

# The History, Present Distribution, and Abundance of Sandalwood on Oahu, Hawaiian Islands: Hawaiian Plant Studies 14<sup>1</sup>

HAROLD ST. JOHN<sup>2</sup>

## INTRODUCTION

TODAY IT IS a common belief of the residents of the Hawaiian Islands that the sandalwood tree was exterminated during the sandalwood trade in the early part of the nineteenth century and that it is now extinct on the islands. To correct this impression, the following notes are presented.

There is a popular as well as a scientific interest in the sandalwood tree or iliahi of the Hawaiians, the fragrant wood of which was the first important article of commerce exported from the Hawaiian Islands.

For centuries the sandalwood, with its pleasantly fragrant dried heartwood, was much sought for. In the Orient, particularly in China, Burma, and India, the wood was used for the making of idols and sacred utensils for shrines, choice boxes and carvings, fuel for funeral pyres, and joss sticks to be burnt in temples. The distilled oil was used in numerous medicines, perfumes, and cosmetics, and as a body rub. The thick oil pressed from the seed was used as illuminating oil.

Though long believed to be native to India, the "white sandalwood," *Santalum*

*album* L., the species first commercialized, is now considered to have been introduced into India many centuries ago and cultivated there for its economic and sentimental values. Only in more recent times has it attained wide distribution and great abundance in that country. It is certainly indigenous in Timor and apparently so all along the southern chain of the East Indies to eastern Java, including the islands of Roti, Wetar, Sawoe, Soemba, Bali, and Madoera. The earliest voyagers found it on those islands and it was early an article of export, reaching the markets of China and India (Skottsberg, 1930: 436; Fischer, 1938). The insufficient and diminishing supply of white sandalwood gave it a very high and increasing value. Hence, trade in the wood was profitable even when a long haul was involved.

## THE GENUS *Santalum*

The genus *Santalum* contains several species and most, if not all, of these are acceptable alternatives or substitutes for *S. album*. Hence, each newly discovered stand of any species of sandalwood attained great economic value. There are now 19 accepted species of *Santalum* occurring naturally from Java to Juan Fernandez, Hawaii, and the Bonin Islands. These species are found as follows:

Java to Timor—*S. album* L.

New Guinea—*S. Macgregorii* F. Muell., *S. papuanum* Summerh.

Australia—*S. lanceolatum* R. Br., *S. obtusifolium* R. Br., *S. ovatum* R. Br.

<sup>1</sup>This is the fourteenth of a series of papers designed to present descriptions, revisions, and records of Hawaiian plants. The following papers have been published as Bernice P. Bishop Museum Occasional Papers: 10 (4), 1933; 10 (12), 1934; 11 (14), 1935; 12 (8), 1936; 14 (8), 1938; 15 (1), 1939; 15 (2), 1939; 15 (22), 1940; 15 (28), 1940; 17 (12), 1943; and nos. 11, 12, and 13 are in press.

<sup>2</sup>Chairman, Department of Botany, University of Hawaii.

New Caledonia, Loyalty Islands, New Hebrides—  
*S. austrocaledonicum* Vieillard

Fiji—*S. Yasi* Seem.

Tahiti, Raiatea, Austral Islands, Rapa, Marquesas  
—*S. insulare* Bertero

Henderson Island—*S. hendersonense* F. B. H. Br.  
Juan Fernandez—*S. fernandezianum* Phil. (now  
extinct)

Hawaiian Islands—*S. ellipticum* Gaud., *S. Frey-*  
*cinetianum* Gaud., *S. haleakalae* Hbd., *S. lanai-*  
*ense* Rock, *S. paniculatum* H. & A., *S. Pilgeri*  
Rock, *S. pyrularium* Gray

Bonin Islands—*S. boninense* (Nakai) Tuyama

#### THE SANDALWOOD ERA IN HAWAII

The Hawaiian people were familiar with the pleasant aroma of the iliahi. They called its wood laau ala (or laau aala), meaning "fragrant wood," and they sprinkled finely powdered heartwood on their kapa or bark cloth to perfume it.

Just how the Hawaiian sandalwood trade began is not known. Perhaps the Hawaiians showed the pleasantly scented wood to the white voyager or "haole." Perhaps, as has been suggested, logs of iliahi were included in firewood furnished to sailing vessels in an island port and some sea captain, veteran of the China trade, recognized the sweet perfume of sandalwood oil coming from the burning wood in the cook stove. The actual beginning is not certainly known, but the first record is as follows (Bradley, 1942: 26-27; see Ingraham, 1791: 15, 19, 20, 23, 24):

The earliest specific mention of sandalwood at the Islands is attributed to Isaac Ridler, a deserter from the "Columbia." Ridler was at Kealakekua Bay in March 1790, during the visit of the "Eleonora"; a year later, he told Captain Joseph Ingraham that while at Kealakekua Captain Metcalfe had engaged in "taking in sandalwood." Metcalfe may have purchased the sandalwood for use as firewood; it is also possible, if we may credit Ridler's testimony, that he was the first to carry sandalwood from the Hawaiian Islands to China for commercial purposes.

In 1790, Captain John Kendrick of the "Lady Washington" left two men on Kauai to collect sandalwood for his next return from Boston. Before May, 1791, Captain

William Douglas of the "Grace" (Ingraham, 1791: 15, 19) put two men ashore on Kauai to collect sandalwood, "which wood he had discovered or a wood similar to it."

There is doubt about the accuracy of these early records, for Amasa Delano (1817: 399; see Bradley, 1942: 27) observed in 1801 that the first sandalwood shipped from the islands to China was not the real sandalwood and was of such inferior quality that the Chinese merchants refused to purchase it.

From 1790 to 1810 sandalwood may have been exported, but if so, in very small quantity, for little record is found. Then, in 1809, two brothers, the American ship captains Jonathan Winship of the "Albatross" and Nathan Winship of the "O'Cain," started on a voyage that established the sandalwood trade. After trading for furs on the coast of Oregon, they sailed in October, 1811, for Honolulu, where they and Captain William Heath Davis of the "Isabella" took on cargoes of sandalwood. The ships sailed to Canton, where the fragrant wood was sold at a large profit. Returning to Honolulu, the three captains persuaded King Kamehameha I to grant them a monopoly of the sandalwood and cotton trade for 10 years. Loading five ships, the three captains sailed to Canton and thus established a highly remunerative traffic. While they were in China, the startling news came that America and Great Britain were at war, and when the captains returned to Honolulu they found Kamehameha unfriendly. He canceled their trade monopoly and refused to renew it, his changed attitude being due, they reported, to British influence (Davis, 1816: 52-53).

Thereafter, though no longer a trader's monopoly, the sandalwood trade developed rapidly and thrived from 1815 to 1826. The successive Hawaiian kings at first followed the example of the shrewd Kamehameha I and kept sandalwood as a royal monopoly,

but later they shared it with the higher chiefs. Taxes, to be paid in sandalwood, were levied on the district chiefs, who in turn levied them on their retainers, the people. Wanting some of the white man's sailing ships, the king bought several, paying for them, it is said, with an equal or a double tonnage of sandalwood. For measuring the amount, a rectangular pit the size of the greatest length, breadth, and depth of the hull was dug, then filled with sandalwood logs (Rock, 1916: 10). These pits are still reported in various parts of the islands, and there is one, identified by the late Albert F. Judd, at about 800 feet elevation on the Kapalama-Nuuanu ridge, on the grounds of the Kamehameha Schools, Honolulu.

After the death of Kamehameha I in 1819, his successors ruled, but without the sagacity and shrewdness of the great king. Their sandalwood monopoly still seemed to them an inexhaustible source of wealth. The wood was marketed in China by the picul (133 $\frac{1}{3}$  pounds) and its value fluctuated from \$3.00 to \$18.00; during the prosperous years 1825 to 1827 it sold at from \$10.50 to \$14.00 a picul. In 1822-23 a total of 20,000 piculs was sold in Canton. The trade was a great resource for Kamehameha I, but for the next two kings, Liholiho and Kauikeaouli, and their womenfolk, it was a bonanza. They paid \$77,000 for a brig and its cargo. They bought frame houses shipped ready-cut, silks, woolens, liquors, cut glass, and luxuries of many other kinds. They paid \$800 for a looking glass and \$10,000 for a brass cannon. With the consent of the eager, competing traders, these purchases were accepted on credit for sandalwood to be delivered later. These reckless purchases piled up royal debts in 1821 of 22,000 piculs—or \$220,000 calculated at \$10 a picul, the quotation for 1821-23 (see Mathison, 1825: 5)—and by 1824 of about \$300,000.

Not only were the logs of sandalwood the prime article of commerce, but for some years they served as a medium of exchange in the absence of a local coinage. This fact is recorded by James Hunnewell (1895: 16), who as a ship's officer made several voyages to Hawaii. When, on one of the voyages, the cargo was only partly disposed of by sale, Hunnewell was left in Honolulu with the remaining part of the cargo to sell. He wrote, concerning the years 1817 and 1818:

Business seems to have been conducted, to a very considerable extent, by barter. Sandal wood was the chief article, indeed it might almost have been called the standard coin, although Spanish silver more nearly reached that definition. There is constant mention of sticks or piculs of the wood, but none of money. May 14th [1818] is a note, "Sold 40 looking glasses for 4 piculs wood"; next day, "Sold the remainder of the muslin, 2 pieces, for 31 piculs wood received." These examples are enough to show the nature of trade.

The king and the chiefs, pressed for payment, put pressure on the people, whose labor made the trade possible and who received little or none of the profit. There are numerous contemporary accounts of the forced gathering of sandalwood. All the inhabitants able to go were ordered into the hills in search of the precious wood. The trees were cut down and chopped into logs 6 to 8 feet long; then with adzes the bark and sapwood were chipped off. Men and women tied the logs to their backs with the fibrous leaves of the ti (*Cordyline terminalis*) and trudged to the measuring pit or to the shore. As many as a dozen small ships were used to haul the logs to Honolulu. Ellis (1826: 275) at Olaa, Hawaii, encountered a chief with about 400 people bearing sandalwood from the mountains. There are also accounts of the gathering of logs by two to three thousand people near Waipio, Hawaii. The following account by a British sailor ("Old Quarter Master," 1839: 220-221) does not seem to have been noticed before, and it is here quoted because of its

charm and because it gives a picture of gathering the wood at night:

January, 1827, weighed and made sail, and after a fine passage anchored within the reefs, at Whahoo [Oahu], where we found an American ship. . . . Sometime before our arrival the Government had purchased a vessel from an American Merchant called the Chinchili; this vessel was to be paid for in sandal wood, which was as usual levied in certain quantities from each of the Chiefs. . . .

The time of cutting it is appointed by the King, and that is invariably at night, but for what cause I could never find out; this time was appointed while we lay here, and the Captain was invited to accompany the young King to view the scene; our cutter was ordered to take the party, and it took us nearly all the forenoon to get to the spot. When the party took horses and left me in charge of the boat, I asked and obtained leave to ascend the hill in the evening; the ascent was painful and fatiguing, but it fully repaid me by the pleasing sight that met my eyes; there stood a vast number of men assembled, each with a torch made from sandal wood, which burns bright and clear, at a certain signal they dispersed; each taking his own way to cut his load, accompanying his labour with a song, to which the whole band within hearing join in chorus; the song we understood not, but in the calm of a beautiful night it was calculated to inspire delight. After the labour of two or three hours the wood is collected together, each Chief inspecting his own lot, judging of the quality by the colour and weight; it is then taken to the water's edge where it is piled end on ready for boats to take away; the people then returned to their homes, and we to the young King's country house, after which I went to the boat.

As the king bought greater and greater quantities of imported goods, his demands for sandalwood in taxes became greater and more frequent. Tax records were kept, some of which are still extant and may be consulted at the Public Archives, Honolulu. The writer studied them carefully in hope of finding exact records, including the localities where sandalwood was cut. The records are few, fragmentary, and difficult to interpret. One of the best is a sheet kept by the Spaniard Francisco de Paula Marin, who was a councilor or business manager of Kamehameha I. The year date is lacking. Each center entry is the name of a district on Oahu or of the chief ruling that district.

Then, in three columns appear the day and month, the number of piculs, and the number of pieces, all written in Spanish. In brackets is here suggested the modern spelling or translation, as follows:

SANDALWOOD TAX RECORD FOR OAHU BY  
DON FRANCISCO MARIN

		Guaguigui [Waikiki]
dia 24 de Septiembre	240 piculs	
25	50	
		Taguipu [Kahuku?]
dia 18 de Septiembre	168	
		Cayrua [Kailua]
16	1200	
		Guaymanamano
		[Waimano]
16	1200	10 pedazos [pieces]
		Caneoje [Kaneohe]
16	800	5
		Teylla [Kealia]
17	1200	
		Cajanu [Kahana?]
17	120	
		Camejameja [Kamehameha, the governor of part of Oahu]
23	4400	
27	1080	
29	230	
		Tonuaunau [unidentified]
28	580	
		Guallanae [Waianaeanae]
23	415	

Marin's journal, in manuscript translation in the Public Archives, also gives some data on the gathering of sandalwood taxes.

MARIN'S JOURNAL NO. 2

27 Sept. 1811. Marin cutting Wood for King.

26 Dec. 1811. Marin goes to cut Wood with the Minister.

4 Aug. 1812. This day the King made a Contract with Captain Guynan [Winship] and Capt. Debes [Davis] not to sell fragrant wood to anyone but to them.

25-26 Oct. 1814. Kealakekua, Hawaii. Went on shore to see King. Spoke to him about perfumed wood. He gave no answer.

18 Feb. 1818. This day weighing wood—116 piculs.

JOURNAL NO. 4

1 March 1819. Quinopu & Quehomaquea left for Waimea to fetch sandalwood [they were probably tax collectors, now unidentified].

## JOURNAL NO. 5

2 Dec. 1819. Poqui [Boki] buys boat of Capt. Luis for twice its full of Sanlegue [sandalwood].

19 March 1821. This day Craymoca [Kalanimoku] started to collect sandalwood and Poqui [Boki] for Quallanae [Waianae].

22 Oct. 1821. Pitt [Billy Pitt or Kalanimoku, the king's prime minister and treasurer] bought schooner "Asta" for 1280 Piculs of Sanlegud [sandalwood].

## JOURNAL NO. 6

15 Jan. 1822. Sandalwood for caulking.

8 Aug. 1822. Embarked sandalwood on ship America.

It will readily be seen that these historic documents are incomplete and lack details as to the exact localities where the sandalwood trees grew.

The tax levies increased, becoming more and more exacting, and as all chroniclers agree, they became an intolerable burden on the people. As the easily accessible sandalwood stands had been felled, the people had to climb farther and farther into the wet, cold mountain forests and the quests were no longer like idyllic song fests. The people were driven to the task, and many died of exposure in the mountains. While they were away in the interior, crops and taro patches were neglected, so that famine came to the islands and took its toll of the king's subjects.

Eventually the shipments decreased and the wood gathered was smaller and of poor quality. In 1828–29, 13,000 piculs of sandalwood were shipped. In 1830–31 the shipments, wholly of small and crooked sticks, brought only \$1.50 a picul. This poor yield finished the sandalwood trade in the Hawaiian Islands. Says Mesick (1934: 140):

A few years later [than 1825], seeing that the supply was rapidly diminishing, the government took steps to conserve it; but despite this tardy measure it is only occasionally that sandalwood trees are found in the Hawaiian forests.

A similar summary (Kuykendall and Gregory, 1926: 116–117) reads:

The reckless way in which the trees were cut destroyed the forests. Very little effort was made to preserve the young trees or to replace those which were cut down. In a few years sandalwood almost disappeared from the islands. Even to-day, a hundred years after the trade was at its height, only a few small groves are to be found.

These statements emphasize the depletion of the stands of sandalwood, but exaggerate the present scarcity.

## BENNETT'S LOCALITY FOR SANDALWOOD

Since locality records given by the earlier botanists and explorers are few and are often lacking in detail, in general they are not quoted here. However, there is one of real interest. Dr. George Bennett (or Bennet) was a British physician who accompanied the Rev. Daniel Tyerman on a world tour. A detailed and readable report on the Christian missions and also an account of their general observations was edited by James Montgomery (1831). The pair visited many island groups, some very remote. In the decade after their return to England, Bennett published several scientific or botanical accounts; then, after settling in Australia, he continued work in natural history. While in England he published "An account of the sandal wood tree" (1832). A specimen of *Santalum* which he had collected on Oahu was deposited with his other collections in the Botanical Museum at Berlin-Dahlem; no other herbarium seems to have any duplicates of his collections.

Professor J. F. Rock (1916: 19–21) studied this specimen in Berlin and stated in his notes that it agreed perfectly with an authentic Gaudichaud specimen of *S. Freycinetianum* Gaud. The data are: "Santalum, Sandalwood Tree, Native name Iliahi or Lauhala. Wouhala, Oahu, Sandwich Islands, December, 1830. The tree is of slow growth and inhabits elevated and rocky situations.

G. Bennett." Rock's paper is a detailed monograph of the Hawaiian species of *Santalum*. For *S. Freycinetianum* he cites only four collections from three localities: "Wahou" [Oahu], Gaudichaud, in 1827; Palolo, Rock nos. 10,063 and 12,512; and Bennett's from "Wouhala." It is obvious that the Hawaiian common name lauhala does not apply to *Santalum*. It means "leaves of the hala tree" (*Pandanus*) and was and is in very common usage in reference to mats, baskets, etc., plaited from the leaves of the *Pandanus*; thus Bennett's use of it for *Santalum* can be rejected as an error. Rock gave no explanation of the locality "Wouhala." The subsequent standard gazetteer of the Territory of Hawaii (Coulter, 1935) includes not only the place names on the current official topographic maps, but also the obsolete names or spellings from all available older maps. It does not include the place name Wouhala or anything like it.

The lengthy journal of Tyerman and Bennett has been scanned for data on this point. They arrived on Oahu in December, 1821, and spent more than 3 months on the island. Bennett gives an account of his ascent on April 26, 1822, of Erihi [Diamond Head], of climbing "the great mountain Punch-bowl," and of climbing on April 28 the Koolau divide, not far from the Nuuanu Pali, "one of the highest accessible points in this island." He and his companion made a tour around the island of Oahu, but he does not in this account mention his finding of the sandalwood at "Wouhala." Bennett later mentioned the sandalwood and this locality, and gave a helpful description of the tree in his book (1860: 420-421), but this is a condensed and paraphrased account from the fuller one (1832: 260-261) which is here quoted:

On the 10th of December, 1829 [1821], I visited the district of Wouhala (Island of Oahu); on ascending a high hill, the plains on the summit were found covered with dry grass, and various plants and shrubs, and at some parts deep wooded glens formed most picturesque and beautiful scen-

ery. Among the specimens of plants, &c., I collected were the following:—

A species of *Cyathodes*, called pokeawi by the natives, bearing small red berries; the same native name is given to red beads, from their resemblance to the berries of this shrub. A species of *Phytolacca*, called poporo-tumai by the natives; the berries (which grow erect in long bunches) yield a reddish brown juice, used for dyeing the native cloth; the berries externally are of a purplish red colour; the leaves of the shrub are cooked and eaten.

On the plains was found a species of *Dianella*, named uki by the natives, bearing small berries of a mazarine blue, which are used by the natives in making a permanent blue dye. The *Pyrus anthyllidifolia* of Smith (in Rees's *Cyclopaedia*), and more recently the *Osteomëlis anthyllidifolia* of Lindley (in the *Linnean Transactions*), called uré by the natives, was very abundant; it is a small shrub, bearing berries of a white colour, containing a reddish juice of sweet and astringent taste; the flowers are white and fragrant.

The mamati or cloth plant, also named oreyna, the *Urtica argentea*; the bark is used in the manufacture of the native cloth, and also produces a flax which might form a useful article of commerce. A species of *Scaevola*, named nouputa by the natives, was also abundant on the hills, bearing yellow flowers.

A shrub, attaining the elevation of 9 or 10 ft., called karia or taria by the natives, was abundant, but the only specimens gathered had abortive flowers.

A small tree, called lumma by the natives, had the leaves when young of a beautiful red colour, and the foliage has a peculiar appearance, apparently from minute glands situated on the upper and under surfaces. There is also a shrub (probably a *Bassia*), called ohava, the seeds of which yield a red dye, used by the natives to stain their cheeks and fingers. A species of *Gnaphalium*, called poina by the natives, was also abundant.

Of the uwara, or sweet potatoes (*Convolvulus Batatas* et var.); which are much cultivated at the Sandwich Islands, there are seventeen varieties.

On the declivities of the hills, and in the ravines, the tui tui, or candle nut tree (*Aleurites triloba*) is seen abundant; the whiteness of its foliage rendering it a conspicuous object. The whiteness is occasioned by a fine white powder on the upper surface of the leaf, which is readily removed by the finger. Under it the leaf is found of a dark green colour. The young foliage is thickly covered with this white powder; the older leaves have little, or are entirely destitute of it. The foliage of this tree varies much in form, depending on the age of the tree or leaves. The flowers grow in erect clusters, are small, white, and possessed of very little fragrance; the fruit is of small size,

globular, rough externally, and contains oily nuts, which, when baked and strung on a reed, are used by the natives of most of the Polynesian Islands as a substitute for candles or lamps, and burn with a clear and brilliant flame. The tree is branchy, attains an elevation of 30 ft. in height, and a circumference of 3 or 4 ft., the timber being of soft quality is useless, except as firewood. A gum is yielded by this tree, both spontaneously, and on incisions being made in the trunk. It is of a yellowish colour, inodorous and tasteless; the natives chew it, but the suspicious family [*Euphorbiaceae*] to which the tree belongs would render caution requisite in its use. I tried it, however, as mucilage for the suspension of some balsams, without any ill effects arising from it.

The turmeric plant (*Curcuma longa*), called oreina by the natives, is abundant wild; the root, as well as that of the noni (*Morinda citrifolia*), is used for dyeing their native cloth of a bright yellow colour.

The foregoing account is quoted exactly as published, including the curious rendering of the scientific names, some unaccented, some with grave, some with acute accents, some in roman type, some in italics or partly so or even with only one letter in italics.<sup>3</sup> Probably Bennett's underlining of the scientific names to be set in italics in his manuscript was hasty, and the underlinings did not equal the names, though he intended them to do so. The printer did not interpret them thus; rather, he followed the copy exactly.

The plants mentioned in Bennett's account are now known as pukeawe (*Styphelia Tameiameiae*); popolo (*Phytolacca sandwicensis*); uki (*Dianella sandwicensis*); uulei (*Osteomeles anthyllidifolia*); m a m a k e (*Pipturus albidus*); naupaka kuahiwi (*Scaevola Gaudichaudiana*); kalia (*Elaeocarpus bifidus*); lama (*Diospyros Hillebrandii*); kealia or alaea laau (*Bixa Orellana*); enaena (*Gnaphalium sandwicenseum*); uala (*Ipomoea Batatas*); kukui (*Aleurites moluccana*); olena (*Curcuma longa*); and noni (*Morinda citrifolia*). Explanatory remarks are here appended for several of these plants.

<sup>3</sup> A few vowel accents unavailable to the printer of PACIFIC SCIENCE have been omitted. [EDITOR.]

The naupaka kuahiwi does not have yellow flowers. There is one native species which does, *Scaevola glabra*, but this grows only on the very crest of the mountains in the Cloud Zone. All indications are that Bennett did not on this day climb to the high peaks, but rather was describing collections made at the lower edge of the forest, in grassland or dry open forest. On Oahu, one of the commonest bushes and one of the first to be encountered on approaching the forest is *S. Gaudichaudiana*, which has white flowers with delicate magenta lines on the veins near the throat, but the flowers, when withering and drying on the bush, turn yellowish. It seems certain that this was the "nouputa" he noted. In confirmation of this, there was a specimen of *S. Gaudichaudiana* from Oahu, collected by Bennett, in the Berlin Herbarium (Skottsberg, 1927: 26).

Bennett's bush the "karia" is certainly kalia (*Elaeocarpus bifidus*), though truly a tree. The native name is a clear indication and the abortive flowers settle the question, for even today nearly every inflorescence through insect injury develops into a large, bright red, abnormal growth almost like a witches'-broom.

The "lumma" is evidently the lama (*Diospyros Hillebrandii*), which is conspicuous in the lower forest in spring because of its flush, or luxuriant young growth with abundant new crimson leaves, which is even more showy than the similar red flush on the cultivated mango tree. The leaves of the lama are not glandular, but both surfaces, and particularly the upper, are strongly salient rugose reticulate, with thin tissue between the meshes of the heavy close network. When looking through a leaf towards the light, Bennett may have mistaken the light intervals for glands.

Bennett's record of the name "ohava" is difficult to identify. There is no such name in the Hawaiian dictionaries or botanical works. The only similar name is hoawa

(*Pittosporum*), which native shrub or tree does not fill the bill. It seems fairly certain that instead, his tree is the introduced shrub *kéalia* or *alaea laau* (*Bixa Orellana*). This is an American tropical shrub, of early introduction into the Hawaiian Islands, but just how early cannot now be definitely stated. Dr. W. T. Brigham (1911: 158), in his account of the dye plants used for coloring *kapa* (bark cloth), wrote:

This shrub was formerly cultivated here for the red dye obtained by macerating the seed pulp, and has become naturalized in places. . . . I found it growing apparently wild in 1864 in Nuuanu and on the barren plains east of Kawaiahaeo church. . . . I believe that the old Hawaiians used the plant as a useful dye at least a century ago.

It is still commonly cultivated and occasionally naturalized in the islands. Brigham's estimate of its introduction would put the date at 1811. If this is correct, by 1831 there would have been plenty of time for it to have become dispersed among the Hawaiian villages. The Hawaiians have always been great plant lovers and skillful gardeners. Each attractive or useful plant has been spread among them with great rapidity.

The *kealia* is not a native plant, but neither is the *uala* (*Ipomoea Batatas*) nor the *olena* (*Curcuma longa*), which latter Bennett thought was growing wild. As Bennett was more zoologist than botanist, perhaps he should be excused for thinking the *olena* a wild plant. Many other explorers and botanists have been fooled by the gardens of the Polynesian peoples. Some of their crops, which need such culture, are planted and tended in well-cultivated fields. Others which grow well without care are planted at the base of the trees in a forest or on a grassy hillside where they grow as if wild, until the planter comes and harvests his crop. Many a botanist visiting a strange tropical island has recorded such plants as wild or native, when the situation is exactly the reverse, the plants being introduced economic species planted and owned by a tiller of the

soil. The noni (*Morinda citrifolia*) is also a cultivated plant, but it seeds and tends to spread in the lowlands.

Bennett (1832: 257) gave more details concerning the sandalwood (*Santalum Freycinetianum*):

At the Sandwich Islands, the tree is named *iliali* or *lauhala*, signifying sweet wood (*lau*, wood, *hala*, sweet) [an error, the meaning being "leaf of the hala tree"; Bennett should have written *laau*, wood, *aala*, sweet]; and, when young, it is of very elegant growth. At *Wouhala* (Island of Oahu), I observed numbers of the young trees, some of which were covered by a profusion of beautiful flowers of a dark red colour; the flowers, however, are often observed to differ in colour on the same tree, and even on the same stalk; they grow in clusters, some having the corolla externally of a dark red colour, and internally of a dull yellow; others having it entirely of a dark red, and others again have the corolla partly red and white externally; the young leaves are of a dark red colour, and give an elegant appearance to the tree. This was not observed in the species found at the Island of *Erromanga*; indeed, the species found at the Sandwich Islands had a more handsome appearance in its growth than that at *Erromanga*. At the Sandwich Islands, two varieties of the wood are observed by the natives, depending, however, only on the age of the tree; the young or white wood is called *lau*, *keo keo* (*lau*, wood, *keo keo*, white); and the red wood, *lau*, *hula hula* (*lau*, wood, *hula hula*, red). [These are now written *laau*, wood; *ulaula*, red.] As before stated, the wood, when taken from a young tree, is white, containing but a small quantity of oil; as the tree increases in growth, the wood becomes of a yellowish colour, and the oldest and best is of a brownish red colour.\* The different varieties of the wood depend, therefore, on the age of the tree; and are of three kinds, white, yellow, and red; of which the yellow and red, from containing the largest quantity of oil, are most esteemed in the Chinese market, where the wood is principally used, the expressed oil being mixed with pastiles, and burned before their idols in the temples. The Chinese are said to procure the oil by rasping the wood, and then expressing it through strong canvass bags.

\* The wood is frequently buried, and the sap [sapwood] allowed to rot off: and this is considered to improve its quality. [AUTHOR'S NOTE.]

By assembling all the data from the plant associations and from the habitat, it has proved possible to spot Bennett's locality, "Wouhala," for the sandalwood. The asso-



ciated plants are characteristic of the lower edge of the dry forests. This habitat, up a high hill with dry, grass-covered plains on top, dissected by deep, wooded glens, is well described by him. Together these data apply to only one section of Oahu—the Leilehua plains or the broad pass between the Koolau and the Waianae Mountains. To avoid the deep, steep-walled gulches cut by the larger permanent streams from the Koolau Range, the old foot and horse trail over the pass kept close to the Waianae Mountains, swinging from Pearl Harbor toward the old hamlet of Lihue, keeping on the right (or east) the largest stream, Waikele, and its tributaries Kipapa and Waikakalaua Streams, all of which have cut deep gulches across the plateau or its slopes. On the upper reaches

of Waikele Stream is Pouhala, about 1 mile south of Schofield Barracks and 1 mile north of Robinson Camp 1 (see Oahu topographic map, 1938 edition). The Wouhala of Bennett is surely Pouhala of today, because the description applies, the place is close to present localities for sandalwood, and Bennett is known to have journeyed through this area.

PRESENT DISTRIBUTION ON OAHU

Accompanying this discussion is a map showing the present occurrence of *Santalum Freycinetianum* Gaud., a species restricted to the island of Oahu, and the only arborescent species on that island. This tree was doubtless the sole source of laau aala for the inhabitants of Oahu. On the map, the solid black dots mark localities for specimens with

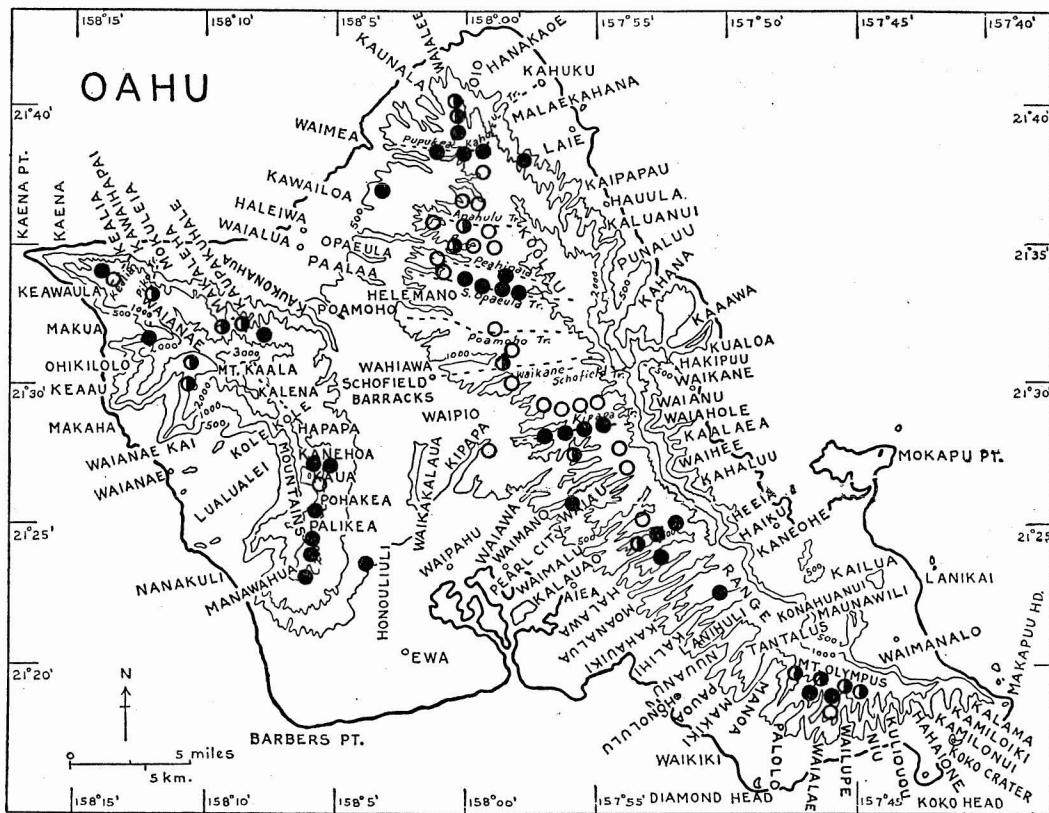


FIG. 1. Present distribution of sandalwood (*Santalum Freycinetianum*) on Oahu. Solid black dots mark the localities for specimens with exact data; half-black dots those with incomplete data; circles those recorded in field notes but without substantiating specimens.

exact locality data, such as part of valley, altitude, etc.; half-black dots mark the approximate place for specimens with indefinite data, such as name of valley or ahupuaa (land division) but nothing more; circles mark the localities without substantiating specimens but recorded in the field notes of William Meinecke, E. Y. Hosaka, or the writer. All these collections and records are subsequent to 1907 and so give a good index of the present distribution, which is wide, extending nearly from end to end of both mountain ranges. The tree is found on both sides of the Waianae Mountains from 500 to 2,400 feet altitude, but there is a break at Kolekole Pass, which is now treeless, denuded, and much eroded. Probably the tree occurred originally all across this stretch. Its absence now may be due to denudation by lumbering, forest fires, or cattle grazing. On the other hand, this low pass was a standard route of travel and was easily accessible to people coming either from the western villages in the Waianae region or from the broad Leilehua or Schofield saddle on the east. Its absence may also be due to despoliation by people in the sandalwood trade or by those in search of timber or fuel.

In the Koolau Range the sandalwood now occurs from 550 to 1,800 feet altitude, from the Niu-Wailupe Ridge to Kaunala and swinging around the northern end to Laie. The sloping north end of the Koolau Range is lower, and therefore does not receive as heavy a rainfall as the more elevated parts. It is noteworthy that on the windward or northeast side of the mountains and the windward shore, southeastward from Laie, there are no stations for the sandalwood. The whole shore and mountain slope is windier and rainier, so that the typical dry lower forest is not well developed here. Though koa (*Acacia Koa* Gray) is present, it does not form a definite zone, rather occurring scattered among other trees characteristic of wet forests. It will be recalled that in the old

sandalwood tax collection record by Marin there were entries of 1,200 piculs from Cayrua, 800 from Caneoje, and 120 from Cajanu. If these names are correctly transliterated as Kailua, Kaneohe, and Kahana, they are districts where no tree sandalwood grows today, and where it is improbable that any ever did grow, the region being too wet. Yet these districts paid a tax in sandalwood. K. P. Emory has suggested to the writer that the men of these districts which lacked sandalwood may have been assigned to cut wood in crown lands in another district and thus to work off their taxes. The remaining districts all have sandalwood in the mountainous (mauka) inland sections. "Camejameja" was probably not the king, but Kamehameha, governor of part of Oahu. The collections entered under his name were made on several dates and are much larger than those from any single district.

Almost down to the present there has been a conspicuous gap in the distribution of sandalwood on the lee (or southwestern) side of the Koolau Range, from Manoa to Moanalua. There is no old record, no published record, no herbarium specimen to represent this region, despite the fact that it is the most thoroughly botanized section in the Hawaiian Islands. All the early explorers came to Honolulu Harbor; later, the resident botanists mostly lived in Honolulu, and all of them repeatedly explored these ridges and valleys just behind Honolulu. As the habitat is suitable, this 8-mile gap is curious. Sandalwood is attractive, easily recognized; it thus has both historic and sentimental interest, and most botanists collect it every time they see it. Consequently the gap is probably not due to lack of collections. Andrew Bloxam (1925: 38) made a record of interest in his connection. On May 13, 1825, he and the botanist James Macrae made a trip up Nuuanu Valley toward the Nuuanu Pali, traversing the 4 or 5 miles

from the lower region, with its huts and taro patches, to the thick woods. He stated:

We found a great variety of ferns and other plants among which the ginger plant was very prominent. We saw several of that beautiful tree the *Eugenia malaccensis*, or Malacca apple, in full bloom with its bright scarlet flowers, the dooe dooe, or oil nut [now called kukui, *Aleurites moluccana*] was very common. We could not find one sandalwood tree, all had probably been cut down about here for the purpose of barter.

This passage testifies to the early despoliation of the stands of sandalwood.

Still in search of records in the region behind Honolulu, the writer made inquiry of malacologists. The terrestrial and arboreal snails on the Hawaiian Islands are numerous, large, and of beautiful form and coloring. For more than a century they have been sought both by amateur nature lover and professional naturalist. As collections have accumulated it has become evident that many of the numerous species and subspecies have very restricted ranges, such as a single valley, or part of a valley, or even a single clump of trees. The land shell collectors become well acquainted with these localities and the species of trees favored by the snails. Thus, many of the collectors have an extensive and accurate knowledge of the native flora. Dr. C. M. Cooke, Jr., of the Bishop Museum, Honolulu, remembers seeing from 1890 to 1892 several sandalwood trees on the Kapalama-Waiolani ridge, just southwest of Napuumaia (in Nuuanu) at about 1,600 feet altitude. This was one of his best collecting localities, and he clearly remembers several sandalwood trees with their bright red, young leaves. George S. Waterhouse likewise remembers seeing sandalwood trees in the same locality between 1903 and 1906. He cut and carried down a good-sized log of the wood, which he kept for many years. He visited the locality frequently, for his brother, Fred Waterhouse, had a mountain cabin on the ridge at Napuumaia. This site is at 1,870 feet elevation

on the west ridge of Nuuanu (see Kaneohe Quadrangle, Advance Sheet, surveyed in 1928). These two reports are considered fully trustworthy, and indicate that *S. Freycinetianum* persisted in Nuuanu as late as the beginning of the present century.

Finally, the writer was delighted on January 9, 1944, to find a single tree, 27 feet high and 10 inches in diameter, on the Kahauiki-Kalihi Ridge at 1,400 feet altitude. It was a vigorous, healthy tree, near the crest of the ridge in the Koa Zone. This collection, filed as H. St. John no. 20,444, fills in the gap and allows the conclusion that the sandalwood originally extended the length of the mountains and occurred on all the ridges behind Honolulu. Its scarcity or absence there now seems due to extermination. To supply the sandalwood trade, the large population of Honolulu would naturally seek the trees on the nearest accessible ridges, which were those behind the city. The resulting destruction of the trees by cutting as well as by heavy and destructive grazing by cattle nearly exterminated the sandalwood in these areas.

The former territorial superintendent of forestry, Charles S. Judd (1927: 43), in giving a detailed account of the sandalwood, stated:

It is not likely, however, that sandalwood will soon, if ever, become much of a factor as a natural resource in the Territory because of the fact that it is of very slow growth, and before it can be artificially propagated with success, much more must be learned of its alleged parasitic habit of growth.

The sandalwood is widespread and occasional in the Waianae Mountains. In the Koolau Range (except behind Honolulu) it occurs on the lee side on nearly every secondary ridge, and is actually common at the lower edge of the forest in the Koa Zone and occasional up into the forest. Young trees are numerous, but so, too, are old trees.

No data have been published as to the rate of growth of this tree. At Kalauao

there are trees 20 feet tall, 6 inches in diameter; at South Opaëula Gulch trees 20 feet tall, 1 foot in diameter; at Laie-Malaekahana ridge a grove with trees up to 20 feet tall, 1 foot in diameter; and at Puu Peahinaia a tree 30 feet tall, 18 inches in diameter. Charles S. Judd (1939: 36) reported and printed a photograph of the largest tree he found, in Waola Valley, Kawaiioa, 30 feet



FIG. 2. Largest known sandalwood tree (*Santalum Freycinetianum*) on Oahu, 28 inches in diameter, Kawaiioa, September 28, 1943. The epiphytes are *Nepbrolepis exaltata*. The figure is Harold St. John.

high, 21.3 inches in diameter. Territorial forest ranger Tom McGuire and the writer found a still larger one on September 28, 1943 (Fig. 2). It is near the north crest of a northern side ridge descending from the Anahulu Trail about one-fourth mile inside the Forest Reserve boundary at about 1,300 feet altitude. The tree had many branches and a wide spreading crown. As its trunk forked 4 feet from the ground, it was measured at 3 feet from the ground. It was 25 feet tall, 78½ inches in circumference, 28 inches in diameter.

#### RATE OF GROWTH

It is natural to inquire as to the rate of growth of *S. Freycinetianum*. A wood section was taken from a branch 1¼ inches in diameter, collected in 1932 by the writer at Paumalu on the Pupukea-Kahuku Trail at the north end of the Koolau Range. The wood was so hard that it was necessary to boil it for 3 days before it could be cut with a microtome knife. To the naked eye, faint, fairly regular rings were visible in a cut stub or in the transverse, stained microscopic section. Under the low-power lens of the compound microscope, these rings were also faintly visible. The wood was dense, of closely massed tracheids, small in diameter, thick walled, and uniform in all parts of the rings. The vessels were in radial rows, but irregularly spaced. The ray cells were uniform. The distinct banding which distinguished the rings was due to a grouping of cells with dark contents, probably tannin. The 15 or so rings might be annual rings, but this is not certain. Conditions are favorable for growth at all times of year on Oahu, as there are never freezing temperatures. There are, nevertheless, definite seasons to which all plants respond, flowering mostly in the spring and summer. There is a belief that these seasons are determined by a rainy and a dry season, but this does not seem to be substantiated. Weather records made

available by the Hawaiian Pineapple Company give data for three stations in the general region from which the wood sample was taken: at Opaepala, Paumalu, and Waimea No. 2. The last, in the upper pineapple fields by the lower edge of the forest above Waimea Camp at about 900 feet elevation, was the closest. Its yearly rainfall was very unequal in successive years. There were, of course, periods of greater rainfall, but at times two or three such wet periods occurred during a single year. These came often in December and August, but not constantly. Considerable differences between the rain-

fall even at adjacent stations indicate that the rain comes mostly from local showers. Sunshine and temperature records were not kept, but these would doubtless show a correlation with the rainfall. The rainfall records fail to show any regular annual maxima which could be correlated with growth rings. The rings noted in the sandalwood specimen are probably not annual rings, but rather wet season or sunny season rings, of which there are one or several each year. Hence, the rings do not clearly indicate the age of the stem. Long-term, precise observations are needed on trees grown beside a weather station before one can interpret rings such as those noted in the sandalwood.

Most of the trees of *S. Freycinetianum* known today are less than 18 inches in diameter (Fig. 3). It seems probable that all or nearly all of these have grown since the end of the Sandalwood Era in 1830. Larger trees such as the one on the Anahulu Trail, 28 inches in diameter, may well have been vigorous young trees that escaped destruction at that time.

#### LOCATION OF ORIGINAL SANDALWOOD FORESTS

The present stands of *S. Freycinetianum* on Oahu are at the lower edge of the dry forest, and the tree is common, beginning at 1,000 or 1,200 feet altitude. Below this are outlying stations at much lower altitude: at Kawailoa, by the rim of the gulch north of the road running straight inland from Ashley, are healthy young trees at elevations as low as 600 feet (specimens collected September 28, 1943, St. John no. 20,364). This is 500 feet lower than, and 2 or 3 miles distant from, the lower edge of the forest.

Another record in the Koolau Range is of a single tree 20 feet tall, 18 inches in diameter, at 550 feet elevation on the north slope of Kipapa Gulch,  $1\frac{3}{4}$  miles above the old territorial highway, and  $2\frac{1}{2}$  miles below the lowest forest stand in the gulch at about

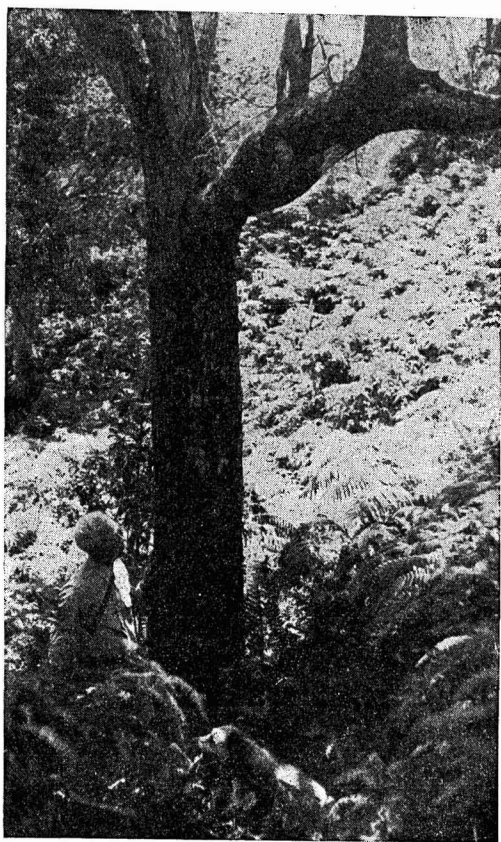


FIG. 3. Sandalwood (*Santalum Freycinetianum*) tree 16 inches in diameter, Anahulu Trail, Kawailoa, 1,500 feet altitude, September 28, 1943, in lower, open forest, with dense fern undergrowth of *Cibotium Chamissoi* and *Dicranopteris linearis*. The figure is Tom McGuire.

750 feet altitude. This record was an observation made by E. Y. Hosaka while studying the flora and vegetation of Kipapa Gulch.

A third low station is in the Waianae Mountains, where a single 20-foot tree occurs in a dry lowland gulch below Puu Kuua at 500 feet elevation (specimens collected November 22, 1931, St. John no. 11,166). This is 2,000 feet below, and 3 miles distant from, the lower forest line near Palehua and Puu Manawahua, where the tree is again found. From the persistence of these isolated trees in the lowlands, even good-sized trees, there are indications that the sandalwood was originally much more common in the lowlands. There are also historic and other records which indicate the same early distribution.

Commander Charles Wilkes (1845, vol. 4: 78-79), reporting on a trip of the naturalists W. P. Rich and W. D. Brackenridge in 1840 from Waialua southward, says:

The next day they proceeded on their way to Honolulu, across the plain between the two ranges of mountains. This plain, in the rainy season, affords abundance of food for cattle in three or four kinds of grasses, and is, as I have before remarked, susceptible of extensive cultivation by irrigation from the several streams that traverse it. The largest of the streams is the Ewa [Waikele]. Scraggy bushes of sandalwood and other shrubs are now scattered over a soil fit for the cultivation of sugar-cane and indigo.

Even in the time of Kamehameha I the sandalwood had been much depleted, so that this monarch put a kapu (ban) on the cutting of young trees. A contrary action, but arising from the same scarcity, was the burning of grassland or forest areas by the natives. This was done on the central plain of Oahu in order to detect standing or fallen logs of sandalwood by the sweet odor of their smoke. The flames, of course, killed many young sprouts and seedlings and prevented the recovery of the depleted stands of sandalwood or other trees.

B. Seemann (1853, vol. 2: 83), who visited Oahu in May, 1849, wrote:

The Oahu Sandal-wood (*Santalum paniculatum*, Hook. et Arn.) [this Oahu species is now known to be *S. Freycinetianum* Gaud.], the Iliahi, or Laau ala (fragrant wood) of the Hawaiians, is now to be found in only one place, called Kuaoho, where it grows on the slopes of hills, close to the sea. Of the splendid groves, with the produce of which formerly so many ships were laden, but a few isolated bushes, which do not exceed three feet in height and an inch in diameter, remain, and these would probably disappear had they not been protected by the law, and thus escaped being converted into fuel.

There is also an exact German translation of this passage (Seemann, "Die Flora von Oahu," 1853: 31). The geographic name "Kuaoho" is unidentified, though Thomas G. Thrum (1904: 72) suggested doubtfully that it might be Kaneohe. This is very unlikely because the two names are dissimilar and the tree does not occur in that humid, wet region. As no recorded geographic name for any land division of whatever size is known that coincides with "Kuaoho," it remains unidentified. The name means "bamboo ridge."

The father of Edward Y. Hosaka is Yahei Hosaka, a farmer who settled in 1908 in Kipapa Gulch, Waipio, on the valley floor  $3\frac{1}{2}$  miles upstream from the bridge on the old paved territorial highway. On both sides of the gulch above his home the steep slopes had a forest cover with many sandalwood trees. The settlers cut the trees, destroying the forest to clear the land for the cultivation of pineapples. The koa (*Acacia Koa*) and ohia lehua (*Metrosideros collina* ssp. *polymorpha*) were used for firewood. As the sandalwood did not make good charcoal, they cut and burned it for mosquito punk.

According to a statement of Dr. H. L. Lyon in 1942, cord wood was formerly cut and hauled to Honolulu, where it was used for cooking and heating. In 1910-11 he examined piles of this cord wood in Wa-

hiawa, cut in the near-by gulches and ridges and destined for the kitchen stoves of Honolulu. A considerable proportion of the logs were sandalwood.

Numerous writers have recorded the decimation of the native forests on the Hawaiian Islands by many agents such as sandalwood cutters, grazing cattle, and fire, and by lumbering for firewood, timber, or charcoal. Hence, there is no doubt that the forests, until the coming of the white man, covered a large portion of the islands. On Oahu the forest did not stop at the 1,000- or 1,500-foot line, but came down in places right to the sea. What trees made up this forest cannot be completely known, but the trees now found at the lower, drier edge of the forest probably combined to form a forest over part of this area. They are the koa (*Acacia Koa*), olopua (*Osmanthus sandwicensis*), iliahi (*Santalum Freycinetianum*), aalii (*Dodonaea viscosa*), ohia ha (*Eugenia sandwicensis*), ohia lehua (*Metrosideros collina* ssp. *polymorpha* vars.), pukeawe (*Styphelia Tameiameiae*), kopiko (*Straussia Mariniana*), and naupaka kuahiwi (*Scaevola Gaudichaudiana*). The Leilehua or Schofield plains between the two mountain forests were densely and continuously forested. On the lowest, driest slopes, an open forest or savanna doubtless spread, largely of wili-wili (*Erythrina sandwicensis*) but also containing the ohe (*Reynoldsia sandwicensis*).

Charles S. Judd (1927: 43) expressed the opinion that the "sandalwood evidently never occurred in pure stands, but was found in small groups or as scattered individuals"; but Seemann (1853, vol. 2: 83) wrote of the splendid groves which formerly existed. To the writer, Judd's conclusion seems a better description of the present status than a reconstruction of the past. Professor J. F. Rock (1916: 13-14) had the same view as Seemann:

Sandalwood must certainly have formed a large percentage of the tree growth in the drier regions

or mixed forests, in the early days, before the value of the wood became known to the natives of these Islands. It must have existed in pure stands, or as forests, or it would have been next to impossible to export as much as \$400,000 worth per annum.

*S. Freycinetianum* has recovered so far today as to be common and widespread, and at numerous parts of Kawailoa, Waimea, and Kaunala, it now forms the lower forest at 1,000 to 1,200 feet altitude. This is at the lower border of the present native forest, but not the natural lower limit of the sandalwood in former times. As E. Y. Hosaka observed during his 92 trips from 1931 to 1934 to study the vegetation of Kipapa Gulch, the sandalwood grew well there at the present lower edge of the forest at about 1,200 feet altitude. Lower down on the sides of the gulch at 700 and 800 feet altitude there were other sandalwood trees, definitely healthier and more vigorous than those above. This was true despite the fact that the surroundings were nearly denuded of native plants and trees, and were more exposed, drier, and more eroded.

The heaviest stands of former times were doubtless at lower elevations, below the Koa Forest Zone of that time. The existing outlying stations of old trees as low as 500 feet elevation, and the greater luxuriance at lower elevations, give an indication of where the old sandalwood stands were. As is true today, there were small stands on ridges or dry habitats far up into the forested mountains up to 2,000 or 2,400 feet altitude. Doubtless the large stands grew at even lower elevations than those of today, approaching or even reaching the shore in regions of moderate rainfall such as Kawailoa and Waimea, at the northern end of the Koolau Range. To judge by the many thousands of piculs of heartwood gathered, sandalwood must have been abundant. Hence, the writer deduces that there were heavy stands of sandalwood either abundant in, or dominant in, a forest zone from about 300

to about 1,000 feet altitude, below the Koa Zone and above the Wiliwili Zone. Probably the tree occurred on the lower, dry slopes of nearly every secondary ridge leading from the Waianae Mountains and on those leading from the leeward side and the north end of the Koolau Range. The northern and southern slopes of the Schofield saddle apparently had much more extensive stands of sandalwood, from Waimano to Honouliuli, and from Pupukeya to Makaleha. This is a deduction from various types of evidence here assembled, which, for the first time, give an indication of the location of the principal stands of sandalwood on Oahu.

Though decimated by the sandalwood trade, the tree persisted on Oahu, survived the overgrazing and forest recession, and is now common and widespread at its former upper limit, now the lower forest line on the lee side of the Koolau Range and on both sides of the Waianae Mountains. Most of its present stations are protected from further destructive exploitation by their situation within the Territorial Forest Reserves.

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