COMMERCIAL FORESTRY IN HAWAII

An Annotated Bibliography

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Request No. B-0578
June, 1964

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FOREWORD

This bibliography presents materials dealing with various aspects of timber production in Hawaii. This is an increasingly significant topic in view of the fact that many qualified foresters and other authorities in land management are persuaded that commercial forestry presents possibilities for significant economic development. About one-quarter of the entire land area of the State suitable for commercial forestry is presently being used exclusively for water conservation or is lying idle. Some estimates indicate that the full utilization of this land could create an industry generating $200 to $250 million of income for the State annually and provide employment for as many as 18,000 persons. (For example, see Nelson and Wheeler, Forest Resources of Hawaii--1961 (page 7), and Bryan, Tree Farming in Hawaii (page 2).)

There has been a deep and abiding concern with forestry problems in Hawaii since the late nineteenth century. In 1903, the Territorial Legislature provided for the establishment of forest reserves. At that time, these reserves were valued mainly for their contribution to water conservation. Enormous areas had been denuded by uncontrolled grazing, and several hundred species of trees were introduced as a conservation measure. Observation of the growth rate of these introduced species reveals that several commercially valuable hardwood species have two, three, or four times the growth rate in Hawaii than in most other parts of the world. The question facing the State now is whether the objective of water conservation can be made compatible with commercial forestry and other uses--the multiple-use concept of land management.

This bibliography reveals the extent of systematic research which has been completed regarding forestry in Hawaii. It does not evaluate the quality of the research, nor assess the extent to which additional research is needed. The annotations are intended to summarize the important points in each work that seem pertinent to the editors.

Eighty-eight citations are furnished, grouped in five categories:

I. Commercial Forestry. This category includes works dealing directly with the commercial uses of timber including cost and profit estimates of tree growing and wood processing (pp. 1-10).

II. Technical Reports. This category includes works dealing with wood quality, timber growth rates and related information (pp. 10-13).

III. Research Inventories and Plans. This category consists of those works summarizing or proposing research in forestry and watershed management (pp. 14-15).

IV. Tree Names and Forest Descriptions. This category includes works dealing more or less exclusively with naming and describing various genera and species of forest plants (pp. 15-16).

V. General Works. This category includes works dealing with the history of forestry in Hawaii, its policies and problems (pp. 16-18).

(The U. S. Forest Service's Pacific Southwest Forest and Range Experiment Station at Berkeley is cited in this bibliography as the Pacific Experiment Station.)

Tom Dinell
Director

June, 1964

I. COMMERCIAL FORESTRY

Arnold, Keith and L. N. Ericksen, [Letter to Walter W. Holt] (June 15, 1961). 8 pp., mimeo.

This letter, from the U. S. Forest Service's Berkeley Station to the state forester, lists figures from mainland sources showing the costs of processing timber for plywood, veneer and other lumber. (The letter is available at the U. S. Forest Experiment Station, 400 S. Beretania, Honolulu.)

Bartholomew, Harland, and Associates, "Analysis of Hypothetical Industry 'B'--Medium-Size Wood Products Plant," in Land for Industry in Hawaii, Economic Planning and Coordination Authority, Hawaii (July 12, 1957), pp. 40-41, Table IV.

This article compares the major estimated production costs of a wood products plant located on Oahu with a similar one on Hawaii. The major disadvantage of a neighbor island site is the transportation cost to Oahu markets. The projected cost of such a plant on Oahu is about $250,000. The Hawaii plant might incur $25-$30,000 more in costs.

"Big Island Timber Seeks Way Out of the Woods," Hawaii Business and Industry, 9:1 (July, 1963), 72-73.

This short article discusses Bishop Estate's research in the Honaunau Forest Reserve and on the slopes of Hualalai. The Estate is spending about $10,000 per year to bring unused lands into production. Although research has uncovered certain problems, especially those related to exceptionally fast tree growth, the trustees are cautiously optimistic. The Estate hopes for cooperation in research with other land owners, even though few are willing to tie up capital for the 30-35 year period necessary for seedlings to reach cutting maturity. One thousand acres of the reserve have been planted to commercial timber trees and 150-200 acres are being planted yearly.

Princess Bernice Pauahi Bishop Estate, Honaunau Forest, The Promise of a Timber Industry (Honolulu, 1963). 17 pp., illus.

This pamphlet summarizes research carried out in the Honaunau Forest Reserve by N. C. Carlson and L. W. Bryan. It contains estimates of the board feet per acre yield of seven hardwood species introduced to Hawaii's forests. These indicate that each 150-200 acre block of the 850 acres then planted in the reserve will eventually yield six to ten million board feet annually. Such a yield should support a large sawmill employing ten to twenty men full-time all year. Estate officers conclude that the experiments in the Honaunau reserve suggest that the State has a potential timber producing industry.

Board of Commissioners of Agriculture and Forestry, A Survey Report of the Timber Industry Potential in the Territory of Hawaii (Honolulu, 1959). 19 pp., mimeo.

The report is a general survey of existing forests in Hawaii and the research up-to-date. Expanded tree planting programs, timber values, and forest taxation are also discussed.

Bryan, Lester W., "Tree Farming in Hawaii" (November, 1957). 10 pp., typewritten.

This article includes a brief survey of timber usage in Hawaii in 1952. The author cites a survey indicating that 100 million board feet of timber would be available for harvesting in 1958, approximately 50 per cent of it consisting of a single species--Eucalyptus robusta. The author finds that there are large areas outside of critical watersheds which can supply commercial timber. There are approximately 272,000 acres of land on Hawaii suitable for commercial forestry. Assuming a cutting cycle of 40 years, and the harvest of 6,800 acres annually at 30,000 board feet per acre, annual production would be 200 million board feet per year. He advocates the local production of utility poles, and suggests that instead of continued planting of an almost infinite number of species only a few of the most valuable commercial species should be planted, like Australian toon, tropical ash, several eucalypti, monkey-pod and three species of pines--loblolly, slash and monterey. He suggests that the average cost for clearing, planting and maintenance until harvest time is $100 per acre. (This report is in the library of the Department of Planning and Economic Development.)

Bryan, Lester W. and Myron L. Wold, Exploitation of Hawaii's Timber Resources (Honolulu, 1957). 100 pp., illus.

This is a report of the author's investigation of forestry and timbering techniques, including logging and milling, in Australia and New Zealand in 1956. Close attention was paid to Australia's utilization of hardwoods, especially, the eucalypti. These grow faster and better in Hawaii than in their native Australian habitat. The authors recommend the expansion of Hawaii's program to utilize mature forest resources to include several specialty products, such as flooring, cargo pallets, structural timbers, utility poles and the like. They also suggest that a plywood plant might be feasible to utilize Hawaiian hardwoods in the manufacture of face veneer. They especially recommend the establishment and maintenance of a sustained yield forestation program in the State.

Carlson, Norman K. and Lester W. Bryan, Hawaiian Timber for the Coming Generations: from a Report on the Honaunau Forest, South Kona, Hawaii; Its Present Condition and Its Potential (Honolulu, 1959). 112 pp., illus.

This is the most comprehensive report available of the research done by the authors in the Bishop Estate's Honaunau Forest Reserve, Hawaii. It describes soil types, rainfall and elevations of various parts of the 10,500-acre reserve, especially those areas in which trees have been planted. Cites problems in clearing lands and those encountered with respect to tree growth are discussed. Data concerning clearing and planting costs in the reserve, as well as estimated maintenance costs until harvest time 30-35 years from date of planting, suggest that about a 400 per cent profit can be made from most of the reserve area.

_____, "The Honaunau Forest: An Appraisal After Seven Years of Planting," Journal of American Forestry, 61:9 (September, 1963), 643-647. Illus.

This article reports that research in the Bishop Estate's Honaunau Forest Reserve indicates that tropical ash and Australian toon will produce 40 thousand board feet per acre in 35 years and produce from an investment of $500 per acre a gross return of $1,900 per acre. Figures are lower for several eucalyptus species but about the same for Queensland-maple.

Castle and Cooke Company, Ltd., Bamboo (January, 1950).

This study concludes, after an examination of the market for bamboo products, that building the industry and extensively cultivating the plant would not be feasible in Hawaii. (This report is in the library of Castle and Cooke Co., Ltd.)

_____, Commercial Forestry on Marginal Land (1950).

This study, concerned with whether non-productive lands might be planted as commercial forest areas, concludes that mahogany appears to offer the greatest potential for commercial forestry. (This report is in the library of Castle and Cooke Co., Ltd.)

"Cork Oaks Grown for Possible Isle Industry," Honolulu Advertiser (April 9, 1950) and "Cork Tree Plantings Being Discontinued" (January 3, 1954).

These articles report the attempt of the Division of Forestry of the Board of Agriculture and Forestry to determine the economic benefits of a local cork industry. In 1952, William Crosby, Territorial Forester, reported that the experimental plantings did not experience good growth.

Department of Agriculture and Conservation, Division of Forestry, Five-Year State Planting Plan for the State of Hawaii 1962-66 (Honolulu, March, 1961). 20 pp., mimeo.

Cost estimates of planting are provided, as well as information regarding location, acreage and species to be planted. The plan implies the development of a commercial timber industry.

Ericksen, L. N., Survey of Wood Utilization Possibilities in Hawaii, Pacific Experiment Station, U. S. Forest Service (Berkeley, 1958). 4 pp., mimeo.

This report summarizes a survey by the author, Chief of the Forest Utilization Research Division of the Pacific Experiment Station, of Hawaii's forests in 1958. It emphasizes that a substantial wood utilization program in the State is possible but must be supported with an adequate and sustained supply of raw materials. This would demand the establishment of a permanent industry, the planting of selected species on suitable sites, and effective management to obtain optimum quality and volumes of timber. The commercial use of Hawaiian woods for construction and furniture has already been demonstrated but the development of markets outside of Hawaii should be deferred until commercial quantities are available.

Fleming, David T., "A Fortune in Our Forests," Hawaii Farm and Home, 7:2 (February, 1944), 6-7. Illus.

The author argues that many areas in the Territory overrun by goats and cattle should be returned to forest primarily for water conservation. He suggests that one way to accomplish this is to indicate the returns private capital might gain through commercial forestry.

Fowler, Nancy C., A Timber Sawmill Built Under State Auspices, Department of Planning and Economic Development, Information and Public Services Office (Honolulu, 1964). 25 pp.

This study, responding to a State Senate resolution of 1963, furnishes estimates of materials and costs needed by a sawmill operation capable of processing five to six million board feet of stumpage per year. After examining the pattern of Hawaii's lumber imports and the state of her forests, the author recommends the establishment of such a mill on the island of Hawaii with state aid at a cost of about $500,000.

Frazier, George D., Forest Products Market Research Program in Hawaii: Progress Report (January 20, 1964). 33 pp.

This progress report concerns work done under the terms of a $15,000 appropriation by the 1963 legislature for a market potential survey for Hawaiian woods. The author records tentative conclusions of a study of the Los Angeles furniture market as a potential market for Hawaiian hardwoods. The entire report finds that the consumer demand for wood products will rise steadily in the future.

Haan, Aubrey and William Crosby, "The Forest Resource," Hawaii Educational Review, 38:10 (June, 1950), 249-251. Illus.

The authors list five aspects of a program for improvement of the forest resource, one of which is developing the forest to provide wood for small industry. They argue that a heavier research commitment must precede the development of commercial forestry.

Hawaiian Electric Company, Limited, "Hawaii Cuts into a Growing Future" (Honolulu, 1959). 8 pp., illus. Booklet No. 1.

This brief pamphlet gives general information concerning Hawaii's timber potential and also discusses conclusions reached at the Timber Potential Conference, February 2-7, 1959, sponsored by various Chambers of Commerce. These indicate a belief in the potential of commercial forestry and outlines an 8-point research program to make capital investment less risky.

"Hawaii Fern-Wood, Ltd. Sees Expansion," Hawaii Business and Industry, 7:3 (September, 1961), 66-67.

This article discusses the operations of the Hawaiian Fern-Wood, Ltd. and the views of its president, Myron Wold. The company produces finished products from both tree fern and hardwoods grown on Hawaii. In a single year the company milled 70,000 board feet of hardwoods into irrigation stakes for sugar plantations. These hardwoods have also been used for the manufacture of pallets, flumes, fine flooring and paneling. Tree fern is made into growing-stakes for orchids and the like and is sold locally and on the mainland. Each tree fern specimen is utilized entirely for commercial purposes. Wold sees a large and viable timber industry in the islands within 30 years, based largely on the hardwoods, which can easily supply the state's needs.

Hosaka, Edward Y., "The Problems of Forestry and the Work in Progress Toward Reforestation in the Territory of Hawaii" (unpublished thesis, University of Hawaii, 1930). 49 pp., illus.

The author describes in detail the Board of Agriculture and Forestry and its mandate under the law. He discusses forestry activities and identifies some of the problem areas which have been solved. He predicts that a timber industry is possible in the near future (after 1930) in terms of such items as poles and fencing.

Judd, Charles S., "The Mesquite Circles the Globe," Hawaiian Forester and Agriculturist, 28:3 (July-September, 1931), 57.

This article discusses the commercial uses of mesquite (algaroba or kiawe), which was brought to Hawaii in 1928 by Father Bachelot. The wood makes valuable fuel and durable posts; its flowers bear pure white honey which is harvested and exported, and its pods supply fattening fodder for stock at dry season. Hawaiian mesquite was sent to Bahrein, off the east coast of Arabia, and used to supply shade, feed for animals and firewood.

_____, "Reviving the Sandalwood Industry," Paradise of the Pacific, 47:4 (April, 1935), 19-20. Illus.

This article suggests that experiments conducted in sandalwood growing indicate a twentieth century economic potential for reviving the industry in Hawaii. The author includes a description of various species and the difficulties of planting and caring for them.

Landgraf, Max F., "GI Forestry in Kauai," Hawaii Farm and Home, 6:12 (December, 1943), 6-7. Illus.

This describes the uses of forests on Kauai for war purposes and cites statistics concerning the amount of timber cut for these purposes on the island. The author describes forests at Grove Farm Company, Ltd.; Wm. Hyde Rice, Ltd.; Eric Knudsen Ranch; The Lihue Plantation Co., Ltd.

Lucas, Ernesto dela Cruz, "Evaluation of Market Data as a Guide for Forest Development in Hawaii" (unpublished M. S. thesis, University of Hawaii, June, 1963). 61 pp.

Through interviews and analysis of primary materials the author concludes that existing materials are inadequate for planning timber production and processing in Hawaii. He views his own work as partially filling this void. Lumber and wood products imported to Hawaii are classified and described and statistics are provided concerning their quantity.

"Lumber Firms Begin Promotion," Hawaii Business and Industry, 7:9 (March, 1962), 68-69.

This article discusses the plans of the Wood Products Association of Hawaii to promote wood as a building product. This organization, whose members include American Factors, City Mill, Hawaii Builders Supply, Honolulu Sash and Door, Lewers and Cooke, MidPac Lumber, Progress Carpenter Shop and Severin Lumber, accounts for about 90 per cent of all the wood marketed in the State. These firms are concerned with the displacement of wood by substitute construction materials.

Malcolm, F. B., "Factors Influencing an Expanded Sawmilling Industry for Hawaii," Forest Products Laboratory, U. S. Forest Service (Madison, 1960). 22 pp., illus. Report No. 2190.

The fact that the costs of logging and milling are about twice as high in Hawaii as on the mainland can partially be traced to the small capacity and low efficiency of Hawaii's sawmills. Nearly all of the 20 mills reported extant in 1959 were surplus from military forest activities during the war. Of these, only 10 were operating. Four were producing standard length lumber items, all on the island of Hawaii, and six were producing craftwood flitches. The largest was located on the Kulani Prison grounds and produced primarily for prison use.

Nelson, Robert E., "Forest Products Harvested in Hawaii: 1958 and 1960," Pacific Experiment Station, U. S. Forest Service (Berkeley, 1962). 3 pp. Miscellaneous Paper No. 71.

Products milled from Hawaii's forests account for about 1 per cent of the approximately 100 million board feet of wood used annually in the State. This paper analyzes the response to questionnaires sent to all known producers of forest products in Hawaii. As of 1960, the value of Hawaii's forest products had decreased 27 per cent from the 1958 level. The major decrease occurred in the production of craft logs because of the declining availability of valuable monkey-pod. The paper concludes that: (1) eucalyptus lumber is finding a small but growing market owing to the efforts of pioneers in the industry; (2) craft producers have turned to offshore sources for monkey-pod; (3) tree fern logs support an appreciable segment of the forest products manufacturing industry.

_____, "Forestry Potentials in Hawaii" (reprinted from Soil Conservation in the Pacific, Tenth Pacific Science Congress Series (University of Hawaii Press, 1963), 19-21).

The author refers to the 1958 Timber Resource Review and particularly a footnote in that report indicating that figures were not included from Hawaii and other territories because of the minimal timber quantity in these areas. He reports that a timber inventory then underway in Hawaii was leading foresters to believe that the Hawaiian resource was quite large. The fact that more than one million acres of land was performing the single function of providing forage for livestock should, he says, lead to consideration of a multi-use program for these lands involving forestry and ranching. He reports that 1,500 acres were cleared and planted with valuable timber species in the State in 1962 and almost 3,000 acres were to be planted in 1963.

_____, "Silk-oak in Hawaii--Pest or Potential Timber?", Pacific Experiment Station, U. S. Forest Service (Berkeley, 1960). 5 pp., illus. Miscellaneous Paper No. 47.

Ranchers in Hawaii have gone to such expense to eradicate silk-oak (Grevillea robusta), but foresters feel that the tree is one of the most promising for a hardwoods timber industry in Hawaii. The author argues that range and forest values are compatible. After a discussion of the low

commercial potential of native Hawaiian trees, the author notes that silk-oak could be a prime source of fine cabinet wood, plywood, furniture material and general construction lumber because of its fast growth rate in Hawaii and ease in handling. Some silk-oak is milled by Hawaiian Fern-Wood, Ltd., Hilo.

Nelson, Robert E. and E. M. Hornibrook, "Commercial Uses and Volume of Hawaiian Tree Fern," Pacific Experiment Station, U. S. Forest Service (Berkeley, 1962). 10 pp., illus. Technical Paper No. 73.

Several tree fern species grow quite large in Hawaii and almost every part of the plant is commercially useful. The author cites estimates indicating that of the 151,000 acres on the island of Hawaii supporting tree fern where harvesting is permissible, 107,000 acres are under state control. These areas yield 700 to 800 cubic feet of marketable logs per acre in the best districts and 176 cubic feet per acre in others. Harvesting and processing tree fern is the basis of a small but thriving industry in the State.

Nelson, Robert E. and Philip R. Wheeler, Forest Resources of Hawaii--1961, published jointly by the Forestry Division, State Department of Land and Natural Resources, and the Pacific Experiment Station, U. S. Forest Service, Berkeley (Honolulu, 1963). 48 pp., illus.

This is the most comprehensive inventory of standing timber in Hawaii and of lands suitable for growing timber. Of the nearly 2 million acres of forest land in the State, 1.1 million either produces or can produce timber crops. The authors conclude that an export market should be developed for Hawaii's hardwoods, but this must be preceded by a statewide forestation program. The report advocates the application of the multiple-use concept to the management of Hawaii's forest lands and notes the recent shift from custodial preservation of these lands to intensive development and management. Reforestation and the lumbering and wood processing industry which could flourish in the State should concentrate mainly on introduced species of hardwoods since native hardwoods are low in quality. Based on an average value of $25 per thousand board feet of stumpage (standing timber), 100 million board feet (the approximate quantity imported to the state every year) would return $2,500,000. The land producing timber could also produce water, forage resources, recreation areas and wildlife habitats. Twenty-one tables are appended furnishing statistics concerning the distribution of various species of trees and other matters.

Otteson, Conner Piper, A Study of Lumber Distribution in Hawaii (unpublished M. A. thesis, University of Hawaii, 1961). 90 pp.

This work is mainly concerned with the lumber imports into the State. The bibliography contains works useful for such inquiry. The author cites certain problems, like the development of a processing industry and an intensive forestation program, that must be overcome before an expanded forest industry in the islands is possible.

Pickford, Gerald D., "Hawaii Forest Futures," one page mimeo.

This paper argues that few agricultural crops can match the value of timber production. He points to the fact that all of the one million board feet of lumber produced in the State comes from clearing operations which have been proceeding steadily on the island of Hawaii for ranching, sugar and subdivision purposes. One rancher cleared a 36-year-old stand of silk-oak in the Kau district for agricultural use in 1961. He could have realized $120 per acre per year from stumpage for the period 1925-61. (This paper is available at the U. S. Forest Experiment Station, Honolulu.)

_____, "Opportunities for Timber Production in Hawaii," Pacific Experiment Station, U. S. Forest Service (Berkeley, 1962). 11 pp., illus. Miscellaneous Paper No. 67.

This report is a sketch of the history of forest policy in the Territory, as well as a discussion of the State's current forestation plans. The author estimates that over 200 million board feet can be produced annually from the 400,000 acres of forest reserves best suited for timber production.

Ripperton, J. C., "The Hawaiian Tree Fern as a Commercial Source of Starch," Hawaii Agricultural Experiment Station (Washington D. C., July, 1924). 16 pp., illus. Bulletin No. 53.

The author indicates that although tree fern starch compares favorably with cornstarch and arrowroot starch for food and laundry purposes, it cannot compete with these in Hawaii because of the high labor cost involved in processing it. When the industry began about 1920, many were concerned that cutting the trees would impair the water conserving ability of forested areas. Experiments carried out in response to this concern led the author to conclude that cultivating tree fern was not feasible since its growth rate is too slow. He advocates the production of tree fern starch only as a special purpose substance so that it need not compete with cornstarch and potato starch for industrial uses.

"Sandalwood Has Failed to Make Comeback Here," Honolulu Advertiser (November 13, 1949).

The author finds that sandalwood has failed to reproduce itself since its exploitation early in the nineteenth century. Seeds have failed to germinate in nurseries and natural reproduction has been hindered by cattle grazing and by staghorn fern and other plants which crowd out young shoots. However, Indian sandalwood, a close relative of the native species, was being planted at the rate of about 500 trees a year in the Territory in 1949.

Sandvig, E. D., Christmas Tree Production and Sales Policy for Timber and Other Forest Products (Memorandum to Walter W. Holt, State Forester) (October 7, 1959). 9 pp., mimeo.

Basing his comments on cost and revenue figures of a Norfolk-island pine plantation on 3.87 acres of state land in West Maui, the author concludes that the management of land for Christmas tree production would yield in some areas several times more than the $20 per acre per year received from the Maui site. Three pages of the memorandum discuss the rules regulating the activities of the division of forestry.

Schwartz, S. O., "Hardboard from Ohia," Forest Products Laboratory, U. S. Forest Service (Madison, 1960). 10 pp., illus. Report No. 2205.

Ohia wood, defibered in an Asplund Defibrator and refined in a single-disk mill, is a satisfactory raw material for the production of Class I and tempered-grade hardboard.

Skolmen, Roger G., "Forests and Forest Products in Hawaii--Past, Present, and Future" (reprinted from Southern Lumberman, December 15, 1961). 3 pp., illus.

After a general discussion of the history of forest planting in the Territory, the author concludes that small quantities of koa, ohia, Eucalyptus robusta and silk-oak could be exported now as lumber, veneer flitches and logs. These and several other species will become available in quantity in about 20 years.

"Timber--Bigger than Sugar?", Hawaii Business and Industry, 8:8 (February, 1963), 48-50.

This article cites the views of Robert E. Nelson, Research Forester of the U. S. Forest Service in Hawaii, that timber can be a $200 million industry and provide jobs for 18,000 people in 30 years. This is about one-third higher than the present annual sugar industry. Nelson argues that it is presently possible for the market to support two large sawmills--one on Maui with a five million board feet per year capacity and another twice as large on Hawaii. These could produce hardwoods and deliver them to Honolulu at the rate of $160 per thousand board feet as compared with the $210 per thousand board feet paid presently for mainland imports. Imported hardwoods from the mainland are shipped by rail from the eastern region to New Orleans and it is therefore possible for Hawaii to export hardwoods at a cheaper price to West Coast buyers. Nelson also suggests that the 100,000 Christmas trees imported here annually could be easily grown locally.

"Timber Hawaii," Hawaii Farm and Home, 10:11 (November, 1947), 12-16. Illus.

This is a general account of the koa lumbering operation at Kulani Prison, Hawaii. The article reports that Frank J. Connolly of Los Angeles surveyed the feasibility of large scale production of koa near the prison and found the project commercially sound. It also cites estimates that if 100,000 board feet of koa and ohia were harvested from forests on Hawaii each year, it would take 600 years to deplete the reserve if harvested areas were not replanted.

U. S. Forest Service, "Robusta" (Honolulu, 1964). 1 p., mimeo.

This summarizes a survey determining the amount of Eucalyptus robusta standing in Hawaii's forests (110 million board feet); the amount produced and sold (500,000 board feet annually); and the uses to which this lumber has been put. The report concludes that robusta is the species upon which Hawaii must largely base an expanded forest industry.

Zschokke, Theodore C., "Woodlots in Hawaii," Agriculture Extension Service, College of Tropical Agriculture, University of Hawaii (June, 1931). Extra Bulletin No. 14.

The author discusses the uses around the farm and homesite of eight trees common in Hawaii: kiawe, Eucalyptus robusta, black wattle, Java plum, haole koa, Madre cacao, kukui and ohia.

II. TECHNICAL REPORTS

Bryan, Lester W., "Timber Qualities of Some Exotic Timber Trees in Hawaii--A Preliminary Report," Report of the Board of Commissioners of Agriculture and Forestry of the Territory of Hawaii for the biennial period ending June 30, 1952 (Honolulu, 1952), 106-109.

This article contains the results of a timber survey of the island of Hawaii. It indicates that in 1952 there were 800 acres of land supporting about 30 million board feet of stumpage. This amount consisted of 21 introduced species. An examination of the milling characteristics of some of these and other species is contained in a following article by Myron Wold, Hawaiian Fern-Wood, Ltd., "Preliminary Report on Uses and Milling Characteristics of Exotic Timber Trees," (109-112). The milling, checking and warping characteristics of 36 species are discussed.

Cossitt, Floyd M., A Plan for a Centralized Nursery for the State of Hawaii, Pacific Experiment Station, U. S. Forest Service (Berkeley, 1960). 40 pp., illus., maps.

This is a discussion of the Kamuela tree nursery.

Drow, John T. and Omar M. Ali, "Mechanical Properties of Green Ohia from Hawaii," Forest Products Laboratory, U. S. Forest Service (Madison, 1958). 35 pp., illus. Report No. PE-168.

Although ohia is substantially heavier than hickory, one of the heaviest commercial woods grown on the mainland, such properties as bending strength, stiffness, crushing strength and shearing strength, are generally lower.

Gerhards, C. C., "Some Strength and Related Properties of Green Wood of Hawaiian Eucalyptus Saligna," Pacific Experiment Station, U. S. Forest Service (Berkeley, 1963). 8 pp., plus illus.

Evaluations of the properties of this eucalyptus were made from observations of trees grown near Pahala and Honokaa on Hawaii. The greenwood of Eucalyptus saligna, with an average specific gravity of 0.59, averaged higher in strength properties than shagbark hickory and Hawaiian Eucalyptus robusta and ohia. Its shear strength and toughness does not, however, match that of hickory and ohia.

Hicks, Leslie Asa, "Laboratory Experiments of Timber at the College of Hawaii," Ka Palapala, 2:1 (May, 1917), 48-55. Illus.

This article considers the methodology and some findings of engineering tests concerning Hawaiian woods. It discusses structural designs, such as short or long column construction, and reports tests designed to determine the compatibility of different woods with these designs.

Margolin, Louis, "Eucalyptus Culture in Hawaii," Board of Commissioners of Agriculture and Forestry, Division of Forestry (Honolulu, 1911). 80 pp., illus. Bulletin No. 1.

Various eucalypti, all extant in Hawaiian forests, are discussed with respect to comparative commercial worth. The author comments on the uses of these trees in Australia, as well as the problems experienced with growth rate, form and their natural enemies in Hawaii. Although he emphasizes the worth of eucalypti for fuel wood on the plantations, the author suggests that the species Eucalyptus saligna is especially useful as a timber tree.

Pickford, Gerald D. and Russell K. LeBarron, "A Study of Forest Plantations for Timber Production on the Island of Hawaii," Pacific Experiment Station, U. S. Forest Service (Berkeley, 1960). 17 pp., tables, illus. Technical Paper 52.

This report studies growth-rate and form of four introduced species of hardwoods: Eucalyptus robusta (swamp mahogany eucalyptus), Eucalyptus saligna (flooded-gum eucalyptus), Fraxinus uhdei (tropical ash), and Toona ciliata var. australis (Australian red-cedar). The authors, who undertook this study to determine the suitability of these species for use in an expanded forestation program aimed at the development of a commercial timber industry, found that Eucalyptus saligna had the greatest average yield--2,100 board feet per acre per year. They indicate that this figure, as well as those concerning the other three species, can be raised by better planting and management techniques.

"Reforestation Inventory," U. S. Army, Forces in Middle Pacific, Reforestation Series D - Subject 1 (Honolulu, 1946). 8 pp.

This describes the activities of the U. S. Army in transplanting 80,000 forest seedlings on 337 acres. Army planes were also used to scatter 700 pounds of forest seeds on 750 acres of land.

Richmond, George B., "Species Trials at the Waiakea Arboretum, Hilo, Hawaii," Pacific Experiment Station, U. S. Forest Service (Berkeley, 1963). 21 pp., illus. Research Paper PSW-4.

Survival counts were made of 84 exotic tree species planted during 1956-60 in a cleared rain forest area near Hilo. Growth measurements were recorded for five- and six-year old plantings. Most species had good survival, but some failed completely. Soil depth had a strong influence on the rate of growth but not on survival. Several valuable timber species showed remarkable growth. The report lists possibilities for future uses and contains recommendations for the development of the arboretum. Appended is a map of the arboretum indicating the species planted 1956-60.

Skolmen, Roger G., "Robusta Eucalyptus Wood: Its Properties and Uses," Pacific Experiment Station, U. S. Forest Service (Berkeley, 1963). 12 pp., illus. Research Paper PSW-9.

This work summarizes research concerning robusta done in recent years. Eucalyptus robusta (swamp mahogany) is the most abundant of the timber trees introduced into Hawaii. The author finds that the wood of this tree has found market acceptance in Hawaii for rough construction and interior finish. He suggests that the quantity of research concerning robusta done in recent years has yielded information which could lead to an expanded number of uses for the wood.

_____, "Wood Density and Growth of Some Conifers Introduced to Hawaii," Pacific Experiment Station, U. S. Forest Service (Berkeley, 1963). 20 pp., illus. Research Paper PSW-12.

The specific gravity of the wood of 14 conifers grown in Hawaii was measured by means of increment cores. Most species were growing in environments quite different from their native habitats. The specific gravity and growth characteristics under several site conditions were compared. Described in some detail are Norfolk-Island-pine, slash-pine, Jeffrey pine, jelecote pine, cluster pine, Monterey pine, and loblolly pine. More limited information is given for short-leaf pine, Luzon pine, Masson pine, long-leaf pine, eastern white pine, Yunnan pine and Douglas-fir.

Skolmen, Roger G. and Harvey Smith, "Drying of Silk-Oak in Hawaii," Pacific Experiment Station, U. S. Forest Service (Berkeley, 1962). 11 pp., illus. Technical Paper No. 65.

A study of methods of piling silk-oak in Hilo, Hawaii, showed that drying was more rapid in piles spaced 5 feet than in those spaced at 1 foot. Roofing had no influence on drying rate or degrade due to drying. Principal drying defects were blue stain of sapwood, end splitting, and surface checking. The drying of lumber is greatly influenced by Hawaii's great climatic variations and the methods of piling lumber on the yard.

Smith, H. H., "Wood Quality Studies to Guide Hawaiian Forest Industries," Pacific Experiment Station, U. S. Forest Service (Berkeley, 1960). 19 pp., illus. Miscellaneous Paper No. 48.

This report discusses the high quality of wood consumed in the Hawaiian market because of shipping prices, remanufacturing costs and construction habits in the islands. Lumber used in single-wall houses is viewed from both sides. Since Hawaii has no highly developed wood processing industry, lumber is imported in ready-to-use form. The author suggests that more studies be conducted comparing promising Hawaiian hardwoods with imported woods to obtain more solid information about whether or not the substitution for imported species can be made. He reviews what is known about the hardness, strength, natural resistance to termites and disease of nine species growing in the islands and suggests further studies to round out this information. The trees discussed are: ohia, Eucalyptus robusta, Australian toon, shamel ash, cigarbox cedrela, redwood, silk-oak, Nepal alder, Brayley flindersia (Queensland-maple).

Smith, Harvey and Roy H. Baechler, "Treatment of Hawaiian Grown Wood Posts by the Double-Diffusion Wood Preservation Process," Pacific Experiment Station, U. S. Forest Service (Berkeley, 1961). 8 pp. Research Note No. 187.

Twelve wood species were tested with this inexpensive non-pressure preservative treatment developed by the U. S. Forest Products Laboratory at Madison, Wisconsin. Results were quite encouraging, when the availability of the wood as well as treatment was considered, especially for Eucalyptus saligna, silk-oak, Eucalyptus globulus and robusta. The authors suggest that more testing work be done, especially of peeled posts.

Strolman, Robert E., "Preservative Treatments for Eucalyptus Fence Posts," Hawaii Agricultural Experiment Station (Honolulu, December, 1957). 19 pp., illus. Bulletin 14.

After describing the procedure and equipment used in various types of post treatment the author recommends the treatment of bluegum (Eucalyptus saligna) and swamp mahogany (Eucalyptus robusta) posts with creosote either by pressure or bath.

Wold, Myron L., Forest Utilization for Lumber--Seven Selected Hawaiian Hardwoods--Special Report (Hilo, May, 1958). 6 pp., mimeo.

This report rates seven Hawaiian hardwoods according to commercial lumbering purposes. Some of the factors considered are: usable height, rate of growth, potential acre yield, weight, per cent high grade lumber yield, disease susceptibility, and marketability. The seven woods are: Metrosideros polymorpha (ohia); Acacia koa (koa); Eucalyptus robusta (swamp mahogany); Eucalyptus saligna (Sydney bluegum); Grevillea robusta (silk-oak); Fraxinus uhdei (Hawaiian ash); Toona ciliata var. australis (Australian cedar); Cedrela odorata (Spanish cedar). Koa and ohia rated lowest against the criteria and Spanish cedar rated highest.

_____, Utilization of Exotic Hardwoods of Hawaii--Progress Report (Hilo, March 1, 1955). 15 pp., mimeo.

This report summarizes further volume tests of promising tree species and makes further recommendations for possible tree planting programs. Progress reports are given on the testing of the following woods: Albizzia moluccana, Cedrela australia, Jacaranda mimosaefolia, Grevillea robusta (silver oak, silk-oak), Hawaiian ash, and Eucalyptus robusta. A preliminary report on the preservation of species susceptible to the Lictus or powder post beetles includes an explanation of a treatment program using Pentachlorophenol and Isotox. A preliminary report on the economic forest value of tree ferns concludes that the Hawaiian tree ferns are not in danger of becoming extinct, but that a selective harvesting program and planting policy is necessary to maintain proper future harvesting.

Youngs, Robert L., "Physical, Mechanical, and Other Properties of Five Hawaiian Woods," Forest Products Laboratory, U. S. Forest Service (Madison, 1960). 34 pp., illus. Report No. 2191.

This report concerns these woods: ohia (Metrosideros polymorpha), Eucalyptus robusta, Shamel ash (Fraxinus uhdei), Australian red cedar (Cedrela toona var. australis) and redwood (Sequoia sempervirens).

III. RESEARCH INVENTORIES AND PLANS

Anderson, Henry W., Walt Hopkins and Robert E. Nelson, in cooperation with the Forestry Division of the State Department of Land and Natural Resources, "A Program for Watershed Management Research in Hawaii Wildlands," Pacific Experiment Station, U. S. Forest Service (Berkeley, 1962). 15 pp., illus. Technical Paper 72.

This paper presents a list of questions that should be answered in order to determine how to improve the quantity and quality of Hawaii's water resources and to determine the extent to which these resources would be improved or impaired by broadening the uses of watershed areas. The authors suggest that four research areas be covered: (1) inventories of vegetation, soils, physiographic and climatic sites, and hydrologic and meteorological conditions; (2) basic studies of forest hydrology, forest meteorology and plant-soil-water relations; (3) plot and small-scale tests of land management practices; and (4) pilot testing of selected methods on calibrated watersheds.

Arnold, Keith, Status of Forest Research in Hawaii, January 1, 1961, Pacific Experiment Station, U. S. Forest Service (Berkeley, 1961).

This is a compilation of 18 research studies published by the Berkeley Station, U. S. Forest Service, between 1957-1961. (These titles are listed elsewhere in this bibliography.) The report summarizes research in the areas of watershed management, timber management, forest products utilization and forest survey. It is supplemented by a movie concerning Hawaiian forests. (The movie is held at the U. S. Forest Experiment Station, 400 South Beretania, Honolulu.)

Department of Agriculture and Conservation, State of Hawaii, A Wildland Research Plan for Hawaii (Honolulu, 1960). 71 pp., illus.

The first part of this work considers the problems and issues of the 50 per cent of Hawaii's land which performs the single function of providing water supplies. The research plan is divided into first and second priority projects totalling 284 man-years of effort. The projects are categorized in nine groups: (1) watershed research; (2) soils research; (3) silvicultural research; (4) forest products utilization research; (5) grazing land research; (6) wildlife habitat research; (7) recreation research; (8) forest protection research; (9) forest economics research. Several of the suggested projects have already been carried out.

Department of Land and Natural Resources, Division of Forestry, A Multiple Use Program for the State Forest Lands of Hawaii (Honolulu, 1962). 50 pp., illus.

The booklet suggests a multi-use program involving the use of forest lands for water conservation, timber, forage, recreation and furnishing wildlife habitats. The department argues that 300,000 acres of state forest lands should be planted with tree species of known commercial value. A research and development plan for the state-owned forest lands which would cost the State about $11 million over a ten-year period is advocated. The program would receive an estimated $800,000 from the federal government during the period for various cooperative forestry programs. All of this would pertain to lands presently serving as watershed.

Forest Research in Hawaii 1957-1962, Pacific Experiment Station, U. S. Forest Service (Berkeley, February, 1963). 9 pp.

This is a survey of research by bibliographic listing, with an outline of problems in need of further examination.

"Report of the Committee on the Ten-Year Program to the Chairman of the Second Convention of the Forestry Problems of Oahu," Hawaiian Forester and Agriculturist, 26:1 (January-March, 1929), 1.

This report presents to the convention a number of recommendations for a forestry program on Oahu. The report recommends the holding of annual conventions, the introduction of foreign trees and plants, the testing of such trees in well-conducted arboretums and educational work in forestry by the University of Hawaii. The emphasis is on watershed conservation by means of tree species not commercially useful.

U. S. Forest Service in cooperation with the Department of Land and Natural Resources, Forestry Research in Hawaii; Program and Progress (Berkeley, 1963).

This is the latest report of published materials and research in progress concerning forest economics, watershed management, silviculture, and forest products. Appended are examples of research designs and publications.

IV. TREE NAMES AND FOREST DESCRIPTIONS

Bryan, Lester W. and Clyde M. Walker, "A Provisional Check List of Some Common Native and Introduced Forest Plants in Hawaii," Pacific Experiment Station, U. S. Forest Service (Berkeley, 1962). 36 pp. Miscellaneous Paper No. 69.

This index lists the scientific and common names for more than 150 genera of trees plus several shrubs, ferns, and vines.

Hosaka, Edward Y. and T. Thistle, "Noxious Plants of the Hawaiian Ranges," University of Hawaii Agricultural Extension Service (1954). 39 pp., illus. Bulletin 62.

This is a simple listing of noxious plants, along with brief notes concerning them.

Rock, Joseph F., Indigenous Trees of the Hawaiian Islands (Honolulu, 1931). 518 pp., illus.

This is a rather technical description of native trees.

_____, "The Ohia Lehua Trees of Hawaii," Board of Commissioners of Agriculture and Forestry, Division of Forestry, Territory of Hawaii (Honolulu, 1917). 76 pp. Botanical Bulletin No. 4.

This is a technical article describing various species of ohia.

_____, "A Revision of the Hawaiian Species of the Genus Santalum," Board of Commissioners of Agriculture and Forestry, Division of Forestry, Territory of Hawaii (Honolulu, 1931). 43 pp. Botanical Bulletin No. 3.

This is a technical work listing various species of sandalwood.

Swezey, Otto Herman, Forest Entomology in Hawaii, Bishop Museum (Honolulu, 1954). 26 pp., illus. Special Publication 44.

This is a check-list of insect fauna in various kinds of Hawaiian forests.

Zschokke, Theodore C., "A Manual for Tree Planters in the Hawaiian Islands," University of Hawaii Agriculture Extension Service (January, 1930). 50 pp., illus. Bulletin 5.

This is a rather technical discussion of the process of growing and planting trees in the Territory.

V. GENERAL WORKS

Arnold, Keith, Concepts of Multiple Use for Hawaii's Wildland (Paper presented at the Conference on Wildland Research Plan for Hawaii, Honolulu, February 7, 1961), Pacific Experiment Station, U. S. Forest Service (Honolulu, 1961). 4 pp., mimeo.

The author argues that Hawaii is experiencing increasing demands for the use of all her land. Because usable land is so limited, multiple use must be made of it. In this way the full potential of forest lands for water, forage, wood, recreation and wildlife could be realized. (This paper is available at the U. S. Forest Experiment Station, 400 South Beretania, Honolulu.)

Board of Commissioners of Agriculture and Forestry, Territory of Hawaii, Report of the Board of Commissioners of Agriculture and Forestry, Biennial Reports, 1900-1958. (some illustrated)

These reports often include summaries of technical forestry matters as well as discussions of forestry and forest reserve policy.

_____, "Underlying Principles of Hawaiian Forest Policy," Report of the Board of Commissioners of Agriculture and Forestry for the Year Ending December 31, 1908 (Honolulu, 1909), 19-20.

This report outlines the values and uses of the two main classes of forest lands--"water-bearing forest" and "commercial forest".

Bryan, Lester W., "The Big Fence on the Big Island," Paradise of the Pacific 49:4 (April, 1937), 15, 30.

This article describes the construction of a fence enclosing Mauna Kea Forest Reserve. It also mentions the menace of wild sheep which prevented natural reproduction of the predominating tree growth of Mamani.

_____, Twenty-five Years of Forestry Work on the Island of Hawaii (reprint from The Hawaiian Planters' Record, 51:1 (1947), 1-80). 80 pp., illus.

This article summarizes work on the island of Hawaii between 1921 and 1946 in eliminating wild goats, sheep and cattle from the forest reserves, and in fencing and tree planting. Nearly 8 million trees were planted during the period on about 19,000 acres of land. More than 90 per cent of these survived.

Crosby, William, "Forestry in the 49th State," American Forests, 59:7 (July, 1953), 20-22, 43-45. Illus.

This is a general history of the management of forest lands in the Territory. The author was the territorial forester from 1939 until 1955 with a short interruption in 1952.

Hall, William Logan, "The Forests of the Hawaiian Islands," U. S. Department of Agriculture, Bureau of Forestry (Washington D. C., 1904). 29 pp., illus. Bulletin No. 48.

This describes the denuding of forest lands for ranching and sugar production. The author suggests an immediate reforestation program aimed, among other things, at the development of commercial timber stands.

Hawaiian Forester and Agriculturist; a quarterly magazine of forestry, entomology, plant inspection and animal industry, vol. 1-30, no. 1 (January, 1904 and January/March, 1933). Monthly, 1904-22; quarterly, 1923-33.

This journal functioned as the organ of the Board of Commissioners of Agriculture and Forestry, Territory of Hawaii. Several of its issues include the board's annual reports. Other articles deal with technical questions concerning forestry.

Hosaka, Edward Y., History of the Hawaiian Forest, University of Hawaii (1931). 25 pp., typewritten.

This is an account of the views of eighteenth and nineteenth century observers of Hawaiian forests and the uses of these areas.

Hosmer, Ralph Sheldon, "The Beginning Five Decades of Forestry in Hawaii," Journal of Forestry, 57:2 (February, 1959), 83-89. Illus.

This article describes foresters and forestry activity in Hawaii from 1904 to statehood. Its author was the most important pioneer in forest development and utilization in the early years of the Territory.

MacCaughey, Vaughan, "Economic Woods of Hawaii," Forestry Quarterly, 14:1 (March, 1916), 696-716.

This article describes the commercial uses of ohia, koa, kukui, kiawe, sandalwood and hau.

_____, "Hawaii's Tapestry Forests," Botanical Gazette, 70:2 (August, 1920), 137-147. Illus.

This article discusses the topographical and climatic characteristics of Hawaiian rain forests. The author names the plants and trees growing in these areas and briefly discusses the disappearance of forest cover in certain places because of goat and cattle grazing.