Factors Influencing An Expanded Sawmilling Industry For Hawaii
FACTORS INFLUENCING AN EXPANDED
SAWMILLING INDUSTRY FOR HAWAII

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Summary

Hawaii currently imports over 95 percent of her forest products needs. However, she has present and potential timber resources that could easily offset this deficiency as well as create important wood products industries. An expanded sawmilling industry is considered a key to initiating this program. Present sawmilling facilities consist of conventional small sawmills and short log sawmills that principally produce stock for the craftwood industry. These facilities are old and inadequate for an expanded lumber industry. Expanding the industry will require overcoming logging problems caused by steep and rugged terrain, high rainfall, silvicultural and timber management problems, labor training, and transportation. Initially, the expanded sawmill program will include plans for two or three fully mechanized sawmills having annual capacities of 3 to 6 million board feet of lumber items. The density and abrasive characteristics of some woods may cause certain problems in sawing and drying lumber. A key point in the overall sawmilling program will be in marketing—to get local acceptance of homegrown timber species.

1Prepared in cooperation with Region 5 of the U.S. Forest Service, the Pacific Southwest Forest and Range Experiment Station, and the State Forester and Board of Agriculture and Forestry, State of Hawaii.

2Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

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Agriculture is one of the main supports of Hawaii's economy. Sugar, pineapples, and cattle are by far the most important of these products, although culture of flowers has been gaining in importance. Timber, on the other hand, has not been given much consideration recently as a product of any industrial importance. The main value of her forests in the past was considered to be in water conservation and watershed protection. Nevertheless, Hawaii's forest reserves hold the potential of developing an important forest products economy. Currently Hawaii is almost wholly dependent on lumber shipments from outside the Islands to meet her construction and other domestic needs. In 1959 she reportedly imported about 100 million feet of lumber.

Hawaii originally had forest that, according to some reports, completely covered all the Islands. Although the original forest have become depleted from one cause or another, a fairly large acreage of native tree species with varying degrees of commercial importance still remain. Of much more importance, however, is the considerable acreage of forest tree plantations that are now of commercial size and have valuable industrial potential. Coupled with this fact is the possibility of greatly increasing this acreage of forest plantations.

It is very significant in Hawaii's history that in the past two decades far-sighted foresters have been gradually establishing exotic forest tree plantations of various tropical and subtropical species (1). Although previously planted for watershed protection, many of them appear to have a high economic potential for lumber and other forest products. These commercial species are fast growing, and are capable of producing a high volume of wood in a relatively short time. Possibly the most important factor of all is the fact that these woods have a wide range of physical properties that make them valuable for numerous end uses, from construction to fine cabinet work.

The volume of timber available from these plantations, coupled with the volume available from the more desirable of the native species, could form a nucleus of a sizeable forest products industry. However, in order to expand into a major industry, plans for expansion must

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Underlined numbers in parentheses refer to Literature Cited at the end of the report.
be combined with a well-designed, stepped-up tree planting program that would concentrate on the most desirable of the introduced species. Thus, it is conceivable that within 30 to 50 years a sizeable diversified forest products industry could become established in the Islands. This would include veneer and plywood plants, furniture, millwork, and flooring plants as well as a lumber industry. Included also would be a pole and post industry, and possibly one industry requiring wood fiber in some form.

Hawaii's Economic Planning and Coordinating Authority, having recognized the potentials of a forest products economy for the Islands, requested the cooperation of Hawaii's Department of Agriculture and Forestry, and the United States Forest Service, to assist in working out a program aimed at developing these potentials. Because sawmill products are a basic raw material for many woodworking industries, it has been considered that the development of an expanded, dependable sawmill industry using modern methods and equipment would be a key step in establishing other industries. Although the development of a sawmill industry may not appear to present any particularly complex problems, certain factors will influence the economic success of the industry. This report is intended to point up some of these factors, and to suggest equipment, plant layout, and related items that may be best suited to handle Hawaiian timbers.

—Myron L. Wold, president-manager, Hawaiian Fern-Wood Ltd., Hilo, Hawaii, working in cooperation with the Forestry Division, Hawaiian Board of Agriculture and Forestry, pioneered in searching out the utilization potentials of Hawaii's forest plantation species. A report of his findings are contained in the several reports submitted to the Board.

Norman K. Carlson, forester for the Bernice P. Bishop Estate, Honolulu, Hawaii, has also been very active in promoting the potentials of a forest products industry. He has also proposed a self-maintaining industrial forest unit based on plantations of selected species.
Current Status of the Sawmill Industry

E. V. Roberts, in his brief reconnaissance survey of Hawaii's timber resources in 1957, reports that several sawmills were established by early settlers to manufacture lumber and other sawed products for domestic use, but that none of the mills survived. During World War II several portable sawmills were set up by the military forces to saw out lumber products for military uses. These became surplus at the end of the war, were purchased by civilians, and form the basis of the present Hawaiian sawmill industry. Practically no new equipment has been added since, so that age and the state of maintenance of the equipment places these installations, for the most part, in a marginal economic class.

In the spring of 1959, there were reported to be less than 20 mills on the Islands, of which only 10 were known to be operating. Four of the operating mills were more or less conventional-type mills producing standard-length lumber items. These were located on the Island of Hawaii, figure 1. The other six mills were short log or bolt-type mills (fig. 2) that were producing "craftwood" flitches from tree crotches, short bolts, and stumps. (Craftwood is a term applied to wood species used in making bowls, trays, and small furniture items in the Islands.) All of these mills were located on the Island of Oahu.

Of the several other idle mills reported to be on the Islands, only three were found. One of these was a trailer-mounted design that was a small edition of modern mechanized sawmills; it had a live deck and hydraulically operated headblocks and dogs. It was apparently a recent import and was designed for a high degree of mobility, but had not been tried out to determine its practicability on the Island's heavy and large-diameter timber species. The other two mills would be of little value as far as production capacity is concerned.

The four operating mills producing lumber items were on the Island of Hawaii. The largest of the four is owned by a public agency, Kulani Prison, and is located on the premises of the prison 30 miles from Hilo. It was assembled from old and new parts and used primarily for producing material for prison use. Although it has a fairly efficient layout, it would require considerable costly maintenance if it were used for any degree of sustained production.

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5 Memorandum to Director (California Forest and Range Experiment Station), April 18, 1957, from E. V. Roberts, Subject: RE-CAL. FOREST SURVEY, GENERAL, HAWAII.

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Figure 2.--Short-log mill for sawing craftwood flitches, in Honolulu.

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The second of the four lumber mills is a very light mill of standard design and is located on the north end of the island near Honokaa. It is operated principally for custom sawing logs and producing a limited amount of commercial lumber for the local building trade. Craftwood flitches are also produced in the mill. It has very limited commercial potential, but the owner has done a creditable job of promoting the use of Hawaiian grown timbers in his local area—the uses including decorative paneling and flooring, and house framing material.

The third mill is the principal lumber producing unit on the Islands. It is "captive" to one of the larger craftwood manufacturers and produces dimension squares and craftwood flitches, as well as lumber items. The mill has been set up at the edge of the timber in the southwestern area of the island to reduce log hauling to a minimum. Logs are skidded and hauled with a track-type tractor equipped with a bulldozer blade and winch. A log loader (surplus military equipment) and a track-type trailer are used for loading and hauling logs. The production layout of the sawmill is fairly good, but much of the equipment is old and difficult to keep in good condition. Logs and lumber are handled around the sawmill with a lift truck.

The fourth mill is a lightweight standard portable ground mill originally set up to saw tree-fern blocks (a product for the florist industry) and flitches from craftwood species for making craftwood items. The mill is located in Hilo in an open shed-type building. The mill equipment consists only of the basic sawmill, but is fairly well installed and maintained on a concrete slab foundation. Nevertheless, the equipment is old and in need of considerable improvement. A lift truck is used to handle logs and lumber. The production potential of the mill is low. The firm's remanufacturing plant and integral woodworking facilities are housed in a building adjacent to the sawmill and are of a much higher type than the sawmill building and facilities. The operator of this mill has done considerable experimental sawing of plantation timber species on this mill. He has also done considerable work on methods of seasoning as well as remanufacturing the lumber into such high value end products as furniture, paneling, and flooring. (6, 7).

All of the short log-bolter type mills being used in the craftwood industry are old mills, generally in a poor state of maintenance. Nevertheless, at the present time they are of more importance than the lumber producing mills.

Of the six craftwood mills, five are circulars and one is a bandmill. The sawmill and craftwood processing plants of each craftwood setup Report No. 2190

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are situated on the same premises, thus making a closely integrated operation that is highly desirable in a small plant. However, all the craftwood mills have the common fault of being located on much too small an area. This has resulted in cramped quarters for all operations. It is doubtful if any of the sawmills have a log storage yard more than 40 feet square. Of the five circular mills, all except one had a top saw, but only one could be considered in a reasonably good state of repair and maintenance. This one mill also was the most efficient from the standpoint of equipment layout and material flow. The bandmill setup was probably the best maintained although it was put together from two small secondhand mills. It was underpowered, but the light bandsaw required on this size mill would not stand a heavy feed.

For craftwood items the choice, highly figured wood comes from large, heavy limbed shade trees. Production of the craftwood mills is slow, not necessarily because of the condition of the mills but because of the presence of rock and metal in logs being sawed, which can severely damage the saw. Attempting to chop out this foreign material would destroy high value, choice, figured wood. Consequently, sawing such logs is considered a calculated risk--metal detectors would be of very little value.

None of the current sawmill installations, as they now exist, can be given much consideration in an expanded lumber industry for the Islands.

Timber Resources

Exact data on the timber resources of the Islands has not been determined. However, a timber resources survey being conducted (5) should give a reliable estimate, not only of volume of timber available by species, but also the acreage of forest lands that have high-volume growth potential. This last factor has a considerable bearing on the future of a stable expanded lumber industry. Likewise, the current volume of timber available has an important influence on the choice of equipment and type of sawmill installation required for initiating the program. Consequently, although estimates are for the most part no more than well informed "guesses," the information is reviewed here.

It has been roughly estimated that there is about 2 million acres of present or potential forest land on the Islands, or about one-half the land area of Hawaii. Of this total, about 500,000 acres are potentially...
commercial timber. About 90 percent of this, or 450,000 acres, is on the Island of Hawaii, known as the Big Island. About four-fifths of this potentially commercial timber is native forest and one-fifth consists of forest tree plantations. In addition, there is believed to be another 500,000 acres of forest land not now supporting forest growth of much commercial value. There is also about another 1,000,000 acres of land that can be classed as forest land.

Native Timber

Only two native species, koa (Acacia koa) and ohia (Metrosideros polymorpha), are in sufficient volume to be considered of commercial importance. Practically the entire commercial volume of koa is believed to be on the Big Island. Koa has high value, being highly prized for furniture and craftwood manufacture. The commercial volume of koa has been estimated to be about 80 million board feet, but the volume is scattered over a large acreage. The future status of koa is uncertain because young growth has been damaged by cattle. The animals have been permitted to run wild in the forest areas and feed on the palatable young vegetation. Without control of this problem, koa will become of very minor importance.

Ohia is the most important native species on the Islands from the standpoint of volume and acreage (fig. 3). Although a high percent of the ohia acreage is in scrubby and low-quality timber, it has been estimated that there is about 550 million board feet of ohia saw timber available. Probably less than 100 million feet can be considered reasonably accessible and of the quality that could be considered for inclusion in an expanded lumber industry—that is, timber with relatively straight boles and a minimum indication of spiraling contour of the stem. Ohia wood has a fine texture and an attractive dark color and is reported moderately resistant to termites and marine borers. On the other hand, the wood is very heavy and hard, and contains a silica extractive that is abrasive to cutting tools. This makes it difficult to saw and machine. However, it is believed that these faults can be overcome by use of abrasive-resistant cutting tools (saw teeth and planing knives).

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6Another species, monkey pod (Samanea saman), primarily a shade tree but highly prized for craftwood, is also in short supply. Very little attention is being given to future systematic plantings. However, from the standpoint of present volume it is of minor importance.

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Plantation Timber

Over a thousand species of trees are reported to have been planted on about 92,000 acres in the past 75 years (1). However, much of the acreage is in very small tracts, windbreaks, and roadside plantings. Nevertheless, there have been fairly large blocks planted, with the bulk of the acreage planted in the past 25 years (fig. 4), mostly by Civilian Conservation Corps labor. The best results apparently have been obtained from various species of Eucalyptus, Casuarina, Araucaria, Cedrela, Fraxinus, Grevillea, Sequoia, and Pinus. Included among these species are woods with physical properties desired for such uses as framing lumber and similar building construction items, and others with the physical properties required for heavy construction. Most of them have decorative and machining properties desired for such uses as furniture, flooring, paneling, millwork, or cabinet work. A few have exceptionally attractive color and grain characteristics.

Some of these desirable species reportedly have also shown remarkable growth characteristics—a volume production of 50,000 board feet per acre in less than 50 years being not unusual.

Rough estimates of the present merchantable volume indicates that there is close to 200 million board feet from 35 to 70 years old on the plantations (fig. 5). It is believed that about 140 to 150 million feet of this is potential saw timber; over 90 million is on the Big Island and over 40 million on the Island of Maui, the remainder being located principally on Molokai.

A high percent of this volume consists of a number of species of Eucalyptus—E. robusta, E. globulus, E. resinifera, E. saligna, and several others. These species are about the weight and hardness of white oak and somewhat refractory. The logs tend to split open when felled and bucked, and tend to "spring" and split somewhat when stresses are released in sawing.

Although it is expected that the expanded lumber industry would have to get its start largely on these species, it is anticipated that there is a sufficient volume of the other plantation species that are lighter in weight, are less refractory, and have at least equally desirable properties to make it a diversified industry, particularly as the younger plantations of these species mature. These include Grevillea robusta, Cedrela toona, Fraxinus uhdei, and Araucaria excelsa.

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Figure 3. -- Ohia (Metrosideros polymorpha) of sawtimber size. This species is prevalent on the Islands and its wood has good characteristics. However, it presents problems in logging as well as sawing and seasoning.
Figure 4.—Forest tree plantations on the Island of Maui. Plantations range from numerous small acreages (as seen on mountains in background) to areas of several hundred acres.
Figure 5. -- *Eucalyptus robusta* plantation near Hilo, partially thinned for military timbers and showing trees approximately 35 years old.
Figure 6.—Tractor and logging arch as used on logging studies at the Fernow Experimental Forest in West Virginia.
Logging Problems

Logging costs, as reported by some of the operators on the Islands, are about twice those of comparable operations on the Mainland (2). There are a number of factors that contribute to this situation—probably some more than others. Many of these are discussed here. However, this discussion is not intended to evaluate them. It is merely intended to point them up and suggest possibilities that may help to overcome them. It undoubtedly will take some intensive study of the overall situation to come up with the best solutions. None of these problems are insurmountable. A study of some of the hardwood logging practices on the Mainland that might apply to the Islands' conditions would especially be of value; that is particularly true of the experimental logging being conducted on the Fernow Experimental Forest in West Virginia, where mountain logging practices are being studied (fig. 6), and the work that is being done on the Coweeta Hydrologic Laboratory in North Carolina, where logging on watersheds is being studied.

Topography

Practically the entire area of each of the major islands is a volcano mountain range or a volcano mountain so that the land slopes rapidly upwards from the sea coast to heights ranging slightly over 4,000 feet on Oahu—the lowest of the major islands—to nearly 14,000 feet on Hawaii, the Big Island. Hawaii itself is about 100 miles long in its greatest dimension and has three volcano peaks—one 8,251 feet high, one 13,680 feet high, and one 13,784 feet high. Thus, there is a rise from sea level to these heights in less than 50 miles from practically any place on the Island. The Big Island also has about 90 percent of the present timber resources of the Islands; therefore, it is probably the one on which the major expansion of the lumber industry will take place.

While the islands are characterized by very steep slopes and cliffs (known as palis), there are also considerable areas of relatively level lands that occur at various elevations on saddle plateaus between volcanic domes and on the gentler lower slopes of the volcanoes. There are no extensive coastal plains on any of the four islands. Erosion of the volcanic domes has left more or less radial drainage patterns and has resulted in numerous ravines and gulleys. In other areas on the lower slopes of volcanoes, lava flows have created
relatively large areas of fairly uniform terrain, ranging from gentle to rather steep slopes. These lava flows are made up of comparatively smooth, pavement-like lava called "pahoehoe," a more or less porous pumice-like rock that is not particularly strong, and areas adjoining these pahoehoe flows made up of crumbled lava rock called "aa." A layer of soil made up of finely crumbled aa and other eroded volcanic rock, volcanic cinders, humus, and probably some clay, covers a considerable area of the older of these pahoehoe lava flows. There are deep pockets of this soil, but mostly the pahoehoe has only a relatively shallow layer of soil covering it. Soil in the aa lava flow areas is generally much deeper, but has a very rocky character due to the large chunks of aa lava, which resembles black furnace slag. Successive lava flows have in some areas formed a crust or shell of pahoehoe over the soil of former lava flows, which can result in "sink holes" if broken through. It will require a good knowledge of the soil and terrain to be able to log efficiently in such areas. For instance, in the building of skid roads, an understanding of the character of the lava rock and soil conditions is essential to avoid breaking through the "crust" of lava and developing mud sink holes.

A great deal of the logging will be done on this type of terrain because many of the plantation timber areas have been established on them.

Rainfall

Rainfall on the Islands is distributed fairly uniformly over the year so that there is no rainy or dry season—although there is usually slightly more rainfall in the winter months. There seems to be no specific elevation at which the maximum rainfall occurs, but there appears to be a "rain belt" at roughly 2,500 to 5,000 feet in which an annual rainfall of from 100 to 350 inches occurs on the windward side. On individual islands the maximum rain belt may occur at different elevations and at correspondingly different maximum rainfall ranges. On islands having elevations greater than 5,000 feet, rainfall will lessen above this belt.

The high annual rainfall presents certain logging problems that will bear on the selection of logging equipment and logging methods. A considerable acreage of eucalyptus is planted in the so-called "rain belt." In such areas rain usually occurs 200 to 300 days per year and in some areas more than 300. Although there are not many days when the rainfall will be torrential in character, some days the amount of
rain will be sufficient to hinder logging operation and even require shutdowns.

**Labor Skills**

Lack of experience and background in industrial logging practices can no doubt explain some of the high logging costs. There are few supervisors on logging and milling operations who have had previous milling experience on the Mainland and probably fewer workers; and for the most part their experience has been with very small operations. Nevertheless, these men have served as a sort of nucleus on a more or less trial-and-error basis in developing the logging methods and techniques that are currently being used. In time these men will work out the solutions to the problems of reducing logging costs, but the program of expansion should not wait on them. The program of expansion could be greatly augmented if a skilled logger, who has had experience in the hardwood areas of the eastern United States, could be obtained for a year or two to help train woods workers and assist in organizing a logging program. This period of time is probably sufficient because the timber workers (and labor in general) appear to have a good sense of mechanical know-how and a willingness to work and learn. Supervisors and workers both would benefit from guidance in how best to handle logging equipment and to fell, buck, skid, and load timber.

**Equipment**

Logging equipment currently being used is very inadequate for an expanded lumber industry. Much of the equipment now being used was surplus from the military logging and milling operations conducted on the Islands in World War II, figure 7. Some new trucks and bulldozers have been added, and the chain saws used for felling and bucking are for the most part new equipment. Although military timber operations are frequently highly mechanized, the machines used are designed for universal application and seldom are particularly suited to an economical commercial logging operation; nor are military timber operational methods particularly suited to a commercial operation.

Consequently, logging equipment more specifically designed for commercial logging operations is needed. However, some exploring will be needed to determine what type would be best suited to conditions on the Islands.
The chain saws being used appear to be adequate, but the abrasive character of such woods as ohia may require the use of chains with special, hardened alloyed steel.

Skidding currently is being done with track-type bulldozer tractors on which are mounted a winch with a 5/8-inch cable to pull logs to the skid road. One operator is currently skidding logs 32 to 36 feet long, which is recognized as an efficient practice. This method has an advantage over skidding single short logs, but it is believed a tractor equipped with a logging arch (preferably an integral arch) would be much more efficient. Arches will raise most of the log off the ground, greatly reducing the area of bark and wood into which lava rock can become embedded in the skidding. In addition, arches may make it feasible to skid tree-length material to a landing where there might be a better chance to buck for quality and for such other products as posts, poles, and veneer bolts. With such equipment it is possible to reach out as far as 400 feet with a cable to pull logs to the skid road, thus permitting more efficient layout of skidding and logging roads. For some of the larger tracts, some consideration might be given to the use of rubber-tired logging tractors, particularly those with integrated arches, figure 8. These machines are more or less of a new development and reportedly have certain advantages over the track-type tractors. When operating in areas of loose aa rock the maintenance cost on rubber-tired logging tractors could very well be considerably lower than that of track-type tractors. There are some areas, however, that are so rough that some sort of cable system might be considered for skidding logs to a landing.

The type of equipment used for loading out and hauling (and possibly the bucking and skidding practices) no doubt will be governed by the size of the timber tract being logged. Portable jammer-loaders could possibly be used where there are large acreages in a single block; where a high volume of large-diameter timber is to be logged, a heel boom-type loader might be more economical. It is probable that tree-length skidding would be most practical on the larger acres logged. For the larger tracts, standard logging trucks using pole trailers possibly would be the most efficient for hauling. On a current operation a standard two-ton (nominal rating) truck (approximately 18,000 pounds gross cargo weight) has been converted to a pole trailer, increasing its carrying capacity one-third to approximately 29,000 pounds gross cargo weight. This appears to be working satisfactorily. However, a three- or five-ton (nominal rating) tractor-trailer would carry pay loads up to approximately 40,000 to 50,000 pounds gross cargo weight.
Figure 7. -- Surplus military equipment being used in loading and hauling koa logs (Acacia koa) on the Island of Hawaii. The machine on the left is a track-type portable crane for loading. The machine on the right is a track-type "low boy" trailer for hauling.
Figure 8. Wheel tractor with integrated arch may have advantages in skidding and hauling in areas of high rainfall.

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Figure 9.--Eucalyptus robusta plantation that is approximately 35 years old and in need of thinning.
Figure 10. --Coppice growth on a Eucalyptus robusta plantation, 3 years after a logging operation.
Small tracts, windbreaks, and roadside strips can probably be logged most economically with a small crew that will log, load, and haul as an integrated unit. A well designed self-loading truck could serve such operations, which could be so designed as to cable skid for short distances. For such an operation it would probably be necessary to buck to standard mill length in the woods.

Timber Management

Full technical information is lacking on how best to manage these timber lands in order to obtain maximum volume and quality. Nevertheless, whatever timber management practices are recommended, they necessarily will have an influence on logging methods and the type of equipment used. Many of the plantations were closely planted--some spacings originally as close as 6 by 6 feet. This has resulted in trees of considerable height but the diameter growth has been slow (fig. 9). The military timber operations provided evidence that, when thinned, the plantations respond very favorably and the trees will appreciably (fig. 5) increase in diameter in a relatively short time; this appears to be particularly true of eucalyptus. There is also evidence that most sprouts and coppice growth (fig. 10) from stumps develop very rapidly after logging, thus rapidly re-establishing the forest without replanting. It is conceivable that, when placed under technical management, some of these plantations (and future plantations) can be made to yield 80,000 board feet to the acre in 40 years or less. There are indications that some of the current plantations around 45 years old now have such a stocking. Undoubtedly many of the current plantations will be thinned, possibly taking out only the trees of merchantable size. A small tractor capable of maneuvering among the remaining standing trees might be required for this type of operation. As has been indicated, some of these forest areas have been designated as watershed protection forests and, subsequently, will require special logging treatment in order to maintain the effectiveness of the forest in soil stabilization and the retarding of water run-off.

The growth and other characteristics of the timber may also have a bearing on logging practices, particularly felling practices. For example, ohia has a fluted and buttressed trunk formed from aerial roots, and eucalyptus under certain conditions will form aerial roots surrounding the trunk. The choice, larger diameter, old-growth koa likewise has a trunk that is fluted and often buttressed for 3 to 5 feet above the ground. Frequently 4 to 8 feet of these butts are of such poor quality that they must be bucked off. Such trees are troublesome
to fell and may require special techniques. The weight of the logs must also be considered—ohia is heavier than hickory and eucalyptus weighs only slightly less than hickory (3).

While none of the above logging problems bulk large in the overall timber harvesting picture, collectively they help keep logging costs high. Consequently, before any large-scale expansion of the lumber industry is initiated, many of these problems should be solved. A thorough study is needed to determine which areas contribute the most to high costs and attempts made to solve them first.

Transportation System

A good road system is essential to keeping logging costs down, particularly good main haul roads. Hawaii is fortunate in this respect because the road system in and around the sugar cane and pineapple plantations on the individual islands either go past or close to the forest tree plantations that currently have timber of commercial size. These roads are high standard heavy-duty all-weather roads designed to carry loads of 30 tons or more, gross cargo weight. It is anticipated that maximum loads of logs will not be in excess of 25 tons.

In certain areas, however, it may be necessary to extend these heavy-duty roads to reach some of the larger, more remote timber areas. In the overall plan to develop new forest plantation areas, provisions should be made for high standard heavy-duty main haul roads as well as an adequate secondary haul and skid road system. Such roads should be looked upon as permanent investments, so that amortizing the cost of the road system would be projected to the harvesting of the timber crop. Each product harvested, thinning as well as the final crop, should be considered in amortizing the road investment. Where roads will have multiple use, the forest crop should not have to bear the full cost.

Sawing Problems

In addition to logging problems, there are also certain sawmilling problems that must be solved. These possibly may not be as difficult as the logging problems, but need to be recognized. The several
species of Eucalyptus are hard, heavy woods in the range of specific gravity between hard maple and hickory. Ohia, on the other hand, is heavier and harder than hickory, and in addition has a silica extractive in it that tends to dull saws quickly. A saw fitter experienced in fitting and tensioning for hardwoods will be required (at present saws must be sent to the Mainland for tensioning and maintenance). It is probable that teeth made of a hard metal alloy that resists dulling will be required for sawing ohia.

Some plantation species, notably eucalyptus, have a central cylinder area of the tree (or log) known as "brittleheart" (brittleheart is sometimes called "juvenile wood" but possibly is caused from compression). The wood from the brittleheart area, as its name implies, is brittle and will break readily when given a sharp blow. There is no specific transition zone in the heart to detect this condition, although there is a slight difference in color from adjacent wood. The wood is also usually lighter in weight. Internal stresses also cause the ends of the logs to split open from 1 to 2 feet when they are felled and bucked and, when being sawed on the mill, the boards or cants frequently will split more. Wold indicates he has developed sawing techniques that help to reduce the splitting tendency and believes he can readily recognize brittleheart from its color and weight. Probably sawyers and lumber handlers can be trained with Wold's methods, but more investigation is required to take personal judgment out of the method of detecting brittleheart.

In his utilization studies, Wold found that the Forest Products Laboratory's recommended air seasoning practice for dense hardwoods, with stickers spaced 12 to 18 inches apart (fig. 11), reduces warping of such species as eucalyptus to a minimum; however, he has done little on kiln drying schedules. This will require more research as will also the final "end-use" moisture content. There is a wide range of relative humidity on the islands that will require a good understanding of equilibrium moisture content control to avoid end-use problems.

In spite of the need of solving these problems, there is a stronger need to immediately initiate an active sawmilling program. It should not be a "crash" program, but started in a relatively small way and expanded as quickly as problems are solved and financial and marketing conditions will permit. It should be so designed as to be readily fitted into such timber management plans and working circles as will be developed.
Future Sawmilling Facilities for an Expanded Lumber Industry

If the nearly 200 million board feet of commercial saw timber currently available from the forest tree plantations was strategically located and markets could absorb the production, two or three sawmills of 8 to 12 million board feet annual capacity (40 to 60 thousand board feet per day) could be supported by this volume for a period of about 10 to 15 years. Supplemented by in-growth and native species, this could no doubt be extended to 20 years. The volume of merchantable timber available on the Island of Hawaii (the Big Island) possibly could support two such mills, but the timber is not strategically located with regard to the road system and logical mill sites (source of skilled labor and seaport shipping facilities) to do so at the present time. Consequently, the logical plan would be to consider two or three smaller sawmill enterprises of 15 to 25 thousand board feet daily capacity (or even smaller). The volume of commercial saw timber available on Maui likewise could support a single mill of 15 to 25 thousand board feet daily capacity (five million board feet annual capacity). This size of mill is in line with mills in the hardwood industry on the Mainland that produce the bulk of the hardwood lumber items. There are a number of larger hardwood mills, but these smaller mills are the backbone of the hardwood lumber industry.

Although there is insufficient information available at present to state specifically where the mills should be located, it seems logical that on the Island of Hawaii the largest would be located at Hilo; this should have a production potential of about 5 to 8 million feet annually. A second mill on Hawaii, possibly located at Kailua Kona, would have an annual production potential of 3 to 5 million feet. It is possible that a third and fourth mill might be considered in the future of Hawaii--one in the vicinity of Naalehu and one on the north side of the Island near Waimea (Kamuela) or Honokaa--with a production potential of 2 to 3 million per year.

The current information on the timbers and conditions on Maui would indicate the logic of having only one mill on this island located near Kahului. The size and character of this mill would be comparable to the one suggested for Hilo.

A mill having an annual capacity of 2 to 3 million feet could probably handle the timber on Molokai.

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Figure 11. — Piling for air seasoning of dense hardwoods.

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Figure 12.—Layout of proposed sawmill unit for the Islands.
It is doubtful if Oahu or Kauai have sufficient timber to support permanent lumber-producing mills. Oahu has plantations with timber of commercial size, but it possibly has much greater aesthetic and watershed protection value, which would exclude any widespread timber operation. In the event some of this would be harvested, the logs could be barged to a mill on Molokai, Maui, or Hawaii. Some consideration might be given to the use of a highly mobile (wheel mounted) sawmill on these smaller island operations to supplement the larger mills. Such mills could be readily barged to islands having only a small volume of timber where they would operate for a time on small plantations of timber and the windbreak timber. They could produce lumber for local use or produce flitches and cants to be shipped back to one of the principal mills.

It should be recognized that the above outline of sawmill locations and productions are simply suggestions. Authoritative decisions on each sawmill site proposal can only be made when full information is obtained on available saw timber. With this information it should be possible to develop timber management plans with well-organized working circles to encourage wise use of the timber. These plans no doubt will recognize the fact that no rapid expansion of the lumber industry should be considered until the several major logging problems discussed are solved, but more especially until full information is available in potential markets.

Proposed Initial Sawmill Unit Plan for a Sawmill Enterprise

While bandsaw headrigs are frequently found in hardwood sawmills producing less than 5 million feet per year on the Mainland, it is recommended that circular saw headrigs be used for the initial installations on the Islands. As the sawmilling industry and sawmilling skills develop, consideration might be given to using band headrigs. Circular headrigs can do the same character of sawing as band headrigs if properly maintained and are less costly. The advantage of the band is about a 5 to 10 percent lumber volume gain due to the use of a saw with a narrow kerf.

The unit plan given below is developed with a circular headrig in mind. It has the potential of producing up to 4 million feet per year of stock 2 inches and less in thickness without a resaw. With the addition of a resaw the production possibly could be increased to 6 million. This type of installation should prove adequate for initiating an expanded
sawmilling enterprise on both Hawaii and Maui. A lift truck of about 7-1/2 ton capacity should be able to handle both logs and lumber around the mill.

A mill in this production class will require an initial area of about 5 acres for the sawmill facilities (2 acres for log yard, 2 acres for lumber seasoning yard, and 1 acre for sawmill plant including dry kiln). It would be possible to get by with 3 acres, but in so doing certain inefficiencies develop in log and lumber handling that contribute to higher production costs. In addition, there is a tendency in designing the building and equipment installations on too small an area to reduce work space and equipment spacing, further reducing efficiency in handling of materials and in machine operations.

If a remanufacturing facility is planned, it will require additional area.

It is recommended that the proposed mill unit be fully mechanized, having a layout as suggested in the attached plan (fig. 12). The plan as shown anticipates a production potential of 2 to 3 MBF per hour. The addition of a resaw to the left of the edger would increase the production potential to about 4 MBF per hour.

The mechanized log deck includes three live chains (to permit handling logs of several lengths) powered by an electric motor and activated from the sawyer's position. The log turner and loader should be the combination nigger-flipper type hydraulically powered and also activated from the sawyer's position. Either a hydraulic or an electric feed works system can be used, although a hydraulic system is suggested. Thus, the two hydraulic systems can be combined.

The feed works can be either the cable or shotgun-piston type. A cable type would be a more flexible installation in the event that markets will require long dock and heavy construction timbers.

The sawmill carriage should be in the weight class of about 7,000 pounds (fig. 13) and have at least four headblocks that can open to 44 inches. The headblocks need to be equipped with hydraulically operated retractable-type tong dogs that will hold "springy" cants tight to the headblock knees. Each knee should also be designed to set out independently for taper. Knees and dogs would be operated from the sawyer's position. The carriage setworks should be electric and likewise operated from the sawyer's position, and of a design to make positive accurate sets to within 1/64 inch of the setting, whether moving a heavy or light load.
Figure 13.—Heavy type sawmill carriage and log turning equipment suggested for future sawmill installations.
Figure 14. --Details of a conveyor chain dip tank.

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The sawmill husk assembly should be designed to include the supporting frame and saw mandrel assembly for a 36-inch top saw used with a 54-inch main saw (or comparable size combinations). The main saw mandrel would be at least 3 inches in diameter to be strong enough to transmit power to the hydraulic feedworks and log turner (through pulleys mounted on the mandrel) as well as power to the headsaw from a direct-drive 200-horsepower electric motor without causing vibrations in the saw. Eight-inch spiral rolls should be included in the husk assembly, mounted to serve as an automatic offbearer. These would also be powered from the headsaw mandrel.

The live belt conveyor assembly from the headsaw through the length of the mill should be powered by an electric motor mounted at the rear end so as to pull the belt rather than push it. The recommended belt speed would be about 175 feet per minute. Hydraulically powered sweep assemblies can be mounted along the live belt at the edgerman's position and the trimmerman's position with foot-level control valves at each position. A hydraulically powered sweep will be included at the edgerman's position to deflect trash (slabs and bark) to the trash conveyor.

The edger should be designed to take pieces at least 32 inches in width and be equipped with three saws, one fixed and two movable. The set-lever scale bars must be graduated for 1/4-inch set intervals to facilitate getting maximum width and grade. The edger will be powered by an electric motor and belted to reach a feed speed up to 150 feet per minute. The top of the edger table should be about 30 inches high from the floor of the edgerman's pit, but about 4 inches lower than the top of the live conveyor belt. A 3-foot storage area (cushion) between the live conveyor belt and the edger can receive boards swept from the belt from edging. The 4-inch drop between the belt and the edger will facilitate delivering the boards to the edgerman. The distance provided between the edger and headsaw should be at least 24 feet.

A shadow-line edger guide over the edger will facilitate the edgerman's decisions in ripping and edging for grade. A guide light over the carriage at the log deck will also aid the sawyer in spotting the sawline at headrig.

A two-saw trimmer of either the push button or Canadian-type can be operated by the edger offbearer. Lumber will be only rough trimmed.

A dip tank for an insecticide and fungicide bath treatment of green lumber should be provided. This will serve to protect lumber from

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insect and fungus attack while it is being air seasoned. This is a surface treatment only and will not protect lumber in use. Details for constructing a dip tank are contained in figure 14. Provisions can be made for a surface bath or spray treatment for timber in the conveyor line outside the mill.

It is absolutely essential that an adequate foundation be provided on which the sawmill trackway and sawmill husk is mounted. The track and husk should be cushioned with pressure-treated wooden members securely bolted to the concrete and to the husk and track.

Structural members used in the building must be pressure-treated at the base where they will be in contact with moisture and termite tunnels.

Expanded Sawmill Facilities for Craftwood Items

At the present time there appears to be no point in attempting to expand the sawmilling facilities for the craftwood industry. The craftwood industry "mushroomed" after the war and depended almost entirely on monkey pod and koa. These woods have low shrinkage values, are reportedly easy to dry, and are prized because of their figure, color, texture, and ease of machining. According to a number of craftwood industry people, the high demand for these species has resulted in the supply becoming greatly depleted. Monkey pod, the most desirable of these species, is especially in short supply. Prices paid for better specimens of this species are comparable to highly prized black walnut species on the Mainland, and prices are expected to get higher. The best trees are shade trees grown around individual residences, so the industry is dependent on a great many individual owners. Very little organized planting has been done to replenish the supply and, as the tree takes nearly 100 years to develop the color and grain characteristics desired, there appears to be little chance for expanding the industry on the above species alone. However, there are species such as mango, milo, and kamani that could be promoted, but additional information is needed on the volume available and trade acceptance. In the meantime, the need is to improve existing plants, rather than just increase their number.

Some units should be replaced while other units could do a more acceptable job of sawing if put in good mechanical condition. Replace-
ment units could be of the short log-type sawmills with a top saw similar to the one shown in figure 2. However, the new units should have heavier carriages with at least 40-inch headblock openings, and loading and turning equipment heavy enough to efficiently handle the large-diameter crotches, stumps, and butt pieces. The craftwood industry would derive considerable benefit from the services of a circular sawmill specialist experienced in working with hardwood mills. Although some benefit would be derived from group meetings, the most benefit would come from working individually with operators.

Marketing Lumber Products (4)

Marketing the lumber products may be the major problem. Although the Island reportedly imports 100 million feet of lumber annually, it is largely made up of yard lumber and other construction items, and is mostly softwoods. Species of eucalyptus, which makes up a major volume of the merchantable plantation species, are heavy hardwoods that would not be acceptable for uses where ease of handling, nailing, and hand tool work is a requisite. Consequently, they could not take over much of the yard lumber market, and it will take a good selling job to make inroads on the construction market. In the more or less decorative fields, such as paneling, millwork, and flooring, there would be a much greater potential. There no doubt are numerous other uses, but it will take a rather concentrated effort to search them out and "sell" the end users. Wold's sawing and utilization studies of several of the more promising woods are an excellent start in the marketing direction, but searching for markets will require knowing what property specifications the "end-users" require for their product. This, of course, requires knowledge of the physical properties of the wood. Although there probably would be a "flush" of orders for lumber when the availability of Hawaiian woods is announced, the long-range, large-volume markets for forest products will depend largely on the sound technical information and actual experience records of end use that are available.
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