# Calophyllum calaba L.

# María, Santa-María

**Guttiferae -- Mangosteen family**

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María *(Calophyllum calaba)* is a medium-sized tropical evergreen tree known also as santa-maría or false-mamey. It is frequently used for reforestation. Although it is easily established by direct seeding and grows well in almost all soils, its growth is generally slow. It tolerates salt spray and forms a dense crown with small fragrant flowers that make it popular as a shade tree or a protective hedge. The wood is used widely in the tropics where a strong, moderately durable timber and general utility wood is needed.

## Habitat

### Native Range

María is native to Puerto Rico and the Virgin Islands and widely distributed through the West Indies. It ranges from Mexico through the Guianas to Peru, Bolivia, and Brazil. It is naturalized in Bermuda and has been introduced in southern Florida (15).

In Puerto Rico, it is native to the moist coastal and limestone regions, probably ranging through 150 in (492 ft) in elevation. Elsewhere in the Caribbean, marfa is found near the coast at low elevations on moist through wet sites, and occasionally in areas that are inundated during part of the year (16,18,30,31). In northern South America, it is found along river banks and in stream valleys (25). The tree, when established, is capable of growing on degraded soils.

### Climate

In Puerto Rico, maría is found naturally in the Subtropical Moist Forest life zone. Annual rainfall varies from about 1500 to 2000 mm (59 to 79 in), with annual evapotranspiration ranging from 1500 to 1780 mm (59 to 70 in). Mean annual temperature is 25° C (77° F) with little variation during the year (7). Plantations, however, have been established in wetter and drier sites including the Subtropical Dry Forest life zone with annual rainfall of only 1000 mm (39 in). Plantation sites in the Cordillera Central and the Luquillo Mountains have annual rainfall as high as 3050 mm (120 in). In Nicaragua, maria occurs in Lowland Rain Forest and Lower Montane Rain Forest (5) with annual rainfall ranging from 1980 to 5000 mm (78 to 197 in) (31). In British Honduras (19) and elsewhere in the Caribbean, annual rainfall varies from about 1500 to 2500 mm (59 to 98 in). None of these areas has temperatures below freezing.

### Soils and Topography

María is native to the sandy soils on the north coast of Puerto Rico where it grows mainly on soils of the orders Inceptisols, Oxisols, and Alfisols. It is also found on coastal sands in the central Lesser Antilles (4). In Puerto Rico, it has been planted in the interior mountains on deep clays and serpentine soils, and on shallow limestone soils at lower elevations near the coast (22). In general, it tolerates degraded sites and a variety of drainage conditions. It may be found on ridges, slopes, coves, flats, and swamps.

In Puerto Rico, maria is not planted on good sites because faster growing species are preferred. It is recommended, however, where erosion has depleted soil fertility, for straight slopes, ridges, and convex slopes (22). In British Guiana and Surinam it grows in freshwater swamps; and in Jamaica it is found on volcanic and metamorphic shales (2,25).

### Associated Forest Cover

In Puerto Rico, maría is associated with ucar *(Bucida buceras),* roble blanco *(Tabebuia heterophyll1a),* algarrobo *(Hymenaea courbaril),* palo de pollo *(Pterocarpus officinalis),* and palma real *(Roystonea borinquena),* all in the Subtropical Moist Forest.

Elsewhere within its range, marfa is a constituent of several different forest types (table 1) and is found in association with numerous species. In particular, the tree is found in moist to wet primary forest at low elevations, and in secondary forest. In Central America, it is often found in association with caoba hondureña *(Swietenia macrophylla)* and cedro hembra *(Cedrela odorata)* (18). In British

Honduras, it is found in successional forests along with the genera *Orbignya, Dialium, Virola, Termmalia, Symphonia,* and *Vochysia (30).* In the Lesser Antilles, it is associated with almácigo *(Bursera simaruba),* malagueta *(Pimenta racemosa),* laurel avispillo *(Nectandra coriacea),* and cupey *(Clusia rosea)* (4).

**Table 1-**Presence of maría *(Calophyllum calba)* in tropical forests of the Western Hemispheres

| Location[1] | Forest type classification | Annual rainfall | |
|---|---|---|---|
| | | mm | in |
| Puerto Rico (15) | Subtropical Moist Forest, limestone | 1500 to 2000 | 59 to 79 |
| British Honduras (19) | Tropical Moist Forest | 2000 to 4000 | 79 to 157 |
| Nicaragua (31) | Lowland Evergreen Forest | 2000 to 4000 | 79 to 157 |
| | Lower Montane Forest | 3000 to 5000 | 118 to 197 |
| Jamaica (1,2) | Evergreen Seasonal Forest, limestone | 2000 | 79 |
| | Lower Montane Rain Forest | 3000 | 118 |
| Cuba (25,29) | Lowland Rain Forest | 1500 | 59 |
| St. Kitts (4) | Dry Evergreen Forest | 1500 | 59 |
| Dominica (4) | Secondary Rain Forest | 2000 | 79 |
| Martinique (4) | Evergreen Seasonal Forest | 1500 to 3000 | 59 to 118 |
| Surinam (16) | Marsh Forest | NA [2] | NA |
| Costa Rica (13,27) | Tropical Moist Forest | 1000 to 2000 | 39 to 79 |
| | Tropical Wet Forest | 2000 to 4000 | 79 to 157 |
| | Premontane Wet Forest | 2000 to 4000 | 79 to 157 |
| Venezuela (10) | Tropical Moist Forest | 1000 to 2000 | 39 to 79 |
| | Premontane Wet Forest | 2000 to 4000 | 79 to 157 |

[1]Holdridge (12,13)-Puerto Rico, British Honduras, Costa Rica, and Venezuala; Beard (2,5)-Nicaragua
Jamaica, Cuba, St. Kitts, Dominica, and Martinique; Lindeman (16)-Surinam.
[2]Not Available

# Life History

The mature maría tree is easily identified by a combination of characteristics including its opposite, elliptical, dark-green leaves with numerous parallel, lateral veins and very dense foliage. A yellowish sap exudes from broken leaves, twigs, and incisions in the trunk. The bark has many diamond-shaped fissures.

In Puerto Rico, the tree commonly attains a height of 12 to 20 m (39 to 67 ft) and about 45 cm (18 in) in diameter. Where conditions are favorable elsewhere in its range, it sometimes attains a height of 30 to 45 m (100 to 150 ft) and is supported by a straight, unbuttressed bole 90 to 215 cm (35 to 85 in) in diameter. At maturity, maría is a canopy tree with a dense, rounded crown.

## Reproduction and Early Growth

**Flowering and Fruiting-** María is polygamous; male and bisexual flowers are borne in 5-cm (2-in) racemes on the same tree. The bisexual flowers have four white, rounded, and concave sepals about 0.65 cm (0.25 in) long; the smaller white sepals are commonly absent. Male flowers have about 40 to 50 stamens in a prominent orange cluster more than 6 mm (0.25 in) across, and often a rudimentary pistil. In Puerto Rico, flowering is chiefly in the spring and summer, and the fruit matures in the fall (15). In Trinidad the normal flowering period is in September and October, but trees flower at other times. The fruits, which are globose, one-seeded drupes, about 2.5 cm (1 in) in diameter, usually ripen the following May or June. Some trees have been observed to flower and fruit when only 3 years old. Good seed years were found to be irregular in Trinidad (23) although the tree fruits abundantly on an annual basis in Puerto Rico.

**Seed Production and Dissemination-** A substantial portion of the seeds fall below the parent tree where they germinate and form dense stands of seedlings. On steep slopes, however, some are removed by heavy rains.

Seeds maintain their viability well, and a fair germination rate is attained even with seeds that have been stored for 1 year in a dry room. Average germination in Puerto Rico is about 70 percent.

Use of fresh seeds is desirable in the establishment of plantations. Usually seeds are sown directly into the soil and demonstrate a favorable germination capacity except when the seeds are empty.

In Trinidad, the agouti (a tropical rodent) sometimes carries off the fruits and stores them in caches; bats also aid in dispersal (23). In Puerto Rico, birds, bats, and rats are dispersal agents (21).

**Seedling Development-** During the storage of fruits, the water content should not be lower than 35 percent nor the storage temperature below 0° C (32° F) (37). germination is hypogeous and occurs within 6 weeks, provided the seeds are sown without an endocarp. Untreated fruits give the same results after 16 weeks. Retarded germination is caused by the endocarp, which inhibits water uptake. The endocarp may be broken by striking with a hammer.

Broadcasting of seeds in suitable conditions results in germination. Plantations, however, are usually established by planting seeds in the ground at a depth of 2.5 cm (1 in) using a dibble. Direct sowing of maría fruits has been done under the light shade of pino australiano *(Casuarina equisetifolia),* in areas where farmers wanted to perpetuate windbreaks. The seedlings demonstrated nearly 100 percent survival with a height growth of 1.2 in (4 ft) in only 2 years. María has also been seeded within rows of beans that provide shade and protect the seedlings from desiccation (23). In the mountains of northeastern Puerto Rico, where annual rainfall is more than 2500 mm (98 in), fruits were placed in raised piles of earth where they germinated and grew successfully (11).

The first leaves are produced when the seedling is about 10 cm (4 in) tall. When the seedling reaches about 15 cm (6 in), as determined by the reserve food supply in the seed, it often ceases to grow in height while the root system establishes itself Seeds sown in nursery beds produce plants with a maximum height of 1 m (3 ft) in 1 year.

Several experiments have been conducted with maría seedlings by personnel of, the Institute of Tropical Forestry. Seeds pregerminated in wet moss and later planted with radicles or hypocotyls 8 cm (3 in) or under were less successful than dibbled fruits without pretreatment. Bareroot plantings cut to about 10 cm. (4 in) in height, in exposed conditions, failed nearly 100 percent because of desiccation. The results were the same in heavy shade. In exposed conditions, transplanting of maría. has only been successful when the plants were moved with a ball of earth. Best results are achieved when the transplants are moved during the rainy season.

**Vegetative Reproduction-** maría does not coppice, except when very young, nor does it produce root suckers. Similarly, neither root nor shoot cuttings have been proved successful as a means of establishment.

## Sapling and Pole Stages to Maturity

**Growth and Yield-** Growth of maría at all stages in the life cycle appears to be slow in Puerto Rico. The tree does not reach its maximum size on the island, and most of the growth records are for poor sites.

**Table 2-**Mean annual increment and yield for plantatio-grown maría *(Calophyllum callaba)* in tropical forests of theWestern Hemishphere

| Location | Site characteristics | | | Stand | Mean annual increment | | | | | Mean annual yeild | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Elevation | Rainfall | Soil | Density | Age | Height | D.b.h. | Volume | Biomass | Volume | Biomass |
| | (m) | (mm) | | (tree/ha) | (yr) | (m) | (mm) | ($m^3$/ha) | (t/ha) | ($m^3$/ha) | (t/ha) |
| *Trinidad* | | | | | | | | | | | |
| Carretera Arena | 46 | 2440 | Sandy | 620 | 9 | 1.2 | 11 | 4.33 | 2.20 | 0.22 | 0.11 |
| | | | | 304 | 14 | 1.1 | 10 | 5.29 | 2.69 | 1.00 | 0.52 |
| | | | | 185 | 19 | 1.0 | 9 | 4.95 | 2.51 | 1.74 | 0.90 |
| | | | | NA[2] | 31 | 1.0 | 11 | NA | NA | NA | NA |
| South Watershed | 35 | 1650 | Sandy | 1349 | 8 | 1.4 | 14 | 5.25 | 2.67 | 0.75 | 0.38 |
| Reserve | | | | 823 | 14 | 1.1 | 11 | 7.21 | 3.68 | 2.21 | 1.12 |
| | | | | 311 | 25 | 0.8 | 10 | 7.12 | 3.63 | 3.84 | 1.95 |
| | | | | NA | 34 | 0.6 | 10 | NA | NA | NA | NA |
| Puerto Rico | | | | | | | | | | | |
| Maricao | 630 | 2670 | Serpentine | 1297 | 25 | 0.7 | 6 | 12.60 | 6.41 | 7.00 | 3.56 |
| | | | | 1001 | 33 | 0.6 | 7 | NA | NA | NA | NA |
| Luquillo | 450 | 3050 | Clay | 922 | 22 | 0.7 | 7 | NA | NA | NA | NA |
| | (ft) | (in) | | (Trees/acre) | (yr) | (ft) | (in) | ($ft^3$/acre) | (tons/acre) | ($ft^3$/acre) | (tons/acre) |
| *Trinindad* | | | | | | | | | | | |
| Carratera Arena | 150 | 96 | Sandy | 251 | 9 | 3.9 | 0.44 | 61.86 | 0.98 | 3.17 | 0.05 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 123 | 14 | 3.6 | 0.39 | 75.57 | 1.20 | 14.30 | 0.23 |
| | | | | 75 | 19 | 3.3 | 0.43 | 70.72 | 1.12 | 24.80 | 0.40 |
| | | | | NA | 31 | 3.3 | 0.43 | NA | NA | NA | NA |
| South Watershed | 110 | 65 | Sandy | 546 | 8 | 4.6 | 0.54 | 75.00 | 1.19 | 10.72 | 0.17 |
| Reserve | | | | 333 | 14 | 3.6 | 0.42 | 103.00 | 1.64 | 31.63 | 0.50 |
| | | | | 126 | 25 | 2.6 | 0.38 | 101.72 | 1.62 | 54.86 | 0.87 |
| | | | | NA | 34 | 2.0 | 0.38 | NA | NA | NA | NA |
| Puerto Rico | | | | | | | | | | | |
| Maricao | 2,070 | 105 | Serpentine | 525 | 25 | 2.3 | 0.22 | 180.00 | 2.86 | 100.00 | 1.59 |
| | | | | 405 | 33 | 2.0 | 0.28 | NA | NA | NA | NA |
| Luquillo | 1,480 | 120 | Clay | 373 | 22 | 2.3 | 0.27 | NA | NA | NA | NA |

[1]Height and diameter values derived from dominant and codominat trees only.
Volume determined outside bark to an upper stem diameter of 10 cm (3.9 in).
Biomass=VolumeX0.51 (specific gravity of María) estimate is high because no correction is made for bark thickness.
[2]Not Available

Plantations in Trinidad and Puerto Rico vary from 22 to 34 years old and show that volume mean annual increment (MAI) ranges from 4.3 to 12.6 $m^3$/ha (61 to 180 $ft^3$/acre) (table 2). Height MAI varies from 0.6 to 1.4 m (2.0 to 4.6 ft) and diameter MAI from 5.6 to 13.8 mm (0.22 to 0.54 in). Crude estimates of biomass MAI range between 2.2 and 6.4 metric t/ha (0.98 and 2.86 tons/acre). Additional measurements elsewhere in Puerto Rico confirm these diameter and height growth rates (table 3).

**Table 3-**Mean annual increment for plantation-growth maría *(Calophyllum calaba)* in Puerto Rico (20,22)

| Location | Site Characteristics | | | Stand Age | Mean annual increment | | |
|---|---|---|---|---|---|---|---|
| | Elevation | Rainfall | Soil | | Height | D.b.h. | Basal area |
| | (m) | (mm) | | (yr) | (m) | (mm) | ($m^2$/ha) |
| Guajataca | 150 | 2000 | Limestone | 13 | 0.2 | 5.3 | 0.67 |
| Luquillo | 450 | 2550 | Deep clay | 13 | 0.5 | 7.0 | 0.88 |
| Luquillo | 360 | 3050 | Deep clay | 6.5 | 0.9 | 8.2 | NA[1] |
| Luquillo | 300 | 2500 | Shallow clay | 7 | 0.9 | 8.7 | NA |
| Luquillo | 300 | 2500 | Clay | 13 | 0.7 | 9.6 | NA |
| | (ft) | (in) | | (yr) | (ft) | (in) | ($ft^2$/acre) |
| Guajataca | 490 | 79 | Limstone | 13 | 0.7 | 0.21 | 2.92 |
| Luquillo | 1,480 | 100 | Deep clay | 13 | 1.6 | 0.28 | 3.83 |
| Luquillo | 1,180 | 120 | Deep clay | 6.5 | 3.0 | 0.32 | NA |
| Luquillo | 980 | 98 | Shallow clay | 7 | 3.0 | 0.34 | NA |
| Luquillo | 980 | 98 | Clay | 13 | 2.3 | 0.38 | NA |

[1]Not available.

**Rooting Habit-** María is a deep-rooted species, at least when young. The seedling produces a definite tap root with a quantity of short side roots at regular intervals.

Even on the exposed limestone hills where the soil is too shallow for planting seedlings, roots of maría, once established, penetrate to considerable depths. Planting in shallow soil pockets on lower slopes and bottom lands has given excellent results.

**Reaction to Competition-** María is intolerant of intense shade in the seedling phase. Seeds below the dense cover of the parent tree may germinate but often become encrusted with mosses and lichens. In contrast, seedlings in full sunlight may suffer from sun scorching in the dry season. Light shade in the first couple of years appears to yield the best growth. After successful establishment, however, full sunlight is needed for most rapid development. Overall, maría is classed as intermediate in tolerance to shade.

In areas subject to drought, weedings may not be needed. In humid areas, circular weeding 1 m (3 ft) around the seedlings should be done at least once a year for 3 years. In an experiment conducted by

Institute of Tropical Forestry personnel with seedlings planted in *Panicum* spp. and *Ipomoea* spp. undergrowth, the weeded seedlings had 50 percent survival with an average height of 2.3 m (8 ft), but the unweeded trees showed only 12 percent survival and growth to 1.2 m (4 ft).

maría has a sturdy stem and its greatest attribute is its ability to dominate grass, ferns, or vines when planted on adverse sites (21). Usually close spacings of 1.8 by 1.8 m (6 by 6 ft) or 1.5 by 1.5 in (5 by 5 ft) are used to accelerate crown closure and preclude lateral branching (20). Wider spacings yield more rapid diameter increment but create poor tree form.

Attempts to improve growth by thinning have been tried in dense, overstocked 18-year-old stands in Puerto Rico (34). The stands were located infertile serpentine soils in the western Cordillera, and had densities ranging from 1,280 to 3,530 stems per hectare (518 to 1,429/acre). The stands were about 10 to 15 m (35 to 50 ft) tall and about 10 cm (4 in) in d.b.h.

Basal areas ranged from 13.3 to 37.9 $m^2$/ha (58 to 165 $ft^2$/acre). The difference in diameter between dominant and suppressed stems was only 2.5 cm (1 in).

In the most dense stand, basal area was reduced from 37.9 $m^2$/ha (165 $ft^2$/acre) to 25.7 $m^2$ /lia (112 $ft^2$ /acre), but no acceleration in diameter growth was observed after 5 years. A heavier thinning was made on adjacent plots, leaving only 18.4 $m^2$/ha (80 $ft^2$ /acre). In this instance, 85 percent of the residual trees had crown freedom and overhead light. After 3 years, no detectable acceleration in diameter growth was evident. Crowns were still narrow, and few new branches were formed (33).

**Damaging Agents-** The heartwood is rated as durable to moderately durable with respect to decay resistance but susceptible to marine borers (6,8), the drywood termite *(Cryptotermes brevis)* in Puerto Rico (18,36), and the subterranean termites *(Captotermes brevis, Heterotermes convexinotatus, H. tennis,* and *Nasutitermes corniger)* in Panama (6). When maría was substituted for imported track sleepers in British Honduras, a marked difference was observed between wet and dry sections of the track. In wet sections, fungal attack was prevalent; in the dry section, termite attack was more pronounced (24).

A fast-killing wilt that affects all tree sizes in about the same length of time was observed in Central America (9). It is first evidenced by a dry branch in the tree top, followed in 4 weeks by chlorotic foliage, and then death. Internally, dark-brown streaking is observed in the vascular system caused by a gum that plugs the vessels. The causal agent is a species of *Cephalosporium.* The disease

was described as the first epidemic disease in Central America and was compared in its virulence to chestnut blight *(Cryphonectria parasitica),* Dutch elm disease *(Ceratocystis u1mi),* or persimmon wilt *(Acremonium diospyri)* of the United States (32).

In Trinidad, a leaf curl is prevalent on young plants and may be a response to weather conditions. A thread blight fungus (possibly *Corticium stevensii)* was observed on one estate, and in another area, a few trees were attacked by a root fungus tentatively identified as a species of *Rosellinia.* Trees of large size in Trinidad are usually sound to the base (23).

Also in Trinidad, maría is infected by mycorrhizae that are present throughout the root system but not extremely abundant. Similar mycorrhizae have been found in 85 percent of the species in the Trinidad flora including other forest species (14).

In Puerto Rico, an unidentified seed borer was observed in Maricao Forest (11). More common, however, are splotches on leaves and premature defoliation when thrips (Thripidae) infestation is heavy.

# Special Uses

The wood of maría is widely used in the tropics. The heartwood varies from yellowish pink through reddish brown while sapwood is generally lighter in color. The grain is usually interlocked, and the specific gravity ranges from 0.51 to 0.57. The wood is fairly easy to work, rating above average in shaping, sanding, and mortising, and below average in planing, turning, and boring. It is moderately difficult to air-season and shows moderate to severe warp. The sapwood is easily impregnated with preservatives by either pressure or open-tank-bath methods, but the heartwood is extremely resistant to impregnation (8,17,18).

María wood is suitable for general construction, flooring, bridge construction, furniture, boat construction, cabinetmaking, shingles, interior construction, agricultural implements, poles, crossties, and handles (15,25). It is a good general utility wood where a fairly strong and moderately durable timber is required. In British Honduras, it was substituted for imported creosoted sleepers but required replacement after 3 or 4 years (24). In Mexico, attempts to use the timber in the veneer and plywood industry were not entirely successful (26).

The tree is also planted for shade along streets and as a windbreak or to protect against salt spray near the ocean. Frequently it is pruned to form a dense hedge along property lines in urban areas (28).

The latex from the trunk has been employed medicinally. The fruits are used as hog-feed, and lamp oil is extracted from the seeds (15,25).

The tree's adaptability to a variety of sites in Puerto Rico has made it popular among soil scientists and foresters for rehabilitation of degraded lands.

## Genetics

There is ample debate over the nomenclature of maría. *Calophyllum brasiliense* var. *antillanum* (Britton) Standl. was considered a variety of C. *brasiliense* Camb. (15). The former was also considered synonymous with *C. calaba* Jacq., but not L., as well as with *C. antillanum* Britton and *C. jacquinii* Fawc. & Rendle (15). Later, however,*C. brasiliense* Camb. was replaced by *C. calaba* L.

The "variety" *antillanum is* found in Puerto Rico and the Virgin Islands and ranges from Cuba to Jamaica through the Lesser Antilles to Granada. A closely related species, *Calophyllum lucidum* Benth., or a variety known as galba, grows in Trinidad, Tobago, and British Guiana (15). The timbers are similar in appearance and technical properties and they are marketed under a single trade name (18).

Much work needs to be done on the Guttiferae family and the genus *Calophyllum.* Because the range of this species is extensive, approximately from latitude 23' N. to 20° S., it is likely that other varieties remain to be described, and further changes in nomenclature may be expected.

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