produced in abundance by large trees. Nursery seedlings are easily produced in containers. The seed begins germinating in about 6 days. Careful site selection (rainfall of 1000 to 1700 mm/yr and fertile soils) and good protection from weeds and livestock are essential for successful plantation establishment.

**References:** Francis 1992d, Francis and Liogier 1991, Geary and Briscoe 1972, Longwood 1962, Marrero 1949a, Wadsworth 1944c.

***Schizolobium parahybum* (Vell.) Blake**  
**LEGUMINOSAE (CAESALPINIOIDEAE)**  
**Fire tree, faveira**

Fire tree is a fast-growing pioneer tree that is native from Mexico through northern South America. It produces a tough but relatively soft wood used for utility plywood and rough lumber. It bears showy yellow blossoms and is planted elsewhere as an ornamental. The species has naturalized in Jayuya and at the Arboretum. It grows rapidly, although with higher-than-desirable mortality at establishment. One individual of a closely related species, *Schizolobium amazonicum* Huber ex Ducke, which was planted in the Botanic Garden, reached about 12 m in height in 3 years before the formation of branches.

**References:** Francis 1989f, Francis 1992d, Francis and Liogier 1991, Institute of Tropical Forestry 1963.

***Senna siamea* Irwin & Barnaby**  
**LEGUMINOSAE (CAESALPINIOIDEAE)**  
**Yellow cassia, casia de Siam**

Yellow cassia, an exotic species, grows well in fertile, moderately dry or moist sites. Planted trees and naturally regenerated stands are within areas receiving from 1200

to 2500 mm of precipitation. On the dry end of the rainfall spectrum, the tree is more likely to grow in areas that are underlain by igneous rocks than limestone. During the 1920's, 1930's, and 1940's, yellow cassia was widely distributed to farmers and was planted along highways. A few scattered trees from those plantings remain along the island's highways and in the CNF. A few forest plantings also were made. One planting at St. Just on abandoned farmland yielded plants 0.75 to 2.5 m in height in 18 months. Stump plants gave better results than striplings or bareroot stock. Planting at 2.5 by 2.5 m should give good results. Early growth is rapid; young trees grow a meter or more per year and about 1.5 cm/yr d.b.h. To allow growing space for larger trees, the trees must eventually be thinned. Yellow cassia trees generally do not reach more than 0.6 m d.b.h. in Puerto Rico, and they show signs of senescence by 50 years. The species provides a good windbreak and roadside shade tree. The wood is heavy, hard, and is used elsewhere for fuel.

**References:** Bates 1939, Chudnoff and Goytia 1972, Englerth 1960, Francis and Liogier 1991, Francis and Rodríguez 1993, Gregory 1946, Marrero 1947a, Marrero 1949b, Marrero 1950a, Marrero 1950b, Parrotta and Francis 1990, Wadsworth 1949.

***Simaruba amara* Aubl.**  
**SIMARUBACEAE**  
**Amara, aceituno**

Native to South America and the Lesser Antilles, amara is an important timber tree in the moist and wet forests of those regions. It was not recorded how many seedlings were planted at El Verde in 1953, but 12 were alive and measured 1.2 to 4.6 m in height at 3 years. At age 9, 6 trees measuring 3.0 to 7.6 m remained. In 1993, at 30 years old, just 3 of the original trees remained. They measured 14 to 24 m tall and 14 to 31 cm d.b.h. However, seeds eaten and carried by doves have resulted in seedlings from a few cm to small pole-size trees in openings for about 1 mile in every direction. A planting at Cambalache completely failed.

**References:** Francis and Liogier 1991.

***Spathodea campanulata* Beauv.**

**BIGNONIACEAE**

**African tulip tree, tulipán**

African tulip tree is one of the most abundant early secondary forest trees in the moist portion of Puerto Rico. Forest plantings, to date, have been limited to one very small test, but the species has been widely and successfully planted as an ornamental. In moist areas of Puerto Rico, African tulip tree aggressively invades disturbed areas and becomes a difficult weed in pastures, farms, and secondary forest. The wood is soft and of no commercial worth. Its small, winged seeds germinate readily on wet soil. In the nursery, they can easily be germinated on wet peat. Seedlings take 3 months or more to reach 4 cm, after which they grow rapidly, perhaps sustaining 1 to 2 m of height growth per year through the pole stage. Height then slows as the tree approaches a maximum height of 20 to 35 m. Diameter growth of dominant individuals on good sites may be as high as 5 cm/yr; natural stands may add 20 m<sup>3</sup>/ha/yr.

**References:** Chudnoff and Goytia 1972, Englerth 1960, Francis 1990h, Francis 1992d, Francis and Liogier 1991, Francis and Rodríguez 1993, Institute of Tropical Forestry 1962, Kramer 1925, Tropical Forest Research Center 1959.

***Spondias mombin* L.**

**ANACARDIACEAE**

**Hogplum, jobo**

Hogplum is a common minor fruit tree in moist forests, along fence rows, and on farmsteads in Puerto Rico and throughout much of tropical America. No forest plantings are known, but roadside, farmstead, and fencerow planting—for fruit and shade—have been very common. The fruit is also eaten by wild and domestic animals and birds. The species is easily grown from seeds or cuttings. The growth rate of hogplum in Puerto Rico is not precisely known. An early height growth of 1 m/yr and d.b.h. growth rates of 0.5 to 2.0 cm/yr have been estimated from tree sizes and approximate ages. Although not used locally, hogplum wood is suitable for light construction, molding, utility plywood, and pulp.

**References:** Francis 1992e, Francis and Rodríguez 1993, Tropical Forest Research Center 1958, Wolcott 1946.

***Stahlia monosperma* (Tul.) Urban**

**LEGUMINOSAE (CAESALPINIOIDEAE)**

**Cobana negra**

Cobana negra is a medium-sized tree endemic to the southern coastal areas of Puerto Rico. Because it was overcut for furniture and construction wood, it is now rare. The dark brown heartwood is heavy and strong and resists rot and termites. Plantings were made in Cambalache in 1943 and 1944. In the first, where potted stock had been used, the plantation failed during a severe drought. The later planting, a direct seeding, was successful and resulted in 160 plants (some were doubles that resulted from planting 2 seeds per spot). The plantation was first measured at 44 years. Sixty-one trees averaged 7.6 m in height and 7.0 cm d.b.h. The largest trees were about 10 m tall and 10 cm d.b.h. Another similar plantation is located in the Vega Forest, but trees there have not been measured. Cobana negra is not recommended as a plantation species for wood production because of its very slow growth. It has, however, been suggested as an ornamental.

**References:** Little and Wadsworth 1964, Pennock 1967.

***Sterculia apetala* (Jacq.) Karst.**

**STERCULIACEAE**

**Panama tree, anacagüita**

Panama tree is a stately, large-leaved exotic tree of Central America and South America. Widely planted, it is found along roads and in parks and estates within coastal areas of Puerto Rico. Its large, beanlike seeds germinate quickly. Propagation is usually by potted seedlings, which grow rapidly after outplanting. Wildland plantings have not been attempted, but no difficulties in doing so are likely. Panama tree has naturalized in several areas and has spread into secondary forest. Irritating hairs shed by its leaves and fruit seriously decrease the popularity of this species.

**References:** Francis and Rodríguez 1993, Francis and Liogier 1991, Little and Wadsworth 1964, Schubert 1979.

***Syzygium jambos* (L.) Alst.**

**MYRTACEAE**

**Rose apple, pomarrosa**

Rose apple was brought to Puerto Rico from somewhere in Asia during colonization. It was originally valued as a fruit tree and is still eaten in rural areas. Rose apple is a good fuelwood, and it is also good for producing stakes and small posts, particularly by the coppice method. However, once established on a site, rose apple is hard to eradicate. Its seeds are recalcitrant and should not be dried. There are about 400 seeds/kg and, because many seeds are polyembryonic, generally will germinate at more than 100 percent. Seedlings grown in nursery bags reach plantable size (24 cm) in about 8 months. Plantations have also been established by direct seeding. Untreated cuttings placed in moist ground also root readily. Rose apple requires a moist habitat. In areas with less than 1700 mm of annual rainfall, it is largely confined to stream banks and adjacent wet areas. In areas with more than 1700 mm of precipitation, rose apple also grows in upland positions. A plantation established in Río Abajo in 1942 is still dominated by rose apple. Another plantation was established in Toro Negro at the same time. Rose apple is tolerant, and plantations of the species develop slowly. Plantings for fuel, stakes, or posts should be spaced at about 2 by 2 m and should be weeded for at least 2 years. Height growth averages about 0.5 m/yr in the first 10 years. Open-grown trees can add as much as 0.5 cm/yr in diameter; crowded stems grow very slowly. After cutting, growth of the coppice for the first few years, both in diameter and height, is somewhat faster than seedlings. Yields of 11 to 23 m<sup>3</sup>/ha/yr are estimated.

**References:** Chudnoff and Goytia 1972, Englerth 1960, Francis 1990i, Gregory 1946, Marrero 1947a, Marrero 1949a, Marrero 1950b, Wadsworth 1943a, Wadsworth 1943c, Weaver and Nieves 1978, Wolcott 1946.

***Tabebuia donnell-smithii* Rose**

**BIGNONIACEAE**

**Primavera**

Primavera is a fast-growing timber tree from southern Mexico and Central America that produces a furniture-quality wood. Although somewhat large for a residential ornamental, because of its spectacular yellow floral display, primavera would fit well into landscaping

designs for parks and estates. Hurricane Hugo felled much of a plantation of 30-m trees near Catalina, in the CNF, where sapling and pole-sized regeneration were established, although a number of large trees remain. The species is also well represented in a successful test planting at Cambalache and by a very fast-growing individual at the Botanic Garden in Río Piedras. A number of unexplained failures have also occurred in Puerto Rico.

**References:** Francis 1989g, Francis 1992d, Marrero 1965b, Tropical Forest Experiment Station 1949, Tropical Forest Experiment Station 1950, Tropical Forest Experiment Station 1954, Wadsworth 1960a.

***Tabebuia heterophylla* (DC.) Britton**

**BIGNONIACEAE**

**Roble**

Roble is a medium-sized native tree with good form and very useful wood. An annual display of pink flowers makes it a popular ornamental despite an often scraggly appearance, which results from witches' broom, a virus common to roble in urban areas. During the 1930's and 1940's, the species was used to reforest abandoned pastures and farmland. Wildlings from 30 to 90 cm tall were used and gave early survivals of 20 to almost 100 percent. When adequate moisture was available at planting time, mortality was almost always related to competition from grass or vines. Planting stock can also be grown from seeds. Because they quickly lose their viability, roble seeds should be sown soon after collection. Seeds germinate rapidly on wet peat. Early growth is about 30 cm/yr, increasing somewhat after 2 or 3 years, until final heights of 12 to 22 m are reached. Maximum diameters depend a great deal on site quality and competition. The Puerto Rican champion roble has a diameter of 50 cm; individuals in many stands that have become established on depleted agricultural fields will never exceed 30 cm d.b.h.

**References:** Chudnoff and Goytia 1972, Englerth 1960, Kramer 1925, Marrero 1949a, Marrero 1949b, Marrero 1950a, Marrero 1950b, Martorell 1953, Schubert 1979, Southern Region 1990, Wadsworth 1943b, Wadsworth 1943c, Wadsworth 1948, Wadsworth 1949, Wadsworth 1960a, Wadsworth and Englerth 1959, Weaver 1990c, Wolcott 1946.

***Tamarindus indica* L.**

**LEGUMINOSAE (CAESALPINIACEAE)**

**Tamarind, tamarindo**

Although planted throughout the tropics, tamarind is native to Africa. Principally valued as a fruit tree, tamarind is useful as cattle shade, for conservation planting in rocky, dry areas, and for fuelwood. Tamarind has naturalized in the drier parts of Puerto Rico.

Seedlings are easily produced in the nursery but take about a year to reach plantable size. They survive outplanting well if given good weed protection. A test planting of 49 trees at Albergue Olimpico on eroded soil 20 cm deep over fractured igneous rock had 59 percent survival and added 0.76 m of height in 4 years. The tallest individual grew almost 2 m.

**References:** Francis and Liogier 1991, Little and Wadsworth 1964, Marrero 1949a, Parrotta 1990b, Schubert 1979, Wolcott 1946.

***Terminalia ivorensis* A. Chev.**

**COMBRETACEAE**

**Idigbo**

Idigbo is a valuable timber tree from Africa that has been introduced in forest adaptability trials. Its form is excellent, with long, regular internodes and a very straight bole. Idigbo wood is valued for furniture, veneer, and trim. Successful plantings have been made in the Luquillo Experimental Forest Arboretum and at a site (Adaptability Study) on private property near Lares. Small numbers of trees have been successfully planted on at least two other sites. Natural reproduction is competing successfully with secondary vegetation near the Arboretum plantation, and a number of trees have reached a codominant canopy position. Winged seeds ripen in late summer and must be collected from the ground or by climbing the often tall trees. There are about 6,000 seeds/kg, which should be sown in potting mix or fine sand soon after collection. New seedlings should be pricked into nursery bags under light shade. After recovery of the root system, they should be given full sunlight. After about 6 months, the seedlings will be ready to transplant (0.4-0.5 m). Full sunlight and well-distributed rainfall of at least 1300 mm annually is required. Idigbo tolerates a wide range of soils and elevations where it has demonstrated good survival and

aggressive growth. During the early years, from 1.0 to 1.5 m/yr of height growth is common in Puerto Rico. Depending on competition, individual trees sustain a 0.5 to 2 cm/yr increase in d.b.h.

**References:** Francis [n.d.], Francis 1989f, Francis 1992d, Francis and Liogier 1991, Lugo and others 1990a, Lugo and others 1993.

***Thespesia grandiflora* (DC.) Urban**

**MALVACEAE**

**Maga**

Maga, an endemic, medium-sized tree, is prized for its large, dark-pink flowers now recognized as the State flower of Puerto Rico. The species is site demanding and is most often found in the forests of the moist limestone hills. The fruits are eaten, and its seeds dispersed by fruit bats and, possibly, birds. Maga trees grow very well if planted on deep, loose, and fertile soil, but each year hundreds die or stagnate after being planted on compacted fill in urban areas. Because maga produces a beautiful, workable, and termite-resistant wood, which is in demand for fine furniture, and because seedlings are easy to produce in the nursery, a number of plantations were established in the 1930's and 1940's. Slow growth relative to invading secondary forest trees doomed that effort; only scattered, disappointingly small remnant trees remain. The seeds, which number 3,900 seeds/kg, are available in small numbers almost throughout the year. Highly recalcitrant, they should be planted immediately. Grown in plastic nursery bags, seedlings should be ready for outplanting (40 cm in height) in about 6 months.

**References:** Francis 1989h, Marrero 1942a, Marrero 1947a, Marrero 1950b, Martorell 1953, Schubert 1979, Southern Region 1990, Tropical Forest Experiment Station 1952, Tropical Forest Research Center 1957, Wadsworth 1943c, Wolcott 1940, Wolcott 1946.

***Thespesia populnea* (L.) Soland. ex Correa**

**MALVACEAE**

**Portiatree, emajaguilla**

Portiatree is a small tree that originated somewhere in the Old World Tropics. It now grows on tropical coasts throughout the world. Portiatree is grown in nurseries in

Puerto Rico and planted in coastal areas as an ornamental. To some extent, it is used in conservation plantings, both within beach-strand vegetation and on better drained sites near mangroves. The species grows well on sandy or moist calcareous soils, and its size makes portiatree manageable in yards and along streets. Seeds are available most of the year and are collected by picking the fruits from trees or off the ground. The seeds require no special treatment, and about 70 percent germinate. Nursery seedlings are reported to reach 15 cm in height in about 3 months. On good sites, planted trees can be expected to grow about 0.5 m/yr. Portiatree reaches a maximum height of about 12 m and 50 cm d.b.h. Used in turnery and carving, portiatree is a high-value, beautiful dark, reddish-brown wood.

**References:** Francis and Liogier 1991, Francis and Rodríguez 1993, Little and Wadsworth 1964, Martorell 1953, Parrotta 1994d, Pennock 1967, Schubert 1979, Southern Region 1990, Winters and Almeyda 1953.

***Toona ciliata* M. Roem.**

**MELIACEAE**

**Burma toon, tun**

This native of southern Asia and Australia was introduced as a substitute for the native Spanish cedar, which proved nearly impossible to grow in plantations because of shoot borers. Burma toon is resistant to the mahogany shoot borer, is very similar in appearance to Spanish cedar, and produces a wood of similar value. The seed sources first planted at several points in the CNF give the same outstanding form as Spanish cedar, while sources used in the Arboretum tend to be short-boled and open-crowned. Trees today range from 20 to 60 cm d.b.h. Natural regeneration has occurred in some areas. Other plantings, which were successful in their early years at Cambalache and Toro Negro, have not been found. Seed, nursery, and planting practices are the same as for Spanish cedar or West Indies mahogany.

**References:** Francis 1989f, Tropical Forest Experiment Station 1949, Tropical Forest Experiment Station 1950, Tropical Forest Experiment Station 1954.

***Triplaris cumingiana* Fisch. & Mey.**

**POLYGONACEAE**

**Triplaris**

This beautifully flowering species, native to South America, was planted in 1938 at Sabana in the CNF. A group of 19 six-year-old trees there were from 5 to 7 m tall and averaged 12 cm d.b.h. None of these trees could be found years later. There are about eight trees of unknown age in the Botanic Garden. The largest measures 20 m tall and 55 cm d.b.h. Seedlings and pole-sized regeneration can be found within 300 yards of the parent trees. *Triplaris* is occasionally planted as an ornamental.

**References:** Francis and Liogier 1991, Marrero 1947a, Pennock 1967.

***Zanthoxylum flavum* Vahl**

**RUTACEAE**

**Satinwood, acetillo**

Satinwood is a medium-sized tree of moist and dry forests that produces a lustrous yellow wood with a satiny feel and a strong but pleasant odor of spicy coconut, which remains for many years. It was once the most valuable wood in Puerto Rico. So much was used locally and exported for fine furniture, paneling, carving, and turnery, that the species became rare. The seeds of West Indian satinwood are infrequently borne and generally give low germination because of perforation by seed insects. Seedlings, however, survive transplanting well. A total of about 2 ha of plantations have been established in Guajataca in three different efforts. Growth has been slow. As a maximum height of 20 to 25 m is approached, early height growth of a little over 0.5 m/yr slows. Early diameter growth of about 0.5 cm/yr slows to between 0.3 and 0.4 cm/yr after about 25 or 30 years. Rotations necessary to produce trees with 50 cm d.b.h. would be 120 years or more. The species is sometimes used as an ornamental. It has a fine appearance, grows somewhat faster as an ornamental than in forest plantations, and tolerates poor soils and fill dirt.

**References:** Little and Wadsworth 1964, Marrero 1949a, Marrero 1950b, Tropical Forest Experiment Station 1952.

## ***Ziziphus mauritiana* Lam.**

### **RHAMNACEAE**

#### **Jujube, aprín**

A native of India and Southeast Asia, jujube is a small- to medium-statured minor fruit tree that has become widely established in Vieques and naturalized, to a limited extent, in the dry south coast of Puerto Rico. The small, plumb-like fruits are eaten out-of-hand in rural areas. Because of its hooked thorns, the species is not very desirable as an ornamental. In places other than Puerto Rico, its wood is used for fuel, tool handles, and wood carving. Although suffering greater than desirable mortality, seedlings in the nursery average more than 0.5 m height growth in 4 months. Plantings in Cambalache and St. Just eventually failed. Future plantings should probably be confined to drier portions of the island.

**References:** Francis and Liogier 1991, Francis and Rodríguez 1993, Marrero 1949a, Wadsworth 1947a.

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## **Appendix**

**Table 1—Summary of attributes<sup>a</sup> and benefits from the principal species treated in this report**

| Species                                                 | Native/<br>exotic | Tree<br>type | Size | Shade<br>tolerance | Use   | Wood<br>products |
|---------------------------------------------------------|-------------------|--------------|------|--------------------|-------|------------------|
| <i>Acacia auriculiformis</i> A. Cunn. ex Benth.         | X                 | Hw           | M    | In                 | O,C   | U,S              |
| <i>Adenanthera pavonina</i> L.                          | X                 | Hw           | M    | Md                 | O     | S,U              |
| <i>Agathis robusta</i> (C. Moore) F.M. Bailey           | X                 | Co           | L    | Md                 | O,T   | S,P,A            |
| <i>Albizia carbonaria</i> Britton                       | X                 | Hw           | M    | In                 | C,A   | U                |
| <i>Albizia lebbek</i> (L.) Benth.                       | X                 | Hw           | M    | Vi                 | O     | A,U              |
| <i>Albizia procera</i> (Roxb.) Benth.                   | X                 | Hw           | M    | Vi                 | T,C   | F,A,U            |
| <i>Aleurites moluccana</i> (L.) Willd.                  | X                 | Hw           | L    | In                 | O     | U                |
| <i>Andira inermis</i> (W. Wright) DC.                   | N                 | Hw           | M    | In                 | T,O,C | F,I,U            |
| <i>Anthocephalus chinensis</i> (Lam.) A. Rich. ex Walp. | X                 | Hw           | L    | In                 | T     | S,P              |
| <i>Araucaria bidwillii</i> Hook.                        | X                 | Co           | M    | Md                 | O     | S,P,U            |
| <i>Araucaria columnaris</i> (Forst.) Hook.              | X                 | Co           | M    | Md                 | O     | S,P,U            |
| <i>Araucaria heterophylla</i> (Salisb.) Franco          | X                 | Co           | L    | Md                 | O,T   | S,I,P            |
| <i>Artocarpus altilis</i> (S. Park) Fosb.               | X                 | Hw           | M    | In                 | G     | A                |
| <i>Bambusa glaucescens</i> (Willd.) Siebold & Holt      | X                 | Gr           | Sm   | In                 | C     | A,P,S            |
| <i>Bambusa longispiculata</i> Gamble ex Brandis         | X                 | Gr           | Sm   | In                 | C     | A,P,S            |
| <i>Bambusa tulda</i> Roxb.                              | X                 | Gr           | Sm   | In                 | C     | A,P,S            |
| <i>Bambusa tuldooides</i> Munro                         | X                 | Gr           | Sm   | In                 | C     | A,P,S            |
| <i>Bambusa vulgaris</i> Schrad. ex Wendl.               | X                 | Gr           | Sm   | In                 | C     | A,P,S            |
| <i>Buchenavia tetraphylla</i> (Aublet) R. Howard        | N                 | Hw           | V    | In                 | T,C   | S,F,I            |
| <i>Bucida buceras</i> L.                                | N                 | Hw           | L    | In                 | T,O   | S,I,U            |
| <i>Byrsonima spicata</i> (Cav.) H.B.K.                  | N                 | Hw           | M    | Md                 | T,C,O | F,I,U            |
| <i>Calophyllum calaba</i> L.                            | N                 | Hw           | M    | Md                 | T,O,C | S,I,U            |
| <i>Cariniana legalis</i> (Mart.) O. Ktze.               | X                 | Hw           | L    | In                 | T     | F,S,U            |
| <i>Casuarina cristata</i> Miq.                          | X                 | Hw           | M    | In                 | C,O   | S,F              |
| <i>Casuarina equisetifolia</i> L. ex J.R. & G. Forst.   | X                 | Hw           | L    | In                 | O,C   | S,U              |
| <i>Catalpa longissima</i> (Jacq.) Dum. Cours.           | X                 | Hw           | M    | In                 | T,O,C | F,I,S            |
| <i>Cavanillesia platanifolia</i> H.B.K.                 | X                 | Hw           | M    | Vi                 | O     | —                |
| <i>Cecropia schreberiana</i> Miq.                       | N                 | Hw           | M    | In                 | C,A   | A,P              |
| <i>Cedrela odorata</i> L.                               | N                 | Hw           | L    | In                 | T,C,G | F,I,A            |
| <i>Ceiba pentandra</i> (L.) Gaertn.                     | N                 | Hw           | V    | In                 | O,C   | S,U              |
| <i>Citharexylum fruticosum</i> L.                       | N                 | Hw           | Sm   | In                 | A,C   | S,U              |
| <i>Clitoria fairchildiana</i> R. Howard                 | X                 | Hw           | Sm   | In                 | O     | U                |
| <i>Coccoloba uvifera</i> (L.) L.                        | N                 | Hw           | Sm   | Vi                 | O,C   | U,A              |
| <i>Cocos nucifera</i> L.                                | X                 | Pa           | M    | In                 | G,O   | S                |
| <i>Cordia alliodora</i> (Ruiz & Pav.) Oken              | N                 | Hw           | M    | In                 | T     | S,F,U            |
| <i>Cunninghamia lanceolata</i> (Lamb.) Hook.            | X                 | Co           | M    | Md                 | T,O   | S,U              |

**Table 1—Summary of attributes<sup>a</sup> and benefits from the principal species treated in this report (continued)**

| Species                                         | Native/<br>exotic | Tree<br>type | Size | Shade<br>tolerance | Use | Wood<br>products |
|-------------------------------------------------|-------------------|--------------|------|--------------------|-----|------------------|
| <i>Dacryodes excelsa</i> Vahl                   | N                 | Hw           | L    | Md                 | T,C | F,I,S            |
| <i>Dalbergia sissoo</i> Roxb.                   | X                 | Hw           | Sm   | Vi                 | T   | A,F,I            |
| <i>Delonix regia</i> (Sojer) Raf.               | X                 | Hw           | M    | In                 | O   | U                |
| <i>Enterolobium cyclocarpum</i> (Jacq.) Griseb. | X                 | Hw           | V    | Vi                 | O,G | S,F,I            |
| <i>Erythrina poeppigiana</i> (Walp.) O.F. Cook  | X                 | Hw           | V    | In                 | G   | S,U              |
| <i>Eucalyptus citriodora</i> Hook.              | X                 | Hw           | L    | In                 | T   | S,U              |
| <i>Eucalyptus deglupta</i> Blume                | X                 | Hw           | L    | Vi                 | T,O | F,P,U            |
| <i>Eucalyptus grandis</i> W. Hill ex Maiden     | X                 | Hw           | V    | Vi                 | T   | P,S,U            |
| <i>Eucalyptus pellita</i> F. Muell.             | X                 | Hw           | L    | In                 | T   | P,S,U            |
| <i>Eucalyptus resinifera</i> J.E. Smith         | X                 | Hw           | L    | In                 | T   | P,S,U            |
| <i>Eucalyptus robusta</i> J.E. Smith            | X                 | Hw           | L    | In                 | T,C | P,S,U            |
| <i>Eucalyptus tereticornis</i> J.E. Smith       | X                 | Hw           | L    | Vi                 | T   | P,S,U            |
| <i>Eucalyptus torelliana</i> F. Muell.          | X                 | Hw           | M    | In                 | O   | S, U             |
| <i>Eucalyptus urophylla</i> Blake               | X                 | Hw           | L    | In                 | T   | P,S,U            |
| <i>Eucalyptus x kirtoniana</i> F. Muell.        | X                 | Hw           | L    | In                 | T   | P,S,U            |
| <i>Fraxinus uhdei</i> (Wenzig) Lingelsh.        | X                 | Hw           | M    | Md                 | O,T | F,I,U            |
| <i>Genipa americana</i> L.                      | N                 | Hw           | M    | In                 | G,T | S,A,U            |
| <i>Gliricidia sepium</i> (Jacq.) Walp.          | X                 | Hw           | Sm   | Vi                 | G   | U                |
| <i>Gmelina arborea</i> Roxb.                    | X                 | Hw           | M    | In                 | T   | P,S,U            |
| <i>Guaiacum officinale</i> L.                   | N                 | Hw           | Sm   | In                 | O,C | A                |
| <i>Guarea guidonia</i> (L.) Sleumer             | N                 | Hw           | L    | Md                 | T,C | F,I,U            |
| <i>Haematoxylum campechianum</i> L.             | X                 | Hw           | Sm   | In                 | C   | A,U              |
| <i>Hernandia sonora</i> L.                      | N                 | Hw           | L    | In                 | T,C | P                |
| <i>Hibiscus elatus</i> Sw.                      | X                 | Hw           | M    | In                 | T,O | F,I,S            |
| <i>Hura crepitans</i> L.                        | N                 | Hw           | L    | In                 | G,C | P,U              |
| <i>Hyeronima clusioides</i> (Tul.) Muell-Arg.   | N                 | Hw           | M    | In                 | T,C | F,I,U            |
| <i>Hymenaea courbaril</i> L.                    | N                 | Hw           | L    | In                 | T,O | I,A,S            |
| <i>Inga vera</i> Willd.                         | N                 | Hw           | M    | In                 | G,C | U                |
| <i>Juglans jamaicensis</i> C. DC.               | N                 | Hw           | M    | In                 | T,C | F,I,A            |
| <i>Khaya grandifoliola</i> C. DC.               | X                 | Hw           | L    | Md                 | T   | F,I              |
| <i>Khaya nyasica</i> Stapf. ex Baker f.         | X                 | Hw           | L    | Md                 | T   | F,I              |
| <i>Khaya senegalensis</i> Juss.                 | X                 | Hw           | M    | In                 | T,O | F,I,A            |
| <i>Lagerstroemia speciosa</i> (L.) Pers.        | X                 | Hw           | M    | In                 | O,T | F,I,U            |
| <i>Laguncularia racimosa</i> (L.) Gaertn. f.    | N                 | Hw           | Sm   | In                 | C   | F                |
| <i>Leucaena leucocephala</i> (Lam.) de Wit      | X                 | Hw           | Sm   | In                 | C   | U,S              |
| <i>Lysiloma latisiliqua</i> Gray ex Sauv.       | X                 | Hw           | Sm   | In                 | T,C | I,A,F            |

**Table 1—Summary of attributes<sup>a</sup> and benefits from the principal species treated in this report (continued)**

| Species                                             | Native/<br>exotic | Tree<br>type | Size | Shade<br>tolerance | Use   | Wood<br>products |
|-----------------------------------------------------|-------------------|--------------|------|--------------------|-------|------------------|
| <i>Maesopsis eminii</i> Engl.                       | X                 | Hw           | M    | In                 | T,C   | S,F,I            |
| <i>Mammea americana</i> L.                          | N                 | Hw           | L    | T                  | G,O   | A,U              |
| <i>Mangifera indica</i> L.                          | X                 | Hw           | L    | Md                 | G,O   | S,F,U            |
| <i>Manilkara bidentata</i> (A. DC.) A. Chev.        | N                 | Hw           | L    | Md                 | T,C   | S,I,A            |
| <i>Melicoccus bijugatus</i> Jacq.                   | N                 | Hw           | M    | In                 | G,O   | I,U              |
| <i>Ochroma pyramidale</i> Cav.                      | N                 | Hw           | M    | In                 | T,C   | A                |
| <i>Ocotea moschata</i> (Meissn.) Mez                | N                 | Hw           | M    | Md                 | T,C   | F,A,I            |
| <i>Parkia timoriana</i> (DC.) Merrill               | X                 | Hw           | M    | In                 | O     | S,U              |
| <i>Peltophorum pterocarpum</i> (DC.) Black. & Heyne | X                 | Hw           | M    | Vi                 | O     | F,U              |
| <i>Petitia domingensis</i> Jacq.                    | N                 | Hw           | M    | Vi                 | T,C   | I,F,U            |
| <i>Pimenta racimosa</i> (Miller) J.W. Moore         | N                 | Hw           | Sm   | In                 | G,O,C | S,U              |
| <i>Pinus caribaea</i> Morelet                       | X                 | Co           | L    | Vi                 | T,C,O | S,P,U            |
| <i>Pinus patula</i> Schiede & Deppe                 | X                 | Co           | L    | Vi                 | T     | S,P,U            |
| <i>Piptadenia peregrina</i> (L.) Benth.             | N                 | Hw           | Sm   | Vi                 | C     | U,S              |
| <i>Pithecellobium arboreum</i> (L.) Urban           | N                 | Hw           | M    | In                 | C,O   | A                |
| <i>Pithecellobium dulce</i> (Roxb.) Benth.          | X                 | Hw           | M    | In                 | O,C   | U,A,S            |
| <i>Platysmiscium pinnatum</i> (Jacq.) Dugand        | X                 | Hw           | M    | In                 | O,T   | F,I,U            |
| <i>Pouteria multiflora</i> (A. DC.) Eyma            | N                 | Hw           | M    | Md                 | G,C   | F,I,U            |
| <i>Prosopis juliflora</i> (Sw.) DC.                 | X                 | Hw           | M    | Vi                 | G     | A,U              |
| <i>Prunus occidentalis</i> Sw.                      | N                 | Hw           | L    | Md                 | T,C   | F,I,A            |
| <i>Pterocarpus indicus</i> Willd.                   | X                 | Hw           | L    | Md                 | O,T   | F,I,A            |
| <i>Pterocarpus macrocarpus</i> Kurz                 | X                 | Hw           | L    | Md                 | O     | F,S,I            |
| <i>Rhizophora mangle</i> L.                         | N                 | Hw           | Sm   | Vi                 | C     | U,S              |
| <i>Roystonea borinquena</i> O.F. Cook               | N                 | Hw           | M    | In                 | O,C   | S                |
| <i>Sabal causiarum</i> (O.F. Cook) Becc.            | N                 | Pa           | Sm   | In                 | C,O   | S                |
| <i>Samanea saman</i> (Jacq.) Merrill                | X                 | Hw           | L    | Vi                 | G,O,T | F,S,A            |
| <i>Schizolobium parahybum</i> (Vell.) Blake         | X                 | Hw           | M    | In                 | T,O   | S,P              |
| <i>Senna siamea</i> Irwin & Barnaby                 | X                 | Hw           | M    | Vi                 | G,O   | U,A              |
| <i>Simaruba amara</i> Aubl.                         | X                 | Hw           | M    | Md                 | T,C   | S,P,A            |
| <i>Spathodea campanulata</i> Beauv.                 | X                 | Hw           | L    | In                 | O     | P,S              |
| <i>Spondias mombin</i> L.                           | N                 | Hw           | L    | In                 | G,C   | S,P,U            |
| <i>Stahlia monosperma</i> (Tul.) Urban              | N                 | Hw           | Sm   | In                 | C,O   | A,F              |
| <i>Sterculia apetala</i> (Jacq.) Karst.             | X                 | Hw           | L    | In                 | O     | P                |
| <i>Swietenia macrophylla</i> G. King                | X                 | Hw           | L    | In                 | T,O   | F,I,S            |
| <i>Swietenia mahagoni</i> Jacq.                     | X                 | Hw           | M    | Vi                 | O,T   | F,A,I            |
| <i>Swietenia mahagoni</i> x <i>macrophylla</i>      | X                 | Hw           | L    | In                 | T,O   | F,I,S            |

**Table 1—Summary of attributes<sup>a</sup> and benefits from the principal species treated in this report (continued)**

| Species                                          | Native/<br>exotic | Tree<br>type | Size | Shade<br>tolerance | Use   | Wood<br>products |
|--------------------------------------------------|-------------------|--------------|------|--------------------|-------|------------------|
| <i>Syzygium jambos</i> (L.) Alst.                | X                 | Hw           | Sm   | T                  | G,O   | U,S              |
| <i>Tabebuia donnell-smithii</i> Rose             | X                 | Hw           | L    | In                 | T,O   | F,I,S            |
| <i>Tabebuia heterophylla</i> (DC.) Britton       | N                 | Hw           | M    | In                 | O,T,G | S,F,P            |
| <i>Tamarindus indica</i> L.                      | X                 | Hw           | M    | Vi                 | G,O   | A,U              |
| <i>Tectona grandis</i> L. f.                     | X                 | Hw           | M    | In                 | T,O   | F,I,A            |
| <i>Terminalia catappa</i> L.                     | X                 | Hw           | M    | In                 | O,T   | F,I,S            |
| <i>Terminalia ivorensis</i> A. Chev.             | X                 | Hw           | L    | In                 | T     | I,F,S            |
| <i>Thespesia grandiflora</i> (DC.) Urban         | N                 | Hw           | M    | In                 | O,C   | F,A,I            |
| <i>Thespesia populnea</i> (L.) Soland. ex Correa | X                 | Hw           | Sm   | Vi                 | O     | A,F,U            |
| <i>Toona ciliata</i> M. Roem.                    | X                 | Hw           | L    | In                 | T     | F,I,S            |
| <i>Triplaris cumingiana</i> Fisch. & Mey.        | X                 | Hw           | L    | In                 | O     | S,U              |
| <i>Zanthoxylum flavum</i> Vahl                   | N                 | Hw           | M    | In                 | T,C   | F,A,I            |
| <i>Ziziphus mauritiana</i> Lam.                  | X                 | Hw           | Sm   | Vi                 | G,C   | U,A              |

<sup>a</sup> Native/exotic: N = native, X = exotic; Tree type: Co = conifer, Hw = hardwood, Gr = grass, Pa = palm; Size: Sm = small, M = medium, L = large, V = very large; Shade tolerance: To = tolerant, Md = mid-tolerant, In = intolerant, Vi = very intolerant; Use: T = timber, O = ornamental, G = agroforestry and fruits, C = conservation including wildlife; Wood products: S = structural and posts, F = furniture, I = interior, A = arts and crafts, P = pulp and chips, U = fuel.

**Table 2—Summary of site requirements and recommended management practices for the principal species treated in this report<sup>a</sup>**

| Species                                                 | Parent material | Incompatible soil properties | Planting method | Management method |
|---------------------------------------------------------|-----------------|------------------------------|-----------------|-------------------|
| <i>Acacia auriculiformis</i> A. Cunn. ex Benth.         | L,V,F           | Pd                           | N,Ds            | Ns,I,B            |
| <i>Adenanthera pavonina</i> L.                          | L,V             | C,P,Pd                       | N,Ds            | B,I               |
| <i>Agathis robusta</i> (C. Moore) F.M. Bailey           | S,V             | D                            | N,Br,W          | I,B,U             |
| <i>Albizia carbonaria</i> Britton                       | V               | D,P                          | N               | I,B               |
| <i>Albizia lebbek</i> (L.) Benth.                       | L,V,F           | Lp,Pd                        | N,Ds            | I,B               |
| <i>Albizia procera</i> (Roxb.) Benth.                   | L,S,V,F         | Pd                           | N,Ds            | I,B,Ns            |
| <i>Aleurites moluccana</i> (L.) Willd.                  | V,L             | C,D                          | N,Ds            | I,B               |
| <i>Andira inermis</i> (W. Wright) DC.                   | L,V,F           | D                            | N,Ds            | I,B,Ns            |
| <i>Anthocephalus chinensis</i> (Lam.) A. Rich. ex Walp. | L,V             | C,Lf,P,D                     | N               | B                 |
| <i>Araucaria bidwillii</i> Hook.                        | L,S,V,F         | D                            | N               | I,U,B             |
| <i>Araucaria columnaris</i> (Forst.) Hook.              | L,S,V,F         | D                            | N               | I,B               |
| <i>Araucaria heterophylla</i> (Salisb.) Franco          | L,S,V,F         | D                            | N               | I,B               |
| <i>Artocarpus altilis</i> (S. Park.) Fosb.              | L,V             | C,Lf,D                       | N,W             | I                 |
| <i>Bambusa glaucescens</i> (Willd.) Siebold & Holt      | V,L,S,F         | D                            | Ct,N            | I                 |
| <i>Bambusa longispiculata</i> Gamble ex Brandis         | V,L,S,F         | D                            | Ct,N            | I                 |
| <i>Bambusa tulda</i> Roxb.                              | V,L,S,F         | D                            | Ct,N            | I                 |
| <i>Bambusa tuldoidea</i> Munro                          | V,L,S,F         | D                            | Ct,N            | I                 |
| <i>Bambusa vulgaris</i> Schrad. ex Wendl.               | V,L,S,A         | D                            | Ct,N            | I                 |
| <i>Buchenavia tetraphylla</i> (Aublet) R. Howard        | V,L,S           | D                            | N               | I,B               |
| <i>Bucida buceras</i> L.                                | V,L,F           | Pd                           | N               | I,B               |
| <i>Byrsonima spicata</i> (Cav.) H.B.K.                  | V,L,S           | D,Lf                         | N               | I,B               |
| <i>Calophyllum calaba</i> L.                            | L,A,V,F         | D                            | N,Ds            | I,B               |
| <i>Cariniana legalis</i> (Mart.) O. Ktze.               | V               | D                            | N               | B,I               |
| <i>Casuarina cristata</i> Miq.                          | V,S,L,F         | C                            | N               | B,I               |
| <i>Casuarina equisetifolia</i> L. ex J.R. & G. Forst    | V,S,L,F         | C                            | N               | B,I               |
| <i>Catalpa longissima</i> (Jacq.) Dum. Cours.           | V,L             | C,D                          | N,Ct            | B,I               |
| <i>Cavanillesia platanifolia</i> H.B.K.                 | V               | Pd                           | N               | I                 |
| <i>Cecropia schreberiana</i> Miq.                       | V,L,S           | C,Lf,D                       | N               | Ns,Bt             |
| <i>Cedrela odorata</i> L.                               | V,L             | C,Lf,D                       | N               | I                 |
| <i>Ceiba pentandra</i> (L.) Gaertn.                     | V,L,A,F         | Lf,D                         | N               | I                 |
| <i>Citharexylum fruticosum</i> L.                       | V,L,S,F         | Pd                           | N               | B                 |
| <i>Clitoria fairchildiana</i> R. Howard                 | V,L,F           | D                            | N,Ct,Br         | I,B               |
| <i>Coccoloba uvifera</i> (L.) L.                        | V,L,F           | Lf,Pd                        | N               | I,B               |
| <i>Cocos nucifera</i> L.                                | A,L,V,F         | D                            | Ds              | I,B               |
| <i>Cordia alliodora</i> (Ruiz & Pav.) Oken              | V,L             | C,D                          | N               | B                 |
| <i>Cunninghamia lanceolata</i> (Lamb.) Hook.            | V               | P,D                          | N,Br            | I,B               |
| <i>Dacryodes excelsa</i> Vahl.                          | V               | D,C,Lf,P                     | W               | U,I               |
| <i>Dalbergia sissoo</i> Roxb.                           | L,V             | Pd,Lp                        | N               | I,B               |
| <i>Delonix regia</i> (Sojer) Raf.                       | L,V,A,F         | Pd,Lf                        | N               | I                 |
| <i>Enterolobium cyclocarpum</i> (Jacq.) Griseb.         | L,V,F           | Pd                           | N,Ds            | I                 |
| <i>Erythrina poeppigiana</i> (Walp.) O.F. Cook          | L,V             | C,Lf,D                       | Ct,N,Ds         | I,B               |
| <i>Eucalyptus citriodora</i> Hook.                      | V               | Lf,D                         | N               | B                 |
| <i>Eucalyptus deglupta</i> Blume                        | A,V,L           | Lf,D,C                       | N,Ct            | I,B               |
| <i>Eucalyptus grandis</i> W. Hill ex Maiden             | V,L,A,S         | D,Lf,C                       | N,Ct            | B                 |

**Table 2—Summary of site requirements and recommended management practices for the principal species treated in this report<sup>a</sup> (continued)**

| Species                                             | Parent material | Incompatible soil propertie | Planting method | Management method |
|-----------------------------------------------------|-----------------|-----------------------------|-----------------|-------------------|
| <i>Eucalyptus pellita</i> F. Muell.                 | V,L,A           | D,Lf,C                      | N               | B                 |
| <i>Eucalyptus resinifera</i> J.E. Smith             | V,L,A           | D,Lf,C                      | N               | B                 |
| <i>Eucalyptus robusta</i> J.E. Smith                | V,L,A,S         | D,C                         | N               | B                 |
| <i>Eucalyptus tereticornis</i> J.E. Smith           | V,L,A           | C                           | N               | B                 |
| <i>Eucalyptus torelliana</i> F. Muell.              | V,L,A           | D,C                         | N               | I,B               |
| <i>Eucalyptus urophylla</i> Blake                   | V,L,A           | Pd,C                        | N               | B                 |
| <i>Eucalyptus</i> x <i>kirtoniana</i> F. Muell.     | V,L,A,S         | D,C                         | N               | B                 |
| <i>Fraxinus uhdei</i> (Wenzig) Lingelsh.            | V,S,L,A         | D,Lf,C                      | Br,N,Ct         | I,B,I,n           |
| <i>Genipa americana</i> L.                          | V,A             | D,Lf,C                      | N               | I,B               |
| <i>Gliricidia sepium</i> (Jacq.) Walp.              | L,V,F           | Pd                          | Ct,N,Ds         | I                 |
| <i>Gmelina arborea</i> Roxb.                        | A,V,L           | D,Lf,C                      | N,Ds            | B                 |
| <i>Guaiacum officinale</i> L.                       | L,V             | Pd                          | N               | I                 |
| <i>Guarea guidonia</i> (L.) Sleumer                 | V,L,A           | D,C                         | N,Br            | B,U,Ns            |
| <i>Haematoxylum campechianum</i> L.                 | L,V,F           | Pd                          | N               | I,B               |
| <i>Hernandia sonora</i> L.                          | V,A             | D                           | N               | B                 |
| <i>Hibiscus elatus</i> Sw.                          | L,V             | D,Lf,C                      | N,Br,W          | B,I,n             |
| <i>Hura crepitans</i> L.                            | A,V,L           | D,Lf                        | N,Ds            | I                 |
| <i>Hyeronima clusioides</i> (Tul.) Muell-Arg.       | L               | Lf,C                        | N               | B                 |
| <i>Hymenaea courbaril</i> L.                        | V,A,L,F         | D,C                         | N               | I,B               |
| <i>Inga vera</i> Willd.                             | V               | D,Lf                        | N               | I,B               |
| <i>Juglans jamaicensis</i> C. DC.                   | V               | Lf,D,C                      | N,D             | I,B               |
| <i>Khaya grandifoliola</i> C. DC.                   | V               | D,C,Lf                      | N               | B                 |
| <i>Khaya nyasica</i> Stapf. ex Baker f.             | V,L             | D,Lf,Pd                     | N               | B                 |
| <i>Khaya senegalensis</i> Juss.                     | V,L             | D,Lf                        | N               | I,B               |
| <i>Lagerstroemia speciosa</i> (L.) Pers.            | V,I.,F          | Pd,Lf                       | N               | I                 |
| <i>Laguncularia racimosa</i> (L.) Gaertn. f.        | A               | D                           | N,Ds            | B                 |
| <i>Leucaena leucocephala</i> (Lam.) de Wit          | V,L,F           | Pd,Lp                       | N,Ds            | B,N               |
| <i>Lysiloma latisiliqua</i> Gray ex Sauv.           | L               | Pd                          | N,Ds            | B                 |
| <i>Maesopsis eminii</i> Engl.                       | V               | D,Lf                        | N,Ds            | B,I,n             |
| <i>Mammea americana</i> L.                          | V,L             | D,Lf                        | N,Ds            | I                 |
| <i>Mangifera indica</i> L.                          | V,L,S,A         | Lf                          | N,Ds            | I                 |
| <i>Manilkara bidentata</i> (A. DC.) A. Chev.        | V,L,A           | C,Lf                        | N               | B,U               |
| <i>Melicoccus bijugatus</i> Jacq.                   | V,L,A,F         | Lp,C                        | N,Ds            | I                 |
| <i>Ochroma pyramidale</i> Cav.                      | A               | C,Lf,Pd                     | N               | B                 |
| <i>Ocotea moschata</i> (Meissn.) Mez                | V               | D,Lf,C                      | N               | B                 |
| <i>Parkia timoriana</i> (DC.) Merrill               | V,L             | D,C,Lf                      | N               | I,B               |
| <i>Peltophorum pterocarpum</i> (DC.) Black. & Heyne | V,L,A,F         | Pd,Lf                       | N               | I,B               |
| <i>Petitita domingensis</i> Jacq.                   | V,L             | D,Lf,C                      | N               | I,B               |
| <i>Pimenta racimosa</i> (Miller) J.W. Moore         | V,L,S,F         | Pd                          | N,W             | I,B               |
| <i>Pinus caribaea</i> Morelet                       | V,S             | D,P                         | N,Br            | B                 |
| <i>Pinus patula</i> Schiede & Deppe                 | V,S             | D,P                         | N,Br            | B                 |
| <i>Piptadenia peregrina</i> (L.) Benth.             | V,L             | Pd                          | N,Ds            | I,B               |
| <i>Pithecellobium arborieum</i> (L.) Urban          | S,V,L           | D,Lf,P                      | N,D             | I,B               |
| <i>Pithecellobium dulce</i> (Roxb.) Benth.          | V,L,A,F         | D,Lf                        | N,Ds            | I,B               |

**Table 2—Summary of site requirements and recommended management practices for the principal species treated in this report<sup>a</sup> (continued)**

| Species                                          | Parent material | Incompatible soil properties | Planting method | Management method |
|--------------------------------------------------|-----------------|------------------------------|-----------------|-------------------|
| <i>Platysmiscium pinnatum</i> (Jacq.) Dugand     | L,V             | Pd                           | N               | B,I               |
| <i>Pouteria multiflora</i> (A. DC.) Eyma         | V               | D,Lf,C                       | N,Ds,W          | I,B               |
| <i>Prosopis juliflora</i> (Sw.) DC.              | V,L,F           | Lp                           | N,Ds            | B                 |
| <i>Prunus occidentalis</i> Sw.                   | V               | D,Lf,C                       | N               | B,Ln              |
| <i>Pterocarpus indicus</i> Willd.                | V,L             | D,Lf                         | N               | I,B,U             |
| <i>Pterocarpus macrocarpus</i> Kurz              | V,L,S,F         | D,Lf                         | N               | I,B,U             |
| <i>Rhizophora mangle</i> L.                      | A               | D                            | Ds,W            | B                 |
| <i>Roystonea borinquena</i> O.F. Cook            | V,L,A           | D                            | N,W             | I                 |
| <i>Sabal causiarum</i> (O.F. Cook) Becc.         | L               | Pd                           | N               | I                 |
| <i>Samanea saman</i> (Jacq.) Merrill             | V,L             | D,C                          | N               | I                 |
| <i>Schizolobium parahybum</i> (Vell.) Blake      | V               | D,Pd,Lf,C                    | N,Ds            | I,B               |
| <i>Senna siamea</i> Irwin & Barnaby              | V,L,F           | Pd                           | N               | I,B               |
| <i>Simaruba amara</i> Aubl.                      | V               | D,Lf                         | N               | B                 |
| <i>Spathodea campanulata</i> Beauv.              | V,L,A,F         | D,C                          | N               | I,B,Ns            |
| <i>Spondias mombin</i> L.                        | V,L             | Lf,Pd                        | N,Ds            | I                 |
| <i>Stahlia monosperma</i> (Tul.) Urban           | V,L             | Pd                           | N               | I                 |
| <i>Sterculia apetala</i> (Jacq.) Karst.          | V,F             | Pd,Lf                        | N               | I                 |
| <i>Swietenia macrophylla</i> G. King             | V,L,S,A         | D,Lf,C                       | N,Br,Ds         | I,B,Ln            |
| <i>Swietenia mahagoni</i> Jacq.                  | V,L,S,F         | Pd,Lp                        | N,Br            | I,B               |
| <i>Swietenia mahagoni</i> x <i>macrophylla</i>   | V,L,S,A         | Lf,C                         | N,Br,Ds         | I,B,Ln            |
| <i>Syzygium jambos</i> (L.) Alst.                | V,L             | D,Lf                         | N,Ct,Ds         | I,B,U,Ns          |
| <i>Tabebuia donnell-smithii</i> Rose             | V               | D,Lf,C                       | N               | I,B               |
| <i>Tabebuia heterophylla</i> (DC.) Britton       | V,L,S,F         | Pd                           | N,Ct            | B,Ns              |
| <i>Tamarindus indica</i> L.                      | V,L,F           | Lp,Pd                        | N,Ds            | I                 |
| <i>Tectona grandis</i> L. f.                     | V,L             | Pd,Lf                        | N               | B                 |
| <i>Terminalia catappa</i> L.                     | A,F             | Lf,D                         | N               | I                 |
| <i>Terminalia ivorensis</i> A. Chev.             | V               | D,Lf                         | N               | B,Ln              |
| <i>Thespesia grandiflora</i> (DC.) Urban         | L,V             | D,Pd,Lf,C                    | N               | I,B               |
| <i>Thespesia populnea</i> (L.) Soland. ex Correa | A,F             | Lp,Lf                        | N               | I,B               |
| <i>Toona ciliata</i> M. Roem.                    | V,L             | D,Lf,C                       | N,Br            | B                 |
| <i>Triplaris cumingiana</i> Fisch. & Mey.        | V               | D,Lf                         | N               | I                 |
| <i>Zanthoxylum flavum</i> Vahl                   | S,L,V,F         | Pd                           | N               | I,B               |
| <i>Ziziphus mauritiana</i> Lam.                  | A,F             | Pd                           | N,Ds            | I                 |

<sup>a</sup> Parent Materials: A = alluvial, F = fill dirt, L = limestone, S = serpentine, V = volcanic, igneous, and nonlimestone sedimentary; Incompatible Soil Properties: C = compaction, D = excessive drainage, Lf = low fertility, Lp = low pH, P = high pH, Pd = poor drainage; Planting Method: Br = bare-root seedling, Ct = rooted cutting or other vegetative propagation method, Ds = direct seeding, N = potted or other containerized nursery seedling, W = wildling; Management Method: B = solid block planting, I = trees planted individually, Ln = line planting or reinforcement planting, U = underplanting with release.

**Table 3—Additional species that offer a good chance of success given good site selection and proper planting, but are of minor importance, are recommended by only a few successful individuals, have given mixed results in trials, or have some serious drawback**

| Species name                                                          | Situation                                                                                                                                                                                                                                                  |
|-----------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Acacia mangium</i> (L.) Willd.<br>Mangium                          | An attractive exotic ornamental and light timber species with early growth of 1 m/yr or more to a maximum height of about 15 m. Dieback and heavy mortality begins after about 8 to 10 years (Francis and Liogier 1991).                                   |
| <i>Acrocomia media</i> O.F. Cook<br>Corozo                            | Spiny native palm with relatively rapid growth, now used in landscaping. Seeds take about 1 year to germinate (Francis 1993a, Francis and Rodríguez 1993).                                                                                                 |
| <i>Albizia</i> sp. “kalkova”                                          | Thirteen trees have survived and grown relatively well on a rocky site in St. Just (Marrero 1949a).                                                                                                                                                        |
| <i>Aleurites fordii</i> Hemsl.<br>Tung-oil tree, palo de aceite       | A widely planted ornamental and source of drying oil. One forest planting failed due to short stature (Francis and Liogier 1991).                                                                                                                          |
| <i>Araucaria cunninghamii</i> Ait. ex D. Don<br>Hoop-pine             | A stately conifer with valuable wood. Plantings in Carite, the CNF, and Toro Negro. The Carite plantation reached 24 m in height and 31 cm d.b.h. in 26 years. Saplings prone to tipping and older trees may be killed by a coccid insect (Francis 1988a). |
| <i>Artocarpus heterophyllus</i> Lam.<br>Jackfruit, jaca               | A naturalized fruit tree with good form and rapid growth that is competitive in secondary forest (Francis and Liogier 1991).                                                                                                                               |
| <i>Bambusa textilis</i> McClure                                       | Clump-forming bamboo native to China. It has medium-diameter culms, cane heights of 12 m, and resistance to powder-post beetle. Flowering decimated plantings in Mayaguez, Río Piedras, Toro Negro, the CNF, and St. Just (White 1948).                    |
| <i>Berrya ammonilla</i> Roxb.                                         | A timber tree from southern Asia. Several trees grew exceptionally well at U.P.R. in Río Piedras but failed in Cambalache and St. Just.                                                                                                                    |
| <i>Byrsonima lucida</i> (Miller) L.C. Rich.<br>Candle berry, aceituna | A native tree of dry and rocky areas, useful for fuel, conservation plantings, and as an ornamental. Planted in Cambalache but grew slowly (Little and Wadsworth 1964, Marrero 1949a).                                                                     |

**Table 3—Additional species that offer a good chance of success given good site selection and proper planting, but are of minor importance, are recommended by only a few successful individuals, have given mixed results in trials, or have some serious drawback (continued)**

| Species name                                                  | Situation                                                                                                                                                                                                                                                            |
|---------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Calycophyllum candidissimum</i> (Vahl) DC.<br>Dágame       | A small exotic tree useful for timber and ornamentals. Planted successfully in Río Abajo, but failed in three other places (Marrero 1949a).                                                                                                                          |
| <i>Calypttranthes luquillensis</i> Alain                      | Small endangered endemic being grown in the Arboretum. Five of eight wildlings had survived and grown well at 8 years. Two plants have been produced by air layering. Has potential as an ornamental.                                                                |
| <i>Carapa guianensis</i> Aubl.<br>Carapa                      | An important exotic timber tree. A 1953 planting in El Verde (CNF) has grown and reproduced. An Arboretum planting destroyed by high winds. (Francis 1989f, Francis 1992d, Francis and Liogier 1991).                                                                |
| <i>Castanospermum australe</i> A. Cunn.<br>Black bean         | An Australian timber tree valued for wood carving and cabinetry. After 9 years, survival and growth were good in the Arboretum (Francis 1989f).                                                                                                                      |
| <i>Castilla elastica</i> Carv.<br>Castilla rubber             | Large tree imported to test for rubber production. Planting not advised because of a tendency to spread (Francis and Liogier 1991).                                                                                                                                  |
| <i>Casuarina fraserana</i> Miq.<br>Western Australian she-oak | A tree from eastern Australia that grew well in a single planting in Cambalache.                                                                                                                                                                                     |
| <i>Clusia rosea</i> Jacq.<br>Pitch apple, cupey               | Medium-sized native tree sometimes planted as an ornamental. Easily propagated by rooted branch cuttings, wildlings, or potted seedlings. Growth is relatively slow and it is prone to breakage in storms (Francis 1993d, Francis and Rodríguez 1993, Wolcott 1945). |
| <i>Coccoloba diversifolia</i> Jacq.<br>Dove plum, cucubano    | A native species of moist forests with very hard wood, mostly used for fuel. Small plantations in St. Just and Cambalache survived, but grew slowly (Chudnoff and Goytia 1972, Englerth 1960).                                                                       |
| <i>Coccoloba rugosa</i> Desf.<br>Ortegón                      | A rare tree from the mountain forests of eastern Puerto Rico. A planting in the CNF reached 5.5 m in height in 10 years. The DNR has established a number of trees.                                                                                                  |

**Table 3—Additional species that offer a good chance of success given good site selection and proper planting, but are of minor importance, are recommended by only a few successful individuals, have given mixed results in trials, or have some serious drawback (continued)**

| Species name                                                 | Situation                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Coffea arabica</i> L.<br>Coffee, café                     | Small tree or shrub from Africa grown for coffee and naturalized widely. Useful for fuel and as a wildlife food plant (Wadsworth 1960b).                                                                                                                                                                                                                                                                                                                         |
| <i>Colubrina arborescens</i> (Miller) Sarg.<br>Abajuelo      | Small to medium native tree useful for fenceposts, fuel, and as an ornamental. Planted trees grew about 1 m/yr in Monte Guilarte and Río Abajo, but failed in St. Just and Cambalache (Brush 1925b, Little and Wadsworth 1964, Marrero 1947a, Marrero 1949a, Marrero 1950b, Tropical Forest Experiment Station 1949, Tropical Forest Experiment Station 1953).                                                                                                   |
| <i>Cordia obliqua</i> Willd.<br>Manjack, cereza              | An excellent wildlife food producer from India, best for areas receiving 1200 mm m.a.p. Planted as a living fencepost and a roadside ornamental, but escaped in a few areas (Francis and Liogier 1991).                                                                                                                                                                                                                                                          |
| <i>Cordia sulcata</i> DC.<br>White manjack, moral            | A medium-sized native species valued as a wildlife food plant. Small plantings in the CNF and Río Piedras grew slowly. The seedlings are drought sensitive (Chudnoff and Goytia 1972, Englerth 1960, Francis 1995b).                                                                                                                                                                                                                                             |
| <i>Cupania americana</i> L.<br>Candlewood, guara             | A medium-sized native species used for fenceposts. A planting in St. Just failed and plantations in Río Abajo and Cambalache grew slowly (Francis 1991a, Marrero 1949a, Tropical Forest Research Center 1958, Wadsworth 1947b).                                                                                                                                                                                                                                  |
| <i>Cupressus lusitanica</i> Mill.<br>Mexican cypress, ciprés | Exotic conifer that produces excellent wood and acceptable Christmas trees. Early growth is rapid, but slows later. Windthrow has destroyed several plantations on deep clay. Best survival has been in Maricao, Río Abajo, and Monte Guilarte (Brush 1925b, Francis 1989f, Francis 1992d, Francis and Liogier 1991, Geary and Briscoe 1972, Southern Region 1990, Tropical Forest Research Center 1955, Tropical Forest Research Center 1957, Wadsworth 1960a). |
| <i>Entandophragma angolensis</i> C. DC.                      | A valuable timber tree from Africa. One well-formed survivor of 27 planted in the Arboretum (Francis 1989f).                                                                                                                                                                                                                                                                                                                                                     |

**Table 3—Additional species that offer a good chance of success given good site selection and proper planting, but are of minor importance, are recommended by only a few successful individuals, have given mixed results in trials, or have some serious drawback (continued)**

| Species name                                                 | Situation                                                                                                                                                                                                                          |
|--------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Erythrina fusca</i> Lour.<br>Swamp immortelle, bucare     | Naturalized exotic that grows along rivers and on wet coastal plains. It is a useful ornamental and living fencepost. The seeds germinate well and the tree grows rapidly (Francis and Rodríguez 1993, Little and Wadsworth 1964). |
| <i>Eucalyptus saligna</i> Sm.<br>Willow-leaf gum             | The fastest growing eucalypt in the Arboretum. Most tipped or snapped during Hurricane Hugo (Francis 1989f, Francis 1992d, Lugo and others 1990a).                                                                                 |
| <i>Eucalyptus tessilaris</i> F. Muell.<br>Moreton Bay ash    | Showed excellent growth at Albergue Olimpico and Canyon San Cristobal; failed in the Arboretum because of excess precipitation.                                                                                                    |
| <i>Ficus citrifolia</i> P. Miller<br>Jagüey                  | Common native frequently used as a living fencepost. A good wildlife food plant easily propagated from cuttings (Francis 1994a, Chudnoff and Goytia 1972, Englerth 1960, Tropical Forest Research Center 1958).                    |
| <i>Forestiera rhamnifolia</i> Griseb.                        | Shrub or small tree from Mona Island and elsewhere in the Antilles. Demonstrated good survival and acceptable growth in St. Just and Cambalache.                                                                                   |
| <i>Goetzea elegans</i> Wydler<br>Matabuey                    | Endemic shrub or small tree endangered in the wild. Efforts to save the species have resulted in successful forest plantings. It is now regularly sold as an ornamental (Francis 1989f, Francis and Rodríguez 1993).               |
| <i>Grevillea robusta</i> A. Cunn.<br>Silk oak, roble de seda | Widely planted ornamental of Australia. Successfully planted in Maricao. In most areas, trees lose vigor in 10 to 20 years (Marrero 1950b, Martorrel 1953, Wolcott 1945).                                                          |
| <i>Guazuma ulmifolia</i> Lam.<br>Guácima                     | A medium-sized tree of the moist and dry secondary forests. It is useful as a fodder tree and for fuel. Plantations have given mixed results (Francis 1991b, Francis and Rodríguez 1993, Marrero 1949a, Schubert 1979).            |

**Table 3—Additional species that offer a good chance of success given good site selection and proper planting, but are of minor importance, are recommended by only a few successful individuals, have given mixed results in trials, or have some serious drawback (continued)**

| Species name                                                     | Situation                                                                                                                                                                                                                                                         |
|------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Guettarda valenzuelana</i> A. Rich.<br>Cucubano de monte      | A small to medium-sized native tree that failed when planted in Cambalache but survived underplanting in the CNF and gained vigor after release.                                                                                                                  |
| <i>Hibiscus pernambucensis</i> Arruda<br>Sea hibiscus, emajagua  | Exotic species that forms dense thickets; cultivated formerly for cordage and now occasionally as an ornamental. Easily propagated from cuttings or seeds (Francis and Rodríguez 1993).                                                                           |
| <i>Inga fagifolia</i> (L.) Willd.<br>Guamá                       | A native species used for coffee shade, fenceposts, and fuel. Propagated easily from seeds, but growth is moderate and the species has at least 2 serious pest and disease problems (Francis 1994b, Francis and Rodríguez 1993, Marrero 1954, Wadsworth 1944c).   |
| <i>Inga fastuosa</i> (Jacq.) Willd.<br>Guaba venezolano          | A vigorous coffee shade species native to northern South America that has declined in popularity and become uncommon (Chudnoff and Goytia 1972, Englerth 1960, Hernández 1930, Marrero 1954).                                                                     |
| <i>Inga quaternata</i> Poepp. & Endl.<br>Guamá venezolano        | A coffee shade species native to Central America and South America and widely planted and naturalized in the central mountains. It has recalcitrant seeds but is easy to grow and establish (Francis and Liogier 1991, Francis and Rodríguez 1993, Marrero 1954). |
| <i>Jacaranda mimosifolia</i> D. Don<br>Jacaranda, flamboyán azul | A blue-flowered, small ornamental tree that is widely planted but lacks vigor in moist and wet areas. (Schubert 1979, Southern Region 1990).                                                                                                                      |
| <i>Leucaena diversifolia</i> (Schlecht.) Benth.                  | One experimental planting at Toa Baja on coastal sand gave excellent growth and survival. It has the same uses as <i>L. leucocephala</i> (Parrotta 1990a, Parrotta 1991b).                                                                                        |
| <i>Leucaena pallida</i> Britt. & Rose                            | One experimental planting at Toa Baja grew more slowly than <i>L. leucocephala</i> or <i>L. diversifolia</i> (Parrotta 1990a, Parrotta 1991b).                                                                                                                    |
| <i>Licaria parvifolia</i> (Lam.) Kostermans<br>Canelillo         | A native tree of moist forest useful for fuel and conservation plantings. Nursery-grown trees survived well in an underplanting in Cambalache, but grew slowly because they were not released (Little and Wadsworth 1964).                                        |

**Table 3—Additional species that offer a good chance of success given good site selection and proper planting, but are of minor importance, are recommended by only a few successful individuals, have given mixed results in trials, or have some serious drawback (continued)**

| Species name                                                    | Situation                                                                                                                                                                                                                                                            |
|-----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Luehea speciosa</i> Willd.<br>Guásima verde                  | Medium-sized exotic tree that yields a valuable wood. A small plantation in Cambalache grew moderately well and reproduced abundantly (Francis and Liogier 1991).                                                                                                    |
| <i>Magnolia portoricensis</i> Bello<br>Jagüilla                 | A beautiful endemic tree of the high rainfall mountains and a promising ornamental. Two plantings have grown slowly but steadily. Seedlings must be inoculated with soil from under wild jagüilla trees. (Francis and Rodríguez 1993, Marrero 1949a, Marrero 1950b). |
| <i>Margaritaria nobilis</i> L.f.<br>Millo                       | A small tree useful for posts and fuel. One planting in the CNF grew 7.5 to 12 m in 10 years; another failed in Cambalache (Marrero 1949a).                                                                                                                          |
| <i>Melia azedarach</i> L.<br>Chinaberry, alelaila               | A naturalized exotic tree planted as an ornamental for its blue flowers. Easily propagated from seed in moist and dry areas. The wood is good for crafts (Kramer 1924, Parrotta 1994b).                                                                              |
| <i>Moringa oleifera</i> Lam.<br>Horseradish tree                | A small, naturalized exotic tree that is occasionally planted as an ornamental. The seeds and pods are eaten elsewhere in the world (Francis and Liogier 1991, Parrotta 1993c).                                                                                      |
| <i>Muntingia calabura</i> L.<br>Capulín                         | An exotic ornamental with a small edible fruit. It quickly invades disturbed areas in northern central portions of Puerto Rico (Little and others 1974, Schubert 1979).                                                                                              |
| <i>Neolaugeria resinosa</i> (Vahl) Nichols.<br>Aquilón          | A small native tree. Two trees of a small planting grew into the forest canopy at Cambalache.                                                                                                                                                                        |
| <i>Ocotea floribunda</i> (Sw.) Mez<br>Laurel espada             | Large native timber tree of the moist and wet forests. Two small underplantings of wildlings in CNF gave good survival. Several of the trees are now dominants (Francis and Rodríguez 1993).                                                                         |
| <i>Parkinsonia aculeata</i> L.<br>Jerusalem thorn, palo de rayo | Naturalized spiny exotic of dry areas that is sometimes used as an ornamental. Direct seeding gave limited success in Salinas (Francis and Liogier 1991, Francis and Rodríguez 1993, Schubert 1979).                                                                 |

**Table 3—Additional species that offer a good chance of success given good site selection and proper planting, but are of minor importance, are recommended by only a few successful individuals, have given mixed results in trials, or have some serious drawback (continued)**

| Species name                                                                                    | Situation                                                                                                                                                                                                                   |
|-------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Pera blumeliaefolia</i> Griseb.<br>Lemon-wood                                                | Valuable timber tree from Cuba planted in Cambalache where it survived and grew at rates similar to <i>Bucida buceras</i> .                                                                                                 |
| <i>Pinus caribaea</i> var. <i>bahamensis</i> Barrett & Golfari<br>Bahamas pine                  | Grew well in the Arboretum but more slowly than Honduras pine. It is adapted to high pH soils near the ocean (Francis 1989f, Francis 1992a, Geary and Briscoe 1972).                                                        |
| <i>Pinus caribaea</i> var. <i>caribaea</i> Barrett & Golfari<br>Caribbean pine, pino del Caribe | Grew more slowly than Honduras pine in the Arboretum but had better form and hurricane resistance. One plot only (Francis 1989f, Francis 1992a, Geary and Briscoe 1972).                                                    |
| <i>Pinus elliottii</i> var. <i>densa</i> L. & D.<br>Slash pine                                  | Timber tree of Florida seed source that had good survival and form, but growth considerably below that of <i>P. caribaea</i> (Briscoe 1959, Francis 1989f).                                                                 |
| <i>Podocarpus coriaceus</i> L.C. Rich.<br>Caoba del país                                        | Native conifer normally restricted to rocky primary forest sites. It is not difficult to germinate and grow, but development is very slow (Francis and Rodríguez 1993, Marrero 1949a).                                      |
| <i>Pouteria hotteana</i> (Urban & Ekman) Baheni                                                 | Rare native tree now being grown in the Arboretum. Planted as potted seedlings under a shelterwood, they showed good survival and vigor. After 2.5 years, heights ranged from 20 to 110 cm (Little and Wadsworth 1964).     |
| <i>Quararibea turbinata</i> (Sw.) Poir.<br>Swizzle-stick tree, garrocha                         | Small native tree of moist and wet forests that survived transplanting well at St. Just but grew very slowly.                                                                                                               |
| <i>Senna spectabilis</i> (L.C. Rich.) Irwin & Barneby<br>Yellow shower                          | Medium-sized exotic tree that has aggressively invaded pastures and rangeland. It is easy to grow and is sometimes planted as an ornamental (Francis and Liogier 1991, Francis and Rodríguez 1993, Little and others 1974). |
| <i>Sesbania grandiflora</i> (L.) Pers.<br>Báculo, gallito                                       | Quick-growing, short-lived small legume from southern Asia and Australia used for food, fodder, and as an ornamental (Little and Wadsworth 1964, Parrotta 1991a, Parrotta 1991b).                                           |

**Table 3—Additional species that offer a good chance of success given good site selection and proper planting, but are of minor importance, are recommended by only a few successful individuals, have given mixed results in trials, or have some serious drawback (continued)**

| Species name                                                       | Situation                                                                                                                                                                                                                 |
|--------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Sloanea berteriana</i> Choisy<br>Motillo                        | Medium to large native tree of wet and moist forests. A small planting of wildlings at El Verde survived satisfactorily and grew 0.5 m/yr in the first 9 years (Chudnoff and Goytia 1972, Englerth 1960, Marrero 1949a).  |
| <i>Swietenia humilis</i> Zucc<br>Pacific Coast mahogany            | Native of Mexico and Central America and least successful of the mahoganies in Puerto Rico, it is most adapted to dry areas (Francis 1992d, Geary and others 1973, Glogiewicz 1986, Institute of Tropical Forestry 1963). |
| <i>Syzygium malaccense</i> (L.) Merr. & Perry<br>Manzana de Malaya | An exotic fruit tree that is an excellent ornamental and good wood producer, the species is adapted to moist upland areas. It is reproduced from seeds (Francis and Liogier 1991, Little and Wadsworth 1964).             |
| <i>Tabebuia rosea</i> (Bertol.) DC.<br>Roble venezolano            | Widely planted and successful exotic ornamental capable of greater size than <i>T. hererophylla</i> . Several forest plantings failed.                                                                                    |
| <i>Terminalia latifolia</i> Sw.                                    | A timber tree native to Jamaica. At Cambalache, it had good early survival and grew a maximum of 8 m in 6 years. At 32 years, mean survival was 21 percent, height was 19 m, and d.b.h. was 23.3 cm.                      |
| <i>Terminalia myriocarpa</i> Heurck & Muell.-Arg.                  | A native of India. Plantings failed in Río Abajo; grew well for 8 years and stagnated and died in Catalina; grew and reproduced in Maricao (Francis and Liogier 1991).                                                    |
| <i>Terminalia muelleri</i> Benth.                                  | A native of Australia. After 10 years, a small planting in Susúa had 61 percent survival and averaged 6 m in height and 6.2 cm d.b.h.                                                                                     |
| <i>Terminalia oblonga</i> (R.&P.) Steud.                           | A native of Mexico that has naturalized in the Botanic Garden. It is fast growing, has good form, and produces abundant seed crops (Francis and Wadsworth 1991).                                                          |

**Table 3—Additional species that offer a good chance of success given good site selection and proper planting, but are of minor importance, are recommended by only a few successful individuals, have given mixed results in trials, or have some serious drawback (continued)**

| Species name                              | Situation                                                                                                                                                                                                        |
|-------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>Vitex agnus-castus</i> L.              | This common, medium-sized ornamental produces food for wildlife.                                                                                                                                                 |
| <i>Vitex divaricata</i> Sw.<br>Higüerillo | A valuable native timber tree that had early height growth of 60 cm/yr at El Verde and similar growth in a private line planting at Cidra but failed at Río Abajo and Río Piedras (Marrero 1947b, Wolcott 1946). |

**Table 4—Species that failed in test plantings because of complete mortality or high mortality and slow growth**

| Species name                                         | Apparent cause of failure                                                                            |
|------------------------------------------------------|------------------------------------------------------------------------------------------------------|
| <i>Abies religiosa</i> (H.B.K.) Schlecht. & Cham.    | Wrong climate                                                                                        |
| <i>Acacia aulacocarpa</i> A. Cunn. ex Benth.         | Unknown (Parrotta 1990a, Parrotta 1991b)                                                             |
| <i>Acacia farnesiana</i> (L.) Willd.                 | Wrong technique                                                                                      |
| <i>Acacia giraffae</i> Burch.                        | Wrong climate                                                                                        |
| <i>Acacia koa</i> A. Gray                            | Wrong site (Brush 1925a, Francis 1989f)                                                              |
| <i>Acacia seyal</i> Del.                             | Unknown                                                                                              |
| <i>Acacia woodii</i> (Burt) Davy                     | Wrong climate                                                                                        |
| <i>Acer pseudoplatanus</i> L.                        | Wrong climate                                                                                        |
| <i>Alchornea latifolia</i> Sw.                       | Unknown (Francis 1993b)                                                                              |
| <i>Acrocarpus fraxinifolius</i> Wight                | Unknown (Francis 1989f)                                                                              |
| " <i>Afromosa elata</i> "                            | Unknown (Francis 1989f)                                                                              |
| <i>Albizia julibrissin</i> (Willd.) Durazz.          | Wrong climate                                                                                        |
| <i>Araucaria angustifolia</i> (Benth.) Kuntze        | Wrong climate (Francis 1988a, Francis 1989f)                                                         |
| <i>Ardisia obovata</i> Hamilt.                       | Unknown                                                                                              |
| <i>Ateramnus lucidus</i> (Sw.) Rothm.                | Wrong site                                                                                           |
| <i>Avicennia germinans</i> (L.) L.                   | Wrong procedure (Jimenez and Lugo [n.d.], Marrero 1950b)                                             |
| <i>Bulnesia arborea</i> (Jacq.) Engler.              | Unknown                                                                                              |
| <i>Bumelia cubensis</i> Griseb.                      | Wrong procedure (Marrero 1950b)                                                                      |
| <i>Caesalpinia procera</i> Poepp. ex Spreng.         | Unknown                                                                                              |
| <i>Callitris glauca</i> R.Br. ex Baker & H.G. Smith  | Wrong site                                                                                           |
| <i>Callitris intratropica</i> R.T. Bak. & H.G. Smith | Wrong site                                                                                           |
| <i>Carmonema ovalifolium</i>                         | Unknown                                                                                              |
| <i>Casuarina cunninghamiana</i> Miq.                 | Unknown (Kramer 1924, Marrero 1950b)                                                                 |
| <i>Casuarina glauca</i> Sieber ex Sprengel           | Unknown                                                                                              |
| <i>Casuarina stricta</i> Aiton                       | Unknown                                                                                              |
| <i>Ceiba acuminata</i> (S.Wats.) Rose                | Wrong site                                                                                           |
| <i>Chamaecyparis lawsoniana</i> (A.Murr.) Parl.      | Wrong climate                                                                                        |
| <i>Chickrassia tabularis</i> Adr. Juss.              | Wrong site (Francis 1989f)                                                                           |
| <i>Chionanthus domingensis</i> Lam.                  | Unknown                                                                                              |
| <i>Chlorophora</i> sp.                               | Wrong site (Francis 1989f)                                                                           |
| <i>Cordia dodecandra</i> DC.                         | Unknown                                                                                              |
| <i>Cordia laevigata</i> Lam.                         | Unknown                                                                                              |
| <i>Cryptomera japonica</i> D.Don                     | Wrong climate (Francis 1989f)                                                                        |
| <i>Dendrocalamus stricta</i> Roxb.                   | Unknown                                                                                              |
| <i>Diospyros virginiana</i> L.                       | Wrong climate                                                                                        |
| <i>Entandophragma utile</i> (Dawe & Sprague) Sprague | Unknown (Francis 1989f)                                                                              |
| <i>Eucalyptus acmenioides</i> Schau.                 | Unknown                                                                                              |
| <i>Eucalyptus alba</i> Reinw. ex Blume               | Unknown (Figueroa and Whitmore 1980, Lugo and Francis 1990, Tropical Forest Experiment Station 1954) |

**Table 4—Species that failed in test plantings because of complete mortality or high mortality and slow growth (continued)**

| Species name                                    | Apparent cause of failure                                                         |
|-------------------------------------------------|-----------------------------------------------------------------------------------|
| <i>Eucalyptus botryoides</i> Sm.                | Unknown (Wadsworth 1948)                                                          |
| <i>Eucalyptus camaldulensis</i> Dehn.           | Wrong seed source, wind damage<br>(Francis 1992c, Parrotta 1990a, Parrotta 1991b) |
| <i>Eucalyptus cladocalyx</i> F. Muell.          | Wrong climate                                                                     |
| <i>Eucalyptus cneorifolia</i> DC.               | Unknown                                                                           |
| <i>Eucalyptus crebra</i> f. Muell.              | Unknown (Francis 1989f)                                                           |
| <i>Eucalyptus globulus</i> Labill.              | Wrong climate (Tropical Forest Experiment Station 1953)                           |
| <i>Eucalyptus gummifera</i> (Gaertn.) Hochr.    | Wrong climate                                                                     |
| <i>Eucalyptus leucoxylon</i> F. Muell.          | Wrong climate                                                                     |
| <i>Eucalyptus maculata</i> Hook.                | Wrong climate                                                                     |
| <i>Eucalyptus madenii</i> F. Muell.             | Unknown                                                                           |
| <i>Eucalyptus marginata</i> Donn ex Smith       | Wrong climate                                                                     |
| <i>Eucalyptus microcorys</i> F. Muell.          | Unknown                                                                           |
| <i>Eucalyptus pauciflora</i> Sieber ex Sprengel | Wrong climate                                                                     |
| <i>Eucalyptus</i> “paulistana”                  | Unknown                                                                           |
| <i>Eucalyptus pilularis</i> Smith               | Unknown (Tropical Forest Experiment Station 1953)                                 |
| <i>Eucalyptus populnea</i> F. Muell.            | Unknown                                                                           |
| <i>Eucalyptus sideroxylon</i> Cunn. ex Woolls   | Unknown                                                                           |
| <i>Eucalyptus viminalis</i> Labill              | Wrong climate                                                                     |
| <i>Eucalyptus</i> x <i>affins</i>               | Unknown                                                                           |
| <i>Eugenia domingensis</i> Berg.                | Wrong site                                                                        |
| <i>Eugenia stahlia</i> (Kiaersk.) Krug & Urban  | Wrong site (Francis and Rodríguez 1993)                                           |
| <i>Ilex nitida</i> (Vahl) Maxim.                | Unknown                                                                           |
| <i>Inga edulis</i> Mart.                        | Unknown (Hernandez 1930)                                                          |
| <i>Inga spuria</i> Humb. & Bonpl ex Willd.      | Unknown (Marrero 1954)                                                            |
| <i>Licaria triandra</i> (Sw.) Kostermans        | Wrong planting method                                                             |
| <i>Meliosma herbertii</i> Rolfe                 | Unknown                                                                           |
| <i>Micropholis chrysophylloides</i> Pierre      | Wrong planting method (Marrero 1949a, Weaver 1993a)                               |
| <i>Mimusops elengi</i> L.                       | Unknown                                                                           |
| <i>Ocotea coreacea</i> (Sw.) Britton            | Wrong planting method                                                             |
| <i>Ocotea membranacea</i> (Sw.) Howard          | Wrong planting method                                                             |
| <i>Ocotea portoricensis</i> Mez                 | Wrong site, wrong planting method                                                 |
| <i>Ocotea sintenisii</i> (Mez) Alain            | Unknown                                                                           |
| <i>Ocotea spathulata</i> Mez                    | Not weeded                                                                        |
| <i>Olea</i> sp.                                 | Wind damage (Francis 1989f)                                                       |
| <i>Ormosia krugii</i> Urban                     | Wrong site                                                                        |
| <i>Paraserianthes falcataria</i> (L.) Nielson   | Wrong site                                                                        |
| <i>Picea sitchensis</i> (Borg.) Carr.           | Wrong climate                                                                     |

**Table 4—Species that failed in test plantings because of complete mortality or high mortality and slow growth (continued)**

| Species name                                       | Apparent cause of failure                                          |
|----------------------------------------------------|--------------------------------------------------------------------|
| <i>Pinus ayacahuite</i> Ehrenb. ex Schlecht.       | Wrong climate (Francis 1989f)                                      |
| <i>Pinus chiapensis</i> (Mart.) Anderson           | Wind damage (Francis 1989f)                                        |
| <i>Pinus echinata</i> Mill.                        | Wrong climate (Francis 1989f)                                      |
| <i>Pinus elliotii</i> Engelm. var. <i>elliotii</i> | Wrong climate (Francis 1989f, Institute of Tropical Forestry 1963) |
| <i>Pinus insularis</i> Endl.                       | Wrong climate (Francis 1989f, Francis 1992c)                       |
| <i>Pinus massoniana</i> D. Don                     | Wrong climate (Francis 1989f, Institute of Tropical Forestry 1963) |
| <i>Pinus merkusii</i> Jungh. & de Virese           | Wrong climate (Whitmore 1972)                                      |
| <i>Pinus michoacana</i> Mart.                      | Wrong climate (Francis 1989f, Institute of Tropical Forestry 1963) |
| <i>Pinus montezumae</i> Lamb.                      | Wrong climate (Francis 1989f, Institute of Tropical Forestry 1963) |
| <i>Pinus occidentalis</i> Swartz                   | Wrong source (Institute of Tropical Forestry 1963)                 |
| <i>Pinus oocarpa</i> Schiede                       | Wrong climate (Francis 1989f, Institute of Tropical Forestry 1963) |
| <i>Pinus patula</i> Schl. & Cham.                  | Wrong climate (Francis 1989f)                                      |
| <i>Pinus pseudostrobus</i> Mart.                   | Wrong climate (Francis 1989f, Francis 1992c)                       |
| <i>Pinus taeda</i> L.                              | Wrong climate (Francis 1989f, Institute of Tropical Forestry 1963) |
| <i>Piscidia carthagenensis</i> Jacq.               | Unknown                                                            |
| <i>Platanus occidentalis</i> L.                    | Wrong climate (Geary and Briscoe 1972)                             |
| <i>Poeppigia procera</i> Presl.                    | Unknown (Marrero 1949a, Tropical Forest Experiment Station 1949)   |
| <i>Robinia pseudoacacia</i> L.                     | Wrong climate (Brush 1925b)                                        |
| <i>Sequoia sempervirens</i> (D. Don) Endl.         | Wrong climate                                                      |
| <i>Sesbania sesban</i> (L.) Merr.                  | Unknown (Parrotta 1991b)                                           |
| <i>Sideroxylon foetidissimum</i> Jacq.             | Wrong site (Marrero 1950b)                                         |
| <i>Simaruba glauca</i> DC.                         | Unknown                                                            |
| <i>Taxodium mucronatum</i> Tenore                  | Wrong climate                                                      |
| <i>Terminalia pyrifolia</i> Kurz                   | Unknown                                                            |
| <i>Terminalia superba</i> Engl. & Diels            | Unknown                                                            |
| <i>Terminalia tomentosa</i> Mart. ex Eichl.        | Unknown                                                            |
| <i>Tetragastris balsamifera</i> (Sw.) Kuntze       | Wrong planting method (Marrero 1950b)                              |
| <i>Tristania conferta</i> R. Br.                   | Unknown                                                            |
| <i>Widdringtonia whytei</i> Rendle                 | Wrong climate                                                      |

**Francis, John K.** 1998. Tree Species for planting in forest, rural, and urban areas of Puerto Rico. Gen. Tech. Rep. IITF-3. Río Piedras, Puerto Rico: U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry at Río Piedras, Puerto Rico. 82 p.

Responding to near total deforestation in Puerto Rico, in the 1920's the U.S. Department of Agriculture, Forest Service, began to produce tree seedlings, reforest degraded lands, establish planting trials, and conduct silvicultural research. In 70 years, an extensive body of knowledge has been accumulated. Advances in tree seed handling, nursery practice, plantation establishment, and plantation management made in Puerto Rico are summarized. The report details tree species recommended by local research and experience for planting in wildland, farm, and urban forestry. Site requirements, management techniques, growth rates, and benefits are given.

**Keywords:** Deforestation, plantation establishment, plantation management, Puerto Rico, reforest, silvicultural research.



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