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Cordia sulcata DC., known as white manjack and wild clammy-cherry (English), moral, moral de paz, and ateje cimmarrón (Spanish), and mapou, mahot grandes feuilles, and bois bré (French) (15, 16), is a common medium-sized tree of secondary forests in the Caribbean region (fig. 1). Its distinctive leaves are large, rough, and hairy, and the tree produces clusters of white fruit (13). The wood is currently used for posts and fuel. White manjack fruit is valuable as a food source for wildlife, and the tree itself protects against erosion during natural reforestation.

HABITAT

Native Range

The native range (fig. 2) of white manjack includes Cuba, Hispaniola, and Puerto Rico in the Greater Antilles, the Virgin Islands, Antigua, Saba, St. Eustatius, St. Kitts, Montserrat, Guadeloupe, Marie-Galante, Dominica, Martinique, St. Lucia, St. Vincent, and Barbados in the Lesser Antilles, and the island of Trinidad (4, 15, 16, 18). There have been no reports of the species being planted or becoming naturalized in any other area.

Climate

White manjack grows in subtropical moist and subtropical wet life zones (14) where the mean annual precipitation is between 1300 and 3000 mm. Most of the native range has an annual dry season of about 2 months. The mean annual temperature varies from 24.5 °C at higher elevations in the north to 27.5 °C at the southern end of the range (21). Temperature differences between summer and winter and day and night are both minimal.

Soils and Topography

White manjack may be found growing in soils derived from limestone and other sedimentary rocks and in soils derived from various types of igneous rocks, including serpentine. A wide variation in soil properties is tolerated, such as soil textures of sandy loams through clays with pH values ranging from 4.8 to 7.0. The soils must be moderately well drained to well drained at both surface and subsurface lay-

ers. White manjack grows on ridges, slopes, and valley bottoms. The species inhabits sites from near sea level to at least 600-m elevations in Puerto Rico and probably at even higher elevations in Hispaniola and Cuba.

Associated Forest Cover

White manjack was found growing in openings in a wet forest in St. Vincent dominated by *Dacryodes excelsa* Vahl, *Ficus insipida* Willd., *Sloanea caribaea* Krug & Urban, *S. truncata* Urban, and *Vitex divaricata* Sw. (2). A similar forest type in Puerto Rico contained many small white manjack trees growing in openings in association with the larger *Beilschmiedia pendula* (Sw.) Hemsl., *Buchenavia capitata* (Vahl) Eichl., *Cinnamomum elongatum* (Nees) Kostermans,



Figure 1.—The bole of white manjack (*Cordia sulcata* DC.) growing in Puerto Rico.

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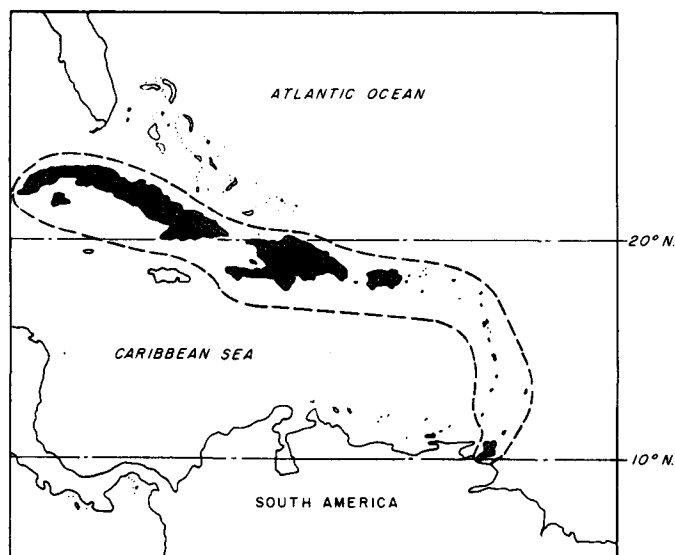


Figure 2.—The native range of white manjack (*Cordia sulcata* DC.) in the West Indies is indicated by the area within the dashed line.

Cyrilla racemiflora L., *D. excelsa*, *Guarea guidonia* (L.) Sleumer, *Magnolia splendens* Urban, and the smaller but plentiful palm, *Prestoea montana* (R. Grah.) Nichols. (5). The mature moist secondary forest on the upper slopes of Boggy Peak in Antigua was dominated by *Inga laurina* (Sw.) Willd. with white manjack, *Clusia major* L., *F. citrifolia* Mill., *Lonchocarpus benthianus* (Jacq.) DC., and *Pisonia subcordata* Sw. forming most of the remaining forest canopy (11). In a somewhat drier (1300 mm of annual precipitation) site in St. John, U.S. Virgin Islands, white manjack was an important component of a stand that contained *Andira inermis* (W. Wright) HBK., *Bucida buceras* L., *Bursera simaruba* (L.) Sarg., *Guapira fragrans* (Dum.-Cours.) Little, *Spondias mombin* L., and *Zanthoxylum martinicense* (Lam.) DC. (22).

In the 1980 survey of the secondary forest timber resources of Puerto Rico, white manjack ranked 25th in terms of total basal area (0.9 percent) of the 190 species of trees identified. The diameters at breast height (d.b.h.'s), which ranged up to 45 cm, were about average for all species in the survey. The species is more important in abandoned coffee shade forests than in other types of secondary forests (3). In two plots in a moist secondary forest in the limestone hills of Puerto Rico, white manjack averaged 2.9 m²/ha of a total average basal area of 19.4 m²/ha (6). In a subtropical moist secondary forest in St. John, U.S. Virgin Islands, white manjack comprised 0.5 percent of a total basal area of 25.1 m²/ha (22).

LIFE HISTORY

Reproduction and Early Growth

Flowering and Fruiting.—The tiny flowers of white manjack are borne in terminal panicles. Flowering occurs

from spring to fall, and mature fruit may be found in scattered trees throughout the year. The mature fruit are drupes about 1 cm in diameter that are waxy white with sticky flesh (16). They are borne in large clusters produced in abundance by trees receiving full sunlight. A sample of fruit from Puerto Rico yielded 2,600 fruits per kilogram (17).

Seed Production and Dissemination.—There was an average of 5,300 air-dried seeds per kilogram in one sample of white manjack seeds collected in Puerto Rico (17) and 10,200 seeds per kilogram in another (12). Seeds for propagation are most easily collected by clipping clusters of ripe fruit from trees with pruning poles. The fruit is then macerated and wet sieved to separate the seeds from the pulp. The seeds should be air-dried and stored in a sealed container in a refrigerator. White manjack seeds are dispersed by birds and bats and commonly reach pastures and abandoned fields, as well as disturbed forest sites (18).

Seedling Development.—Germination of white manjack seeds is epigeous (18). In five germination tests on samples from Puerto Rico, an average of 19 percent of the seeds germinated, requiring an average of 21 days after sowing for germination to begin (12, 17).

Seedlings of white manjack are sensitive to drought stress (author, personal observation). Regular irrigation of containerized nursery seedlings is essential. Light artificial shade is probably beneficial because it promotes higher humidity. Even with well-developed root systems, potted nursery seedlings will suffer some leaf damage or loss if they are transplanted during sunny periods without frequent rainfall. Planting bare-root seedlings is likely to result in high mortality.

Nineteen seedlings grown in plastic nursery bags in a shade house averaged (mean $\pm$ standard error) 40 $\pm$ 2 cm in height 7 months after sowing. From these, 12 were outplanted in full sun in a moist forest area in Puerto Rico and averaged 72 $\pm$ 4 cm in height after 1 year and 91 $\pm$ 6 cm in height after 2 years. Even though the seedlings were short, the stems were thick in proportion, and the branches displayed a drooping form (author, personal observation).

Vegetative Reproduction.—White manjack coppices well, especially the young plants (18). No information is available on its rooting or grafting ability.

Sapling and Pole Stage to Maturity

Growth and Yield.—White manjack may reach heights of 20 m and d.b.h.'s of 45 cm on good sites (3, 13). The growth rate of white manjack is documented by a single reference. Weaver (22) reported a mean annual diameter increment of 0.10 $\pm$ 0.03 cm/yr over 5 years for 14 trees on St. John, U.S. Virgin Islands. Such a slow growth rate may reflect severe competition in a marginally dry habitat. Judging from the size of trees in secondary forests of known age, white manjack under less competition in moist habitats probably grows at rates five times as fast (author, personal observation).

Rooting Habit.—Seedlings produce a taproot with many fine lateral roots. Saplings retain the taproot and develop a few extended laterals with fine tertiary roots tipped with rhizomorphs (author, personal observation). White manjack may be endomycorrhizal as is the closely related *Cordia borinquensis* Urban (8).

Reaction to Competition.—White manjack is intolerant of shade (18). Seedlings do survive and grow in competition with brush and weeds of similar height but do not survive below a closed forest canopy. Adult trees not in dominant or codominant crown positions rarely produce fruit, and trees completely overtopped die in a few years from suppression (author, personal observation).

It is sometimes necessary in the course of forestry operations to kill white manjack trees in order to make room for more valuable species. A 5-percent solution of the herbicide 2,4,5-T in diesel oil was applied to hack-frill girdles in several species, including 25 white manjack trees. After 6 to 12 months, 92 percent of the trees were dead and the remainder, moribund (20). Although the use of 2,4,5-T is no longer permitted in areas subject to United States law, these results give an indication of the effectiveness of herbicides applied to hack-frill girdles. Less effective, but legal, methods such as 2,4-D applied to hack-frill girdles and deep-notch girdles are suggested for killing white manjack when it becomes necessary.

Damaging Agents.—Most of the white manjack timber volume encountered in the 1980 Puerto Rican survey of secondary forest resources was defect free. Just 18 percent of the volume was listed as cull, and only one-fifth of that was culled due to rot (1). White manjack wood in contact with the ground is subject to attack by both fungi and termites. Because of the combined effects of both decay and termites, 90 percent of untreated posts in a test conducted in a moist area of Puerto Rico were unserviceable at the end of 1 year. The remaining 10 percent were affected by rot. The estimated average service life of untreated posts in the test was 0.9 year (9). The service life of white manjack posts can be extended up to 11 years by treatments with chemical preservatives (7). Penetration of the wood by preservatives in diesel oil using the cold-soak method approximates the median depth for a large number of Puerto Rican species tested (10).

In Puerto Rico, occasionally white manjack leaves (groups to whole crowns) are so completely riddled by leaf skeletonizer insects, possibly *Pyrrhalta varicornis* (Weise), Coleoptera, that they look like screen when viewed against the sky (author, personal observation). Several insect species have been collected from white manjack in Puerto Rico (19). Of particular note are *Elabra aureovittata* (DeLong), a homopteran that can be found on most white manjack in Puerto Rico and St. Thomas, and *Nasutitermes costalis* (Holmgren), Isoptera, the wetwood termite that builds nests and runways on this and many other tree species and feeds on dead twigs and other accessible dead wood (19).

SPECIAL USES

White manjack wood has a light-tan color overall; the interior of the vessels are brown, with the intervening tissue a dark ivory. There is only a slight difference between sapwood and heartwood. The wood is of medium density. Two trees sampled by the author had densities (ovendried) of 0.48 and 0.52 g/cm³. Other sources list the wood density as about 0.6 g/cm³ (air-dried) (16, 18). White manjack wood is relatively soft and easily worked and has been used for coopeage and boxes. Today, the wood of this species is used

mainly for fuel, charcoal, and treated and untreated fenceposts. Although somewhat limited for commercial harvests by its small size, white manjack wood should be suitable for plywood corestock and medium-density flakeboards.

Because it is common and an abundant producer of fruit throughout most of the year, white manjack is an important source of food and cover for birds. Whetmore (23) found seeds he classified as "moral" (probably a combination of white manjack, *C. borinquensis*, *C. collococca* L., and *C. laevigata* Lam.) in the stomach contents of 12 species of birds in Puerto Rico. Probably, the fruit is also consumed by domestic chickens, goats, and pigs as well as bats, land crabs, and rodents.

White manjack has sometimes been used in roadside plantings. However, because of its rough and open crown, the species has not been well accepted as an ornamental. It might be planted as a wildlife food plant and in wildland habitat restoration. White manjack is normally a component of the spontaneously regenerated secondary forest on abandoned farmland and other formerly disturbed areas.

GENETICS

The genus *Cordia* contains approximately 250 tree, shrub, and vine species from tropical areas (15). *Cordia sulcata* does not have any botanical synonyms.

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