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Issued January 23, 1913.

U. S. DEPARTMENT OF AGRICULTURE,
FOREST SERVICE—Circular 211.
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GREENHEART.

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WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1913.

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GREENHEART.

IMPORTANCE OF THE WOOD.

Greenheart (*Nectandra rodiei* Schomb.) is a South American and West Indian tree belonging to the laurel family (Lauraceæ), which includes our red bay (*Persea borbonia* (Linn.) Spreng.) and sassafras (*Sassafras sassafras* (Linn.) Karst.). Native Indian names for it are bebeeru, bibiru, supeira, and sipiri. Another name sometimes given it is torchwood, due to the fact that the heartwood of older trees, which is full of oil, burns readily.

The truly remarkable lasting qualities of mature greenheart wood have given the tree a world-wide reputation. Authentic records show that the best grades surpass iron and steel in durability when placed in water or in contact with the soil. This extraordinary freedom from decay is due in part to the presence in the wood of an alkaloid known as biberine,¹ and in part to the presence of resinous substances known as tyloses. These latter consist of reddish-brown masses of parenchymatous (living) cells growing in solid masses within vessel cavities, often completely filling them. As they develop with the growth of the tree they turn dark, sometimes coloring the wood nearly black. It is the extent of their development, and consequently the age of the tree, which in large measure determines the color of the wood,² thus giving rise to three varieties—yellow, gray, and black greenheart—recognized in the trade. As might be expected, the black variety is the most durable, since the dark color testifies in general to the abundant development of tyloses.

Next to sugar, greenheart has long been the chief article of export from British Guiana. Its valuable properties first became known to English timber merchants in 1769, and from then on it has been imported in large quantities, first into England and later into the United States. Although already well known, its importance in the timber trade in this country promises to increase, since no other foreign wood is so well adapted to so many important uses.

¹ First discovered in the bark and seeds by Dr. Rodie in 1834. It is now used as a substitute for cinchona. Both the bark and seeds have a market value as sources of supply and are exported in quantity. See "The Technologist," vol. 3, 1863, pp. 140-142.

² The dark color of the wood may also in some instances be due to the character of the soil in which the tree grew, since trees growing in wet or dark mucky soil take up highly colored substances, which, in their upward course through the stem of the tree, are deposited on the inner walls of the wood elements.

USES AND DURABILITY.

Greenheart is unsurpassed as a construction timber. It finds its chief use in ship and dock building, especially for keelsons, beams, engine bearers, planking, dock gates, lock gates, piers, and piling. When placed in water it is proof against the ravages of the teredo,¹ and on land it is exempt from the attack of white ants. It has been known to stand in wharves for a period of 30 years, and logs of greenheart which have remained under water for 100 years have kept in perfectly sound condition. All the gates, piers, and jetties of the Liverpool docks and practically all the lock gates of the Bridgewater Canal (England) are of greenheart. It furnished the material, also, for the 50 pairs of lock gates in the Manchester (England) Ship Canal. Indeed, the chief engineer of this canal has asserted that, apart from its practically unlimited durability, greenheart has many advantages over steel for such purposes. It is, in fact, impossible to fix a limit to the durability of lock gates built of greenheart, the only element in their construction which might curtail their length of service being the iron bolts and other fastenings. These, however, can usually be renewed without serious difficulty. When the greenheart dock gates in the Mersey Harbor were removed, in order that the channel might be deepened and widened, the wood originally used in their construction was again employed in building the enlarged gates. Similarly, the wood in the gates of the Canada Dock, built in 1856, was used again in its reconstruction in 1894. The use of greenheart has been specified for sills and fenders in the lock gates of the Panama Canal.

Nansen's ship, *The Fram*, and the Antarctic ship, *Discovery*, were constructed of greenheart. The wood is used also for trestles, bridges, buildings, shipping platforms, staging, millwork, cellar flaps, flooring, wagons, and for all purposes involving great wear and tear. It is highly esteemed as a furniture wood, and is used extensively for carriage shafts. The ends of logs removed in the woods to facilitate snaking are used for such articles as automobile spokes, belaying pins, and tobacco pegs, and for all kinds of turnery. Greenheart and the wood of an associate species known as cumaroo, cumaru, tonquin, tonkabean, or niob (*Dipteryx odorata* Willd. = *Coumarouino odorata* Taubert) have a reputation for fishing rods both in this country and in Europe. The darker grades of greenheart resemble the wood of lignum vitæ (*Guaiacum officinale* Linn.), and are considered an excellent substitute for the latter.

Though exceedingly durable, greenheart tends to split and splinter, and requires great care in seasoning and in working. The logs often cleave at the ends into four segments, but cracks do not usually ex-

¹ It is said that even in tropical waters sea-worms do not penetrate beyond the sapwood.

tend more than 2 or 3 feet from the end. This defect, though serious, is to some extent compensated for by the fact that the logs do not split and form deep shakes along the side in seasoning as do the majority of other woods, so that there is not, after all, more than the ordinary amount of waste in conversion. The wood, moreover, is remarkably free from knots, and generally sound. In addition to its use as timber, great quantities of greenheart are made into charcoal.

DISTRIBUTION.

Greenheart inhabits parts of British, Dutch, and French Guiana, Venezuela, Brazil, Colombia, Peru, Trinidad, Jamaica, and Santo Domingo. It is the most important tree of British Guiana, the only place where it is being cut. There it is found most abundantly along the Essequibo, Demerara, and Berbice Rivers. Much of the best quality of greenheart now marketed comes from Morabelli Creek, a tributary of the Essequibo River, where the tree attains its greatest size and produces the best grade of wood. Greenheart grows along the seacoast and watercourses, seldom extending more than 50 miles inland and never more than 100 miles. It is most plentiful and reaches its best development on a strip between 2 and 3 miles wide just back of the deposit of alluvial soil along the coast and rivers. It seldom grows on sites much above sea level or on clay soil. It can not thrive on rocky soil or on moist hillsides. In British Guiana the southern limit of distribution is marked by the elevated regions. Invariable associates of greenheart are the mora (*Dimorphandra mora* Benth.) and wallaba (*Eperua falcata* Aubl.), though these spread over a much larger area.

LOGGING AND TRANSPORTATION.

The present cost of placing greenheart timber on the market is high. This is the result chiefly of (1) the great expense of logging, due to antiquated methods of extracting the logs and the high cost of hauling them; (2) excessive waste in logging; and (3) high transportation charges.

The present methods of logging greenheart are antiquated, laborious, and expensive. All hauling in the forest is done either by gangs of men or by oxen. Hand labor is employed exclusively in cases where the timber is within a short distance of the place of shipment. Where it is cut on the slopes of hills fronting a navigable stream oxen are used in getting the logs out. Both methods are crude, slow, and wasteful at best.

The timber is not hewed in the careful manner that mahogany, cedar, and many other woods are when prepared for shipment, but goes to market only partially dressed. To facilitate snaking the butts of logs are invariably tapered for 3 or 4 feet from the end, and go to market in this condition instead of being cut off square.

Transportation facilities in the forests of British Guiana are at present exceedingly crude. Only the more accessible parts of the forests in which the choicest greenheart timber is found have as yet been exploited. Besides greenheart, only a few of the better-known timbers, such as wallaba and more recently crabwood (*Carapa guianensis* Aubl.), have been taken. These timbers have been cut along all the principal waterways as far upstream as the falls and rapids which obstruct navigation. The vast and valuable forests of greenheart above the falls are still to be opened up. To exploit the remaining stands of greenheart in British Guiana will, however, require much time and labor. As the vast resources of the country become better known efficient means of transportation to the untouched forest areas in the interior will no doubt be provided.

When greenheart was first exploited \$1 per cubic foot was the price usually paid for the timber at the point of shipment. While the present price paid for greenheart is considerably less, the wood now obtained is of an inferior quality, since it is immature and, consequently, less durable. Tracts are now being cut over in some places for the third time, and trees which previously escaped observation or were thought too small to be used are taken. Logs 2 feet in diameter or over yield the best grades. Trees of smaller dimensions have a good deal of sap and are not durable. Their timber, moreover, is likely to shrink and split considerably in seasoning. At present practically all the greenheart timber is shipped to Liverpool and New York. These are the two chief distribution points, and the necessary reshipping of such extraordinarily heavy material approximately doubles the cost of direct shipment.

MARKET.

While the demand for greenheart timber is great, it is not keeping pace with the increased use of fancy cabinet woods and of construction material. The extensive employment of reinforced concrete for wharf construction tends, for one thing, to curtail the output. The volume of native timbers, principally greenheart, exported from British Guiana during the 20 years previous to 1909 is given in the table following:

Exports of timber from British Guiana¹ from 1889 to 1909.

Year. ²	Amount.	Year.	Amount.
	<i>Cubic feet.</i>		<i>Cubic feet.</i>
1889-90	296, 151	1899-1900	170, 632
1890-91	332, 098	1900-1901	287, 640
1891-92	312, 801	1901-2	313, 571
1892-93	325, 863	1902-3	340, 260
1893-94	234, 870	1903-4	273, 542
1894-95	238, 993	1904-5	293, 315
1895-96	175, 520	1905-6	276, 765
1896-97	404, 234	1906-7	170, 985
1897-98	283, 634	1907-8	232, 669
1898-99	250, 463	1908-9	191, 409

¹ Greenheart is exported only from British Guiana and the island of Trinidad.

² The fiscal year includes the 12 months from April 1 to March 31.

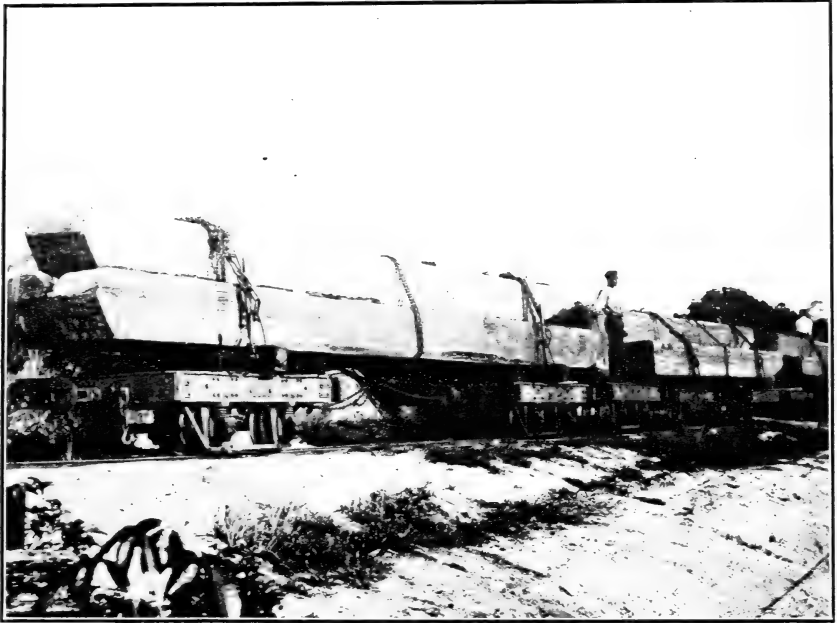
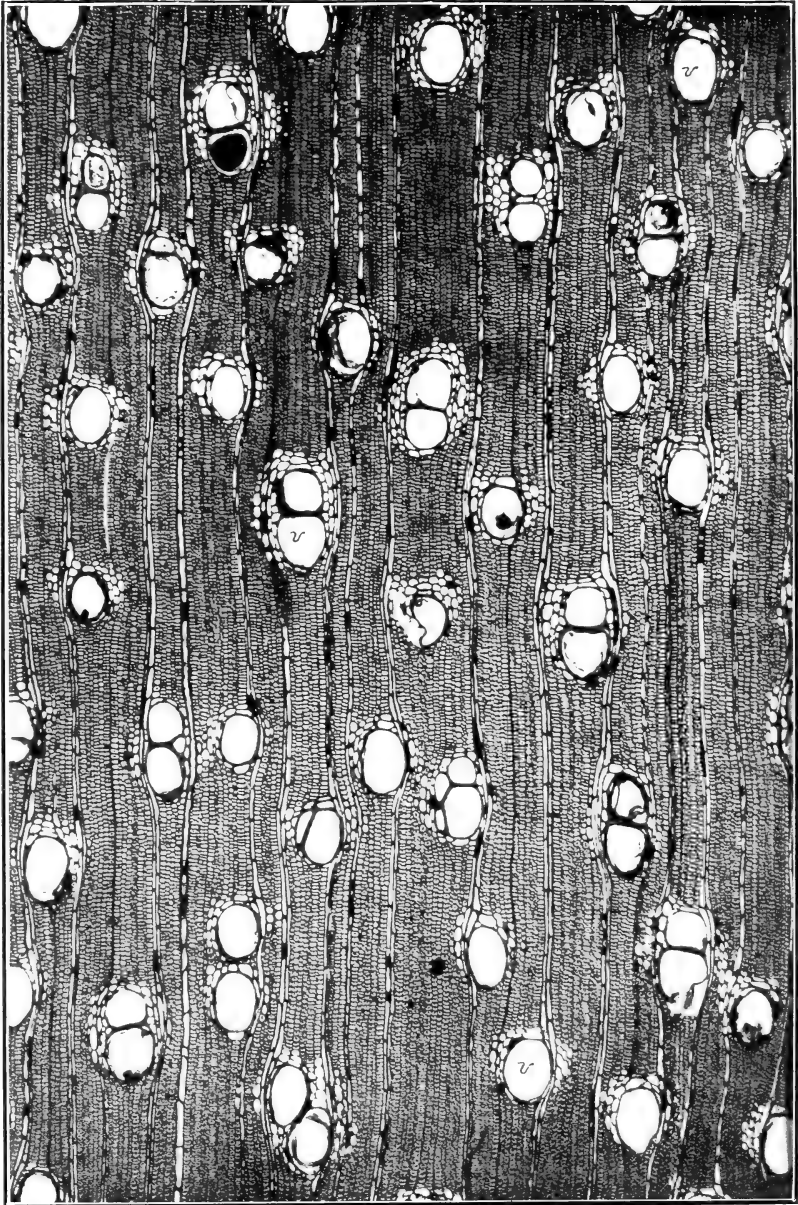


FIG. 1.—A TRAINLOAD OF GREENHEART LOGS FOR EXPORT.



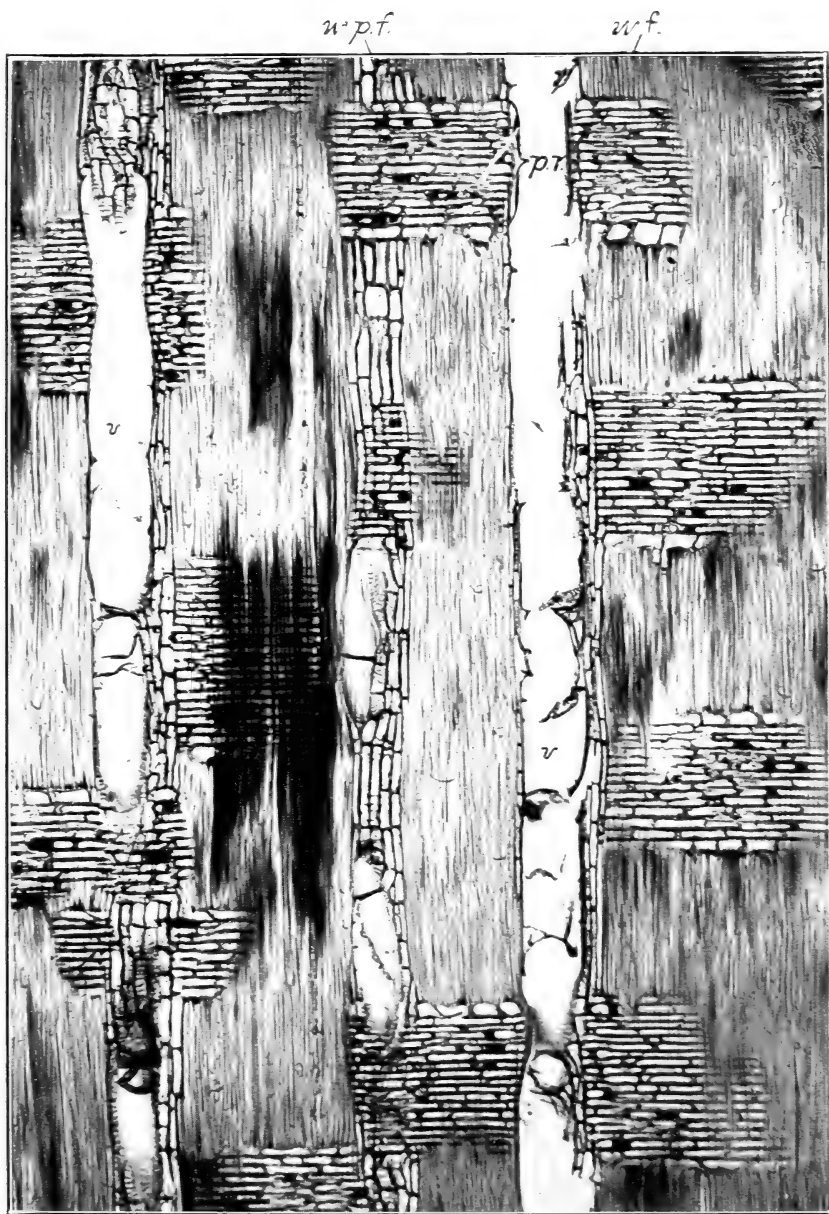
FIG. 2.—LOGGING GREENHEART WITH OXEN.

p. r. *w. f.* *w. p. f.*



TRANSVERSE SECTION OF GREENHEART WOOD.

The large black spot in upper left-hand corner represents tylosis. *v.*, vessel; *p. r.*, pith ray; *w. p. f.*, wood-parenchyma fiber; *w. f.*, wood fiber. Magnified 50 diameters.



RADIAL SECTION OF GREENHEART WOOD.

v., vessel; p. r., pith ray; w. p. f., wood-parenchyma fibers; w. f., wood fiber. Magnified 50 diameters.

wf *pr*



TANGENTIAL SECTION OF GREENHEART WOOD.

v., vessel; *p. r.*, pith ray; *w. f.*, wood fiber. Magnified 50 diameters.

These amounts do not include the vast quantity of greenheart cut each year for charcoal. Approximately 80,000 barrels of this are exported annually. The demand for the wood of young greenheart trees for charcoal became so great that legal restrictions had to be placed upon the cutting of young growth. The market for charcoal is apparently more stable than that for timber, since the amounts of the former exported from year to year show a gradual increase, while the amounts of timber usually fluctuate.

THE TREE.

Greenheart is a large tree, ranging from 60 to 100 feet in height, and from 2 to 4 feet or more in diameter. The trees are without branches for from one-fourth to one-third of their total height. They generally have clean, symmetrical boles for the first 50 or 60 feet, and logs or timbers from 18 to 20 inches square can often be obtained. The bole is free from knots, and unlike that of many of the greenheart's associates is not buttressed. The crown is open and broad with a few heavy branches. The tree is an evergreen, but during the dry season has fewer leaves than during the wet season. Owing to the absence of distinct rings of annual growth, the age at which greenheart reaches maturity is not accurately known. The tree, however, grows very slowly. Specimens known to be 70 years old have reached a diameter of scarcely 8 inches. Hence it is probable that trees of merchantable size, say 20 inches in diameter, are about 250 years old, while others of still larger proportions are relatively older.

GROSS CHARACTERS OF THE WOOD.

When freshly cut the sapwood of greenheart is pale yellow and the heartwood usually of a light grayish-brown, often striped. On exposure the wood turns dark, the outer layers assuming a dark greenish or chestnut color, while the center turns a deep brownish-purple or almost black. The color of both heart and sap wood varies considerably in different trees, and in different parts of the same tree. The heartwood may, in fact, vary from pale yellow to black, and just what the actual color is can not be ascertained until the sapwood has been cut through. The proportion of sapwood is usually excessive, especially in young trees, often amounting to one-fifth and sometimes to one-third of the volume of the trunk. This, however, has little effect upon the lasting qualities of the wood when used above water.

The wood of greenheart is exceedingly hard and heavy (specific gravity from 1.08 to 1.23, or about 75 pounds per cubic foot), tough, strong, elastic, and fine grained. It is said to be the strongest timber in use, with a crushing strength of 12,000 pounds per square inch, 65

per cent greater than that of English oak. In a smooth transverse section (unmagnified) it resembles superficially the wood of palm.

ANATOMICAL CHARACTERS OF THE WOOD.

Like a number of other tropical hardwoods, greenheart shows no annual rings of growth. The ground mass of the wood is composed of small, thick-walled wood fibers arranged in radial rows (transverse section). The vessels, plainly visible to the naked eye on a smooth transverse surface, are distributed either singly or in pairs arranged radially. They are surrounded by several rows of wood-parenchyma fibers which under a compound microscope can be distinguished from wood fibers by their thin walls. The pith rays are very narrow and visible only when magnified.

The *pores* (Pl. III, *v.*) are arranged either singly or in pairs, with an average diameter of 0.13 millimeter, and are fairly constant in size throughout the wood. In outline they are either round or elliptical, with the greatest diameter in the radial direction, and are fairly thick walled. The vessel walls (Pls. III and IV, *v.*) in contact with the pith-ray cells and with wood-parenchyma fibers have numerous bordered pits with transitions to simple pits. These are sometimes large and elliptically elongated, a group often resembling scalariform (ladder-like) markings. The partition wall where the vessel segments join end to end is wholly absorbed (simple perforation), leaving an open passage between the segments. The original partition wall is at right angles to the axis of the vessel, and each vessel segment ends in a small projection which overlaps the next segment above and below. The segments of which the vessels are composed consist of cells approximately five times as long as wide (0.67 millimeter in length).

Wood fibers (Pl. II, *w.f.*) are small in diameter and have such thick walls that the lumina or cell cavities often resemble mere dots in transverse section. The fibers vary in length from 1.14 to 1.51 millimeters, with an average of 1.28 millimeters. The pits are simple, with very narrow canals. These latter are not visible except in transverse section under the high power of the microscope.

Wood-parenchyma fibers (Pl. III, *w.p.f.*) have very thin walls and are only sparingly developed, except where they are grouped around vessels with which they communicate through the round or transversely elongated pits mentioned above. The cells composing the wood-parenchyma fibers show considerable variation in length. The end walls of individual cells are usually at right angles to the long axis of the fiber.

Pith rays (Pl. IV, *p.r.*) are usually from 1 to 2 cells wide and from a few to 30 or occasionally 40 cells high. Individual ray cells

vary in size. Their shape as seen in tangential section is usually round. In radial section they appear as elongated brick-shaped cells, varying greatly in length, with oblique end walls. Both the end and radial walls have small, round, simple pits.

SUBSTITUTES FOR GREENHEART.

The constant drain for more than 100 years upon the most accessible stands of greenheart in British Guiana has stripped the forest of its best material and resulted in the appearance on the market of certain substitutes. The woods of three other species of *Nectandra*, the white cirouballi or siruaballi (*Nectandra surinamensis* Mes.), yellow cirouaballi (*Nectandra pisi* Miq.), sometimes called "black cedar," and the keritee or kretti (the exact species of which is not known), which grow with greenheart throughout its entire range, are occasionally cut and sold with the genuine. While they closely resemble it, they are inferior in durability. The white cirouaballi, however, is an important tree, and its wood is likely to be substituted more extensively as the supply of true greenheart diminishes. The woods of the two other species are much lighter than true greenheart, the yellow cirouaballi weighing 52, and the kretti 32 pounds per cubic foot, as against 75 pounds for the genuine, and their substitution should be easy to detect. These two species work well, and are used largely for planking. The kretti wood strongly resembles cigar-box cedar (*Cedrela odorata* Linn.) in aroma, grain, texture, and ease of working, but is very much paler in color.

The woods of two species of leguminous trees of West Africa have been introduced into English markets as substitutes for greenheart, under the name of African greenheart. One is from the recently described tree *Piptadenia* (called "okan" by the natives), which attains large size, especially in the Gold Coast region. This wood is valued at from 30 to 36 cents per cubic foot. The other species is an undescribed tree from Nigeria, which yields a wood known locally as *essago*, selling for from 36 to 42 cents per cubic foot. Both of these species are inferior to true greenheart, and it is not likely that they will take its place to any great extent.

An East African tree called greenheart is *Walburgia ugandensis* Sprague, better known to the natives of East Africa as "masuka" or "m'ziga." Its heartwood is green in color, beautifully figured, and sweet scented. The supply, however, is rather limited, and it is not likely to enter the markets of Europe or America. None of the African woods possesses the lasting qualities of the true greenheart of British Guiana.

Several comparatively unimportant trees of the West Indies are called greenheart, but they are not sufficiently valuable to enter into competition with true greenheart. One of these is the snakewood,

ironwood, or abelluello (*Colubrina ferruginosa* Brongn.), often called West Indian greenheart. The wood is strong and durable, but is much inferior to the true greenheart. The tree from which this comes is comparatively small, seldom over 75 feet high, and 2 feet in diameter, even in Martinique, where it attains its best development. Owing to its small size, the substitution of this wood for true greenheart must necessarily be very limited. Another species of this genus, *Colubrina reclinata* Brongn., a relatively low tree, seldom over 60 feet high, found in the mountains of Cuba, yields a strong and durable wood sometimes referred to as greenheart. The greenheart of Jamaica (also called cogwood or cerillo) is the *Ceanothus chloroxylon* Nees. It is a small tree and does not enter into competition with the genuine greenheart. Still another tree from Jamaica sometimes called greenheart is *Zizyphus chloroxylon* Oliver. It is of good size throughout the interior hills, though not plentiful. The wood is dark, close grained, and weighs about 70 pounds per cubic foot.

Greenheart is the name applied also to a Jamaican tree, *Sloanea jamaicensis* Hook., which grows from 70 to 100 feet in height, with a trunk about 2 feet in diameter. It is confined largely to the interior of the island, where it attains its largest sizes in the limestone soil. The wood is very hard, heavy, fine grained, dark colored, and is suitable for a good many purposes. It is said to be very durable in contact with the soil.

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