

John K. Francis

*Guaiacum officinale* L., commonly known as lignumvitae (English), guayacán (Spanish), and bois de gaoac (French), is a beautiful, small- to medium-sized tree of dry tropical forests (fig. 1). It has a dense crown of dark-green leaves and smooth, mottled bark. Its beautiful blue flower is the national flower of Jamaica (1). The dense, resinous wood was once important in commerce but now is so rare that it is only used for wood carving and, unfortunately for this rare and slow-growing tree, charcoal.

## HABITAT

### Native Range

The native range of lignumvitae includes the South Caicos in the Bahamas, the Greater Antilles, most of the Lesser Antilles, Venezuela, Colombia, and Panama (fig. 2) (4, 12, 22). The species is also native to Aruba, Bonaire, Curacao, and Tobago (24). It is present, but may not be native, in Trinidad (19) and Guyana (15). However, because of development, harvest, and fires, lignumvitae is near extinction on several of the Lesser Antilles islands (12). It is believed to have become extinct on Buck Island in the U.S. Virgin Islands (27). Lignumvitae is planted as an ornamental in Florida, Bermuda, and other tropical areas (15).

### Climate

The climate in the native range of lignumvitae is mild and dry. Mean annual temperature varies from about 24.5 °C in the Bahamas to about 27.5 °C along the northern coast of South America (25). Frost does not occur over any of the range. In Cuba, mean annual rainfall in areas supporting lignumvitae ranges from about 500 mm to 800 mm (3). Areas in Puerto Rico where lignumvitae grows receive from about 750 to 1000 mm of rainfall per year (5). The range in Haiti extends to areas receiving as little as 300 mm of precipitation annually.<sup>1</sup> These habitats usually experience a dry season of 2 or more months. Because of the maritime influence, relative humidity is usually quite high. It averages 80 percent in Puerto Rico (5).

<sup>1</sup>Jenkins, Michael B. 1988. The useful trees of Haiti; a selected review. Unpublished manuscript on file with: U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry, Río Piedras, PR. 238 p.

John K. Francis is a research forester at the International Institute of Tropical Forestry, U.S. Department of Agriculture, Forest Service, Río Piedras, PR 00928-2500; in cooperation with the University of Puerto Rico, Río Piedras, PR 00936-4984.

## Soils and Topography

As with most species, lignumvitae probably grows best in deep, rich, medium-textured soils. In Cuba, the best growth has been noted on sandy alluvial soil near the mouths of rivers (3). However, because the species grows so slowly, it usually survives only in sites with very poor soil, where competition is low. These sites are generally rocky, with only a shallow cap of soil over rock. Typically, the rock is porous limestone in coastal areas. However, the species also grows on soils derived from igneous and metamorphic rocks including serpentine.

Lignumvitae grows on all soil textures but requires good drainage. Soil pH's associated with free lime (to about 8.5) are tolerated, and acid soils (to about 5.0) do not seem to be damaging to the species (author, personal observation). The mild salt spray received 100 m or so inland from shorelines does not appear to be damaging to lignumvitae.

Lignumvitae may be found growing on all slope positions and in flat to steep terrain. The species is found near sea level and ascends dry hills to elevations of 300 or 400 m (3).

## Associated Forest Cover

In Cuba, lignumvitae is frequently associated with *Albizia cubana* Brit. & Wilson, *Lysiloma subicu* A. Rich., *L. latisiliquum* (L.) Benth., *Phyllostylon brasiliensis* Capanema, *Bursera simaruba* (L.) Sarg., *Behaimia cubensis* Griseb., *Hypelate trifoliata* Sw., *Colubrina elliptica* (Sw.) Briz. & Stern., *Gymnanthes lucida* Sw., and *Guaiacum sanctum* L. (3). The following association containing lignumvitae was



Figure 1.—A lignumvitae (*Guaiacum officinale* L.) tree, a residual from a former forest, that has been incorporated into landscaping in Puerto Rico.

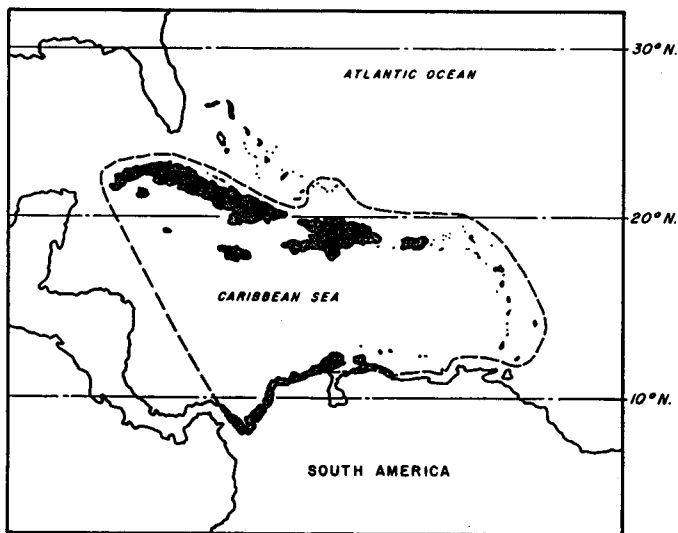


Figure 2.—The native range of *lignumvitae* (*Guaiacum officinale* L.) in the Caribbean area, indicated by the shaded area.

observed in the dry forest of the Dominican Republic: *P. brasiliensis*, *Pisonia discolor* Spreng., *Capparis* sp., *Acacia lutea* (Mill.) Hitchc., *Prosopis juliflora* (Sw.) DC., *Caesalpinia coriaria* (Jacq.) Willd., *Parkinsonia aculeata* L., *G. sanctum*, *Bursera simaruba*, *Maytenus buxifolia* (A. Rich.) Griseb., and *Bourreria succulenta* Jacq. (8). Portions of the island of Barbuda are dominated by an association of *lignumvitae* and *Canella winterana* (L.) Gaertn. (author, personal observation). Areas of broken limestone in Guadeloupe are dominated by *Bumelia salicifolia* (L.) Sw. and *Erythroxylum brevipes* DC. with lesser quantities of *Bucida buceras* L. and *lignumvitae* (2).

## LIFE HISTORY

### Reproduction and Early Growth

**Flowering and Fruiting.**—*Lignumvitae* trees may flower at any time from spring to fall and are covered with flowers for about a month (23). In Cuba, the flowering period is from March to May (3). The slightly fragrant flowers are borne in umbel-like clusters and vary in color from pale blue to blue violet. The fruits are two-sectioned, flattened capsules that generally contain two seeds per fruit. The fruits are orange or orange brown when mature and abundant enough on many trees to add to the ornamental effect. At maturity, they split open to expose seeds that are covered with red, fleshy arils (15). Several trees in a plantation in St. Croix, U.S. Virgin Islands, flowered and produced seeds about 25 years after planting (author, personal observation). One hundred ripe fruits collected in dry forests in Puerto Rico averaged  $0.394 \pm 0.011$  g per fruit (author, personal observation).

**Seed Production and Dissemination.**—Seeds of Cuban *lignumvitae* average between 2,500 and 3,800 seeds per kg (3). Production during a good seed year can amount to several thousand seeds per large tree. The seeds are presum-

ably dispersed by birds attracted to the fleshy aril. Also, pigs and goats eat the fruits and subsequently spread the seeds (3).

Seeds are harvested by cutting fruits from trees with pruning poles or by collecting seeds that have fallen to the ground. Usually, seeds must be removed from the fruits. Seed removal can be done by hand (a tedious process), or the fruits can be dried in the shade, soaked to soften the fruit, and then wet-sieved to remove the fruit pulp (3). The seeds are again dried and then stored at 5 to 8 °C. Stored seeds, however, begin to lose their viability after 1 month (3). A better strategy may be to germinate the seeds at once and maintain the slow-growing seedlings in the nursery until needed.

**Seedling Development.**—Germination is epigeous and begins within 10 to 12 days after sowing. Up to 60 percent of fresh seeds in Cuba germinate (3). A test using Puerto Rican seeds obtain 9-percent germination with fresh seeds, 5-percent with seeds stored for 1 month at 5 °C, 20-percent with seeds stored for 1 month at 26 °C, and 10-percent with seeds stored for 2 months at 26 °C (17). Another test of Puerto Rican seeds yielded only 7-percent germination in the first month, with an additional 41 percent germinating over the next 9 months (author, personal observation). In a test of several seed pretreatments, cycles of daily soaking and drying for 1 week gave the only improvement in germination over that of untreated seeds (6).

A small group of seedlings ( $n = 14$ ) grown by the author averaged  $18.9 \pm 1.2$  cm in height 2 years after sowing. Growth appears to accelerate after seedlings reach 20 cm in height—the minimum necessary before outplanting. The use of containerized stock is highly recommended. Wildlings can be transplanted, but extreme care is required in the transplanting process (23). A recovery period, as potted plants in the nursery, would probably aid survival. Bare-root planting and direct seeding have not given good results (3, 18). A well-prepared site for planting and good follow-up weed control is essential. A planting under a light overstory of planted legume trees, *Leucaena leucocephala* (Lam.) de Wit, produced good results in Puerto Rico (18). The initial spacing should be 2 by 2 m or 2.5 by 2.5 m (3).

**Vegetative Reproduction.**—Seedlings, saplings, and young trees will coppice when cut (3). There is no evidence of grafting or rooting of cuttings.

### Sapling and Pole Stage to Maturity

**Growth and Yield.**—*Lignumvitae* grows very slowly. The survivors in a Puerto Rican plantation grown on shallow soil over limestone with 750 mm of annual precipitation ranged from 1.8 to 3.0 m in height at 7 years and 3 to 4.5 m at 15 years.<sup>2</sup> Remnants of two other plantings, 41 and 49 years old in the same area, averaged 4 and 3 m in height and 13 and 9 cm in diameter at breast height (d.b.h.), respectively (26). A small plantation of 50 surviving trees in St. Croix, U.S.

<sup>2</sup>U.S. Department of Agriculture, Forest Service. [n.d.] Unpublished data on *Guaiacum officinale* L. On file with: U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry, Río Piedras, PR 00928-2500. [Not paged].

Virgin Islands, on shallow clay over limestone averaged  $2.7 \pm 0.1$  m in height and  $2.9 \pm 0.2$  cm in d.b.h. after 23 years (author, personal observation). The largest tree was 4.0 m tall and 6.7 cm in d.b.h.

The largest lignumvitae tree known in Puerto Rico measures 75.1 cm in d.b.h. and 11.5 m in height.<sup>3</sup> Trees up to 92 cm in d.b.h. and 14 m in height have been reported in Cuba (3). Such large trees were probably common before the days of heavy harvesting. Judging from the growth rates recorded for plantations of lignumvitae, trees approaching 1 m in d.b.h. must exceed 200 years of age and may be much older.

**Rooting Habit.**—Seedlings produce abundant fine, fibrous roots. Large trees have large lateral roots protruding above the surface where the soil is clayey, compacted, or shallow over rock. No buttressing is evident even on large trees.

**Reaction to Competition.**—Lignumvitae is shade intolerant, although seedlings and young trees do grow under the open canopies of dry forests and in small gaps between trees. Lignumvitae trees in a codominant canopy position are fairly common, not because they are taller than associated species, but because the crowns are full and dense and do not allow other species to grow under or too near them. Many of the individuals actually reaching a codominant canopy position do so on very rocky terrain or poor soils where competition for light is naturally low.

The reproductive strategy in lignumvitae seems to depend on relatively high seed production in mature trees, wide dispersal, and establishment of many seedlings. Because of very slow growth, most lignumvitae seedlings are eventually suppressed and killed. A few scattered individuals in fortuitous positions gradually assume codominance in the canopy and attain the vigor necessary to flower and fruit.

An inventory in two areas of dry forests in the Dominican Republic found 117 and 150 of 3,600 and 4,000 stems per hectare, respectively, were lignumvitae (11). This amounted to 0.2 and 0.1 m<sup>2</sup>/ha out of a total of 11.9 and 6.6 m<sup>2</sup>/ha, respectively, of total basal area. The lignumvitae trees in those stands averaged 4.8 and 2.9 cm in d.b.h. and 3.9 and 3.0 m in height, respectively. Scattered trees are the norm; however, small stands with a high proportion of lignumvitae do occur (author, personal observation).

**Damaging Agents.**—A number of species in the insect families Coleoptera, Homoptera, Lepidoptera, Orthoptera, and Thysanoptera attack lignumvitae foliage, and, at times, can defoliate trees (20). Mortality of trees has not been noted, however. Lignumvitae wood is not only resistant to the dry-wood termite, *Cryptotermes brevis* (Walker), but it also actually repels them (28). The wood is also highly resistant to marine borers (*Toredo* spp.) and rot (16).

Humans are the principal enemies of lignumvitae. The tree has become rare in most of its native range because of harvesting, land clearing, and fire. Lignumvitae is thin barked and apparently sensitive to fire. However, it is resistant to

grazing. The island of Barbuda has abundant reproduction of lignumvitae, and trees of all sizes are found in areas where grazing by goats, cattle, deer, and feral donkeys is so severe that a browse line is pronounced and the ground is almost devoid of low vegetation (author, personal observation).

## SPECIAL USES

The 2- or 3-cm thick sapwood of lignumvitae is light tan to cream colored with annual rings visible. The heartwood is dark greenish brown to almost black. The texture is very fine, and the grain is strongly interlocking. The wood has an oily feel and a slight smell due to a natural material known as guaiac resin (16).

Lignumvitae wood is hard and very heavy. The wood density ranges from 1.20 to 1.36 g/cm<sup>3</sup> air-dried (16) and 1.05 g/cm<sup>3</sup> oven-dried (7). The wood is difficult to dry without shakes and endsplits developing. Lignumvitae wood is reported to be three to four times as hard as English oak (*Quercus robur* L.) and harder than any common wood in the United States (16). Because of hardness, it is difficult to work with handtools and power tools. The wood is very strong but somewhat susceptible to splitting on the tangential plane (16). Details of the mechanical properties are given in "Tropical Timbers of the World" by Chudnoff (7).

Lignumvitae wood requires special settings to plane (16). It is difficult to saw but does not dull tools excessively due to the high resin content. It turns, shapes, and sands well. The resin, which may comprise one-fourth of the weight, ensures a high polish but makes gluing difficult and prevents penetration of chemicals (7). The wood of lignumvitae has a pH of 4.6, a middle-of-the-range value for hardwoods in Puerto Rico (21); acid corrosion of fittings would be expected to be minor.

Because of its hardness, toughness, and self-lubricating properties, lignumvitae wood was very important as bearings and bushing blocks for steamships and in pulleys, mallets, and other equipment (7). With the advent of plastics and other new materials and the extreme scarcity of lignumvitae, these uses have all but disappeared except in a few rural areas (3). The disappearance of lignumvitae from Haiti is attributed to harvesting as a source of blue and green dye.<sup>1</sup> The wood is currently used to make excellent cutting boards, mortars and pestles, and for wood carving. Lignumvitae is still harvested locally to make charcoal, a regrettably low-value end product of this rare and slow-growing tree (11).<sup>1</sup>

Lignumvitae has a long history of use in herbal medicine. From pre-Colombian times until recently, an extract of the wood was used to treat syphilis (9). The extracted resin is still used to dull toothache pain and to treat skin infections, rheumatism, and gout (15). A "bush tea" is prepared in the Lesser Antilles as an abortifacient; however, it must be used with care as an overdose can be fatal (10).

Lignumvitae is planted in many dry to moist tropical countries, particularly around the Caribbean, as an ornamental. It is an evergreen with pleasing, dark-green foliage, an attractive bark, beautiful flowers, and a manageable size. It can be pruned into a hedge or sculpted (13). The main drawback is its very slow growth. The flowers are a source of nectar for honeybees (15).

<sup>3</sup>Big Tree Registry of Puerto Rico. [n.d.] Statistics. On file with: U.S. Department of Agriculture, Forest Service, International Institute of Tropical Forestry, Río Piedras, PR 00928-2500. [Not paged].

## GENETICS

There are six species of *Guaiaicum*, all native to tropical America (12). The sister species, *G. sanctum* L., often grows in association with *lignumvitae* in the Greater Antilles and the Bahamas. However, no hybrids have been reported.

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