Sandalwood was one of the earliest commodities of trade for the Kingdom of Hawaii with the European world. This trade was brought about by massive harvests of wood which led to the disappearance of the trees from the land. St. John (1947) has traced the beginning of the trade to as early as 1790, twelve years after the discovery of the islands by Cook. The height of the trade was between 1810 and 1825 but it was not until 1819, the middle of this period of heavy harvest, that Gaudichaud made the first collections of the genus in Hawaii for botanical study. Several other collections were made during the next decade, but there were no early records concerning the distribution of the plants prior to the trade. While the earliest explorers made careful and accurate descriptions of the avifauna, little description of flora and vegetation was made, probably due to the inability of the observers to distinguish between plant species. Evidence of this is included in the journal of Clerke, present on Cook's voyage, where a list of known plants was included, presumably provided by Nelson, the botanist. Mostly those plants that they had identified were plants that the voyagers had encountered in other ports, for at the end of the list Clerke indicated "that there were about twenty species of ferns, and fifty or sixty sorts of trees and shrubs that I knew nothing of."

We are left, therefore, with no descriptions of former forests of sandalwood, but Rock (1916) indicated that there must have been great forests of the trees for there to have been as much as $400,000 income from the trade in one year. If the weight of the wood exported in a single year is calculated from this based on the price of $10.00 per picul (133.3 lbs.), twenty-five hundred tons of wood per year was exported at the height of the trade. Virtually the entire population was mobilized to supply the king's monopoly on the precious wood, and all districts were required to pay taxes of sandalwood. Degener (1930) has written that this massive employment of manpower was resented, and workers would destroy young plants so that future harvests would be impossible.

Debts were incurred by the Kingdom because of the trade, and little trading was done after 1830. The later shipments were supposedly of inferior quality reportedly due to the absence of the once easily available choice wood, and the adulteration of the low quality sandalwood with substitutes.
Such harvests drastically affected the distribution of the genus in the first half of the nineteenth century, but the effect of the trade on the present distribution of sandalwood can only be estimated. I feel there has been considerable recovery of the plants due in part to their ability to produce root suckers. This characteristic can be easily noted in areas where fires have burned, or roads have been cut. Even in areas that have not been disturbed, many young plants have been seen to originate as root suckers rather than by growing from seed. The felling of trees would likely be stimulus to sucker production. If the removal of young plants as suggested by Degener occurred over a long period of time, then this would certainly interfere with the recovery.

Presently sandalwood is known throughout the main Hawaiian Islands, and is quite common in many areas. The genus may be broken down into two distinct groups. The first of these, the Freycinetianum group, consists of plants with medium to long flowers, which are usually red in color, especially in bud, as is illustrated by *Santalum haleakalae*, the sandalwood found in Haleakala National Park. The other group, the Ellipticum group, is characterized by plants with short flowers which are greenish to greenish brown in bud, illustrated by *S. paniculatum*, the species of sandalwood found in Hawaii Volcanoes National Park. Plants of the first group are trees found on the islands of Kaua'i, O'ahu, Moloka'i, and Lā-na'i in dry to mesic forests, and on Maui, in the alpine region as well. Plants in the second group may be shrubs or trees, and are found presently on all the major Hawaiian Islands with the possible exception of Ni'ihau and Ka-ho'olawe which have been poorly botanized recently. In the past a colony of *Santalum ellipticum var. laysanianum* could be found on Laysan Island, in the Leeward Chain, but that taxon is now extinct. Each of these groups include species that are arborescent, and would have provided choice wood for the harvest.

The following features of the wood were examined to see if any differences between the taxa could be observed: tangential and radial vessel diameter, vessel length, number of vessels per square millimeter, fiber length, ray height in cells and microns, rays per millimeter in tangential section, and number of crystal chains per millimeter in radial section.

In transection, the wood of all species is diffuse porous, sometimes tending toward semi-ring porous, with the vessels usually distributed throughout the wood, but in some cases, rings are formed where vessels are either absent or very abundant. The tendency of the wood to show either of these patterns is not of taxonomic significance within *Santalum*—no taxon being consistent either in the presence or absence of the rings, or in the manner of their formation. These
rings, as they are not found in a regular pattern in a sample, cannot be considered annual rings, but are more likely a response to some other environmental condition such as drought or fire. The wood has apotracheal diffuse parenchyma, and in longitudinal sections, chains of axial parenchyma cells, containing rhomboidal crystals, are seen.

Also observed in longitudinal sections are tyloses, intrusive growths of parenchyma cells into old vessel members. Tangential sections of the wood illustrate the uniseriate and biseriate rays which may be filled with resin. When material is macerated the vessels are observed to be of various lengths and may have one, two, or no tails.

Of all the characters examined, no characteristics of the wood were of taxonomic significance. In the accompanying graphs of tangential vessel diameter, crystal chains per millimeter, and rays per millimeter, it is seen that the ranges for all taxa, and groups, overlap considerably, and the means are also close. The other characters examined were equally as useless as taxonomic criteria.

Characteristics of the leaves, being more a function of environmental conditions, were more distinctive. For instance, the thickness of the leaf varies considerably. In arid areas where plants of the taxon *Santalum ellipticum* var. *littorale* are exposed to sea spray, thick leaves develop where most of the cells are of the same type—mostly palisade parenchyma. In taxa that grow in areas not so extreme, a bifacial anatomy may be noted where there are two distinct tissue layers in the mesophyll.

Another characteristic of leaf anatomy that appears to be correlated with environmental conditions is the upper epidermis of *Santalum haleakalae*. Plants of this taxon which grow in the crater region at high elevations and are subject to considerable solar radiation, have peculiar bottle shaped upper epidermis cells. However, plants of this taxon found in not so extreme environments have more conventional epidermal cells which indicate that the formation of the cells may be an environmental response.

In conclusion, there appear to be no significant differences in the wood of the various taxa of *Santalum*, and the differences in leaf anatomy probably reflect adaptation to local environments.
Literature Cited


