

Distribution and Status of Sandalwood in Hawai'i¹

Lani Stemmermann²

Abstract: This paper attempts to summarize what is known of the distribution and status of sandalwoods in Hawai'i. Four species of sandalwood are recognized as being endemic to the Hawaiian Islands, and one has been introduced. Ecological factors affecting the present and former distribution of Hawaiian sandalwoods are considered.

The sandalwood trade had significant impact on the economy of the Hawaiian Islands during the first century following western contact. No doubt exists that sandalwoods in Hawai'i today are much more limited in their distribution than they were formerly because of the history of harvest and subsequent land use changes. At present, sandalwood is found on most of the main Hawaiian islands, with a total of four species recognized in the recently published *Manual of Flowering Plants of Hawaii* (Wagner and others 1990) as being endemic to the Hawaiian Islands. That nomenclature is presented here, though it does not agree necessarily with previous more extensive studies of the group (Rock 1916, Skottsberg 1927, Stemmermann 1980a, St. John 1984). The distribution of these species is listed in *table 1* and roughly illustrated in *figure 1*.

Workers in the past have recognized two groups of Hawaiian sandalwoods: Those with red flowers and those with green flowers. There are two recognized species in the red-flowered section, both of which are trees. *Santalum freycinetianum* was described from O'ahu and is now also recognized from Moloka'i. Varieties of this species are known from Kaua'i to Maui. The red-flowered sandalwoods of Kaua'i and Lana'i were previously recognized as distinct at the specific rank, but are now recognized as varieties of the type species. These are var. *pyrularium* (Kaua'i) and var. *lanaiense* (Lana'i). Variety *lanaiense* is also known from the leeward slopes of Maui. *Santalum haleakalae*, the other red-flowered species, is found at high elevations on Haleakala, Maui, from roughly 6000 ft (1830 m) to treeline. At lower elevations it intergrades with *S. freycinetianum* var. *lanaiense*.

Two species are now recognized in the green-flowered group. Both have very aromatic flowers. One species, *S. ellipticum*, is usually a shrub, and is known from all of the main Hawaiian Islands except Ni'ihau. It undoubtedly grew there also at one time, and though it was formerly known from both Laysan Island and Kaho'olawe, it is now extinct on those islands. Plants of this

Table 1—Distribution of *Santalum* in Hawai'i¹

Species	Island Distribution ²								
	Ly	N	K	O	Mo	L	Ma	Ka	H
<i>S. freycinetianum</i>									
var. <i>pyrularium</i>			X ³						
var. <i>freycinetianum</i>				X	X				
var. <i>lanaiense</i>						X	X		
<i>S. haleakalae</i>							X		
<i>S. ellipticum</i>	eX		X	X	X	X	X	eX	X
<i>S. paniculatum</i>									
var. <i>paniculatum</i>									X
var. <i>pilgeri</i>									X

¹From Stemmermann (1980a), according to the nomenclature in Wagner and others 1990.

²Island distribution: Ly-Laysan, N-Ni'ihau, K-Kaua'i, O-O'ahu, Mo-Moloka'i, L-Lana'i, Ma-Maui, Ka-Kaho'olawe, H-Hawai'i.

³X-present, eX-Extinct.

species are sometimes found growing near the coast. Then they are low plants with thick leaves (to 2+ mm). These coastal populations have been recognized as distinct at both the specific and varietal rank in the past but are now included within the species proper. Several other varieties of this species have also been recognized in the past, but not by recent workers.

The second species in the green-flowered group is *S. paniculatum*, known only from Hawai'i. This species includes shrubs and small trees and is widely distributed on the island of Hawai'i. One variety is recognized, var. *pilgeri*, which has been considered by some taxonomists as a distinct species. It is endemic to the montane forest region of the Kona (western, leeward) coast of Hawai'i. One of the largest Hawaiian sandalwoods, *S. p.* var. *pilgeri* is presently being commercially harvested.

In addition to these four native species, *S. album* is occasionally cultivated in Hawai'i. It was planted as a timber crop species in the early 1900's as a means of renewing the sandalwood industry. Though none of the forestry plantations are known to have been successful, a few trees may persist. An interesting sterile hybrid between the endemic Hawaiian *S. freycinetianum* and *S. album* is grown at the University of Hawaii's Lyon Arboretum.

SANDALWOOD SPECIES RELATIONSHIPS

Skottsberg (1927), believed that there were separate natural introductions of red and green-flowered sandalwoods to the Hawaiian Islands, and that they evolved independently to produce the array of sandalwoods now extant. When Skottsberg (1930) considered the genus *Santalum* in its entirety, he recognized the red-flowered Hawaiian sandalwoods (characterized by flowers longer than broad with campanulate-cylindric receptacles, perigynous ovaries, and long styles) as belonging to

¹Presented at the Symposium on Sandalwood in the Pacific, April 9-11, 1990, Honolulu, Hawai'i.

²Instructor, University of Hawaii at Hilo, Hawaii Community College, Hilo, Hawaii.

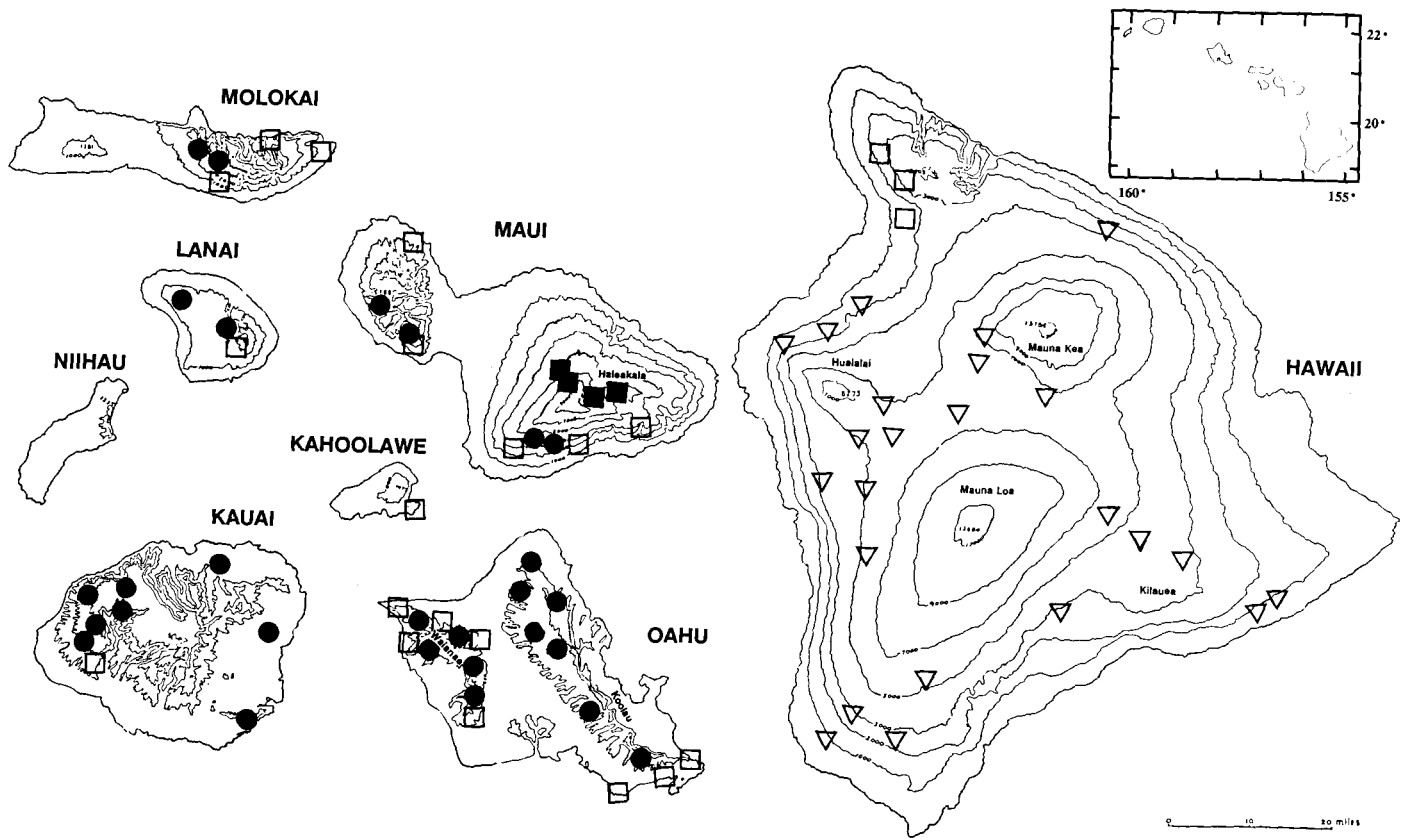


Figure 1—Generalized distribution of Hawaiian sandalwoods.

section *Eusantalum*. In addition to the red-flowered Hawaiian species, several others were included in this group, including *S. album* (Timor to India), *S. macgregorii* (Papua New Guinea), *S. austrocaledonicum* (New Caledonia, Vanuatu, Loyalty Islands, Isle of Pines), *S. yasi* (Fiji), and *S. lanceolatum* (Australia). The sandalwood from the Ogasawara Islands are also included in this group (Tuyama 1939).

Those green-flowered Hawaiian species (characterized by flowers about as broad as long, with obconical receptacles, inferior ovaries, and short styles) were referred to as section *Hawaiiensia* (Skottsberg 1930), which Skottsberg considered to be endemic to the Hawaiian Islands. At the same time that Skottsberg described these two sections with representatives from Hawai'i, he also recognized a third section of the genus, section *Polynesica*, characterized by whitish to greenish flowers with short conical receptacles, semisuperior ovaries, and short styles. Included in that group are *S. insulare* (various Pacific Islands) and *S. fernandezianum* (Juan Fernandez Islands). Subsequently, Fosberg and Sachet (1985) suggested that there were insufficient differences between the Hawaiian green-flowered sandalwoods and those in south-eastern Polynesia to warrant the recognition of separate sections. They expanded the circumscription of section *Hawaiiensia* to include those species formerly included within the section *Polynesica* and eliminated that section.

Distinct from these two presently recognized sections of sandalwoods are those Australian species that had previously been included in the genus *Eucarya*.

ECOLOGICAL FACTORS AFFECTING DISTRIBUTION

Several ecological factors affect the distribution of the Hawaiian sandalwoods. In general, sandalwoods in Hawai'i occur in dry to mesic forests. When the green- and red-flowered sandalwoods occur on the same island, the red-flowered taxa are found at higher elevations and in relatively mesic habitats, while the green-flowered *S. ellipticum* is found at lower and drier sites. No Hawaiian sandalwoods are found in areas of very high rainfall—in excess of 150 inches (3800 mm) annually—but some can be found in very dry coastal areas—with annual rainfall less than 20 inches (500 mm) annually—such as Diamond Head, Makapu'u and Ka'ena on O'ahu. Other dry areas likely once supported sandalwood, but these populations have been lost as humans have encroached on those habitats.

Plants in dry areas tend to have smaller leaves than plants from more mesic sites, and sandalwoods are no exception. Within species, those from drier sites are smaller-leaved than those in mesic sites. Populations with the largest leaves, *S. freycinetianum* from O'ahu and Kaua'i, and *S. paniculatum* var. *pilgeri* from

Kona, which grow in mesic sites, all exhibit wood and foliar morphological characteristics typical of species from mesic environments (Stemmermann 1980b).

In contrast, *S. ellipticum*, *S. paniculatum*, and *S. freycinetianum* from Moloka'i, Lana'i, and Maui, and the high elevation *S. haleakalae*, which all grow in relatively dry sites, exhibit wood and foliar morphological traits typical of species found in dry sites. The red-flowered high elevation *S. haleakalae*, which can be found up to 8500 ft (2590 m), exhibits many morphological characteristics typical of plants in high dry sites, including specialized foliar epidermal cells (Stemmermann 1980b). These high elevation plants routinely experience nightly frost.

In addition to tolerance of low rainfall and frost by some species, many Hawaiian sandalwoods are at least somewhat fire-tolerant. Both red- and green-flowered species have been seen to produce root suckers which grow into sizable plants in areas that have burned. In some areas much of the natural reproduction appears to be from suckers rather than seed.

Seed predation has been seen in populations of all species, with both rats and cardinals known to consume large quantities of *Santalum* seed. Neither species is native to Hawaii, but sandalwood seed may have comprised part of the diet for at least two birds once common in the upland Kona forests where *S. paniculatum* var. *pilgeri* is found. These birds, the 'alala, or Hawaiian crow (*Corvus tropicus*), and the Palila (*Loxioides bailleui*), one of the finch-billed Hawaiian honeycreepers, are now both considered endangered species and are restricted to only a small fraction of their original distribution. Other now extinct Hawaiian bird species similarly may have utilized sandalwood seed.

ESTIMATED PAST DISTRIBUTION

Each of the four species enumerated above are extant in the Hawaiian Islands, though all are likely much less common now than previously. The present distribution of all Hawaiian sandalwoods undoubtedly reflects their past history of exploitive harvest and forest extirpation. While no species of sandalwood in Hawai'i has been known to become extinct due to harvesting, most of the harvest in the 1800's occurred before thorough botanical investigation of the Hawaiian Islands. Possibly species that were never documented became extinct. The sandalwood trade began as early as 1790, with the years of heaviest harvest between 1815 and 1825. The first collection of Hawaiian sandalwoods for taxonomic study was made in 1819 by Gaudichaud, who described two species from his collections.

Rock (1916) reasoned that if the amount of sandalwood sold in the early part of the 19th century was accurately recorded, there must have been pure forests that were subsequently decimated. In assessing sandalwood from O'ahu, St. John (1947) deduced that "there were heavy stands of sandalwood either abundant in, or dominant in, a forest zone from about 300 to about 1,000 feet [90-300 m] altitude, below the koa [*Acacia*] zone, and above the wiliwili [*Erythrina*] 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 Ko'olau Range." He

further suggests that the present distribution of sandalwood reflects only its former upper range, since it has been almost wholly displaced from its lower range by loss of forests in those areas.

St. John's (1947) conclusions regarding the former distribution of sandalwood on O'ahu can probably also be applied to other Hawaiian islands. Sandalwoods probably were once common, if not abundant, throughout the Hawaiian lowlands, particularly on the leeward and drier slopes. Records of sandalwood harvests indicate the extent of wood that was shipped from Hawaii, and most of this came from the lowlands. The only taxon officially recognized as endangered is the red-flowered variety from Lana'i and Maui, *S. freycinetianum* var. *lanaiense*. Its scarcity can be attributed to forest loss from the slopes of those islands. Elsewhere, too, forest loss has been cited as causing the extinction of *Santalum*, such as *S. fernandezianum* from the Juan Fernandez islands (Skottsberg 1930). In addition to commercial harvest and forest extirpation, heavy grazing of the native vegetation was responsible for the extinction of *S. ellipticum* from Laysan and Kaho'olawe. This species, however, is still found on many other Hawaiian islands.

MANAGEMENT NEEDS IN HAWAII

In Hawaii, extensive stands of sandalwood are only known from the island of Hawai'i. These populations of *S. paniculatum* are now commercially harvested. Hawaii may be the only region in the world where sandalwood is being commercially harvested without regulation. Without a management plan to regulate the industry, preserve some of the remaining old growth, and manage the resource as a renewable resource, the presently harvested species should be considered endangered. Old wood is wood in which the valued resins are deposited, and the present monetary incentive to utilize this wood is considerable. A market for the wood from local woodworkers threatens trees near roads, and foreign markets threaten the extant forests.

What impact will removal of these old growth forests have on other species dependent upon this ecosystem? Because these trees are an important component of these high-elevation mesic forests, their removal will increase the fragmentation of habitat that once supported several species that are now endangered, including the Hawaiian crow, the Akiapola'au, and the Palila. It is not known to what degree these bird species use—or used—the sandalwood areas, or to what degree they—or other species—may utilize the old growth associated with these forests. Aside from bird species, numerous arthropods typically are closely associated with individual plant species, and those associated with sandalwood populations should be considered threatened.

Hawai'i has the greatest number of candidate endangered species of any state in the United States. While the sandalwood being harvested is not considered endangered, biologists suspect that commercial interests are endangering this species. Monetary incentives need to be reversed so that landowners are duly compensated for their stewardship of these living Hawaiian heirlooms.

REFERENCES

- Fosberg, F. R.; Sachet, M. H. 1985. *Santalum* in Eastern Polynesia. *Candollea* 40(2): 459-470.
- Rock, J. F. 1916. The sandalwoods of Hawaii. Hawaiian Board of Agriculture and Forestry, Botanical Bulletin 3:1-43.
- St. John, H. 1947. The history, present distribution and abundance of sandalwood on Oahu, Hawaiian Islands: Hawaiian Plant Studies 14. *Pacific Science* 1: 5-20.
- St. John, H. 1984. Revision of the Hawaiian species of *Santalum* (Santalaceae). Hawaiian Plant Studies 109. *Phytologia* 55:217-226.
- Skottsberg, C. 1927. *Artemisia, Scaevola, Santalum, and Vaccinium* of Hawaii. Bulletin 43. Honolulu: Bernice P. Bishop Museum. 89 p. + 8 pl.
- Skottsberg, C. 1930. The geographical distribution of the sandalwoods and its significance. *Proc. Fourth Pacific Science Congress (Java)* 3:435-442.
- Stemmermann, L. 1980a. Observations of the genus (Santalaceae) in Hawai'i. *Pacific Science* 34:41-54.
- Stemmermann, L. 1980b. Vegetative anatomy of the Hawaiian species of (Santalaceae). *Pacific Science* 34:55-75.
- Tuyama, T. 1939. On *Santalum boninense*, and the distribution of the species of *Santalum*. *Jap. J. Bot.* 15:697-712.
- Wagner, W. L.; Herbst, D. R.; Sohmer, S. H. 1990. Manual of the flowering plants of Hawai'i. Honolulu: University of Hawaii Press and Bishop Museum Press; 1218-1223.