PUBLIC LAND POLICY IN HAWAII: THE MULTIPLE-USE APPROACH

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FOREWORD

Publication of this revised and expanded report on the multiple-use approach to management of Hawaii's natural resources constitutes one of the concluding phases of a research program dealing with public land policy in Hawaii. This research program was initiated by the Legislative Reference Bureau in 1963 at the request of Hawaii's State Legislature. The Bureau was asked to prepare a comprehensive historical analysis of public land policies and practices of the federal and state governments, with particular emphasis on a review and analysis of land policy in Hawaii from 1893 to the present. Three major monographs were prepared in response to this request: Hawaii's Public Land Laws: 1897-1963 (1963); Land Exchanges (1964) and The Multiple-Use Approach (1965).

Public response to publication of the multiple-use study was such that copies of the monograph were quickly exhausted. The volume has been out-of-print for several years and virtually unobtainable. Because of continuing, persistent demand for the volume and because the data contained in it are indispensable for adequate understanding and consideration of the analyses presented in other monographs in this series, especially the concluding volume, the Bureau is responding to the suggestion of legislators and others to make this new edition available. A proper response to this suggestion required that our staff update the extensive annotated bibliography material which has been found to be especially useful to those interested in the multiple-use approach. It has also been necessary to incorporate minor changes in the text to take account of the findings of post-1965 research and other developments. As is evident from the Summary that follows, revisions in the 1965 text have been minimal.

The 1963 legislative request for research on land policy in Hawaii was broadened and extended in 1965 through Senate Resolution Number 128, which requested that the Legislative Reference Bureau update its earlier study of Hawaii's "large private land owners." Specifically, this Senate Resolution requested the Legislative Reference Bureau to study Hawaii's "large private land owners and land use, giving special attention to the many important factors relating to our land resources."

Three additional monographs were prepared in response to the 1965 legislative request: Land Reserved for Public Use (1966); Major Landowners (1967); and An Historical Analysis (1969). These

monographs amplify the findings of this study of the multiple-use approach to land management and may best be understood by reference to it.

Note should be taken of one major addition that has been incorporated in this revised edition of the multiple-use study. A number of legislators and other policy makers have suggested that a capsulized statement of our findings would be helpful. Accordingly we have prepared the brief summary that immediately follows this Foreword. The addition of this summary has further facilitated the updating of the study by minimizing changes in the earlier text, for it has enabled us to take account of recent developments and to incorporate substantive points of interest based on extended discussions held with interested individuals as we updated our materials. Significant portions of the overall presentation and argument have been condensed in this summary, and the interested reader will, of course, find the full, supporting arguments and data in the body of the report.

The execution of the original study and this revised edition would not have been possible without the assistance of many individuals and agencies, including Dr. Harold Baker, Director of the Land Study Bureau of the University of Hawaii and Mrs, Faith N. Fujimura, cartographer at the Land Study Bureau. We are, as always, especially indebted to Mr. James Dunn, Hawaii's extraordinarily knowledgeable, former Territorial and State Surveyor and to Miss Agnes Conrad, State Archivist. Mr. Robert Nelson and Mr. Roger Skolmen of the Forest Service, United States Department of Agriculture, were unstintingly generous, and made it possible for us to prepare and to update the comprehensive bibliography without which this study would be manifestly deficient. We are also obligated to the U.S. Forest Service for the photographs appearing in chapters I, III, and V. Mr. George K. Ikeda and Mr. Robert T. Hokama of the Legislative Reference Bureau assisted in preparation of the text, while Nancy K. Hammond of the Social Science Research Bureau, Michigan State University, edited the manuscript. Miss Hanako Kobayashi edited and ordered the extensive footnotes and the annotated bibliography. Mrs. Maizie Yamada and Miss Evelyn Goya of the Legislative Reference Bureau typed the revised manuscript.

The Legislative Reference Bureau is especially indebted to the many readers who displayed extraordinary patience in criticizing successive drafts of the original study. That their generosity was not exhausted was manifested by their additional contribution in assisting us with the task of revision. These readers and consultants include persons of diverse backgrounds: businessmen, attorneys,

engineers, academics, and numerous officials from federal, state, and county governments. Their suggestions proved extremely helpful and have largely been included in the study.

Staff and financial assistance were provided by the All-University Research Fund of Michigan State University and by the Rockefeller Foundation. To those individuals and organizations here enumerated and to the many others who assisted us in the preparation of this study, we express our sincere appreciation.

I am especially grateful to Professor William V. Frame of the Department of Political Science, Kenyon College for his indispensable contribution to the revision of this study. To Professor Robert H. Horwitz of Kenyon College I should like to express appreciation for his years of service as an associate of the Legislative Reference Bureau in contributing to the preparation of this and other studies and for having served as Director of the Land Study Project since its inception in 1963.

Henry N. Kitamura
Director

August, 1969

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SUMMARY

During the five-year period since this study was first published, the multiple-use approach to the development and management of Hawaii's public land has been accepted increasingly by public policy makers and private landowners alike. Current developments appear to support the basic argument of the study; indeed, they suggest that its recommendations may be of greater import than they were five years ago, when it was suggested that:

> . . .for well over a century, the utilization of Hawaii's public lands has been guided by what may be called the "single-use" approach to land policy--that is, by the view that a given land area, or type of land, should be utilized exclusively for a single purpose at any given time. A notable example of this policy has been the leasing of enormous areas of public land for the exclusive purpose of ranching. Other large tracts of public land have been utilized exclusively for over a half-century as water reserves when, as is now realized, with the introduction of safeguards designed to protect domestic water supplies would have made it possible to utilize these watershed areas for other purposes simultaneously.[1]

Our study postulated that the traditional, "single-use" approach to land management in Hawaii effectively foreclosed the full development of roughly half a million acres of publicly owned forest and related land. This land area has always had the potential to support a commercial timber industry in Hawaii which, at today's prices for hardwood timber, lumber, and other products, could be worth as much as one hundred million dollars per year to the Islands' economy. While this land area is producing timber, it could simultaneously sustain greatly increased recreational activities, be aesthetically enhanced, and materially improve the functioning of watersheds. Thus, by putting the Islands' public land to multiple use, desperately needed recreational resources could be made available for the burgeoning tourist industry and for Hawaii's citizenry alike. A citizenry gaining ever greater leisure and affluence could thereby secure respite from the mounting pressures succinctly described as "urban cramp". The multiple-use of land might also provide some assistance to Hawaii's faltering ranching industry. In any event, conversion of grazed or cultivated land to forest cover (which can provide season grazing and year around recreational use), could significantly enhance watershed values.

An underlying premise of our suggestion for consideration of the multiple-use approach five years ago was that the prospects:

> . . .for commercial forestry in the Islands are excellent. This premise is not arbitrary, nor has it been accepted lightly. The evidence for it has been carefully examined and weighed for many years by businessmen, the U.S. Forest Service, and others. The conclusion to which they have been consistently drawn is that the full development of public and private land suited for timber production could make commercial forestry a major industry in Hawaii within some 35 years. The ultimate size attainable by this industry is necessarily a matter of conjecture, but there is evidence to support the contention that its contribution to Hawaii's economy could eventually equal or even surpass that now being made by the pineapple or sugar industries. The most sanguine estimates suggest that full-scale timber production and processing could generate as much as $150,000,000 to $200,000,000 annually (the present approximate range of the sugar industry), while providing employment for as many as 15,000 to 20,000 people. Furthermore, depending on the extent to which wood processing and associated manufacturing industries were developed in the Islands, the ultimate long-range potential of this complex of related industries could produce an annual return at least twice that derived from timber production and processing alone, while employing as many as 30,000 to 35,000 people.[2]

Developments in Hawaii and elsewhere over the past five years appear to lend credence to these estimates. Of special significance within the state has been the growth of small but developing logging and milling enterprises on the islands of Maui and Hawaii. Within the past few years, four firms have begun to harvest hardwood trees from the Islands' forests, mill them into lumber and other wood products, and market them both locally and elsewhere in the Pacific Basin. While these enterprises do not by any means constitute the first, successful timbering operations in the Islands, and although one of these firms is faltering economically because of poor management practices, the success of at least two of these firms is helping to demonstrate the present economic feasibility of commercial timbering in Hawaii utilizing koa and ohia, as well as stands of exotic hardwoods. The contribution of these firms to Hawaii's economy is pioneering in the sense of opening local, West Coast, and Asian markets to Hawaii-grown wood products. Since all of these markets have been adversely affected by the growing shortage of hardwoods throughout the world, this task is proving to be less difficult than anticipated. Should some of these enterprises become firmly established, it is almost certain that additional North American and Asian investors (a number of whom have already shown interest in Hawaii's commercial timber potential) will seek to establish a variety of wood products plants in the Islands to manufacture hard-board, fiber-board, furniture, and perhaps pulp products.

These sanguine expectations can be fulfilled, however, only if public and private landowners take the necessary steps to insure adequate timber resources in the future. With respect to Hawaii's public land, it is imperative that the State accelerate its present schedule of tree planting as part of an intensive land management program. At the present time, some 2,000 acres of public forest land are annually being planted by the State Division of Forestry. A sustained-yield timbering program commensurate with even a modest estimate of the potential of wood products industries in the State a few decades hence calls for a tree planting program at least three times larger, or a minimum of 6,000 acres planted annually. Such a program would cost approximately $750,000 annually, and would almost immediately yield valuable indirect benefits through the extension of recreational opportunities.

An intensified tree-planting program on public land should also enhance the prospects for the multiple-use of Hawaii's forest land by those private landowners who hold great acreages of forest land. For example, the firm of Alexander and Baldwin is presently selling Eucalyptus robusta stumpage from watershed areas on Maui.[3] Although the corporation is said to plan the replanting of harvested land, there is no evidence as yet that corporate management is convinced of the economic feasibility of undertaking reforestation of underproductive range land. A broadened and intensive statewide tree planting program on public land might contribute convincing evidence to some major private landowners of the feasibility of commercial forestry in the Islands. The possibility of a favorable conclusion being reached is perhaps enhanced by the generally acknowledged failure of traditional ranging practices which no longer serve to support a flourishing ranching industry in Hawaii, as well as the declining economic health of Hawaii's pineapple industry. Many of Hawaii's major landowners are presently searching for new uses for substantial portions of their land.[4] For example, areas planted to "Christmas tree"--timber types can provide cash crops along with forest recreation sites and improved watershed protection.

Any properly developed proposal for multiple-use management of Hawaii's public forest land must also seek maximum development of recreational areas for the ever-increasing number of tourists and the Islands' citizenry alike. This task can be successfully accomplished through close cooperation between many state, county, and federal agencies, including the State Division of Forestry and the Division of State Parks. The continuing failure in Hawaii to develop access to those parts of the public forest land suitable for hiking

and camping is intensifying "urban cramp," is contributing to the overcrowding of inadequate recreation areas, and to a growing but somewhat misguided demand to preserve as much non-urban land in a "natural" and therefore unproductive (except in some aesthetic sense) state. On this score, one may usefully distinguish "preservationists," who seek to preserve large land areas from any kind of use and to retain them in an undeveloped form, and "conservationists," or natural resource managers, who seek full use of resources through multiple-use management. Enormous land areas are already "locked-up" in Hawaii's great national parks, and perhaps additional land should be preserved in this way, but the State's policy makers must give the most serious consideration to the competing claims of preservationists and conservationists. One important, indirect effect of the preservationist attitude toward forest land has been a form of "backlash", i.e., an increasing demand for acquisition of extraordinarily expensive land for public recreation development in other areas--almost without regard to cost. Inasmuch as the State owns vast tracts of land in mountainous areas well suited to multiple-use, it is imperative that this hitherto untapped resource be developed to meet part of the increasing needs of the populace for recreational facilities.

Visitations to Hawaii's state parks, almost all of which are located in beach areas, have skyrocketed in recent years. Statistics released by the State Division of Parks reveals that its facilities were used by some 600,000 visitors in 1963. By 1968, when these facilities had been increased only minimally, the number of visitations reached some 5.3 million. Not only have greater affluence and leisure among Hawaii's residents contributed to this enormous increase, but also the changing character of tourism here is creating a growing demand for more outdoor recreational facilities. The argument advanced in this study in 1965 is even more pertinent now:

> . . .Today, an increasing number of Hawaii's visitors are unable or unwilling to remain long in expensive hotels or resort areas. More than 50 per cent of the tourists now entering Hawaii come from the West Coast, where the population is substantially younger than elsewhere on the mainland. Moreover, increased leisure and affluence in Japan have propelled a growing segment of that country's population into the world tourist market. Hawaii is already receiving increased patronage from Japanese nationals, who share with westerners an increasing appetite for outdoor recreation. This combination of youthfulness and modest, middle-class income suggests that an increasing proportion of these tourists will be in search of camping and lodge facilities comparable to those found in mainland recreation areas.[5]

The underdeveloped character of most of Hawaii's existing state parks, along with the lack of adequate maintenance in these parks, points to the desirability of linking the development of recreational facilities with programs of tree planting and commercial logging through multiple-use forest land management. Commercial forestry requires the development of roads, trails, fences, and the employment of forest rangers. All of these developments would simultaneously serve the requirements of the recreationist. To reiterate a question raised earlier, why not develop outdoor recreational facilities in areas that could support commercial forestry operations?

> . . .Such a combination of commercial forestry and recreational use of mountain land permits public investment to meet a combination of economic and social objectives. Furthermore, forest clearing, reforestation, and maintenance of stands of commercially valuable timber contribute directly to the utility and attractiveness of forest areas for recreation. Intensive development of such areas for recreational use requires additional expenditures for developing camp sites, damming and stocking streams, building lodges, and other improvements, of course. Mainland experience supplies convincing evidence that a significant portion of these development costs can be recovered directly through the leasing of concessions and, indirectly, through the stimulus provided to the economy of surrounding areas. Another significant indirect economic benefit in the case of Hawaii would be the increase in inter-island travel.[6]

Whatever the costs of developing recreational activities in public forest land, they would be relatively insignificant compared to the cost of purchasing and developing additional beach areas for parks--especially on Oahu. We find nothing incompatible between timber production, recreational use, and water production on the same land. Recreation use would be mildly disturbed only every twenty to thirty years when mature stands of timber are harvested. In the meantime, developed forest would provide especially desirable recreational habitat and watershed cover. This would require, as already noted, effective cooperation between governmental agencies.

Another aim of a sound multiple-use program for management of Hawaii's public forest land should be the selection and development of those areas that could strengthen the Islands' faltering ranching industry. It was suggested earlier that if:

> . . .the ranching industry is to be rejuvenated, basic changes in both ranch operation and techniques would be required. Among other things, Hawaii's cattlemen would have to make intensive, rather than extensive, use of land resources. Such a change in ranching practice could significantly increase total yield and improve the quality of island beef. Before sound policy decisions can be made, however, it will be necessary first to determine whether island beef producers should attempt to compete with high-grade mainland beef, the lower-grade imports, or either. . . . In recent years at least, ranching has proven profitable chiefly for the larger operators. At this time there are approximately a dozen. . . . Still they have not been doing well, and their operations have been cut back markedly in recent years. If profit margins continue to fall, it seems probable that they will increasingly be liquidated, and this possibility presents the State with several potentially serious problems, including an adverse effect on balance of payments, increased unemployment--especially on the Neighbor Islands--and considerable losses in taxable income. To avert these ills, Hawaii's beef producers will need both to become more efficient and to develop all possible sources of supplementary income.[7]

The requisite changes have not yet occurred, and it is evident that many of Hawaii's major, private landowners are progressively abandoning commercial ranching operations. Some of them are presently leasing portions of their range land to small ranchers who, because they generally do not calculate the value of their contributed labor as part of operating costs, appear to show some profit. But this practice only serves to emphasize the marginal character of ranching in Hawaii today. While commercial ranching is unlikely to ever again play an important part in Hawaii's economy, it is possible that under the conditions sketched in this study, it may once again become profitable. For example, as part of a multiple-use program some reforested areas may be utilized for cattle grazing. Needless to say, this calls for very careful management and is only feasible after trees have reached a certain height. Under the proper circumstances such grazing practices may even lower the costs of forest management, since there are areas in Hawaii where certain varieties of grass pose a threat to timber seedlings. Controlled grazing can be valuable in keeping some of these varieties of grass in check.

Finally, the reforestation of range land capable of supporting commercial timber could contribute significantly to water conservation, especially in those areas where poor ranching practices--oftentimes pursued in the wake of indiscriminate clearing of trees--have led to excessive flood run off and soil erosion.[8] An important objective of a multiple-use approach to land management in Hawaii should be

that of developing the water-bearing capacity of the land. It has long since been learned, and should not be forgotten, that in Hawaii the water-bearing capacity of watershed areas can be decisively diminished--depending on the land use and management practices that are followed. Cultivation and grazing drastically reduce water holding capacity of soils. Even though commercial forests are logged infrequently (perhaps every thirty to forty years), steps must be taken to prevent contamination of surface or ground water when such operations are undertaken in or near critical watershed areas.

The protection of water resources must, of course, be given the most careful consideration when land is also used for recreational purposes. We cannot emphasize too strongly that land management practices in watershed areas must be informed and guided by all relevant research on water quality, some of which suggests hitherto unsuspected ways in which potential contaminants may reach basal water supplies. Current research is exploring improved methods of detecting such contaminants, and there is a continuing need for expanding such research--and taking it into account in watershed management. Especially careful watch must be maintained over water quality when urban water supplies are not clorinated, the situation prevailing in Hawaii. Given the possibility of misunderstandings on this score, it cannot be emphasized too strongly that the programs of multiple-use advocated in this study take full account of Hawaii's need for abundant and safe water supplies. Water conservation necessarily has been one of the highest uses of our forest lands, and must remain so. But, the single-use approach to land management practiced in the past to achieve this objective need not guide policy in the future. The very important interest in water conservation in forest areas is generally wholly compatible with the multiple-use approach. Certainly, the disturbance of a forest by logging every thirty to forty years is of minor significance to water values as compared to the annual or biannual cultivation of soils for commercial agriculture.

In summary, developments during the past five years confirm the conclusion suggested in 1965:

> . . .Policies suited to an earlier era may well fall short of meeting present needs, to say nothing of future needs. The single-use approach to public forest land management in Hawaii can no longer be accepted uncritically if it can be demonstrated that multiple use of these lands would effectively serve broader purposes, while continuing to insure an adequate supply of water for domestic and agricultural purposes.[9]

CHAPTER I

PUBLIC LAND POLICY—THE PRESENT ISSUE

Pressing, unresolved problems of public land policy presently confront Hawaii's policy-makers. The consequences of official action--or inaction--in coping with these problems will decisively affect the future of the State's economy, the way of life of its citizenry, and the range of alternatives open to policy-makers in the years ahead.[1] Why is the public land question so critical and complex in Hawaii? Because, among other things, rapid change continues to characterize Hawaii, and virtually every fundamental change in this island community is related, directly or indirectly, to land policy.

It is manifest that in recent decades the Islands have been swept by political and economic forces which, having transformed much that was familiar in the pre-war period, have left a "new Hawaii" in their wake. Gone forever is the essentially stable community of the territorial period, a community based predominately on plantation agriculture and characterized by a static economy, long-established ways of doing business, and rather firmly fixed horizons. The old Hawaii has been replaced by an explosively changing community whose expanding population finds employment in an ever-broader variety of occupations. The consequences of these sweeping changes for public land policy are numerous, since patterns of land use developed in an earlier period no longer meet present needs. During the past decade, there have been both an increasing awareness of the need for new public land policies and a persistent demand from many quarters for changes in the public land laws. Such demands are continuing and will persist, for there is little likelihood that Hawaii will again become a static community.

The second state legislature responded to these demands in some measure in 1962 with the passage of Act 32, the first comprehensive revision of Hawaii's public land laws since the innovations made by President Dole during the short-lived Republic. Other land measures enacted during the past decade have been designed to complement the goals of Act 32. A state land use commission[2] has been charged with the protection of prime agricultural land from urban encroachment, while tax measures have been devised, in part, to force idle land into productive use. This program of land legislation is probably one of the broadest and boldest ever undertaken by any American state. Yet because this legislation was drafted and enacted within such a short period and under less than optimal conditions, even its stoutest proponents admit that it requires revision. The criticism, opposition, and misunderstandings inevitably engendered by a land reform program of this magnitude have been compounded by the numerous difficulties

complicating its administration. For example, it is evident that the leaders of various public agencies responsible for administering the various facets of this program do not feel that the laws are entirely sound; requests to the legislature for amendments to the land laws have been frequent. It is important that the state legislature carefully evaluate all major aspects of public land policy at this time to determine, among other things, the adequacy and consistency of the many and varied statutes presently controlling the use of the State's land.

The difficulties faced by Hawaii's citizenry and policy-makers alike in reaching a clear understanding of the public land issue currently confronting the community compound this problem. This is hardly surprising, for the land issue is extremely complicated. It is rooted in the very fabric of Hawaii's political history and is intertwined with virtually every other major issue in the Islands. The land issue is not one which lends itself to easy agreement. Bluntly put, it gives rise to the sharpest disagreement among men of intelligence and good will. Unquestionably, public land policy constitutes one of the most complicated, emotionally charged, and important issues which face Hawaii. Once again it is reaching critical proportions.

What course of action should be considered by Hawaii's body politic in reformulating land policy? We submit that an adequate answer to this question demands the following considerations:

(1) An analysis of pertinent economic, political, historical, and other factors;

(2) An articulation of present and future goals of public land policy for Hawaii; and

(3) A statement of specific policy alternatives.

An historical analysis of Hawaii's public land policy will be presented in a related study within this series. The present study concentrates attention on the articulation of policy goals, with emphasis on certain alternatives for their implementation.

The Goals of Public Land Policy

The ultimate objective of public land policy should be to secure the broadest long-term benefits which the public lands can provide for

the welfare of the community. All too often, the calculation of benefits has been limited largely to short-term economic considerations. Such calculations are insufficient as a guide for public policy formation. Short-term financial interests sometimes conflict with more basic, long-term economic considerations. This appears to be especially true of land policy. While the public lands presently make a significant contribution to the economy, and should continue to benefit established industries, they should at the same time stimulate the development of new industries, as this study attempts to show. Furthermore, important as they are, economic considerations, whether long- or short-term in character, must be weighed against more fundamental concerns. The larger criterion which policy-makers should bear in mind in designing public land policy is the degree to which such policy contributes to the welfare of the citizenry and the overall quality of life within the community, both now and in the future. This criterion has served as the focal point for our investigation, and attention has been afforded to each of a number of related goals which can be realized through more effective use of Hawaii's public lands.

It is probable that some of these far-ranging and seemingly remote goals of public land policy may be viewed with considerable skepticism. It understandably will be asked why, if the public lands have such rich potential, past policy has failed to realize only a small part of it. This question can be fully answered only by considering this study as a whole, but an initial clue to the answer may prove helpful. The fundamental consideration is that, for well over a century, the utilization of Hawaii's public lands has been guided by what may be called the "single-use" approach to land policy--that is, by the view that a given land area, or type of land, should be utilized exclusively for a <u>single purpose</u> at any given time. A notable example of this policy has been the leasing of enormous areas of public lands for the exclusive purpose of ranching. Other large tracts of public land have been utilized exclusively for over a half-century as water reserves when, as is now realized, the introduction of safeguards designed to protect domestic water supplies would have made it possible to utilize these watershed areas for other purposes simultaneously.

The single-use approach to land utilization was, perhaps, appropriate to the economic and political structure of Hawaii during the period extending roughly from 1865 to the Second World War. It was during this period that Hawaii became the world's most efficient producer of sugar and pineapple, and much of the public domain served primarily as an adjunct to the plantation economy. While the single-

use approach to public lands may very well have been basically sound during former times, even then there were critics who objected to the restricted use to which the public domain was being put. This comment is not intended as a criticism of those past policy-makers who worked for the general welfare as they understood it, and it should be emphasized that in the discussions which follow there is no intention of passing judgment on the motives of those who made and administered Hawaii's past public land policies. Nevertheless, it is essential that those policies be examined with a view to understanding their objectives and reevaluating them in the light of present needs and future potentialities.

To reiterate: the most significant and crippling attribute of Hawaii's past public land policy was its single-use approach to land utilization, an approach which will be contrasted throughout this report with the possibilities inherent in multiple use. In order to define more clearly the limitations of the single-use approach, it is necessary to consider one of the major exclusive uses to which much of Hawaii's public lands have been exclusively put during most of the twentieth century--as forest reserves for water conservation and development.

The Forest Reserve Act

The Forest Reserve Act of 1903 was undoubtedly one of the most significant public land measures ever enacted in Hawaii. This Act authorized the governor to place vast amounts of public land, plus private lands temporarily surrendered by their owners, into forest reserves for the primary purpose of protecting water supplies and preventing erosion.[3] This program was necessitated by the depredations to which these lands had long been subjected; upon its success hung the future of Hawaii's commercial agriculture. The sequence of events which led to its passage can be traced to the time when early western explorers and settlers introduced to the Islands such domestic and wild animals as goats, cattle, and new species of pigs. Some of these animals were allowed to roam freely. Their slaughter was forbidden by the king, with disastrous results. The expanding animal population ravaged and sometimes denuded thousands of acres of forest lands. The erosion which followed affected substantial areas. In the case of Kahoolawe and Lanai, entire islands were seriously damaged.[4] Belatedly, the kapu against the slaughter of these animals was lifted,[5] but it was not until the last decade of the 19th century that there was a sufficient decline in the number of wild cattle, goats, and pigs to reduce substantially the destruction of forest cover.

This ravaging of the public domain was partially checked, on some islands at least, by the phenomenal growth of Hawaii's sugar industry, which developed rapidly during the closing decades of the 19th century and the opening decade of the 20th. The sugar planters gradually realized that the welfare of the industry was dependent, at least indirectly, upon the preservation of forest cover. They observed that destruction of forests seemed to decrease the amount of water received from mountain streams and water tunnels. Furthermore, there appeared to be some direct relationship between the forest cover of mountains and the amount of precipitation in these areas. As early as 1856, kamaainas living near the Waimea and Kawaihae areas on Hawaii reported that rainfall was less plentiful than when the Waimea plains were heavily forested. During a visit to Maui in 1873, Charles Nordhoff reported that, as forests were destroyed by uncontrolled grazing, there were increasing complaints that adjoining areas were becoming arid and less fertile. Others have made similar observations of the close relationship between forest cover and rainfall in the Islands. For example, in the lush valley of Kahana on Oahu, heavy tree cover on the windward side of the mountains serves not only to conserve soil that might otherwise be washed into the sea, but also to cool trade winds blowing in from the ocean, thereby increasing the amount of precipitation in the mountain area above the water tunnel network of the Waiahole Water Company.[6] The rather unique combination of climate and topography in the Islands also produces a phenomenon known as "fog-drip." Clouds borne by the trade winds regularly sweep the tops of tree covered mountain ridges. The resulting temperature changes in the moist air produce condensation which falls on the ground below. The importance of this phenomenon to the water cycle in Hawaii has been convincingly documented by Paul Ekern of the Hawaii Institute of Geophysics. He reported that an additional 30 inches of such moisture was harvested by Norfolk-island pine on Lanai during a period when 50 inches fell in the form of rain. Ekern contends that, in areas where "fog-drip" is substantial, as much as 100 additional inches of water a year are added to the total water precipitated by other causes.[7]

The important function of "fog-drip" in the ecology of at least one of the islands is revealed by reference to the history of Kahoolawe, once a heavily forested island. Its delicate ecology was sustained almost entirely by the water harvested from passing clouds. During the 19th century, wild goats, sheep, and other foraging animals became so numerous that they killed many of the trees. The rate of forest destruction was accelerated when the government of the Republic leased the island for grazing. By the time the Forest Reserve Act was passed, tree cover had been virtually eliminated and the island no

longer received the harvest of "fog-drip" on which life depended.[8] Its forests destroyed, the island lay exposed to devastating wind erosion. Top soil was blown into the sea. So much top soil has now been lost that the restoration of Kahoolawe's productivity is unlikely. Today the island is used only as a military target area.

By contrast, evidence of the good effects of reforestation, when accomplished in time, is furnished by Lanai. Following destruction of its forests by wild animals and, later, by exploitive ranching, Lanai was plagued by severe droughts and ravaged by erosion. Especially vigorous tree planting programs were undertaken in the 1920s when the island was purchased by the Hawaiian Pineapple Company. Stands of Norfolk-island pine were planted, and, as a result, one aspect of the water problem was solved and erosion substantially checked. Today Lanai is one of the most valuable agricultural islands in the archipelago.[9]

Similar observations of the relationship between forest cover and rainfall were made by William A. Hall of the U. S. Bureau of Forestry as early as 1903.[10] Hall's recommendations for the establishment of a forest reserve program were based in part on his conclusion that the drastic decline in forest cover on the island of Hawaii had contributed to sharply diminished rainfall, and this decline threatened the operation of plantations along the Hamakua coast.

Other consequences followed the damage done to Hawaii's native forests by foraging animals. The extremely fast growth of certain shrubs and grasses enabled them to take hold in areas damaged by foraging animals. These plants, such as false-staghorn fern, grew so quickly and lushly that they prevented the germination of tree seeds. Under these circumstances, the return of forest cover was restricted, while the heavy mat of roots prevented the absorption of rain with the resulting loss of considerable amounts of water.

The developing recognition of the consequences of forest damage for the future of commercial agriculture contributed to the passage of the Forest Reserve Act. This legislation was sponsored by Hawaii's sugar planters, among others, and its administration has been supervised by men keenly cognizant of the needs of plantation agriculture.[11] Vigorous administration of the Act led to the destruction of as many as half a million wild cattle in forest reserve areas.[12]

Protecting the forests from uncontrolled grazing undoubtedly contributed significantly to saving the remnants of Hawaii's woodlands from total destruction, but it was necessary to counter other threats as well. One of the most menacing of these threats was the wholesale

clearing of forest cover by ranchers. Long before the Act was passed, ranching had become a major industry in the Islands. The rounding up of wild cattle was necessary by the turn of the 20th century to supply the growing population's need for meat. Hawaii's cattlemen traditionally relied almost exclusively upon range feeding of their stock. This grazing management system was formerly dependent upon continuous extensions of range lands to maintain production. Through such additions to ranches, plus occasional overstocking of ranches, cattlemen maintained Hawaii's self-sufficiency in beef until recent decades, but major extensions of ranching operations took place at the expense of the forests. The seriousness of this threat had been recognized by some during the late 19th century. In 1899 the Board of Agriculture reported that:

> For the past twenty years the attention of our Government and of this Forestry Bureau has been called to the destruction of our Native forests on Government lands in particular. . . . It is become a serious problem with us.
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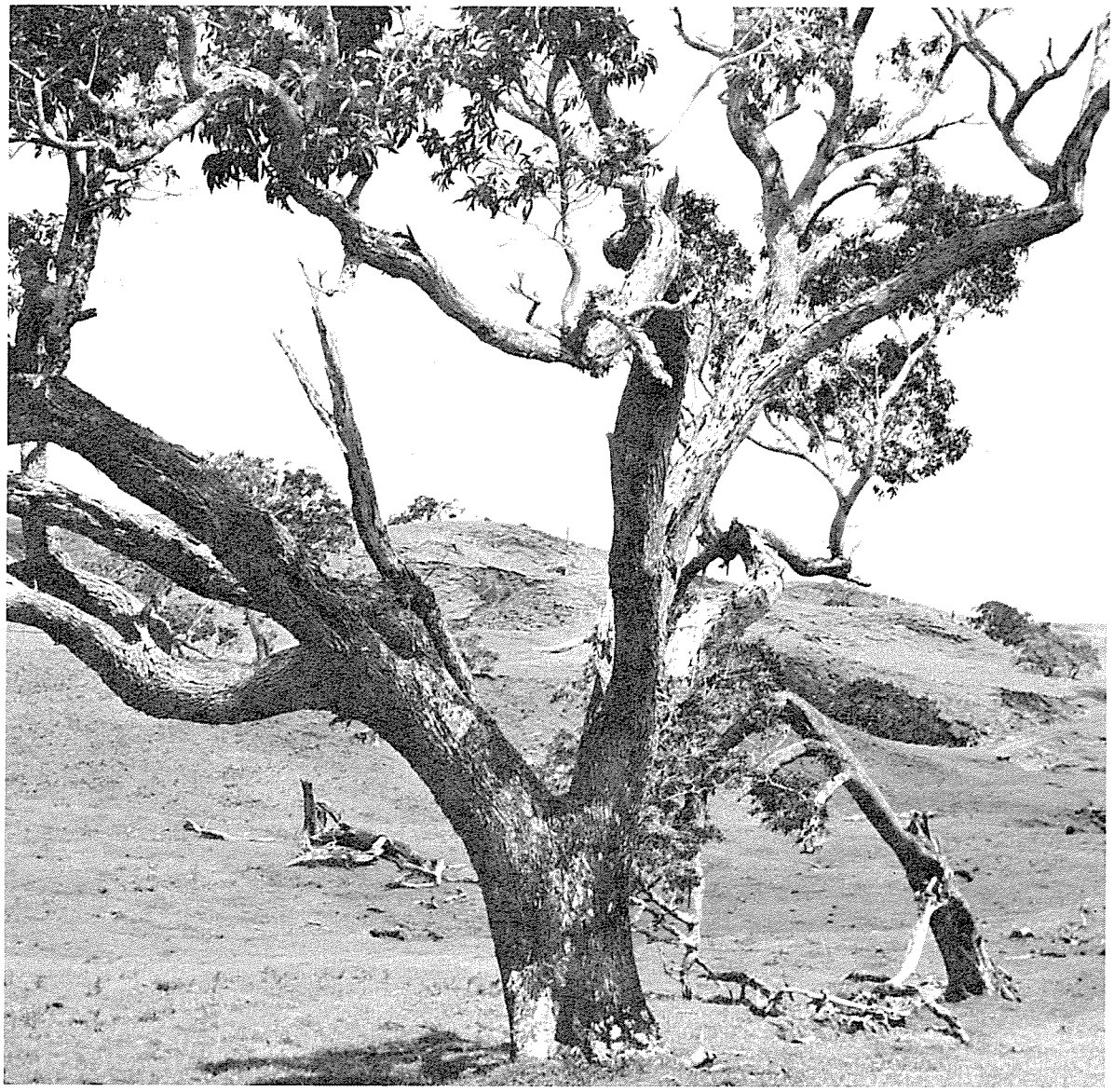
> * * *
>
> Large areas of Public Forests are annually destroyed by fire, orginating [sic] in many instances by cattlemen setting fire to the ferns and underbrush to improve their pasture.
>
> A short time ago a visit was made to Kahana Valley. . . . The Native forest in this valley is in a good state of preservation, but, sorry to say, will not remain so long. It was stated that some enterprising Honolulu business men purchased a few shares of the Native hui, turned in a lot of cattle, and deliberately set fire to the underbrush on the hillside with the view of getting better pasture. If the cattle are not taken away soon it will be but a short time when this Native forest will be destroyed, and the water supply on the low land diminished.[13]

The author concluded that "cattle seem to be the principal enemy of the forests." By way of countering this threat, he recommended that large parts of the government forest lands "should be fenced off at once, for the purpose of preserving the living and growing timber and promoting the younger growth of fern and underbrush."

This theme was reiterated by William A. Hall, who was invited to the Territory by the Hawaiian Sugar Planters' Association in 1902 to explore means of protecting plantation water resources. Hall emphasized that poor ranching practices were responsible for a considerable part of the damage which was being inflicted upon Hawaii's forests. He recommended that forest areas be protected by curbing further clearing by ranchers, as well as by exterminating the wild cattle which continued to forage in forest areas.[14] Hall criticized prevailing ranching practices, noting that cattle were allowed to range extensively, while grazed-out areas were sometimes abandoned by ranch

managers, who found this practice more economical than investing resources in pasture improvement. As a result of these malpractices, thousands of acres of denuded land formerly protected by grass cover were left vulnerable to the destructive forces of wind and water. Erosion was widespread, swift, and catastrophic, for Hawaii's range lands are characterized by steep slopes.[15] Tons of soil, no longer held by trees, shrubs, or adequate grass cover, washed into the sea, leaving behind rocky, low-value soil and near-worthless land. Gullies etched their way steadily into the landscape at an accelerating rate forming barren gulches of the sort pictured in Figure 1, below.

Figure 1



Deforestation May Lead to Soil Losses

Enormous amounts of arable land were seriously damaged or rendered worthless.[16] As long as additional range land could be secured through further clearing of forests, little was done to stem this destructive cycle. Indeed, this problem has not been satisfactorily solved, even today. The destruction of land resources continues, while soil and water conservationists estimate that over 50 per cent of Hawaii's more than one million acres of range land is in need of erosion control or other conservation practices.

Still, some ranchers objected to the introduction of the Forest Reserve Act. Ralph Hosmer, the first territorial forester responsible for administering the forest reserve program, reported that Parker Ranch was initially unwilling to permit incorporation of certain key lands in the reserve system on the ground that these lands were needed for grazing. The ranch resorted to litigation to prevent inclusion of portions of the Kohala Mountains in the system.[17] Fortunately, the power of the sugar planters in the Territory at the time of passage of the Act served to neutralize the ranchers' opposition to the forest reserve system. For that matter, many of the major ranches were subsidiaries of sugar plantations, and it had been at the insistence of the sugar men that the reserve system was established. The predominant position of sugar men over the ranchers, and their intense interest in insuring adequate water supplies for the plantations, softened the opposition to forest protection by independent ranchers.

Though the forest reserve system slowed the ranchers' range-clearing activities, it did little to improve the condition of existing range land. As population increased in the Islands during the first half of the 20th century and as ranching was stimulated by ever-growing demands for meat, the poor quality of range land became increasingly evident. Poor pasture management practices and deterioration of range lands made the maintenance of economically sound grazing operations increasingly difficult. Ranchers inevitably brought pressure on the Division of Forestry to open for grazing land not critically needed for water supply purposes. The records suggest that sometimes the ranchers were successful, and the forests continued to recede before them.

The ranchers were not alone responsible for the disastrous attack on the native forests. Sugar planters had earlier cleared forest lands for plantation use almost as fast as had the ranchers. During this era the sugar mills made extensive use of wood for fuel, and furnished it in generous amounts for their employees' cookstoves and furos (Japanese baths). William A. Hall indicated that there was danger that the:

> Plantations may go so far in the matter [of clearing for cane growing or cutting for fuel] as to bring ultimate disaster upon themselves by ruining their water supply and decreasing the rainfall. Many of the plantations now obtain water from the mountain streams for fluming cane to the mills. There is scarcely enough water for this purpose, and it has been noticed that with the clearing of the lower slopes these small streams have been perceptibly diminished.[18]

The recommendations of Hall and others were taken quite seriously. Providing fuel wood in a manner which would not interfere with water conservation became an initial and principal objective of the forest reserve program. Ralph Sheldon Hosmer, who was appointed to administer the new program at Hall's suggestion, assumed his new duties in 1904. By 1914 he had succeeded in putting 798,214 acres (68 per cent of which belonged to the Territory) into 37 forest reserves.[19]

Hosmer believed that the forest reserves were useful for two primary purposes: water production for the Territory's agricultural industries, and timber production to meet the growing demand for wood products. The forest reserve system, he said, should not lead to "the locking up from economic use of a certain forest area." Even in critical watersheds the harvesting of old trees "is a positive advantage, in that it gives the young trees a chance to grow, while at the same time producing a profit from the forests."[20]

Hosmer further contended that part of the forest reserves could play no part in water conservation, and that commercial timbering should be of primary concern there. In his view, a soundly designed forest reserve system would encourage the uses for which particular areas were best suited: the production of commercially useful wood, water conservation, or some combination of the two.[21] In his initial report to the Board of Agriculture and Forestry, he suggested that some parts of Hawaii's forests could not feasibly supply timber because they were inaccessible, while in other areas it was necessary to harvest timber. He observed that:

> The diminishing supply of wood and timber on the American mainland, the consequent rise in price of all wood products, the local need for wood suitable for fence posts, railroad ties, bridge timbers and the like, not to speak of general construction timber and the necessity for a cheap fuel supply--that already in some districts is a serious problem--all point to the wisdom of tree planting.[22]

Hosmer reported in 1910 that applications for logging rights on government lands were increasing. He maintained that the Division of

Forestry should respond positively and immediately to these applications. He also argued for an enlargement of the government's role in promoting sound forestry practices on private as well as public land[23] for the benefit of both water and wood production:

> In view of the close relation between forest production and the continued success of agriculture in Hawaii, and because of the steadily growing demand for wood of all kinds, it is not only desirable--it is essential--that the citizens of Hawaii be brought to understand and practice forestry.[24]

Hosmer demonstrated his belief in the timber potential of Hawaii's forest lands in 1914 when he recommended that the governor set aside two additional reserves on the island of Hawaii, not for their potential contribution to water conservation, but because he thought they might eventually produce commercial timber and thereby produce revenue for the Territory.[25] During Hosmer's administration (1904-1914) the commercial timber industry made an impressive and promising beginning in Hawaii. In 1907, a contract was signed by the Hawaiian Mahogany Company and the Santa Fe Railway System for the cutting and delivery of 2,500,000 ohia rail ties over a 5-year period.[26] In that same year, the territorial government granted the Bishop Estate the right to "conservatively harvest timber from mountain land near Kona, Hawaii."[27] Commercial timbering was then being carried out on both privately and publicly owned land. Timber owned by the Bishop Estate in the Kau district on Hawaii was cut by the Hawaiian Mahogany Company. Another company harvested koa on the Big Island and shipped 30,000 board feet of saw logs to a mill in California in 1907. The Hawaiian Development Company initiated plans at this time for the establishment of a major lumbering operation as part of its overall plan for the general economic development of the Kona district and received several permits to log government lands in the area.[28]

Hosmer's conviction that Hawaii's forest land could be successfully used for the production of commercial timber carried over into other aspects of his administration of the forest reserve program. For example, he required a lessor of grazing land in the Kukaiau district on the Big Island to plant a minimum number of trees annually on specified portions of the state-owned tracts.[29]

Hosmer also pushed ahead with the importation and testing of exotic trees (trees native to other lands), a program which had been initiated as early as the 1850s. One of the areas partially reforested during his administration was the Tantalus-Nuuanu area, which had been almost completely denuded by wild goats and the cutting

of trees for firewood.[30]

Despite these promising beginnings under Hosmer's administration, Hawaii's infant timber industry was crippled by a combination of unfortunate accidents and developments. A disastrous fire destroyed the Pahoa Mill of the Hawaiian Development Company in 1913. The Pahoa fire coincided with two developments which had an important bearing on the general utilization of Hawaii's forests. One was the sugar mills' adoption of oil for fuel. Of longer range significance was Hosmer's resignation as territorial forester in 1914.

Hosmer was replaced by a forester of strikingly different convictions regarding the use of Hawaii's forests. This new territorial forester was Charles S. Judd, a kamaaina who, after graduating from the Yale School of Forestry, returned to Hawaii to direct the administration of the forest reserve program from 1915 until his death in 1939. Judd assumed the duties of territorial forester at a time when decisions of fundamental importance regarding the future use and development of Hawaii's public lands were being made. New public land legislation had been enacted in 1911. The protracted battle over homesteading was coming to its climax. The suitability of pineapple for plantation agriculture had been demonstrated. By 1915, large-scale agriculture had gained effective control of most of the arable land, and had incorporated into its system those portions of the forest lands which, though unsuited for crops or ranching, were essential for the provision of water for the plantations. The underlying issue which faced Hawaii's policy-makers at that time was whether the fullest long-range economic development of the Territory could be gained through concentrating resources on sugar and pineapple production, along with ranching, or through broadening the economic base. The available evidence suggests that Judd favored the former alternative, for during his administration, forest lands were used almost exclusively as an adjunct to the plantation system. He disagreed with Hosmer's view that a significant portion of Hawaii's forest lands could serve a broad variety of purposes, including the production of timber in commercial quantities, while still performing the essential function of providing water supplies for the plantations. Under Judd's administration, the forest reserve program essentially served the exclusive purpose of supplying water to the sugar industry and urban consumers. Judd staunchly opposed multipurpose management of forest reserve lands on the grounds that disturbance of the forest cover might endanger the functioning of the Territory's agricultural industries. This position was presaged in his first report as territorial forester when he stated unequivocally, "Our forests are more valuable, not for the timber which they produce, but for the

beneficial influence which they exert on a far more valuable product--water."[31]

Although opposed to the development of commercial forestry, Judd actively encouraged the importation and testing of many varieties of trees to determine those best suited to the Islands. Records of tree planting activities during his administration show that many varieties were brought in from Australia and elsewhere. These were planted for windbreaks and for ornamental and other purposes in areas where native trees did not flourish.[32] For such purposes Judd undertook extensive planting programs of imported trees including Java plum, paper bark, various figs, and others not useful for timber to supplement the native forest cover.[33] This program was in keeping with Judd's view that nature should not be assisted in the propagation of the native Hawaiian forest; that artificial propagation, therefore, should be limited to areas beyond the natural habitat of native trees. This program of reforestation, Judd emphasized, was valuable solely "for the beneficial effect which it exerts on the water supply, rather than the exploitation of the forest for timber . . . and any factors which work against these main objects are detrimental to the best interests and welfare of the Territory."[34]

Judd's views determined the scope and character of the Territorial Division of Forestry for nearly three decades. The Hawaiian Sugar Planters' Association, through its Division of Botany and Forestry, supported his program wholeheartedly. This division of the H.S.P.A. was established in 1918 and was headed by Dr. H. L. Lyon, whose views regarding the proper role of Hawaii's forest lands paralleled Judd's own thinking and may well have contributed importantly to it. Like Judd, Lyon believed that disturbing the forest reserve areas by putting them to multiple use could upset the balance of nature, thereby endangering the sugar industry and other industries whose productivity depended upon ample water supplies. His planting recommendations were explicitly designed to forestall the development of a commercial timber industry in Hawaii.[35] The several nurseries which Lyon established and operated were charged with the task of propagating trees useful for some purposes, but worthless for timber production.[36] Working closely with Judd, Lyon paid special attention to the propagation of fruit trees such as figs and plums. Prior to his death in 1957, Lyon avowed publicly and unequivocally that during his career he had been unalterably opposed to the development of a commercial timber industry in the Islands.[37]

Ironically, the research carried out by both Lyon and Judd contributed significantly to present-day knowledge of Hawaii's timber potential. Some of the trees planted under their programs turned out

to be valuable for timber purposes, even though this was completely contrary to their intention. The most notable example of this unanticipated outcome is the Eucalyptus robusta, a tree which is not highly regarded in its native Australian habitat, but which, in recent years, has been recognized increasingly as a potentially valuable hardwood which produces magnificent specimens in Hawaii.

Opposed though they were to the development of a large-scale commercial timber industry, Judd and Lyon did experiment with the cultivation of certain tree species which were thought to lend themselves to plantation-type cultivation. Thus, they experimented with the propagation of rubber trees.[38] In 1921-1922, the Division of Forestry planted in the Waiahole forest reserve nearly 3,000 Chaulmoogra trees which were expected, within about a decade, to produce all of the oil required for the local treatment of Hansen's disease. In 1921-1922, the Division distributed nearly a half million macadamia nut seedlings for planting on homesteads, ranches, plantations, army posts, and even in the zealously guarded forest reserves.[39] Macadamia nut production has achieved significant size in recent years, but not as part of a statewide forestry program and not on public lands.[40]

There was some promise of a new era in the management of Hawaii's forest lands in the mid-1930s with the implementation of the New Deal's Civilian Conservation Corps. The introduction of this program into the Islands brought sustained and substantial federal support, along with a broadening of policy objectives. Although water conservation continued as the paramount objective of forest management, reforestation was given a powerful boost as early as April, 1934, when about 600 young men were put to work building trails, fencing forest reserves to protect them from the depredations of foraging animals, and clearing and planting forest land.[41] William Bryan was placed in charge of the program during an interim period following Judd's death, after which William Crosby, formerly district forester for Maui, became territorial forester in 1939. Crosby asserted that the resources made available through the CCC accomplished more in 8 years than would have been possible in 40 with the territorial legislature's characteristically inadequate appropriations of the 1930s.[42] Unfortunately, the considerable promise of the CCC remained largely unfulfilled, for the outbreak of war in 1941 effectively ended the program.

All available manpower was of course committed to the war effort, and there ensued a drastic cutback in the various programs of the Territorial Division of Forestry, including reforestation and

experimentation. The war did have one unexpected benefit for forestry in Hawaii. The opening phase of the war, marked as it was by large-scale destruction of American shipping, required that Hawaii become considerably more self-sufficient in the production of foodstuffs, building materials, and such than she had been for many decades. Military planners warned that continued destruction of shipping or further disruption of the mainland lumber market channels would require Hawaii to turn to its own forests for wood supplies. Accordingly, saw mills and men experienced in the cutting and processing of timber were brought to Hawaii. At the direction of the military, considerable cutting, milling, and processing of Eucalyptus robusta took place on Kauai, Oahu, and Hawaii during the war years.[43] Knowledge about the possible uses of Hawaii's woods, as well as technology designed to improve harvesting, was somewhat expanded. Consequently, there was renewed interest in commercial forestry which had been one of the keynotes of Hosmer's administration of the forest reserve program 40 years earlier.

The outbreak of war coincided roughly with the appointment of a new territorial forester, as has been noted. Although Crosby appeared initially to subscribe to the Judd-Lyon policies, there were indications that he was more concerned than they had been with the potential of Hawaii's forests for commercial timber production.[44] But this impetus soon diminished with the declaration of peace, and interest in commercial forestry faded rapidly after 1945.[45] Crosby was unable to generate much support for his policies from the territorial legislature or the Board of Agriculture and Forestry, and traditional policies continued to prevail.[46]

It was not until the mid-1950s that interest in commercial forestry in Hawaii revived to any appreciable extent. In 1956, the newly appointed president of the Board of Agriculture and Forestry, C. Eric Reppun, invited the U. S. Forest Service to establish a research office in the Territory. The Service accepted the Territory's proposal and the Honolulu office was established in 1957. The high degree of professional competence characteristic of the Forest Service's staff has been chiefly utilized in carrying out a broad research program designed to facilitate the development of commercial forestry. Beyond this, the Service has construed its proper role in Hawaii as essentially that of an advisory board--responding to requests for information, rather than entering actively into policy-making.

To summarize: during the greater part of the 20th century, Hawaii's more than one million acres of forest land were utilized

primarily as an adjunct to commercial agriculture, and the administration of the forest reserve system was directed chiefly toward the goal of water conservation. Realization of this objective frequently required considerable reforestation, after which, as far as possible, the forests were protected from damage, mainly by being left severely alone. These policies prevailed, even though Ralph Hosmer, the first territorial forester, introduced programs designed to promote multiple use of forest land. His successors, however, concentrated on the single-use objective of water conservation.

Whatever may have been the merits of the single-use approach to forest land management in the past, Hawaii's contemporary needs, together with rapid technological innovations in forest management and timber processing, demands a thorough re-examination of former policies.

CHAPTER II

MULTIPLE USE AND WATER CONSERVATION

During the extended period when Hawaii's public land policy was guided by the single-use concept, developments elsewhere convincingly demonstrated that land could be utilized simultaneously for two, three, or more purposes. This multiple-use approach, as it is called,[1] may dictate the use of a given land area concurrently for water conservation, timber production, and foraging. Another area suitable for multiple use may serve for water conservation, timber production, and a wide variety of recreational pursuits, such as camping, hiking, and hunting.

The multiple-use approach may substantially increase the potential benefits from a particular land area; it is especially promising for the fullest development of Hawaii's public forest lands. Properly applied, it could broaden the Islands' economic base, and also provide social benefits that defy measurement in strictly monetary terms. Multiple use provides the most promising solution to the challenge of land management on an island chain of little more than 4 million acres and subject to extraordinary population pressure. Indeed, both the state legislature and the Department of Land and Natural Resources have agreed that it is no longer possible to satisfy Hawaii's needs by continued reliance on the single-use approach to land mangement.[2]

Although agreement has been reached in principle that the multiple-use approach should be applied in Hawaii, the limited appropriations which have been made for the implementation of the various facets of such a program, as well as the weight of long-established attitudes and practices, have made progress slow. Furthermore, it is not likely that any pronounced movement toward multiple use of Hawaii's public lands will occur unless Hawaii's policy-makers are convinced that adoption of this approach will not endanger the major, established objective of forest land management--water supply--even as broader objectives are achieved. It is therefore necessary to examine carefully the chief objections which have long been made by those opposed to multiple use of Hawaii's forest lands, the alleged danger of water contamination and reduction in water yield. The most determined opponents over the years to introduction of the multiple-use approach to land management have been some officials of several of the county boards of water supply. These officials contended over many years that multiple use would threaten to contaminate the Islands' water supplies. Accordingly, they insisted that the rainfall-infiltration and run-off areas of the forests be protected by a veritable kapu. They feared particularly that the initiation of commercial forestry in these areas might serve to contaminate both

surface and underground water supplies. This position was steadfastly maintained, even though highly qualified foresters and other experts have advanced persuasive evidence that professional management of watersheds for a variety of purposes need not adversely affect the purity of water supplies, and may even tend to increase water yield and improve the timing of flows.[3]

The present study does not permit an exhaustive analysis of the opposing positions, but considerable evidence has been weighed on the question of whether multiple-use management may be applied to Hawaii's forest lands in a fashion compatible with the maintenance of pure water supplies. While it is true that the uncontrolled deposit of enormous amounts of waste or contaminated water in areas above the Islands' basal water tables could dangerously contaminate water supplies, it appears to us that this threat is not inherent in the sound application of multiple-use programs to land management in Hawaii. There are a variety of effective techniques presently available which could prevent the development of such a threat. For that matter, it appears to us that the long alleged threat of water contamination has been overstated, as is suggested by a growing volume of evidence, including the following: since 1962, treated sewage effluent combined with fresh water has been used to irrigate portions of the Oahu Sugar Company's fields located above the basal water supplies of central Oahu.[4] The U. S. Geological Survey estimates that between half and two-thirds of the water utilized for sugar cane irrigation eventually percolates into the basal water supply.[5] Inasmuch as the Oahu Sugar Company's fields are located over a portion of the Ewa district water lens, a portion of the treated sewage from Schofield Barracks is incorporated into the basal water supply--without any apparent adverse effects whatsoever on the quality of the water in the underlying lens. This sewage effluent is, of course, further filtered as it percolates through the earth. On the basis of available evidence, it appears to be in no way noxious by the time it reaches the water lens. If this were not true, those responsible for the purity of Oahu's water supplies would have long since found it necessary to utilize chlorinators at nearby pumping stations. Further reassuring evidence is furnished by a Hawaii Water Authority report issued in 1959 which suggests that, as a last resort, and without reference to economic feasibility, an "adequate water supply can always be made available to the City of Honolulu" by running waste and sewer water through treatment plants and utilizing it for irrigating sugar cane in exchange for fresh ground water.[6]

In this same connection a 1963 research report on the character and extent of water quality problems in Hawaii discloses that groundwater supplies are not contaminated by cesspools, even when these pools

penetrate as deep as 60 feet into areas above basal water sources drawn on for human consumption, so long as the water travels a sufficient distance before it reaches the water table or pumping stations which supply water for domestic use.[7] The weight of evidence gathered to date indicates that sewage contamination is not reaching the basal water stations in Honolulu. The extensive filtration which takes place as contaminated water slowly works its way through many strata of soil and rock seems to have proved effective in preventing contamination. This is the case, even though these strata of lava rock, with their cracks, cinder beds, and lava tubes are a less effective filtering medium than sand, for example, through which it has been demonstrated that bacterial contamination will travel but a few tens of feet. Nevertheless considerable time is required for polluted water to penetrate the many strata of lava materials and lateral movement of ground water ranges from only a few inches to a few feet a day. Thus, months or even years may be required for water to reach withdrawal points at basal water stations. Since intestinal bacteria have a very limited life span in an unfavorable environment, it is fair to conclude that this threat of contamination of basal water supplies can be controlled. Among other things, this calls for carefully regulating the location and construction of septic tanks, cesspools, or similar facilities developed on the public lands.

The examples presented in the foregoing discussion were selected in order to suggest that inasmuch as water contamination has not resulted in these extreme situations, it should not result from careful application of the multiple-use approach to Hawaii's forest areas. The proper development of commercial forestry, recreational facilities in wooded areas, hunting and fishing on the public lands, and the like would not, in any event, lead to the deposit of large quantities of waste in watershed areas. Unless the threat of contamination of surface streams and reservoirs were to become serious,[8] with water being drawn directly from those streams and reservoirs for human use, one may reasonably conclude that multiple use of Hawaii's lands should not pose any serious threat to the Islands' water supplies. At the same time, it should be emphasized that Hawaii's policy-makers and citizens alike must always be concerned with the maintenance of ample supplies of uncontaminated water for domestic consumption. If careful consideration of all pertinent evidence reveals that broader use of watershed areas is compatible with the maintenance of adequate supplies of uncontaminated water, and will also produce other beneficial returns, then traditional concerns should not be allowed to stand in the way of implementing soundly conceived multiple-use programs.

The Threat of Residential Subdivision of Watershed Areas

Another legitimate and understandable concern, especially on the part of officials of county boards of water supply, is that application of the multiple-use approach might lead to extensive subdivision of watershed areas for residential purposes. It must be made perfectly clear that the multiple-use policy recommended in this study does not envision the subdividing of forest lands for residential purposes. For that matter, subdividing land for residential purposes is directly counter to the policy goals of multiple use, since land utilized for residences can be used thereafter only for that purpose alone.

While it is not true that the advocates of sound multiple-use programs propose residential subdivisions within Hawaii's forest lands, it is undeniable that there is mounting pressure to secure land for homesites throughout the Islands, especially on Oahu. These pressures will increase on the Neighbor Islands also, and demands may be made there to utilize portions of the watershed areas for residential purposes, thereby reducing infiltration areas.

Those responsible for the maintenance of adequate water supplies fear that any substantive reduction in the State's forested areas would markedly diminish the quantity of water percolating to the water lenses by increasing the amounts of water lost through run-off. Policy-makers are properly concerned with this threat, but the matter is more complex than water conservationists have commonly suggested. Hawaii's most competent hydrologists have long known that effective techniques are available for recapturing run-off from residential areas. George Y. Ewart, speaking before the Conservation Council in 1961, maintained that more long-range research was needed to find ways of recharging the water lens by capturing the run-off from subdivision areas. He argued that:

> As long as our flood control projects and drainage facilities are designed to serve only one purpose, i.e., get rid of storm waters and run-off as rapidly as possible by wasting them into the ocean, then we must protect our watersheds against urban encroachment with its stripping, grading and scarring operations. . . .[9]

It should be emphasized that not all flood control and drainage facilities in Hawaii have been designed to get rid of storm water and run-off as rapidly as possible. In recent years, several flood control projects have been designed to recharge ground water supplies through the construction of retarding dams and reservoirs which permit

water to percolate through the underlying soil.[10]

Ewart, then, has not been alone in arguing that run-off from houses, lawns, and streets can be directed into recharge sumps or shafts, for these possibilities have long been the subject of extended research, especially by hydrologists and by the boards of water supply.[11] Specific and detailed plans have been made for the development of recharge sumps, but little has been done to implement them--in part because it has not been evident that the maintenance of adequate water supplies on Oahu requires them. Such installations are expensive, especially if run-off is collected near sea-level, for the water has to be pumped up to recharge shafts at higher altitudes to permit percolation into the water lens. It is hardly necessary to add that, if such installations are constructed, suitable precautions will have to be taken to insure that the recaptured water will not contaminate basal water supplies.

In conclusion, we must emphasize that this discussion should not be understood as recommending subdivision of forest reserve areas, but rather as a plea for thorough-going research and exploration of another of the concerns which have been responsible for misdirected opposition to the application of the multiple-use approach to land management. Undoubtedly, these misapprehensions have retarded objective exploration of means for increasing water recovery from both forested and urban areas. This consequence was inevitable as long as Hawaii's policy makers accepted unquestionably the premises underlying the Forest Reserve Act of a half-century ago.

The Multiple Use of Watersheds

The degree to which the premises underlying the Forest Reserve Act has continued to determine public land policy may be more clearly seen by considering the regulations promulgated by the former Board of Commissioners of Agriculture and Forestry of the Territory of Hawaii on December 1, 1941. These regulations still exclusively govern Hawaii's four key watersheds. Among other things, they forbid "the cutting, killing, destroying, injuring, or otherwise damaging, or the removal of any grass, shrub, vine, plant or other vegetation, except as authorized by permission from the Territorial Forester or his agent."[12] Although one can enthusiastically and whole-heartedly agree with the goal of preventing indiscriminate destruction, of ground cover, the question is whether regulations such as these have worked too broadly in restricting the development of forested areas for any purpose other than water conservation. The

deeper significance of these regulations may well be that they stem from and reflect a long-established tradition, as is shown in a major report published by the Honolulu Board of Water Supply in 1948:

> It is the basic proposition of the writer of this report that the accumulated knowledge of the last 70 years should be the best guide to the future. . .of all that we can now do, none could name a more worthwhile objective than to dedicate permanently an area for a "forest reserve," a forest infiltration area through which the water that reaches us as rain may be transmitted to the underground water body upon which the life of Oahu will always depend.[13]

In keeping with this position, the board has, until very recently, opposed application of the multiple-use approach to management of watershed areas. This position was strongly reiterated in a statement presented to the Department of Land and Natural Resources which asserted that the multiple-use concept recently introduced into the state laws is "contrary to past thinking and experience of all who have had any responsibility in the protection of water sources and the supporting watershed and infiltration areas."[14]

Recently, however, the Honolulu Board of Water Supply has become persuaded that although past experience should always be fully evaluated in formulating public policy, this evaluation, if it is to be valid for the present, must also assess new knowledge. It is not necessarily true that the knowledge accumulated in the past in Hawaii is "the best guide to the future". Indeed, it can be a very misleading and inadequate guide in those cases where needs have changed and where additional knowledge has been gained. Policies suited to an earlier era may well fall short of meeting present needs, to say nothing of future needs. The single-use approach to public forest land management in Hawaii can no longer be accepted uncritically where it can be demonstrated that multiple use would effectively serve broader purposes, while continuing to insure an adequate supply of water for domestic and agricultural purposes. In substantial areas of the State, a multiple-use program of forest land management can serve community and plantation water needs fully as well or even more effectively than they are being served now.

CHAPTER III

MULTIPLE USE AND GRAZING

Application of the multiple-use approach may serve to strengthen the Islands' presently depressed ranching industry in significant ways.

In Hawaii, as well as on the American mainland, there has been a traditional conflict of interest, accompanied by sometimes bitter antagonism, between ranchers and conservationists. We have observed earlier that uncontrolled grazing contributed significantly to the destruction of Hawaii's forest cover during the 19th century. Ranchers deliberately destroyed tree cover over enormous areas, and some opposed enactment of the Forest Reserve Act in 1903.

This traditional conflict between ranchers and proponents of sound forest management may be mitigated through application of the multiple-use approach, for it has been demonstrated that land can be used for grazing without undue injury to commercially valuable trees. Systematic experimentation has shown that, when tree seedlings of certain species reach sufficient height, cattle may be permitted to forage among the trees without undue damage.[1] Depending on the tree varieties planted, this form of multiple use may be undertaken in as little as six years after planting. Cattle can then seasonally graze these areas for the following 15 to 20 years, i.e., until tree harvesting time, depending in part upon how closely the stands of trees are planted. This approach demands temporary withdrawal from grazing of those land areas requiring reforestation.

While this type of multiple use of grazing-forest land has long been practiced on the mainland, its application to Hawaii has been delayed--and is likely even now to be resisted--due to certain characteristics of the ranching industry in the Islands. Of fundamental importance is the general reliance of Hawaii's ranchers on extensive, rather than intensive, use of land resources. For example, as of 1962, less than 175,000 cattle were grazing on more than 1,000,000 acres of land, a ratio of approximately one animal to 6 acres.[2] (This ratio includes cattle in feed lots and intensively cultivated pasture. Otherwise it would be considerably higher.) This approach to land utilization constitutes inefficient use of resources. It also fails to produce high-quality beef. As a result, Hawaii's beef producers have had a shrinking share of the State's meat sales, even though the slaughter of locally grown animals has increased.[3] Until recent years, they supplied virtually the entire demand for beef: in 1952, 86 per cent of the local population bought island beef.[4] By 1961, local beef production supplied only 57 per cent of the market demand, while 20

per cent was filled by cheaper, low-quality imports from Australia and New Zealand, and about 23 per cent by high-quality mainland imports.[5] Even if the slaughter of local animals were markedly increased, it is doubtful that low-quality Hawaiian beef could successfully compete with imports under today's conditions of free competition. It is becoming increasingly obvious that Hawaii's ranching industry is in difficult straits, and that an already serious situation will continue to deteriorate as customer preferences continue to change.

These facts are generally admitted, although the underlying causes of consumer demands are not always easy to diagnose, and competent men disagree about them. Among the pertinent factors may be the growing number of mainland migrants to the Islands, increased patronage of restaurants by both tourists and local residents, marked changes in the diet of successive generations of islanders of Oriental ancestry, and greater affluence in the community as a whole. Whatever the causes, the effects grow increasingly serious, and there is no indication of a reversal of the continuing consumer preference for standard grades of beef rather than the home-grown, but tough, local product. As mainland imports successfully challenge island beef producers for the discriminating palate, importation of Australian and New Zealand beef challenges island ranchers for the economy-minded segment of the market. Island ranchers are thus squeezed simultaneously from two directions, and profits from ranching have therefore declined precipitously. One study of the industry's profit margins during the two-year period, 1958-60, revealed that only 37 per cent of the 400 producers were making a net profit. The largest profit realized by the most efficient ranches was only $25 per acre per year, but few ranchers received even that. A more representative profit figure for the period was between $1 and $5 per acre per year.[6]

If the ranching industry is to be rejuvenated, basic changes in both ranch operation and techniques would be required. Among other things, Hawaii's cattlemen would have to make intensive, rather than extensive, use of land resources. Such a change in ranching practice could significantly increase total yield and improve the quality of island beef. Before sound policy decisions can be made, however, it will be necessary first to determine whether island beef producers should attempt to compete with high-grade mainland beef, the lower-grade imports, or either.

Short of resorting to the dubious device of utilizing import quotas or other restrictive practices which generally invite damaging repercussions, it would probably prove extremely difficult for Hawaii's cattlemen to successfully challenge Australian and New Zealand beef

producers. Rather than confront this competition, island beef producers might compete more profitably for the growing market for U. S. choice or prime beef. Successful competition for this market would require at least three major changes in ranching practices. First, it would be necessary to increase the percentage of island beef fattened in feed-pens rather than on the open range. Secondly, a number of changes in shipping practices, grain storage, and related parts of the process would be required to make pen-feeding more economical.[7] Finally, mainland grading techniques would have to be utilized more widely so that island and mainland beef could be marketed together at approximately the same price.[8] It is hardly necessary to add that changes of this magnitude would require a high degree of cooperation within the industry. For instance, steps would have to be taken to facilitate the importation of feed at a bulk rate substantially lower than present container cargo rates.[9] In some cases, this might be accomplished by the establishment of buying cooperatives. Cooperatives might also lower slaughtering costs, secure reduced interisland shipping rates, and reduce other production and marketing costs.[10]

In recent years at least, ranching has proven profitable chiefly for the larger operators. At this time there are approximately a dozen large independent ranches in Hawaii, with a few other large ranches operated as subsidiaries of plantations.[11] As such, they benefit from the generally strong capital positions of the Honolulu-based factors and from sharing overhead costs with other parts of the overall plantation operation. Still, they have not been doing well, and their operations have been cut back markedly in recent years. If profit margins continue to fall, it seems probable that they will increasingly be liquidated, and this possibility presents the State with several potentially serious problems,[12] including an adverse effect on balance of payments, increased unemployment--especially on the Neighbor Islands--and considerable losses in taxable income. To avert these ills, Hawaii's beef producers will need both to become more efficient and to develop all possible sources of supplementary income. It is on this last point that adoption of the multiple-use approach to land management could make an especially valuable contribution.

The rigid separation between range and forest lands associated with the single-use approach has generally precluded even controlled grazing in forest areas. At the same time, ranchers have failed to realize opportunities to supplement income by growing commercial timber on land hitherto used exclusively for grazing. By way of illustrating the wastefulness of past ranching practices as well as some of the potentialities of multiple use, we may observe that

ranchers have regarded silk-oak, a choice cabinet wood, as a range pest. They have systematically eradicated stands of silk-oak from grazing areas. The wastefulness of this practice may be understood when one considers that, if land suited to the cultivation of silk-oak were properly planted to that species, its profit potential within 35 years would be approximately three times greater than the highest returns per acre per year now being realized by Hawaii's most prosperous ranching operation. Pictured below in Figure 2 is a 38-year old planted stand of silk-oak yielding 105,000 board feet per acre.

Figure 2

Stand of Silk-Oak, Island of Hawaii

While full timber yields in areas planted to silk-oak or other timber trees could not be realized without markedly reducing the utility of the land for grazing, the combined yields from timber and grazing could be considerably greater than from either use alone.[13] Multiple use of the hundreds of thousands of acres suited for grazing

and commercial timber production could thereby increase returns significantly.

The long-term welfare of Hawaii's ranching corporations depends indirectly upon the adoption of a multiple-use program which will serve to check soil erosion. A considerable amount of land well suited for timber production as well as for grazing is in need of protection from erosion. Continued erosion of this land will ultimately render it useless for any productive purposes, while reforestation of partially eroded ranch land at this time would minimize run-off and thereby also augment the State's water resources.

In conclusion, there may be resistance to the adoption of the multiple-use approach to grazing land, even though this approach reflects well-established practices elsewhere. Yet there is every indication that it could be successfully and profitably applied to the more efficient utilization of Hawaii's scarce land resources. It will be difficult to break century-long habits and outlooks, but unless Hawaii's ranching practices are greatly improved, this important industry, along with the people and industries dependent upon it for a livelihood, will continue to be confronted by grave difficulties--and even the threat of ultimate failure. Adoption of the multiple-use approach wherever it is feasible would increase the amount of land in productive use in the State, while simultaneously yielding a larger net return to ranchers.

CHAPTER IV

MULTIPLE USE AND RECREATIONAL OPPORTUNITIES

The preceding discussion of the advantages inherent in the multiple-use approach to public land management has been based essentially upon economic considerations. Important as these are, a more immediately promising contribution inherent in the multiple use of Hawaii's scarce land resources is its potential for developing a more salutary way of life for the Islands' citizenry. Without question one of the most wholesome and cherished aspects of life in Hawaii has always been the unexcelled, year-round opportunities for outdoor recreation and enjoyment of the Islands' remarkable natural beauty. In the past, outdoor recreation has been easily and immediately available to virtually all. Manifestly, this is no longer true. Swift population increases, diminishing availability of land, miscarried plans for urban development, and the extraordinarily rapid urbanization of the City and County of Honolulu have occurred, even as opportunities for park development have been largely neglected. As a result, Honolulu's city dwellers suffer increasingly from the condition aptly described as "urban cramp." This situation is neither healthy nor necessary, and is all the more regrettable given Hawaii's unique potential for outdoor recreation.

The deprivations increasingly suffered by the residents of Honolulu's urban complex are accentuated by the fact that the forest reserve lands fringing the urban areas have been generally closed to recreational purposes. Many of these forested areas are not easily accessible, and little has been done to facilitate access to them. To be sure, some of these forested areas are in zones of high rainfall, and safe public use of them would require the development and maintenance of better trails. But, above all, management practices have been designed to discourage the public from making use of the most beautiful and conveniently located forests adjoining Honolulu. As early as 1922, territorial forester Charles Judd reported that his division had closed a 1,500-acre area behind Palolo and Manoa Valleys on Oahu to "trampers," noting that heavy hiking traffic had disturbed forest cover and created difficulties for his rangers. Though these restrictions met with some opposition, he reported that they had been generally accepted "with good grace."[1] Hawaii's forest administrators have permitted limited hunting in forest reserves not considered crucial to the water supply,[2] but territorial foresters have complained that public ignorance of the objectives of the forest reserve system has forced them to make an increasing number of arrests for such violations as hunting without a permit or disturbing forest growth.[3]

Re-examination of these restrictive policies is desirable in the light of two important developments. First, Hawaii's tourist trade has undergone a change in character in recent years as a result of startling developments in transportation, and increasing affluence and leisure. Faster and cheaper air travel is bringing more tourists to Hawaii than ever before. Also, many of these tourists seek a different kind of vacation experience in Hawaii. Until recently, most tourists to the Islands traveled first class, sought accommodations in hotels, and relaxed on the then uncluttered and attractive beaches of Honolulu. Their sightseeing on the Neighbor Islands was usually arranged by travel agencies, and was generally brief. Today, an increasing number of Hawaii's visitors are unable or unwilling to remain long in expensive hotels or resort areas. More than 50 per cent of the tourists now entering Hawaii come from the West Coast, where the population is substantially younger than elsewhere on the mainland.[4] Moreover, increased leisure and affluence in Japan have propelled a growing segment of that country's population into the world tourist market. Hawaii is already receiving increased patronage from Japanese nationals, who share with westerners an increasing appetite for outdoor recreation. This combination of youthfulness and modest, middle-class income suggests that an increasing proportion of these tourists will be in search of camping and lodge facilities comparable to those found in mainland recreation areas.

The importance of these developments is accentuated by fundamental changes in the recreational habits of the present generation of Islanders. Rapid urbanization has coincided with rising incomes for a large majority of Hawaii's residents. Consequently, there is more leisure time, with increasing demands for outdoor recreational opportunities. Data recorded by the State Division of Parks indicate that between 1963 and 1964 visitors to the 22 parks rose by more than half. From less than 600,000 at the beginning of the period, they rose to nearly a million annually,[5] and have now reached almost 6 million a year. Despite the soaring need for park facilities of every kind, only four of the 29 park sites presently developed within the 7,000-acre state park system have lodging facilities, many of which are badly in need of improvement. Within all the state parks there are only 35 lodging units, and not even all of these can accommodate families. Ten of these units are located in Kokee Park, but the supporting facilities required for extended vacationing are insufficient.[6]

Furthermore, park facilities throughout the State are dangerously overburdened. The congestion of recreational facilities, especially on Oahu during holidays, poses a growing menace to safety and health.[7] One measure of the inadequacy of existing facilities, as well as of potential demand, is revealed by the fact that, as additions are made

to established parks, the number of visitors soars. For example, following the development of a new recreation area in an Oahu park, use of the park tripled in a single year. As a result, pressure on the park's facilities was greater than it had been before the addition was made, and adequate supervision and maintenance were not possible.

Unquestionably, unless state and county governments sharply increase appropriations for park expansion and better maintenance of existing parks, these facilities will fall into an even faster "depreciation spiral" marked by misuse and vandalism. Mainland experience reveals that well maintained and strictly supervised parks whose equipment is in good repair invite proper use, but Hawaii's parks (both state and county) have constituted "underdeveloped areas." They are poorly equipped, commonly strewn with rubbish, and supervised inadequately. These conditions encourage the worst tendencies among park users, whose unchecked carelessness and misconduct accelerate the "depreciation spiral." In anticipation of the recommendations which follow, we must emphasize that it would be sheer folly and potentially utterly destructive to open up Hawaii's forest reserves to meet increasing needs for outdoor recreation--unless projected park programs are adequately financed and staffed. The goal of Hawaii's park administrators must be to insure the development and maintenance of first-class parks throughout the State.

Two key questions, then, confront Hawaii's policy-makers in dealing with this problem. First, where can adequate recreational facilities be developed to meet the needs of the citizenry and tourists? Secondly, how can these facilities be properly maintained? In answer to the first question, it may be granted that resort development is continuing at a brisk pace on many of the Islands, but these resorts, with few exceptions, are designed for tourists traveling on comfortable budgets. Nor can the burgeoning demands for outdoor recreation be met to any considerable degree through exclusive reliance on beach areas. The beaches, especially on Oahu, have become almost as congested as the city itself. In addition, resort development and vacation-home building are rapidly exhausting the supply of choice sites.[8]

These considerations point to the necessity for directing attention to the use of the bountiful and beautiful public lands, especially the forest reserves, for meeting recreational needs. Hawaii's forested mountains have traditionally presented a backdrop for the most notable scenic and recreational attractions of the Islands, but their beauty has been generally enjoyed from afar. While it is unlikely that tourists could be attracted in great numbers to resorts located at

considerable distance from beaches, at least for extended periods, cool, wooded, hill areas suited for hiking, riding, hunting, and such pursuits appeal to an increasing number of island residents. This appeal would considerably broaden should there be a major expansion of camp sites, inexpensive lodges, fishing and hunting grounds, and horseback trails.[9]

Application of the multiple-use approach to forest areas could make a significant contribution to the development of recreational areas of this sort. These developments would require a considerable initial expenditure for trail construction, development of camp sites, buildings, shelters, water lines, lavatories, and other facilities. Continuing expenditures would be necessary to insure adequate supervision and maintenance.

While it would be foolish to make such expenditures for sites which might not be adequately patronized, it should be emphasized that the risk inherent in making forecasts of public taste and choice in park utilization can be lowered substantially if recreational development is undertaken as one part of an overall program of a multiple-use program based on large-scale timber production. Commercial forestry demands development of roads, trails, and forest patrols. Fences to control marauding animals, to mark ownership boundaries, and some portions of planted areas are also necessary. Such facilities can be designed to serve simultaneously the objectives of commercial forestry and outdoor recreation, especially in areas likely to attract hikers, campers, picnickers, and sportsmen. Such a combination of commercial forestry and recreational use of mountain lands permits public investment to meet a combination of economic and social objectives. Furthermore, forest clearing, reforestation, and maintenance of stands of commercially valuable timber contribute directly to the utility of forest areas for recreation. Intensive development of such areas for recreational use requires additional expenditures for developing camp sites, damming and stocking streams, building lodges, and other improvements, of course. Mainland experience supplies convincing evidence that a significant portion of these development costs can be recovered directly through the leasing of concessions and, indirectly, through the stimulus provided to the economy of surrounding areas. Another significant indirect economic benefit in the case of Hawaii would be the increase in interisland travel.

Special attention has been directed to the possibility of applying the multiple-use approach to the development of areas in which commercial timbering and recreational uses can be combined, since part of the development costs can be recovered through revenues received

from sale of timber and other aspects of the lumber industry. There are also extensive areas available for outdoor recreation in Hawaii where lumbering is not feasible but where the multiple-use concept can, nevertheless, be advantageously applied. Hawaii has large land areas which are regarded by some as "waste" lands: lava flows, both barren and lush pali areas such as the Napili Coast, and land where access is difficult. These areas appear to be unsuited for commercial forestry or foraging, but some portion of them might be developed for hiking, camping, mountain climbing, game production, hunting, and scientific investigations.[10]

The development of recreational facilities through application of the multiple-use policy may also encourage scientists and others to take increasing advantage of kipukas (lush, fertile plots of land surrounded by barren, rocky waste). These beautiful and unusual areas, which are scattered throughout Hawaii's uplands, could serve as hiking oases and semi-permanent sites for the study of wildlife, native plants, and other phenomena.

Hawaii's policy-makers must at this time give their most serious considerations to the array of benefits which can be realized through development of adequate facilities for outdoor recreation. The State's citizenry and visitors alike continue to be deprived of the enjoyment of incomparable natural resources which, in our view, should be systematically developed in a carefully planned and properly controlled fashion. Continued under-utilization of these natural resources will ultimately have an adverse effect on the vitally important tourist industry.

Important as these considerations are for the State as a whole, they have special significance for the Neighbor Islands, which have suffered a general economic decline since the late 1940s. Having been almost exclusively dependent upon plantation agriculture, the Neighbor Islands were especially hard hit by the mechanization of the plantations and the resulting reduction of employment in the sugar industry.[11] With job prospects so poor, many young people migrated from the Neighbor Islands to Oahu or to the U. S. mainland. Bustling plantation camps and villages of yesteryear have been obliterated or lingered on as depressed--and rather depressing--settlements of retirees. Nor have post-war economic developments in the State benefited the Neighbor Islands proportionately. An inordinate part of the booming tourist business, most of the industrial development, and even the bulk of military activities have been concentrated on Oahu. The future of the Neighbor Islands depends to a great extent upon the application of multiple-use programs for their abundant areas

of inadequately used land. The benefits which can be derived from such programs can be realized only through the concentrated efforts of Hawaii's policy makers in finding solutions to a number of related problems. For example, the problem of providing cheaper and better interisland transportation will have to be solved. Substantial investment of state funds would have to be channeled into the clearing, reforestation, and development of tens of thousands of acres suited for commercial timber production and simultaneous use for camping and other purposes. Neighbor island ranchers, businessmen, and others will require assistance in adjusting their operations to such a new order. The initial costs of originating multiple-use programs will be high, but Hawaii can no longer afford the continued waste of its resources--either human or material.

CHAPTER V

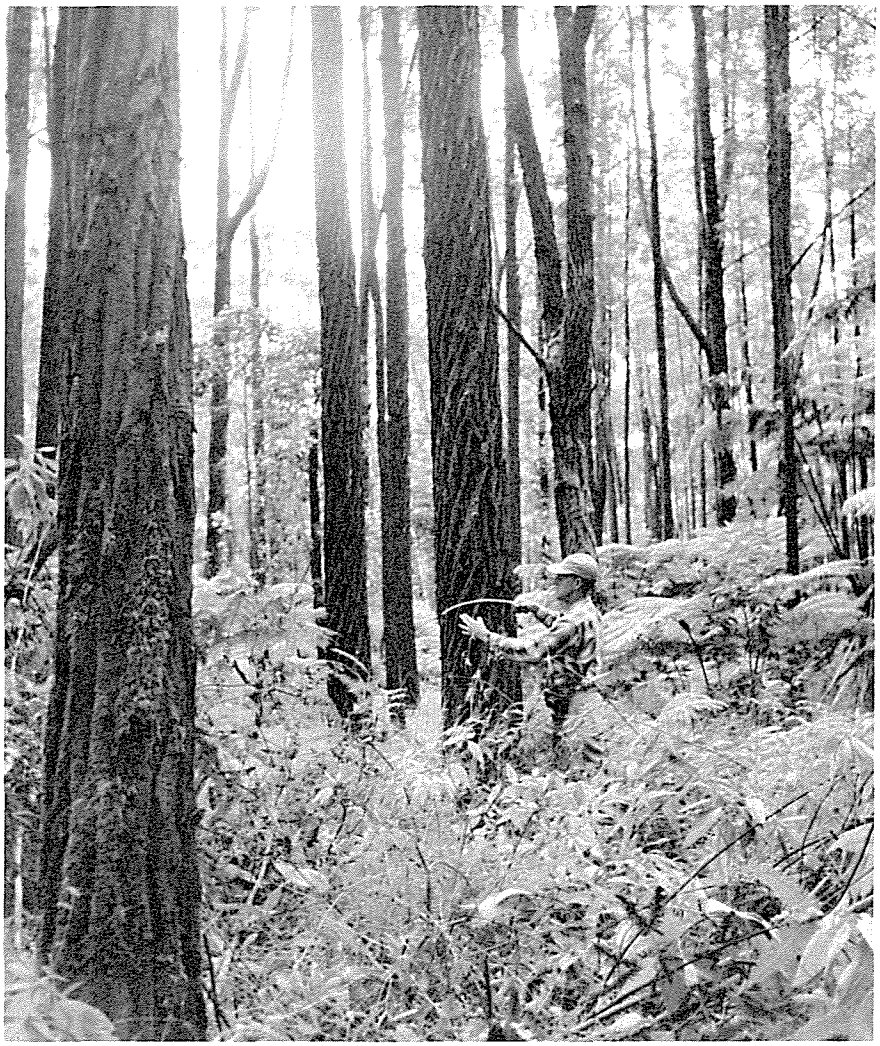
THE PROSPECTS FOR COMMERCIAL FORESTRY IN HAWAII

The foregoing arguments for immediate and broad adoption of the multiple-use approach to management of Hawaii's public lands presuppose that the prospects for commercial forestry in the Islands are excellent. This premise is not arbitrary, nor has it been accepted lightly. The evidence for it has been carefully examined and weighed for many years by businessmen, the U. S. Forest Service, and others. The conclusion to which they have been consistently drawn is that the full development of public and private lands suited for timber production could make commercial forestry a major industry in Hawaii within some 35 years. The ultimate size attainable by this industry is necessarily a matter of conjecture, but there is evidence to support the contention that its contribution to Hawaii's economy could eventually equal or even surpass that now being made by the pineapple or sugar industries. The most sanguine estimates suggest that full-scale timber production and processing could generate as much as $150,000,000 to $200,000,000 annually (the present approximate range of the sugar industry), while providing employment for as many as 15,000 to 20,000 people. Furthermore, depending on the extent to which wood processing and associated manufacturing industries were developed in the Islands, the ultimate long-range potential of this complex of related industries could produce an annual return at least twice that derived from timber production and processing alone, while employing as many as 30,000 to 35,000 people.[1]

Although these estimates may appear surprisingly high at first glance, it must be remembered that they attempt to fully evaluate the potential productivity of an almost completely unique combination of natural resources: soils, climate, and topography--the same combination, it may be noted, which made possible the remarkable success of the Islands' sugar and pineapple industries. Considering these natural assets in greater detail, we may note that land suited for timber growing is available in unexpectedly large amounts. It has been ascertained that possibly as much as 1.4 million acres of the Islands' lands might support commercial timber[2] (as compared with the approximately 233,000 acres now utilized by the sugar industry, and some 66,000 acres by pineapple growers).[3] Of this 1.4 million acres, roughly half is public land,[4] with sizable areas located on each of the major islands.[5] Much of this land is presently serving the single purpose of either water conservation or grazing, while a large part simply remains unused. This partial and, from present perspectives, inefficient land utilization is difficult to understand in view of the extraordinarily favorable growing conditions, climate, and soil types

which make half a million acres of public forest land in Hawaii potentially equivalent in productivity to 2 million or more acres on the mainland. While mainland hardwoods grow at an average rate of about 300 board feet per acre per year, hardwoods in Hawaii grow at three, four, or more times that rate,[6] depending upon the species and a variety of climatic, soil and other factors. Pictured below in Figure 3 is a 38-year old stand of Eucalyptus robusta yielding 130,000 board feet per acre. Given their extraordinarily rapid rate of growth, many extremely valuable hardwood species in Hawaii could be profitably harvested at 30 years of age or less,[7] while mainland hardwoods typically require a century to reach cutting maturity. The implications of this difference for capital investment, rate of return on investment, and other economic factors are obviously of the greatest importance.

Figure 3



Stand of Eucalyptus Robusta, Island of Hawaii

Current research indicates that Hawaii's half-million acres of public forest land alone could support up to 20 billion board feet of timber within as little as 35 to 40 years if the entire area were now planted to appropriate species of hardwoods.[8] Because of past forest management policies, only a small fraction of this area is supporting commercially valuable stands of hardwoods today. A long-term program of reforestation and forest management is mandatory if the economic potential of this land is to be realized. Precisely what return could be expected from such a program when it has reached full production?

If a half-million acres of Hawaii's public lands were planted to high-quality hardwoods, assuming a conservative annual growth rate of 1,000 board feet per acre, these lands could produce a yearly harvest of about one-half billion board feet. If milling, transportation, and marketing facilities were now established, it is estimated that such hardwood stumpage (standing timber) as is available in Hawaii today would be worth about $40 per 1,000 board feet. Based on this estimate, the value of raw stumpage produced annually could be at least 20 million dollars.[9] The value of high-quality hardwoods will undoubtedly increase considerably in future decades. In any case, the value inherent in stumpage constitutes only a small part of the total value of quality wood.[10] Significant multiplication of value comes through manufacture into lumber, veneer, furniture, and other consumer products. At current mainland averages, each dollar's worth of stumpage is increased some twentyfold by the time it reaches the consumer in the form of finished articles. Obviously, not all of the hardwood timber grown in Hawaii would be completely finished in the Islands, but if processing of even a large part of it proceeded no further than milling into rough lumber, veneer flitches, and the like prior to export, stumpage values would be multiplied considerably. If the average multiplication factor were as low as 5, the value of a timbering and wood products industry based on public land use alone would be approximately $100,000,000 annually. As state lands demonstrated their potential for profitable yields, private landowners would be further encouraged to put comparable lands to similar uses. If all land suited to commercial timber production were fully utilized, the return to Hawaii's economy could be two or more times larger than the $100,000,000 potential return from state lands alone.

While the long-term prospects for commercial timbering in the Islands are excellent, this potential cannot of course be realized without a sustained investment program based on detailed, long-range planning. An enormous amount of public and private lands alike is presently encumbered with scrubby growths of low-value, even worthless, timber. Ohia, for example, is growing abundantly, but this

species fails to produce straight clear trunks and is presently of limited value. Furthermore, certain characteristics of the ohia fibre such as its high silica content make this wood expensive to process, although technological advances may subsequently reduce costs markedly. Or, again, koa is extensively scattered throughout Hawaii's forest lands. Koa stands formerly were quite valuable, and this beautiful hardwood was used extensively for furniture manufacture. Reckless cutting and persistent neglect have left most remaining koa stands over-mature, even dying, while the seedlings which would have produced commercially valuable specimens today are being destroyed by foraging cattle. Almost 40 per cent of the forest lands in the State today support commercially worthless growths of kukui, scrubby ohia or koa, and other cull trees. This substandard growth must be cleared and carefully replanted with seedlings of high-value hardwood species, including perhaps koa and ohia in some areas. Observation over many decades has provided considerable evidence that many other fine hardwoods thrive in Hawaii's forests. Some of the most valuable commercial species originated in Australia; others were imported from Mexico, India, and elsewhere.[11] Although these species differ considerably from such familiar American hardwoods as oak, hickory, and maple, they are superior in many respects. Indeed, they compare most favorably in durability, attractiveness and strength with the best hardwoods found anywhere in the world.[12]

Unquestionably, Hawaii is blessed with the land resources, soil types, and favorable growing conditions required for the development of commercial forestry. Nevertheless, there is no point in growing timber if no market exists for it. What, then, are the potential markets for Hawaii-grown hardwoods?

It should be emphasized initially that there already exists a local market for quality hardwoods far exceeding present production. Of the 110 million board feet of lumber consumed annually in Hawaii, 10 million consists of hardwoods, while the remainder consists of softwoods such as Douglas fir and redwood. Hawaii-grown hardwoods could compete successfully in quality and price with hardwoods shipped from the American eastern forests. A thousand board feet of hardwood imported from the U. S. mainland sells in Honolulu for about $220, of which some $50-$75 represents transportation costs. If Hawaii's timber industry were as efficient as that of the mainland United States and if labor costs were approximately the same, locally produced lumber of at least comparable quality should cost no more than $160-$180 per thousand board feet in Honolulu after making an allowance for barging charges from, say, the Big Island or Maui to Honolulu. Actually, the savings should be even greater, for the

development of a major commercial timber industry on the Neighbor Islands should make possible sharp reductions in the current barging rates as well as the development of storage and warehouse operations based primarily on the Neighbor Islands, where land is somewhat less expensive than on Oahu.

If a reforestation program were initiated immediately, it would be about 20 years before island-grown hardwoods could meet even local demands. In the meantime, domestic demand for hardwoods would probably increase as an island-based lumber industry develops.

At best, however, local demand for hardwoods can never absorb more than a small fraction of Hawaii's potential annual timber harvest. Export markets would have to be found for hundreds of millions of board feet of lumber and wood products. Is this possible or likely?

To answer this question we must examine two critical assumptions which underlie the arguments of those who advocate the fullest possible development of Hawaii's timber potential. The first assumption is that world markets will continue to demand wood products at no less than the present rate. The second is that these markets can be efficiently served using Hawaii-grown wood products. First of all, it is important to note that the world timber supply has been steadily shrinking, even as burgeoning population has given rise to sharply increased demand. There are at this time very few countries whose timber resources are keeping pace with their internal demand for wood products.[13] Even fewer countries are able to produce a surplus of hardwoods for export. To be sure, wood has been replaced for some uses by metals, plastics, and other synthetic products. Nevertheless, the demand for wood and wood products continues to grow, even in those highly industrialized countries which have led the way in developing wood substitutes. Hawaii's geographic position favors its becoming a major supplier of hardwoods, especially for the booming metropolitan areas of America's West Coast and possibly Japan. These markets are economically accessible to Hawaii because she is separated from them by water, rather than by extensive land masses over which transportation rates are high. The shipment of lumber and other wood products by sea is much more economical than by rail or highway.[14]

Confirmation of portions of these arguments has been supplied recently by a U. S. Forest Service study which considered the feasibility of providing the hardwood market in the Los Angeles area with Hawaii-grown wood products. The Hawaii state legislature appropriated funds to help finance this study, which specifically considered the needs of the Los Angeles furniture industry. This industry consumes 120 million board feet of wood annually, of which about 60 million

board feet are hardwoods.[15] The latter, such as maple and oak, are shipped by rail from the eastern seaboard, the major remaining hardwood producing area on the American mainland. The difference in shipping costs alone would put Hawaii in a strong competitive position vis-a-vis hardwood producers on the East Coast. Should the Islands develop a sustained growth of standing timber of six or seven high-quality hardwood species, some 35 to 50 million board feet annually of lumber and veneers could ultimately be shipped to this market at a competitive price.[16] These figures are likely to prove conservative, given the continuing shift of population toward the western region of the United States. Additional urban markets there are expanding rapidly, and no end to this development is in sight. It is relevant to note that the timber industry of the western United States produces softwoods, so that Hawaii's production of hardwoods would complement and strengthen this industry, rather than compete with it.

These prospects for an expanded market for Hawaii's timber are improved by the willingness of purchasers of wood products around the world to absorb sizable quantities of such items as veneer flitches, large pieces of well-grained wood cut into thin sheets to be glued over less expensive woods. Timber species already growing in Hawaii such as Australian red cedar, Queensland-maple, tropical ash, and robusta make extremely attractive veneers.[17]

There is another potential advantage in the development of an island-based lumber industry. Hawaii's lumber processing industry has not developed adequately over the years, even though about 110 million board feet of wood go through the hands of the State's lumber wholesalers and contractors annually. Although all of the major lumber importers have planing and finishing mills, these mills are used mainly to cut dimension lumber into smaller sizes and to dress down any flaws. Hawaii's lumber dealers import high-grade finished wood almost exclusively, and there are several factors which have contributed to this practice. In the first place, importers have been understandably anxious to keep inventories down, especially since warehouse and yard space in or near Honolulu is, for whatever reason, restricted and extraordinarily expensive. Consequently, lumber wholesalers have limited imports to a minimum number of varieties. Inevitably, the consumer's range of choice has been curtailed. Second, it has been simpler and more efficient for island lumber wholesalers and contractors to order finished lumber, rather than to pay high shipping charges for rough lumber which would require planing or sanding after delivery in Honolulu. All these circumstances help to explain why the numerous lumber processing plants which abound in the timber-producing areas of the mainland have not been established in

Hawaii. The effects of this have been to sharply limit the commodity and outlet choice open to contractors and other lumber buyers, while depriving Hawaii of the many job opportunities associated with wood processing industries.

These traditional methods of meeting the Islands' lumber needs have stemmed from and reinforced certain construction practices. Virtually all residential buildings in Hawaii are of single-wall construction, which permits siding to be seen from both inside and outside the building. For this reason, most sidings used in Hawaii at the present time are classified "all clear-heart" grade (without flaws). Local conditions also call for lumber such as redwood that is at least somewhat resistant to decay and termite damage. Island building contractors frequently use these softwoods for purposes normally--and better--served by hardwoods. Considerable amounts of Douglas fir are used for flooring, even though this material is easily scratched and marred in such service. Island home builders thus spend more for materials than their mainland counterparts, while using materials which are not especially well suited to local conditions. This situation is unnecessary. Island-grown hardwoods long ago proved themselves superior for flooring and other purposes, not only to Douglas fir, but even to the best mainland hardwoods, such as oak. Island-grown robusta flooring is more resistant to termite damage than many other hardwoods. It is also harder and stands up far better even under hard wear. Furthermore, its rich, warm tone and interesting texture make it considerably more attractive in the view of many.

Island contractors and home builders, although forced to spend excessive amounts for partially unsuitable materials, have not mounted strong pressure for the development of a domestic lumber industry. Some of the underlying reasons for this situation have already been discussed, but it should again be emphasized that the policies followed in managing Hawaii's forest reserves during the half-century following Hosmer's resignation as territorial forester were specifically designed to prevent the development of a commercial timber industry. Large private landowners have, understandably, been little tempted to enter this field,[18] for it requires considerable capital investment over a long period with no prospect of return for many years. Their chief source of rental income was from plantations concerned with maximizing yields from sugar, pineapple and ranching. Furthermore, the pre-war patterns of business in Hawaii were compatible with limited competition among wood importers and wholesalers. Even today, approximately half of the Islands' lumber imports flows through two firms, while six dealers handle approximately 90 per cent of the lumber sales on Oahu. Nor are these the only factors which tend to

restrict the breadth of consumer choice for Hawaii's house builders. As a recent study of the lumber distribution and building industry points out:

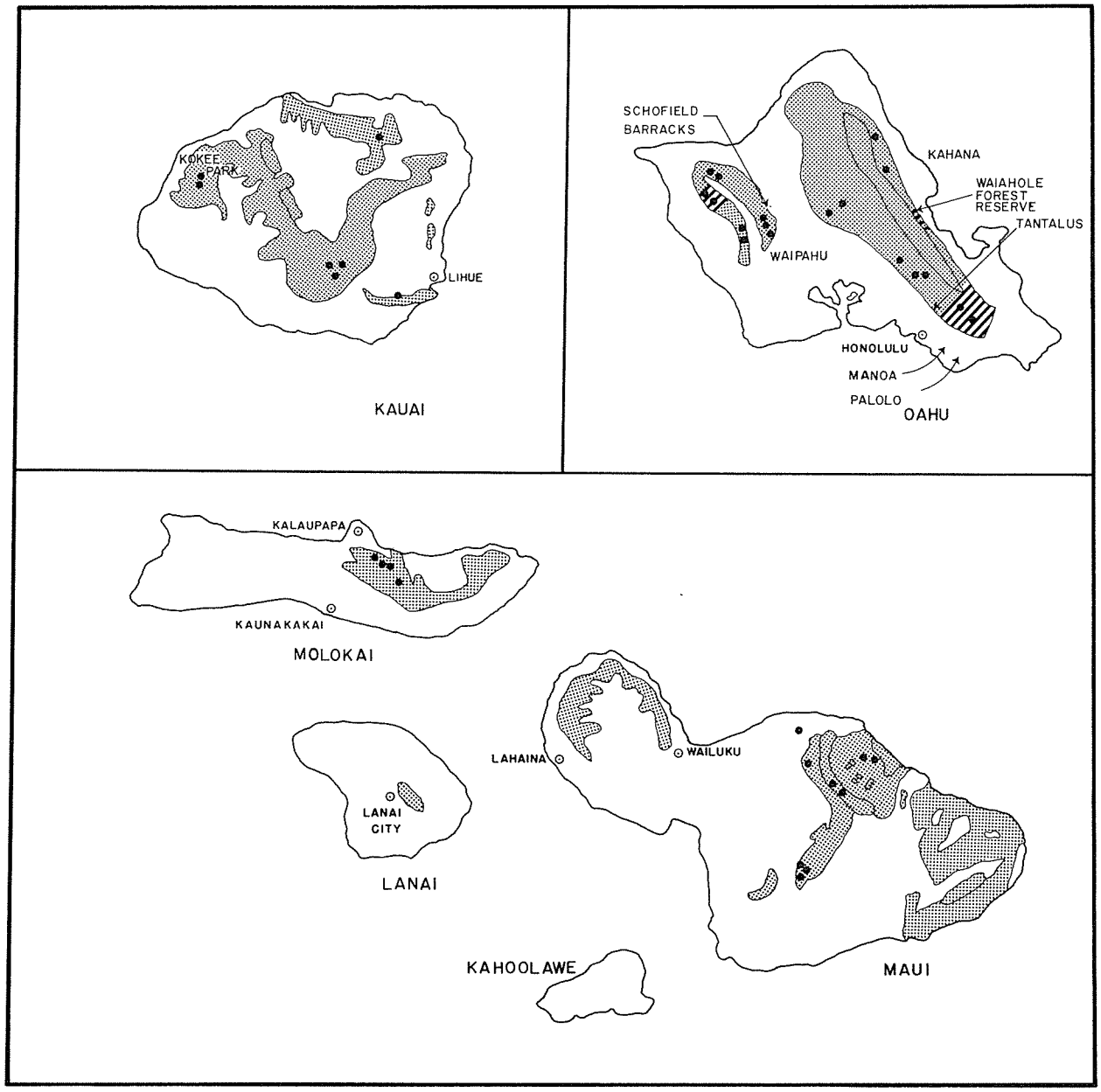
> It is not uncommon for the larger suppliers to have an interest in several subdivisions. This interest can run all the way from the actual purchase or lease of the land, and subsequent development, to aid in obtaining the financing for a development. Through this series of services provided by the lumber dealers, the prospective home builder can get one-step shopping in the purchase of a new home. The dealer can provide financing, recommend a contractor, whom he will bond, and extend credit to, and supply all the lumber and other building materials required for a new home.[19]

To be sure, the home builder can get "one-step shopping", but at the same time his range of choice in building materials is circumscribed by decisions of the lumber importers over which he has virtually no control. The alternative available to those dissatisfied with available materials is to undergo the extraordinary additional expenses for special imports.

The development of a commercial timber industry in Hawaii could contribute to overcoming problems such as these. High-quality hardwoods might be provided at lower prices than now prevail, and in a much wider variety of species and sizes. These woods could be offered for sale by a larger number of supplies than there are at present, thereby increasing competition, while providing consumers with a broader choice. The quality and maintenance costs of island homes could be markedly improved by the use of domestically grown termite-resistant hardwoods. If Hawaii's timber industry were fully developed, it is even possible that island-produced hardwoods could be marketed at a price competitive with that of some imported softwoods. In this event, the present level of consumption of some 10 million board feet of hardwoods annually could be greatly increased.

Hawaii's already important furniture industry would be strengthened by the production of high-quality island hardwoods and would undoubtedly consume considerably more than the 2 million board feet of wood now used annually. A broad variety of locally produced hardwoods, including saligna and robusta, tropical ash, silk-oak, Australian red cedar, Queensland-maple, and koa are well suited for furniture manufacture, and should replace mainland and Pacific Basin imports. An ample and sustained supply of these valuable woods could also stimulate Hawaii's furniture industry in its competition for local markets and would give it a distinct advantage in broadening export markets. The importance of this possibility for improving

COMMERCIAL TIMBER AR



Lands suited for commercial timber.

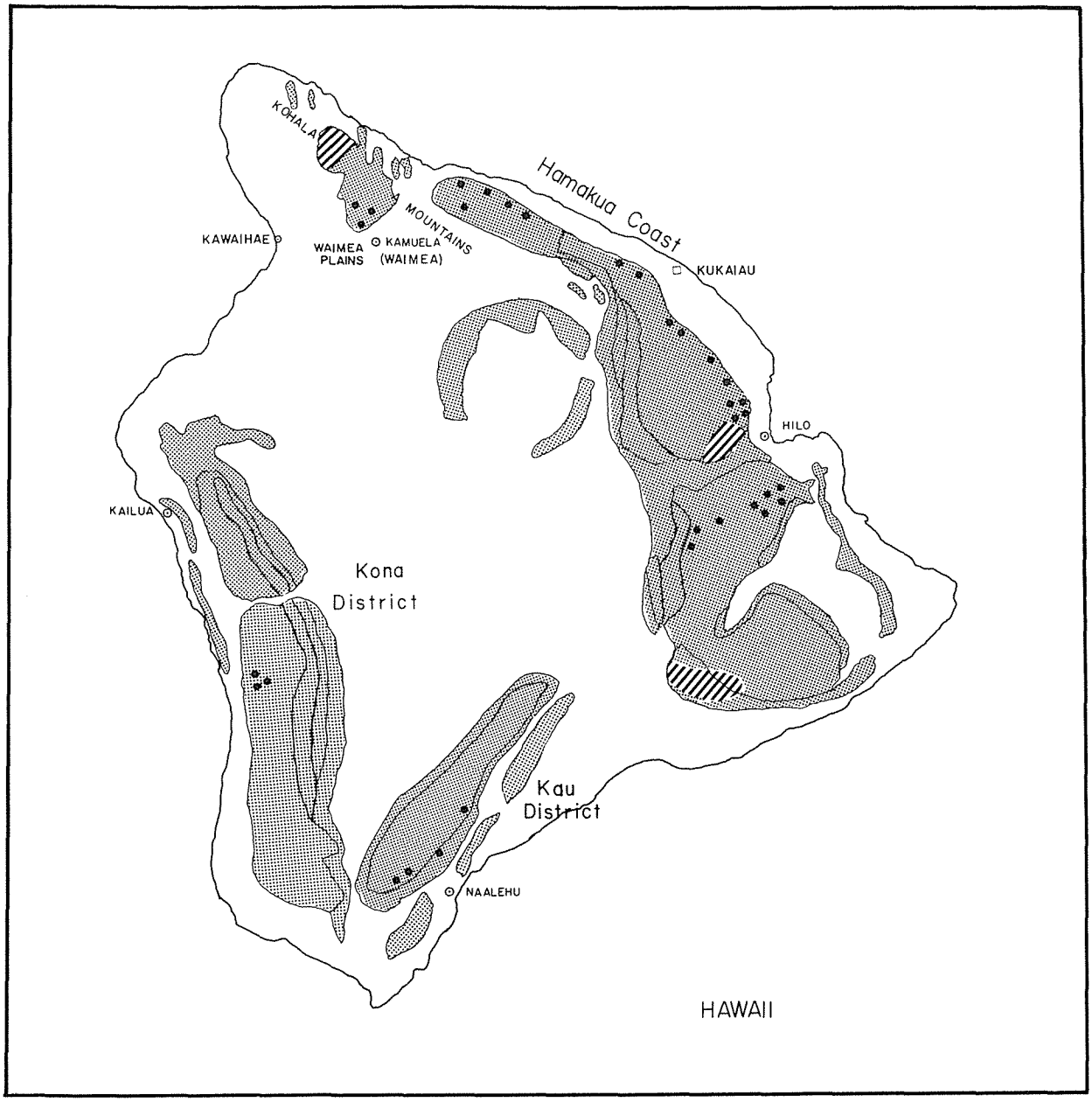
Productive — reserved forest land (watershed or park).

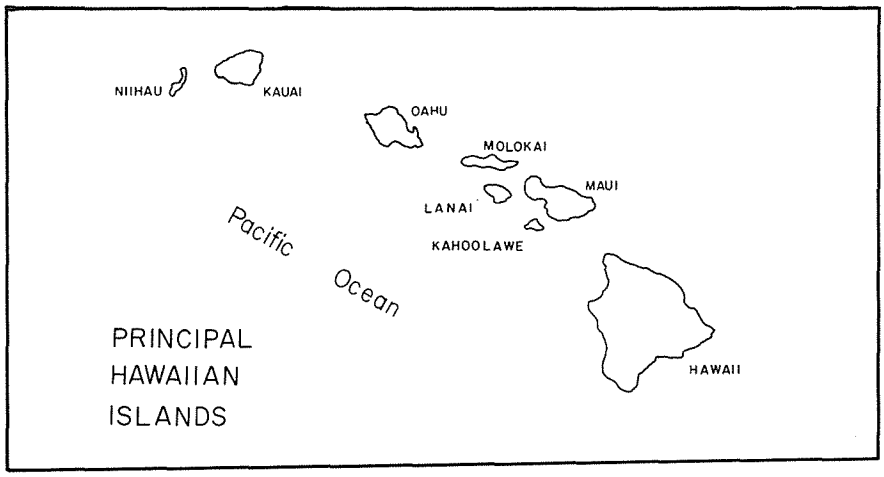
Tree plantation concentration.

Source: Maps based on Forest Resources-1961, State Forestry Division in cooperation with the U.S. Forest Service.

10 5 0 10 20 30 MILES

EAS, STATE OF HAWAII





Hawaii's balance of trade cannot be overestimated. A combination of affluence and improved taste has considerably broadened the market for well-designed, high-quality furniture both in Hawaii and on the American mainland. The potential for continued development of Hawaii's furniture industry is considerable, especially if island-grown wood were available in sufficient quantity.[20]

The woodcraft industry provides another example of an already important island manufacture which is increasingly in need of Hawaii-grown raw materials. Although the volume of woodcraft items sold locally has risen considerably in recent years, the use of local woods has declined as supplies of monkey pod and quality koa timber have diminished.[21] Craft manufacturers now import most of their monkey pod and other woods from Fiji and Indonesia.[22] In some cases monkey pod saw logs are shipped to Hong Kong or other areas where labor costs are low; there they are semi-finished into bowls, table tops, and the like; and are then shipped to Hawaii for final finishing and marketing. These considerable shipping and handling costs could be eliminated if an ample supply of monkey pod and other craft woods were available in Hawaii. The continued growth of tourism will undoubtedly stimulate ever-larger demands for woodcraft products, and export sales should also continue to increase. The net value which this industry can contribute to Hawaii's economy should increase considerably in the years ahead. These gains can be maximized through reforestation programs designed to provide for the cultivation of monkey pod, koa, mango, and other hardwoods suitable for the manufacture of woodcrafts.

The future of Hawaii's furniture and woodcraft industries depends on the development of a commercial timber industry in the Islands for yet another critical reason. It has been noted that supplies of quality hardwoods are decreasing throughout the world, in part because foreign producers have been decimating their forest resources in much the same fashion as did the earlier exploiters of Hawaii's forests.[23] As supplies shrink, prices rise, yet quality has declined in recent years. This has been made clear to Hawaii's wood users, who presently import some 5 million board feet of hardwood timber from the Philippines and other countries in the Pacific Basin.[24] Much of this wood is no longer of premium quality, to say the least, and will become increasingly expensive.

The only effective way in which these problems can be met in the long run is through the extensive development of commercial timbering in the Islands. Systematic and sustained research has demonstrated beyond any reasonable doubt that Hawaii-grown hardwoods compare favorably in all important characteristics with imported hardwoods. What is called for now is the initiation of commercial forestry here

on a sufficiently large basis to achieve economies of scale. This can be accomplished only through making large capital investments in many areas, including: land clearing and reforestation, milling and other machinery, systematic marketing studies, and market development. Island-grown and processed hardwoods can adequately supply the local market and become a major export commodity only when a sustained output of competitively priced, high-quality products has been made available to meet market demands. This goal cannot and will not be reached through continued reliance on the characteristically modest replanting programs of the past, nor through the small milling operations which depend on purchase of stumpage from the surrounding locality. On this point, it is pertinent to consider the possibility that the losses and failures frequently suffered by those who have undertaken small-scale lumbering operations in the Islands may have stemmed largely from a lack of capital sufficient to develop operations of the scope and type required by local conditions. The failure of these inadequately financed operations has, more often than not, been interpreted as providing conclusive evidence that commercial forestry cannot succeed in Hawaii. This conclusion is unwarranted. Nevertheless, past failures should serve as a warning to those tempted to enter this field without adequate resources. More positively, they suggest that commercial forestry can be developed into a profitable and important new industry in the Islands only if its development is underwritten by major capital investment, whether in the public or private sector, or both. Each of these alternatives for forest development requires intensive scrutiny by the State's policy-makers at this time.

These matters have received attention during recent legislative sessions, but insufficient consideration has been given to the most critical issue now at hand: can this "infant industry" best be developed through investment of public funds, through private investment, or through a combination of the two. Until an explicit answer is given to this question, legislation designed to encourage this industry may be misdirected and inadequate, effective administration of forest resources will not be possible, and realization of the enormous potential of commercial timbering will be delayed.

Recently enacted legislation appears to be designed to encourage the development of commercial forestry through both private and public investment, but insufficient attention has been afforded the possibility that certain of these measures may work at cross purposes, or at least fail to prove complementary. For example, let us consider, in this connection, both the chief measure enacted in recent years to encourage private investment in commercial forestry, and a recent

measure intended to facilitate development of forest land through public investment.

In 1963, Act 141 was passed to encourage "the establishment of tree farms" by exempting owners of approved commercial timber land from real property taxes.[25] By substituting yield taxes based on stumpage sales for the annual payment of real property taxes, the law seeks to encourage the investment of private capital in tree farming. It relieves private investors from the burden of land taxes for the extended period during which no return is received from investment. Comparable legislation has proven its worth on the American mainland, but this approach can effectively stimulate substantial investment in tree farming only if landowners may reasonably expect that the possibilities of marketing mature stumpage are reasonably good 30 or more years after they have undertaken tree planting programs. Profit potentialities are distinctly diminished if, among other things, private tree farmers are faced with the prospect of disadvantageous competition.

It is necessary to consider whether the goal of this legislation, which is designed to encourage private tree farming, is reinforced or weakened by the stumpage-cutting license provisions provided by Act 239 which was passed in 1965.[26] Under this law the Board of Land and Natural Resources is authorized to "issue land licenses for the harvesting, milling, and sale of state-owned timber products without recourse to public auction" for a period not exceeding 20 years.

The implementation of this stumpage-cutting license provision could serve to put the State into the timber-growing business, since it would be necessary to replant areas harvested by license holders. If these timber areas are to be properly maintained and developed, the State will find it necessary to undertake road development, provide fire protection, and be fully responsible for supervision and maintenance. A considerable part of the costs would probably be included in general budgets, so that it might well prove difficult, if not impossible, to allocate these costs to specific public forest tracts. Sound pricing of stumpage, especially during initial licensing periods, would then be difficult, and it is likely that stumpage sales would therefore be made at subsidized prices to holders of cutting licenses. The prospects of this development might well deter private investment in tree farming, for competition with state-supported programs could be formidable.

This is not to argue that the State should necessarily refrain from issuing stumpage-cutting licenses. Rather, this discussion is intended to bring into focus the fundamental policy issue which

underlies the stumpage-cutting provisions, namely, the question of whether the State is, in fact, prepared to undertake large-scale reforestation programs at this time. If the State is unable or unwilling to replant extensive acreages of public timber lands harvested under stumpage-cutting licenses, reconsideration of this measure is indicated.

Is the State ready to expand and accelerate its traditionally modest forest planting program? Unfortunately, no definitive answer can be given to this question, but it would be unrealistic to give way to unqualified optimism if the scope of this program in recent decades provides a sound basis for judgment. Proponents of substantially increased tree-planting programs will have to compete for public funds against powerfully supported demands for increased appropriations for education, health and welfare, and many other pressing programs. Faced with such competition, proponents of increased appropriations for forestry programs are going to find it difficult, at best, to secure their objectives. These difficulties should be frankly acknowledged and taken into account in exploring alternative approaches to forest development.

The only major alternative to public investment in securing rapid, large-scale reforestation is the attracting of large private investment. But this may prove impossible unless pertinent modifications are made in the public land laws. The maximum lease term presently available on public lands is 35 years, and even this term is available only as a special dispensation for those lessees who can demonstrate that this period is required for amortization of the investment made by them for land development. Leases of this duration would permit a lessee to plant and harvest no more than a single timber crop. Accordingly, lease lengths would have to be increased to a minimum of 75 years to permit amortization of the investment required to develop commercial timber crops on public lands. It might also be sound to permit the Board of Land and Natural Resources to negotiate the terms of such leases, rather than going through the formality of an auction, for these leases would typically comprise large land areas on which the prospects for genuinely competitive bidding would be small.

If such long-term leases on sizable areas of public land suitable for commercial timber production could be made available, there would be real possibilities for attracting heavy investment by one or more major timber firms. In order to realize the full potentialities of this industry, such producers would have to invest many millions of dollars in land development, reforestation, mill equipment, and the like

over a period of years. It would, of course, be some years before such an investment could prove profitable, but the prospects for reasonable long-term profits are distinctly good.

It must be emphasized that exploration of this approach to development of commercial forestry in the Islands should include the most careful consideration of a variety of safeguards designed to afford broad protection to the public interest. Specifically, it would be necessary to insure that enormous areas of public land were not frozen into the single-use pattern of land utilization criticized earlier in this study. To assure that the public may have reasonable access to and use of these lands, it would be necessary to make explicit reservations in long-term leases for park sites, public camping grounds, and the like. Easements over access and timber roads would have to be provided, with water rights, or even potential sites for dams, secured wherever necessary. This should pose no insuperable problem, for comparable arrangements have been made with major users of public timber land in the western portions of the United States. The working out of comparable arrangements in Hawaii would probably be somewhat more complex, for the islands are small, and population pressure on Oahu is already severe. Under these circumstances, the development of sound multiple-use arrangements would necessitate close consultation with governmental officials responsible for health, water, and other related programs.[27]

It has not proved difficult to devise rent schedules which take these important reservations of public rights into account. Furthermore, some major mainland lessees of public forest lands have taken the initiative in developing public camping areas, hunting grounds, and other recreational facilities within their forests. They have, in short, demonstrated the feasibility of the multiple-use approach. Hawaii could in similar fashion foster the rapid development of commercial forestry through private investment, while simultaneously expanding opportunities for broader use of the public lands by the citizenry.

CHAPTER VI

MULTIPLE USE AND EMPLOYMENT PROSPECTS

Added demands would be made on Hawaii's labor force through implementation of the multiple-use approach to public land management. The initiation of each major phase of a multiple-use program would create hundreds of jobs, with employment swelling into the thousands if commercial timber and woodworking industries achieved large-scale development. It is imperative, therefore, that policy-makers consider the availability of island workers to fill new jobs.

The seriousness of this question is emphasized by our earlier conjecture that Hawaii's chronic labor shortage contributed, at least initially, to the failure to develop commercial forestry in the Islands. A persistent difficulty faced by Hawaii's plantation managers for nearly a century was the recruiting and retaining of an adequate labor force. Typically, the plantations sought to hire the sons of their field workers as these youngsters left school. As late as 1946, laborers were recruited from the Philippines for plantation work. Under these circumstances, Hawaii's business leaders could hardly have been expected to encourage commercial forestry and thereby intensify competition for labor.

The first break in this tight labor situation developed in the wake of postwar mechanization of the plantations. A detailed discussion of the complex question of the size of Hawaii's surplus labor force is unnecessary here, for it is demonstrable that Hawaii is beginning to face a situation comparable to that of the American mainland, where the upgrading of jobs in major industries and automation are increasing unemployment rates especially among unskilled or semi-skilled workers. A large number of these men and women are not just temporarily unemployed: rather, they constitute an expanding pool of "hard-core" unemployed, for their long-term job prospects are distinctly poor.[1] Especially disturbing is that this pool of "hard-core" unemployed contains a growing percentage of workers in their late teens and early twenties who have failed to acquire the skills demanded by today's labor market.[2] Their numbers are supplemented by older workers who have been unable or unwilling to acquire new skills after having been displaced by automation or other innovations.

Fortunately, implementation of multiple-use programs, especially those concerned with park development, outdoor recreation, commercial forestry, and related woodworking industries, would help to provide precisely the kinds of jobs suited for unskilled and semi-skilled workers. Specifically, the initial phases of multiple-use programs require land development: building of forest trails and roads,

construction of campsites, clearing and replanting operations, and the construction of somewhat rough-hewn recreational facilities. Work of this type continues to demand considerable manpower, even though heavy equipment may be used to a limited extent.

Should Hawaii's policy-makers afford serious consideration to this approach to putting unemployed to work, one especially promising vehicle is already available. This is the Economic Opportunity Act of 1964, a cooperative federal-state program designed to provide training and work experience for those between the ages of 16 and 21. Two parts of this program, the Job Corps and the Neighborhood Youth Corps, have proven successful in supplying diverse job training, supplementing formal education, and providing conservation work experience. During the summer of 1965, the Neighborhood Job Corps program undertook park improvement on Oahu, with marked success. This valuable work will be continued during the coming year.

A growing number of Job Corps Conservation Centers have been established on the mainland, and a proposal has been submitted to the federal government for the establishment of a Job Corps Center in Hawaii. Present plans call for it to be located at Koko Head on Oahu, where the unused facilities of a National Guard camp could be refurbished and expanded at minimal cost.[3] Enrollees in the Job Corps would receive orientation at this center, along with considerable academic and technical training. They would then be assigned to one of the "satellite camps" to be located on the Neighbor Islands. Operation of these satellite camps would be assumed by the State Department of Land and Natural Resources and by the National Park Service. This would facilitate the assignment of Job Corps enrollees to conservation work.

Should a Job Corps program develop along these lines in Hawaii, the experience provided in conservation work would fit in perfectly with the implementation of multiple-use programs. Those recruited for work in multiple-use programs would be afforded further opportunities for the acquisition of skills. This point must be considered more fully.

The initiation of most phases of multiple-use programs requires large amounts of unskilled labor. As forest trails and roads are opened, additional opportunities are presented for the use of hand tools and heavy equipment, the handling of which should be part of a fully functioning Job Corps program. These operations typically produce increasing amounts of usable timber. Part of this timber might be sold to private wood processors, but a portion of it can be

used for the construction of public recreation facilities: shelters, pavilions, cabins, fences, and small bridges. Although most such construction would initially utilize lumber supplied by outside sources, timber cutting, trimming, and milling can provide valuable job experience as conservation programs move into more advanced phases. Given the present underdeveloped state of Hawaii's commercial timber industries, it would be necessary to recruit supervisors from the mainland to establish and direct sawmill and related operations.

It should be added that the milling, carpentry, and general construction work which could be carried out by these programs would not compete with private enterprise; nor is there any prospect that the State could or would undertake these activities outside the context of Job Corps and various multiple-use programs on public land. In the long run, for that matter, these programs would make an important contribution to the development of privately owned enterprises, since they would train and make available to the labor market an increasing number of workers equipped with valuable skills. This would be especially true if private owners of land suited for commercial forestry were to become more vigorous in developing their holdings.[4] As the development of commercial forestry progresses, other workers could be trained for employment in furniture manufacture and other woodworking industries. Still other workers would be enabled to pursue careers in the many aspects of conservation work, serving, for example, as rangers, guides, park attendants, and employees of park concessions.

CHAPTER VII

CONCLUSION

This study has sought to explore the proposition that broader and more efficient utilization of Hawaii's public land can be achieved through multiple use than has been possible through the single-use approach of the past. However convincing the evidence in support of this proposition may be, it must be remembered that all proposals for new governmental programs must overcome a final, formidable obstacle: money. We are acutely aware that the scope and cost of governmental services at all levels have increased rapidly during the past decade, especially in such vitally important areas as education and welfare. As expenditures have risen, so have taxes, and the citizens of Hawaii are now among the most heavily taxed in the country. It may therefore be felt that, even though multiple-use programs are desirable, they are not economically feasible for the State to undertake at this time.

In anticipation of this consideration, special emphasis has been afforded throughout this study to the many possibilities for fully utilizing the financial resources, personnel, and research findings presently being made available by the federal government through the Economic Opportunity Act, the "open space" land acquisition act, research and technical assistance programs of the Department of Agriculture, and the like. Cooperation with departments administering these programs can greatly assist the State in designing and implementing promising multiple-use programs. State and federal programs can be made mutually reinforcing, as, indeed, they should be if they are to achieve maximum effectiveness.

In short, the development of multiple-use programs would not require great public expenditures, and these programs would become increasingly self-sustaining as they achieved their goals. This would be all the more probable in Hawaii in view of the enormous potential of her commercial timber industry. Revenues received from lumbering would progressively offset expenses through increased tax yields, receipts from leases of public land, stumpage sales, and indirect contributions to economic development, especially tourism and manufacturing.

In view of the central role which commercial forestry can play in fostering multiple-use programs, it should be reiterated that extended research has definitely established two key findings: (1) that high-quality hardwoods grow rapidly in Hawaii in commercial quantities, and (2) that markets, both domestic and overseas, are available for these products. The managers of wood processing

industries on the Pacific Coast and around the Pacific Basin have become actively concerned with finding new sources of hardwoods and have been affording very serious consideration to Hawaii's forest products. Representatives of American and Japanese timber processors, both large and small, have visited Hawaii in recent years specifically to investigate the possibilities of installing mills to process existing stands of hardwoods into lumber, veneer, and hardboard, and to utilize the residue left from milling for producing fibreboard. Active investigations are continuing. They suggest that existing stands of hardwoods in the Islands have considerably greater potential value than has been commonly thought. Even though the bulk of existing stands is rightly considered to be of inferior quality, it is evident that harvesting this stumpage could yield returns which would contribute significantly to developing milling operations, reforestation, and broad-scale multiple-use programs.

An initial portion of the cost of getting multiple-use programs under way might be covered by receipts received from sales of public lands for homesites on Oahu. Millions of dollars have been received in recent years from such sales, and it would certainly be far-sighted policy to reinvest the equivalent of these revenues in the further development of Hawaii's public lands. Such a policy would stand in marked contrast to that pursued earlier in the century, when receipts from sale of public land were used to defray current expenses of government. Short-term benefits were achieved at enormous long-term costs. It is impossible to calculate the overall losses incurred by careless alienation and neglect of much of the public lands.[1] Our responsibility and challenge today is to develop the public land in a fashion which will make the maximum long-term contribution to the general welfare. The State simply cannot afford to leave idle those resources which are critically needed in this period of expanding population and ever increasing public needs.

Land which has served but a single use should, wherever feasible, be brought into multiple use. Such a serious and sustained drive to make multiple use of Hawaii's public lands could contribute more than any other public program to broadening the State's economic base. It could create a galaxy of new industries based on commercial forestry, strengthen the faltering ranching industry, and sustain tourism. Most importantly, by vastly increasing the opportunities for outdoor recreation, it could enhance the quality of life for the citizenry. All this is promised through optimal use of Hawaii's richest natural resource--her public land.

FOOTNOTES

CHAPTER I

1. A continuing and illuminating analysis of the importance of public land policy in realizing both present and prospective national goals is to be found in many of the publications of Resources for the Future, Inc. See especially Marion Clawson, R. Burnell Held and Charles H. Stoddard, Land for the Future (Baltimore: Johns Hopkins Press, 1960) and Marion Clawson and Burnell Held, The Federal Lands: Their Use and Management (Baltimore: Johns Hopkins Press, 1957). See also Marion Clawson, Man and Land in the United States (Lincoln, Nebr.: University of Nebraska Press, 1964).

2. The State Land Use Commission was created by Sess. Laws of Hawaii 1961, Act 187 and revised by Sess. Laws of Hawaii 1963, Act 205. (Consult Rev. Laws of Hawaii, sec. 98G (Suppl. 1963).)

3. Sess. Laws of Hawaii 1903, Act 44. The statute provided, among other things, that "the Governor may, with the approval of a majority of the Board [of Forestry and Agriculture], after a hearing or hearings . . . set apart any Government land or lands not then under lease, or on which there is a lease of two years or less, as forest reservations. Any lands so set apart shall not thereafter be leased or sold by the Government, or used in any way or for any purposes inconsistent with this Act, except by law fully enacted by the Legislature."

   An extremely significant section of the statute provided that nothing in the Act should be "construed to change any rights in or concerning any water upon or flowing from or through any land set apart or surrendered as a forest reserve . . ."

   Another significant aspect of the Act was the provision that "Any person or persons, corporation or corporations, may at any time surrender to the Government the care, custody and control of any lands, whether held under lease or in fee, as a forestry reservation, either for one or more years, or forever.

   No taxes shall be levied or collected upon any private lands so surrendered for the purposes aforesaid, so long as the same shall remain exclusively under the control of the Government as a forestry reservation."

   This provision for temporary surrender of lands by private parties and corporations was criticized by some on the grounds that it enabled plantations, for example, to maintain watershed areas at public expense while continuing to utilize water rights. Furthermore, the short-term surrender provision made it possible for private landowners to move tracts in or out of forest reserves at their convenience, thereby avoiding the payment of taxes when they wanted to secure only water from the area, while retaining the privilege of withdrawing the land from the forest reserves should they want to make use of it for other purposes.

   These arrangements, which were clearly advantageous to the plantations were not basically modified until 1957, when the minimum term for surrender agreements was increased to 20 years, with provision made for payment to the government for "the then reasonable value of any timber or other crops planted during the term of surrender." See Rev. Laws of Hawaii, sec. 19, Pt. I (Suppl. 1963).

   A further amendment was made to this statute in 1965 which provides that if lands surrendered to the government as forest or water reserves are withdrawn without the consent of the department of land and natural resources prior to the expiration of the 20-year term of surrender, the tax exemption privilege shall be cancelled retroactive to the date of the agreement of surrender and taxes that would have been due shall be payable with a 5 per cent per annum penalty from the date that the payment would have been due. Sess. Laws of Hawaii 1965, Act 265.

4. The enormous damage done to the once heavily populated island of Lanai by wild goats is vividly described by kamaainas who testified before a special committee of the Territorial House of Representatives in 1907. According to their report, as goats denuded hillside areas, soil and rock washed down into streams, clogging them with debris and halting the flow of water to taro patches and ponds downstream. See Hawaii, Journal of the Territorial House of Representatives, 1907, "Lanai Investigation," pp. 1669-70.

5. Regarding the introduction of cattle and other animals into Hawaii by the early explorers and the use of kapus to protect them, see Ralph S. Kuykendall and A. Grove Day, Hawaii: A History (New York: Prentice-Hall, 1961), pp. 33-34. By the time the kapus were lifted the number of wild animals was sufficient to provide the basis for a lively, if short-lived, industry. The hides of slaughtered animals were exported, and boiling plants were busy on several islands in the 1850s extracting tallow from these animals. Estimates of the number of wild cattle slaughtered in forest reserves after the institution of that program are provided by Edward Y. Hosaka, "The Problems of Forestry and the Work in Progress Toward Reforestation in the Territory of Hawaii" (University of Hawaii, 1930), p. 31. (Typewritten). Norman K. Carlson and L. 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: Trustees of the Bernice P. Bishop Estate, 1959), p. 17.

   For an interesting account of the attempt by the authorities of the Hawaii National Park to exclude cattle from the park area on the island of Hawaii, see Russell Anderson Apple, "The History of Land Acquisition for the Hawaii National Park to December 31, 1950" (unpublished Master of Arts thesis, University of Hawaii, 1954), pp. 115-131.

6. The Waiahole Water Company is a wholly owned subsidiary of the Oahu Sugar Company, itself a wholly owned subsidiary of American Factors, Ltd. Water percolates into an elaborate network of tunnels bored deep into the mountain range adjoining the valley of Kahana on the windward side of Oahu. It is carried across nearly the entire width of the island to Waipahu, where it is used to irrigate the plantation's fields. Like other plantation water systems in Hawaii, this work is

a tribute to the imagination, engineering skill, and boldness of the men who built the sugar industry. Completion of the system contributed materially to the transformation of semi-arid waste lands into an extraordinarily productive agricultural area.

7. Paul C. Ekern, "Direct Interception of Cloud Water on Lanaihale, Hawaii," Soil Science Society of America Proceedings, 28(3) (May-June, 1964), 421. The 100-inch figure is a personal estimate of Ekern's. The research reported in his article was carried out between 1955 and 1958.

8. Some hydrologists believe that utilization of fog-drip might contribute significantly to the precipitation of moisture in the area of Kula, Maui. Reforestation of the hills above the town could, in their view, intercept cloud formations which presently drift across that arid area without precipitating their moisture. In point of fact, the Kula area was one of the most productive agricultural regions in the Islands prior to the decimation of its forests in the 19th century.

9. An added informative comment on the phenomenon of "fog-drip" can be found in a letter from Louis H. Herschler, a Civil Engineer, who formerly served with the Hawaii Water Authority, to Herman S. Doi, Acting Director, Legislative Reference Bureau, August 31, 1965.

   "During my visit to the Lanai fog-drip station several years ago, it was interesting to note that the general area was dry, almost to the point of being 'dusty', yet under the Norfolk-Island pine trees one could observe puddles of water. In many other mountain areas exposed to trade winds and low hanging clouds, I have observed that one might get quite wet in walking through shrubs even though there had been no recent rain. Such type of moisture must provide a good portion of the transpiration needs of the local vegetation, reduce rainfall evaporation and result in greater total run-off or percolation of the rainfall."

10. William L. Hall, The Forests of the Hawaiian Islands, U. S. Bureau of Forestry Bulletin No. 48 (Washington: 1904), pp. 17 and 24. See also Lester W. Bryan, "History of Hawaiian Forestry up to and Including 1920," statement prepared for the Fifth World Forestry Congress, August, 1960, pp. 1-2.

11. The Board of Agriculture and Forestry, which consisted of seven commissioners, generally included in its membership plantation managers, ranchers, and associates of the Hawaiian Sugar Planters' Association. For example, see Margaret E. Holden and Robert H. Horwitz, Directory: Agencies and Officers, Territory of Hawaii (University of Hawaii, Legislative Reference Bureau, 1955), p. 7. Related, pertinent aspects of the development of Hawaii's sugar industry are skillfully traced by J. S. Mollett, Capital in Hawaiian Sugar: Its Formation and Relation to Labor and Output, 1870-1957, Hawaii Agricultural Experiment Station, Agricultural Economics Bulletin 21 (Honolulu: 1961).

12. This estimate is based on figures supplied in the biennial reports of the Board of Commissioners of Agriculture and Forestry from 1905 to 1950. See also Hosaka, p. 31. The author reports that from 1925 to 1928, 42,311 wild animals including horses, pigs, and sheep were killed in forest areas. As recently as 1958, nearly 1,000 cattle were killed or driven out of the Bishop Estate's Honaunau forest reserve on the island of Hawaii. See Carlson and Bryan, p. 17.

13. The writer went on to add that "Complaints come to this office from the American Settlement at Wahiawa, Oahu, of the destruction of forests by cattle and fire in the Koolau mountains, from where they get their water supply." Report of the Minister of Interior to the President of the Republic of Hawaii for the Biennium, Ending December 31, 1899, pp. 115-116.

14. Hall, p. 25.

15. See Harland Bartholomew and Associates, An Inventory of Available Information on Land Use in Hawaii, Vol. I: Evaluation and Recommendations, prepared for Economic Planning and Coordination Authority, Territory of Hawaii (Honolulu: 1957), pp. 15-25.

16. A land capability study carried out by the Hawaii Conservation Needs Committee revealed that, as of 1958, 1,351,000 acres of the State's land were susceptible to destructive erosion or that their use was restricted by the threat of excess water. The committee's projection indicated that, as of 1975, 1,328,000 acres would continue to be so characterized. The islands of Niihau, Kahoolawe, land under federal control and certain other areas were not included in this study. See Hawaii, Conservation Needs Committee, Hawaii Soil and Water Conservation Needs Inventory (Honolulu: University of Hawaii, Agricultural Extension Service, 1961), pp. 13-16. See also Gerald D. Pickford, "Hawaii Forest Futures" (U. S. Forest Service, Experiment Station, Honolulu, n.d.), p. 1. (Mimeographed). In order to partially control erosion on range land the State Division of Forestry formulated a five-year tree planting program in 1961. (The program is elaborated in Hawaii, Division of Forestry, Five-year State Forest Planting Plan for State of Hawaii, Fiscal Year 1962-66 (Honolulu: 1961). This program was designed to plant eroded gullies and slopes to various genera of hardy pines. The tree most heavily relied upon has been Pinus radiata (Monterey pine). This tree has an excellent growth rate in Hawaii and, although its shape is not especially desirable, it can produce two sixteen-foot logs per tree which can be used to supply lumber suitable for structural purposes. See Roger G. Skolmen, Wood Density and Growth of Some Conifers Introduced to Hawaii, U. S. Forest Service, Pacific Southwest Forest and Range Experiment Station, Research Paper PSW-12 (Berkeley, Calif.: 1963).

17. First Report of the Board of Commissioners of Agriculture and Forestry for the Period July 1, 1903 to December 31, 1904, p. 48, hereafter cited as Report of the Board . . . and date. It was indicated that the area was in immediate need of protection since over-grazing by the ranch had almost denuded the mountain of forest cover and reduced the amount of annual rainfall in the area.

18. Hall, p. 22. The extent to which forest cover had been removed in the Honolulu area by 1902 is suggested in a petition seeking a franchise for a gas company in Honolulu. The petition "pointed

out the desirability of a gas company in Honolulu 'because of the high cost of firewood for ranges of $10 to $14 a cord'." Honolulu Star-Bulletin & Advertiser, July 19, 1964, p. E-2.

19. Ralph S. Hosmer, "The Beginning Five Decades of Forestry in Hawaii," Journal of Forestry, 75(2) (February, 1959), 85.

20. Report of the Board . . . for the Year Ending December 31, 1905, p. 9.

21. Report of the Board . . . for the Year Ending December 31, 1907, p. 19.

22. Ibid., p. 33.

23. Ibid. Hosmer argued in this respect that it was well within the province of government to take the steps necessary to enable and encourage private owners to manage forests wisely. "It is as much a part of forestry to cut, as to plant, trees. In either case there is a right way and a wrong way to go about the work."

24. Report of the Board . . . for the Year Ending December 31, 1908, p. 34.

25. Report of the Board . . . for the Biennial Period Ending December 31, 1914, p. 36. Hosmer said of these reserves, which were located on Hawaii at upper Waiakea and upper Olaa, "Although without running water it was felt that this section should be under the control of the Board of Agriculture and Forestry, particularly as in time the question may arise of exploiting the timber trees on the trace."

26. Report of the Board . . . for the Year Ending December 31, 1907, p. 11. This many ties is equivalent to about 90,000,000 board feet. See Robert E. Nelson and Philip R. Wheeler, Forest Resources of Hawaii - 1961, Forestry Division, Department of Land and Natural Resources, State of Hawaii, in cooperation with Pacific Southwest Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture (Honolulu: 1963), p. 4.

27. Report of the Board . . . for the Year Ending December 31, 1907, p. 25.

28. Ibid., p. 42.

29. Report of the Board . . . for the Year Ending December 31, 1908, p. 30.

30. Report of the Board . . . for the Year Ending December 31, 1904, p. 15. The Territorial Division of Forestry has been involved sporadically in tree planting in this area since 1900.

31. Report of the Board . . . for the Biennial Period Ending December 31, 1916, p. 23.

32. For example, see Report of the Board . . . for the Biennial Period Ended December 31, 1922, p. 4. Here Judd says that of 109,442 trees of 120 different species planted on 15 reserves between 1920 and 1922, "eucalyptus trees were planted only in unfavorable and dry situations other than the natural range of the native species."

33. Report of the Board . . . for the Biennial Period Ending December 31, 1916, pp. 43-44. The total number of trees planted in the Territory between 1915 and 1916 was reported at 1,803,723. Of this number, only 41,521 were planted for timber.

34. Report of the Board . . . for the Biennial Period Ended December 31, 1918, p. 19.

35. H. L. Lyon, "Ten Years in Hawaiian Forestry," Hawaiian Planters' Record, 33(1) (January, 1929), p. 58. "It has been recognized by all students of the Hawaiian flora that the indigenous trees and shrubs which constitute the rain forest on our watersheds are in a very delicate state of health, and that the slightest interference from man or his domestic animals so disturbs their balance that a rapid deterioration sets in which soon results in the death of the majority of the native plants." See also Harold L. Lyon, "Facts of Great Importance," printed as part of cover on reprint of L. W. Bryan, "Twenty-Five Years of Forestry Work on the Island of Hawaii," Hawaiian Planters' Record, 51(1) (First Quarter, 1947), back cover, pp. 4-5.

Harold L. Lyon of the Department of Botany and Forestry, Experimental Station, HSPA, said in the "preface" to the above reprint:

"It was early apparent to the agriculturalists that the supply of fresh water was the factor which would determine the extent to which the sugar industry could be developed and they early began to urge the adoption of measures that would conserve the Islands' water supply and make it available for agriculture. This included the exclusion of stock from important watersheds and the building thereon of water-conserving forests. They secured the creation of a Board of Agriculture and Forestry, the chief function of which was to protect existing forests and build new ones on denuded watersheds. The foresters employed by the Board soon found that they could not grow the native trees on the altered soils which remained after the native rain forests had been destroyed, for they could not recreate the litter and the undergrowth which these trees required to cover their roots. As a consequence, the foresters had to use introduced trees in building new forests and one of their most difficult problems was to find species that would grow on the Hawaiian soils under the prevailing climatic conditions and produce a water-conserving forest. In the teen years of the present century, the foresters were limiting their forest plantings almost entirely to Eucalyptus, Ironwoods and Silver Oak. These trees grow well but did not create a desirable type of water-conserving forest. It was evident that there was a very urgent need for many additional species of trees and shrubs that would associate themselves together to form an efficient watershed cover. The task of introducing appropriate plants and bringing them together into a congenial society or forest required the services of a botanist and the Board of Agriculture and Forestry had none such on their staff. Recognizing this fact, the Experimental Station, HSPA, organized, in 1918, a Department of Botany and Forestry, staffed by botanists whose primary function was to introduce new trees, shrubs and vines which might be employed in building new forests. . . .

". . . Mr. Bryan's work represents the first, the most important and the most difficult step which had to be taken in order to place the creation of new forests on the watersheds of Hawaii on a

sound, scientific basis; it has demonstrated facts of great importance."

36. See Lyon, Hawaiian Planters' Record, 33(1), pp. 60-83, for Lyon's discussion of the tree varieties cultivated in the Vineyard Street and Manoa Arboretums.

37. Lyon's public avowal on this subject is regarded as common knowledge. Three eminent persons connected with forestry and water conservation in Hawaii independently reported to the authors of this report that they had heard this remark.

38. Experimentation and testing of rubber plants in Hawaii proceeded sporadically from 1900 to about 1950. See, for example, Report of the Board . . . for the Year Ending December 31, 1907, p. 11.

39. Report of the Board . . . for the Biennial Period Ending December 31, 1922, p. 5.

40. As of 1965, approximately 2,000 tons of macadamia nuts were grown in Hawaii, with a value of about $1,000,000. Leadership in the development of this industry has been provided by one of Hawaii's largest agricultural corporations, which has made a substantial long-term investment in orchard development, processing and marketing. Development of the industry required the resources of a corporation able and willing to invest heavily over a long term before realizing any profits.

    With the industry apparently well-established and in need of ever greater production if the potentialities of the mainland market are to be realized, it appears that greater attention should be given to increasing the number and output of independent growers and of making available to them suitable public land. Long-term leases, as well as tax relief would be necessary, since the growth pattern of the macadamia tree is slow. As much as 15 years is required for full yield.

41. Report of the Board . . . for the Biennial Period Ended December 31, 1934, p. 6.

42. Report of the Board . . . for the Biennial Period Ended December 31, 1942, pp. 7-8.

43. Most of the saw mills presently operating in Hawaii utilize war time surplus equipment from these military-sponsored lumbering activities. See F. B. Malcolm, Factors Influencing an Expanded Saw Milling Industry for Hawaii, U.S. Forest Service, Forest Products Laboratory, Report No. 2190 (Madison, Wis.: 1960), p. 4.

44. See Crosby's comment in: Report of the Board . . . for the Biennial Period Ended December 31, 1940, p. 30. ". . . it is highly desirable to pay full attention to selection of species of first-class timber producing qualities, to establish a local reserve of commercial value in our forests for emergency and ultimate regular industrial value to the territory."

45. See Gerald D. Pickford, Opportunities for Timber Production in Hawaii, U. S. Forest Service, Pacific Southwest Forest and Range Experiment Station, Miscellaneous Paper No. 67 (Berkeley, Calif.: 1962), p. 2.

46. Some proponents of commercial timber production continued active, however. The 1952 biennial Report of the Board of Agriculture and Forestry contains an article by L. W. Bryan, District Forester on Hawaii, entitled, "Timber Qualities of Some Exotic Trees in Hawaii--A Preliminary Report," along with an article by Myron L. Wold, a Hilo processor of tree ferns who has long been interested in the expansion of Hawaii's timber industry. Wold's article, which appears at pp. 106-112 of the Report is entitled, "Preliminary Report on Uses and Milling Characteristics of Exotic Timber Trees." It discusses the results of a timber survey carried out on the Big Island, as well as the milling characteristics of several hardwoods available there in commercial quantities.

    Wold has acted vigorously on his conviction that there are great potentialities for commercial timber production in Hawaii. Despite many obstacles, including inadequate equipment and a short-term lease on his mill site, he has expanded production, moving from the processing of tree fern to the milling of a variety of hardwoods. See "Lumber Business Is Growing Rapidly in Hilo," Hawaii Business and Industry, January, 1965, pp. 54-55 for an informative article on his enterprise.

CHAPTER II

1. A definition of the term "multiple use", along with an explanation of its potential application to Hawaii's forest lands may be found in Hawaii, Division of Forestry, A Multiple Use Program for the State Forest Lands of Hawaii: Water, Wood, Forage, Recreation, Wild Life (Honolulu: 1962).

2. The multiple-use approach has been officially advocated as a policy guide by the Department of Land and Natural Resources in considering applications for the use of public forest lands. In this connection, see "A Regulation of the Department of Land and Natural Resources, State of Hawaii, Providing for Land Use Regulation Within Conservation Districts Pursuant to Act 234, Session Laws of Hawaii 1957: Providing for Zones, Subzones, Permitted Uses, Appeals, Enforcement, and Penalty" (1964). Applications for multiple use of state lands are referred to the State Board of Health, and to the Board of Water Supply and other public agencies for their views on whether the proposed use might endanger potable water supplies.

3. See Teruo Yamamoto, Soil Moisture Constants and Physical Properties of Selected Soils in Hawaii, U. S. Forest Service, Pacific Southwest Forest and Range Experiment Station, Research Paper PSW-P2 (Berkeley, Calif.: 1963), p. 6. The author ascertained that soils found under forest cover were more conducive to percolation and infiltration than those found under grass, cultivated areas, and pasture.

4. This treated sewer effluent, which amounts to somewhat less than a million gallons a day, has been furnished without charge to the Oahu Sugar Company since October, 1962. This effluent is combined with fresh water drawn from the company's Waiahole ditch and Navy-owned sources at Kunia, and therefore constitutes only a small percentage of the irrigation water. The mixture is used to irrigate lands to the west of Waikakalaua and generally west of Kunia Road on the plantation's mauka fields at some distance from Waipahu. The Board of Water Supply has two pumping stations near Waipahu Street, east of Kunia Road, and it is problematical whether any of the sewage plant

effluent reaches either of these stations directly. The irrigation water containing the effluent does, however, percolate into the water lens without any deleterious effects on the purity of that source so far as can be determined after three years of this practice.

Extremely important background information on Oahu's water supplies is to be found in Chester K. Wentworth, Geology and Ground-Water Resources of the Honolulu-Pearl Harbor Area, Oahu, Hawaii (Honolulu: Honolulu City and County, Board of Water Supply, 1951) and in Honolulu (City and County), Board of Water Supply, Oahu Water Plan (Honolulu: 1963). See also K. J. Takasaki, George Yamanaga and E. R. Lubke, Preliminary Summary of Findings in Water-Resources Studies of Windward Oahu, Hawaii, Hawaii, Division of Water and Land Development, Water Resources Circular No. 10 (Honolulu: 1962). This report was prepared by the United States Geological Survey.

5. Consult the report by Frank N. Visher and John F. Mink, Ground-Water Resources in Southern Oahu, Hawaii, U. S. Geological Survey Water-Supply Paper 1778 (Washington: U. S. Government Printing Office, 1964), p. 70. This report points out that studies in Maui by the Hawaiian Sugar Planters' Association indicate that the consumptive use of water by sugar cane is about the same as the evaporation from a U. S. Weather Bureau class A evaporation pan in the same area. On this basis, the calculated consumptive use of sugar cane in the Pearl Harbor area is about one-third of the water pumped or diverted to the fields. If all the remaining two-thirds of the water moves downward to the water table by deep seepage, the average recharge to the basal aquifer (underlying about three-fourths of the area irrigated) from water applied to the fields in the Pearl Harbor area amounts to about 90 mgd. Surface run-off from the irrigated area is small. The return of irrigation water to the basal water table has been important in the replenishment of the basal system during the long period of heavy pumping in the Pearl Harbor area.

6. Hawaii, Water Authority, Water Resources in Hawaii (Honolulu: 1959), pp. 54-55. The author of this statement emphasizes that he would not advocate such a procedure except as a "last resort" measure, and that it was written to offset the fears frequently theretofore expressed that the future development of Honolulu (and the island of Oahu) might be curtailed because of a water shortage. The report finds that Honolulu's sewage, supplemented by ground water flowing into the sewers, "about equals the amount of fresh water used daily by the population. If this sewage were adequately treated, it could be used for irrigating sugar cane in exchange for fresh ground water. The Honolulu aquifer could also be recharged with the treated sewage and fresh water withdrawn from the aquifer at some point sufficiently far away to meet sanitation requirements. Such a procedure would probably receive serious objections from an aesthetic standpoint, but does demonstrate that an adequate water supply can always be made available to the City of Honolulu. Since the treatment of sewage and the construction of . . . pumps and other facilities for utilization of sewage plant effluents are relatively expensive, economics may not justify such a procedure being used in Hawaii for many years to come."

7. See Edward F. Eldridge, Report of Research and Research Needs on Water Quality Problems in the State of Hawaii (Portland, Ore.: U. S. Public Health Service, Region IX, 1963), p. 26. One hydrologist reported to one of the authors of this report that cesspools located within 500 feet of a Board of Water Supply pumping station on Wilhelmina Rise do not contaminate the water pumped from that station. A memorandum prepared by the Sanitary Engineering Section of the Honolulu Board of Water Supply in response to this point states that:

   The Waialae Shaft, built in 1937, is located at the base of Wilhelmina Rise in the midst of a residential district. Up to 1951, sewage disposal in the district was by cesspool leaching. In 1951, at the urging of the Board of Water Supply, a sanitary sewer system was installed to eliminate the hazard of contamination of the domestic water source by cesspool leaching.

   Nitrate content at the Waialae Shaft was relatively steady between 1937 and 1941, fluctuating between 0.9 ppm and 1.7 ppm. From 1947 on, there was a steady rise to about 2.5 ppm in 1951, 3.3 ppm in 1953, 4.0 in 1960, and 5.2 ppm in 1964. At these levels nitrates are still safely within generally recognized toxic limits, but the increasing trend is the significant factor here.

   The significance of nitrate content lies in the fact that it represents the last step in the oxidation of nitrogenous organic matter. In a plantation environment, the rise of nitrate content in the ground water may be assumed to be due to the application of fertilizers. However, in a residential environment, as is the case with the Waialae Shaft, the indications are that the increase in nitrates is due to leaching from nearby cesspools.

   The sources of potential contamination of water supplies are many. In Hawaii, they include insecticides and fertilizers increasingly employed by plantations, detergents used in households, and the like.

   There appears to be no threat of a water shortage in Honolulu, one of the few urban centers in the world that finds chlorination of its water unnecessary.

8. Consideration of the types of developments which are feasible on various watersheds must take into account the question of whether it is desired to produce ground water or surface run-off. On Oahu, the emphasis has been on development of basal water supplies and, to a lesser extent, on dike-impounded ground water, although surface water is used to a limited extent for irrigation on Oahu, as in the Wahiawa reservoir system. On the Neighbor Islands surface water use exceeds ground water use.

9. Quotation from a mimeographed copy of the speech presented by Mr. Ewart, Director of Agriculture and Hydrology, American Factors, to the Conservation Council on November 17, 1961.

10. An example of such an installation is the Puukapu watershed project. It utilizes a long, retarding dam which holds water during periods of heavy run-off. Seepage through the underlying soil is expected to empty the reservoir in a matter of days.

11. See the Eighth Biennial Report of the Board of Water Supply, City and County of Honolulu, 1939-1940, p. 179. The "proposed 1941 Board of Water Supply development and improvement program" proposes three recharge tunnels designed to recover nearly six million gallons of water a day. Five hundred foot recharge tunnels were proposed for Palolo and Kalihi, and a 1,000 foot tunnel was proposed for Manoa.

    In May, 1954, Mr. E. J. Morgan and L. J. Watson of the Honolulu Board of Water Supply presented a "review and priorities reevaluation of proposed water development and conservation projects" in which the possibilities of recharge tunnels in Waiomao, Manoa, Nuuanu and Kalihi were carefully considered. The Board of Water Supply recommended that this possibility be investigated by starting "a pilot experimental project in Nuuanu soon," but the development of this facility has apparently not been found necessary.

12. "Regulations of the Division of Forestry" (Board of Commissioners of Agriculture and Forestry, Territory of Hawaii, effective December 1, 1941), p. 3. These regulations apply to the Honolulu Watershed Drainage Reservation, Waiahole Drainage Reservation, Waianae-kai Drainage Reservation, and the Hilo Watershed Reservation.

13. Honolulu (City and County), Board of Water Supply, The Conservation, Development, and Protection of the Water Resources of the Honolulu Urban Area, Vol. 1 (Honolulu: 1948), p. 4.

14. Letter from E. J. Morgan, Manager and Chief Engineer, Board of Water Supply, City and County of Honolulu, to Robert T. Chuck, Manager and Chief Engineer, Division of Water and Land Development, State Department of Land and Natural Resources, May 8, 1964, p. 1. (Mimeographed copies of the letter were distributed at the June 10, 1964 hearing). There is interesting and potentially very significant evidence, however, that this position is currently being reviewed, for in a letter dated August 25, 1965 addressed to the Legislative Reference Bureau, Mr. Morgan notes that while "our view is one of questioning the broad application of the multiple use thinking," he specifically suggests that it is possible to undertake "the application of the multiple-use approach in a manner to the benefit of all." A constructive resolution of differences is perhaps being reached through the arrangement under which the Department of Land and Natural Resources circulates applications for multiple use of public lands through other public agencies whose programs would be affected, including the Board of Water Supply of the appropriate county.

CHAPTER III

1. However, it should be observed that certain native tree species in Hawaii which have shallow root systems do not flourish with cattle grazing about them.

2. These figures have been interpolated from data found in a series by Howard C. Hogg and Harold L. Baker entitled, Ranching Costs and Returns (Hawaii, Kauai, Maui, Molokai, Oahu) (University of Hawaii, Land Study Bureau, Miscellaneous Report Nos. 1-5, 1961-62), and also from Hawaii, Crop and Livestock Reporting Service, Statistics of Hawaiian Agriculture, 1962 (Honolulu: 1963).

3. Perry F. Philipp and Richard C. Creek, The Economics of the Hawaiian Beef Industry in 1962, Hawaii Agricultural Experiment Station, Report No. 135 (Honolulu: 1962), p. 4.

4. "Hawaii's Cattlemen Face Problems," Hawaii Business and Industry, May, 1962, p. 56.

5. "Cattle Raising on Increase in Hawaii," Hawaii Business and Industry, September, 1961, p. 58.

6. These figures were interpolated from data found in Hogg and Baker. Among the reasons given as to why the owners of unprofitable ranch units have often continued operations is that they may have felt that they were making a profit if returns more than offset out-of-pocket expenses. Such calculations typically fail to take into account the value of the time invested in the operation by the ranch owner and frequently by members of his family. They may, of course, consider personal gratification a sufficient form of profit from these activities.

7. This argument is based upon assessments of ranching problems in Hawaii presented in: Philipp and Creek, passim.

8. Philipp and Creek, pp. 6-7. At the present time approximately 40 per cent of Hawaii's beef is graded by federal standards and grade descriptions.

9. An initial step in furthering the pen feeding of stock to upgrade it to meet mainland standards was the establishment of grain elevators at Kawaihae harbor on the Big Island by private investors. The installation of these elevators cut freight rates on grain to about half, from approximately $35 a ton bag freight to about $16 a ton. For An interesting account of this enterprise, see "A Helluva Way to Promote Development," Hawaii Business and Industry, October, 1963, pp. 71-79. The significance of this saving in freight rates can be better appreciated by considering the following facts. Feed which costs approximately $50 a ton at a California mill costs about $82 a ton if shipped to Honolulu in 20-ton containers. When shipped at the 2,000-ton bulk rate, the price is lowered to $56.

10. See Philipp and Creek, p. 11, where it is suggested that there are presently too many slaughterhouses serving Hawaii's beef industry. The consolidation of slaughterhouses would increase efficiency. See also Hawaii Business and Industry, October, 1963, p. 72, for a discussion of the proposed Kawaihae slaughterhouse facilities. The development of this project is contingent upon the State's making public land available at reasonable rates.

11. The large independent ranches are Parker Ranch, Kahua Ranch, Ulupalakua Ranch, Haleakala Ranch, Molokai Ranch, Kaonaulu Ranch, Hana Ranch, the Kona Ranches, Kahuku Ranch, Kipu Ranch, and the Robinson Ranches on Kauai and Niihau. While plantations have steadily abandoned their ranch operations in recent years, Lihue Plantation on Kauai still maintains Princeville Ranch, as does Pioneer Mill on Maui. C. Brewer has set up its Hawaiian Ranch Company as a separate entity, as has Davies with its Kukaiau Ranch.

12. Hawaiian Commercial and Sugar Company is one of the plantations which has abandoned ranching. It now leases range land to others.

13. Silk-oak (Grevillea robusta) is an extremely valuable hardwood, one of the world's choice

cabinet woods. It grows at an extraordinarily rapid rate in Hawaii, and an acre of good, rich land to which it is well adapted can produce 50 to 60 thousand board feet of saw timber in 35 years. It should be emphasized that such yields cannot be achieved where scattered stands prevail, nor on shallow, poor soil. That properly planted stands of silk-oak can develop rapidly under favorable conditions in Hawaii may be further confirmed by consulting Robert E. Nelson and Philip R. Wheeler, Forest Resources of Hawaii, 1961, Forestry Division, Department of Land and Natural Resources, State of Hawaii, in cooperation with Pacific Southwest Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture (Honolulu: 1963). Silk-oak is presently worth about $40 per thousand board feet on the stump, and its harvest should yield a net profit of about $65 per acre per year at this price. By contrast, the highest return to beef producers in Hawaii is about $25 per acre per year. The suggestion that combined ranching-forestry operations would contribute to better land utilization finds additional support in the fact that approximately 45 per cent of the land presently being leased from the State of Hawaii is not in productive use. This can be explained in part by the fact that substantial acreages of land unsuited for the major activity for which a lease was written, e.g., ranching, sugar, or pineapple cultivation, have traditionally been incorporated into large leases. This practice has sometimes worked to the advantage, sometimes to the disadvantage, of large lessees and the State, respectively, under various conditions. (This question will be discussed extensively in a forthcoming study in the Public Land Policy in Hawaii series.) It is now known that portions of these land areas which have hitherto been treated as wasteland can support commercial timber. By putting such ranching-timber lands to multiple use, lessees could increase their profits, while protecting the former wastelands from erosion and other damage. See Gerald D. Pickford, "Hawaii Forest Futures" (U. S. Forest Service, Experiment Station, Honolulu, n.d.). (Mimeographed). See also Robert E. Nelson, Silk-Oak in Hawaii--Pest or Potential Timber?, U. S. Forest Service, Pacific Southwest Forest and Range Experiment Station, Miscellaneous Paper No. 47 (Berkeley, Calif.: 1960).

CHAPTER IV

1. Report of the Board of Commissioners of Agriculture and Forestry for the Biennial Period Ended December 31, 1922, p. 4.

2. Key water conservation areas in the forest reserves are presently designated by the Department of Land and Natural Resources as "restricted watersheds," and access to them is limited to those with special hunting permits, or for other special purposes. These areas are designated on the maps at pp. 42 and 43.

3. See Report of the Board of Commissioners of Agriculture and Forestry for the Biennial Period Ended December 31, 1930, p. 36. In that year, 24 arrests were made for violations of hunting and watershed use regulations. Evidence accumulated during subsequent years indicates that hunting pressure increased. As a result, the Division of Fish and Game was increasingly active in the apprehension and prosecution of violators. In 1940, 659 arrests were made and 541 convictions secured for fishing and hunting violations. See Report of the Board of Commissioners of Agriculture and Forestry for the Biennial Period Ended December 31, 1940, p. 7.

4. See the publications of the Hawaii Visitors Bureau, especially their Annual Research Report: Visitors to Hawaii, March, 1962. On pp. 9-11 it is noted that California was the major source of visitors to Hawaii in 1961. They totaled 94,285 visitors with a median age of 24.9 years. See also Paul G. Craig, The Future Growth of Hawaii Tourism (University of Hawaii, Economic Research Center, 1963), p. 21. Hawaii's population, too, is more youthful than the mainland average. See Hawaii, Division of State Parks, A Comprehensive Plan for Hawaii State Parks (Honolulu: 1962), p. 35, where it is noted that, in 1900, 22.6 per cent of Hawaii's population was under 15 years of age. By 1960 this segment of the population increased to 34.4 per cent. See also Hawaii, Territorial Planning Office, A Territorial Parks System for Hawaii (Honolulu: 1959), p. 20.

5. Hawaii, Division of State Parks, A Comprehensive Plan, p. 42. See also Honolulu Star-Bulletin, July 27, 1964, p. 15. A report released in August, 1965 by the Division of State Parks reveals that usage of "Hawaii State Parks exceeded the 1.5 million mark with an estimated total of 1,893,000 visitations for the fiscal year ending June 30, 1965. This represents an increase of 698,000 visitations over the preceding fiscal year or a 58 per cent gain."

6. See the chart entitled, "Hawaii State Park Areas and Facilities--1964." It is on display at the Division of State Parks, Department of Land and Natural Resources.

7. Reports of park usage during the Labor Day holidays, 1965, confirm this finding. See the Honolulu Advertiser, September 9, 1965, p. A-6, which carries an article entitled: "There Just Wasn't Any Room on Oahu's Beaches."

   "'The situation already is out of hand,' a Parks Department spokesman admitted yesterday. Crowds on the beaches over the Labor Day weekend demonstrated graphically how critical the situation is. A total of 234 people camped at Kaaawa's two-acre beach park during the weekend. Tents were so close together it was difficult to walk across the park . . . 'We're getting into a real bind on camping and parking space,' the Parks spokesman said.

   "At Kaena Point, an area normally visited only by the hardiest of fishermen who brave the bad road in, fishermen were shoulder-to-shoulder last weekend.

   "City lifeguards said approximately 10,000 people were crowded into the two-mile stretch of beach between Sans Souci and Ala Moana Park. Another 3,000 showed up at Hanauma Bay, which has only about four acres of flat land and an acre of safe swimming area . . ."

8. "Hawaii's Shoreline," a study, as yet unreleased, by the State Department of Planning and Economic Development, assisted by the Hawaii Institute of Geophysics, will further describe the situation. As reported in the Honolulu Star-Bulletin, August 10, 1965, p. C-1, the "coastal stretches open for public use are fast dwindling. While the State owns almost all beaches, as much as 73

per cent of them 'may be legally inaccessible to the public' because abutting property is in other hands."

The report adds that "urbanization of the State's shores is rapidly consuming public beaches 'by restricting their access, creating off-shore pollution and causing beach erosion'."

The report "recommends that the State take immediate steps to acquire land for recreational development, establishing 'beach reserves' at such locations as Makena and Fleming's Beach on Maui and Honokahau and possibly Kiholo Bay on the Big Island."

"The report also said long-range possibilities exist for a chain of State parks in the virgin territory of northwest Kauai."

"It proposes no State shoreline park facilities on Oahu except for Kahana Valley . . ."

Fortunately, increasing amounts of federal aid are being made available to assist states in acquiring land for outdoor recreation. An act passed approximately five years ago provided some 20 to 30 per cent of the cost of acquiring open space. Hawaii applied for assistance under this act in its attempts to acquire Kahana Valley State Park.

An extension of this federal program now makes it possible for the State to secure reimbursement for half the cost of acquisition of open space. This change in the law brings it into closer agreement with the Land and Water Conservation Act, which makes available to the State and some of its political subdivisions as much as $1.7 million annually on a 50/50 matching basis. Land could be acquired on Oahu, Hilo, Kahului, and Wailuku under this program.

It is imperative that land be acquired for future park sites before land costs skyrocket further, and before roads and other improvements are installed which increase acquisition costs markedly.

9. See Hawaii, Department of Agriculture and Conservation, A Wildland Research Plan for Hawaii (Honolulu: 1960), p. 2. The authors of this report maintain that "Campers, hikers, horseback riders, and nature lovers are certain to seek the solitude of forests, range, and watershed lands as urban congestion increases." They emphasize, however, the importance of watershed protection, noting on page 14 that "In this State each individual island will have its own specific solution to the problem of making maximum use of wildlands based on existing circumstances. For example, the solution for Oahu with its rapid urbanization and high percentage of privately owned forest lands will undoubtedly differ greatly from that of any other island." This report stresses the importance of basing such decisions on "sound knowledge of local conditions," p. 15, and calls for an extraordinarily concentrated team-research effort to deal with all aspects of the development and implementation of a multiple-use program. See also Hawaii, Division of State Parks, A Comprehensive Plan, p. 39. The report indicates that more leisure and increasing population as well as higher incomes and more travel have increased the use of outdoor recreation facilities in Hawaii by 10 per cent annually. See also "Keeping the Wilderness Wild--How It Will be Done," U. S. News and World Report, August 24, 1964, p. 65.

10. Hawaii, Division of Forestry, A Multiple Use Program for the State Forest Lands of Hawaii: Water, Wood, Forage, Recreation, Wild Life (Honolulu: 1962), pp. 31-32. Signs would have to be posted in such areas to inform hikers of distances, directions, and other needed information.

11. The records kept by the Hawaiian Sugar Planters' Association reveal that the number of employees in the sugar industry has declined from 28,900 in 1945 to 12,500 in 1965.

12. A dramatic example of the type of natural asset which may be developed for relatively low cost is that of the beautiful Akaka Falls Park north of Hilo. This development was initiated by the former Board of Agriculture and Forestry which sought to develop sites such as these. The characteristically inadequate budgets of the territorial period restricted the pace and scope of these developments.

CHAPTER V

1. Such estimates are provided in: "Timber--Bigger than Sugar?" Hawaii Business and Industry, February, 1963, pp. 48-50. With regard to employment, another report indicates that about one person out of every 20 employed in the United States in 1958 was engaged in some aspect of the timber industry. This amounted to 3.3 million employees, of whom 3 per cent were engaged in harvesting, 15 per cent in primary manufacturing, 24 per cent in secondary manufacturing, 25 per cent in construction, and 23 per cent in transportation and marketing. U. S. Forest Service, The Economic Importance of Timber in the United States, U. S. Department of Agriculture, Miscellaneous Publication 941 (Washington: 1963), p. 5.

2. Data concerning the land-use acreage provided in this report were taken from: Robert E. Nelson and Philip R. Wheeler, Forest Resources of Hawaii--1961, Forestry Division, Department of Land and Natural Resources, State of Hawaii, in cooperation with Pacific Southwest Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture (Honolulu: 1963). 1,088,900 acres of land in Hawaii appear to be suited for timber production. An additional 298,700 acres presently used for foraging are suited for trees. Therefore 1,378,600 acres--more than one-third of the State's entire land area might support commercial timber. This excludes 463,600 acres of poor grassland and 489,700 acres of cultivated land intensively utilized for pasture (Table I, p. 35). The forest survey of Hawaii, from which these acreage figures were taken, was undertaken by the U. S. Forest Service and the State Division of Forestry in 1957. It took more than four years to complete.

3. Acreage presently being used for sugar cultivation is as follows: Hawaii, 47,007; Maui, 21,558; Oahu, 17,884; and Kauai, 24,350. See Hawaiian Sugar Planters' Association, Manual, 1965 (Honolulu: 1965).

   Acreage in use for pineapple cultivation as of 1964 is as follows: Oahu, 20,900; Molokai,

16,600; Lanai, 15,900; Maui, 10,600; Kauai, 2,300: total 66,300. See Pineapple Growers Association of Hawaii, Pineapple Fact Book, Hawaii, 1965 (Honolulu: 1965).

4. Ibid., Table IV, p. 38. The State owns 487,300 acres of commercial forest land, which is defined as that which either now supports or can support commercial timber. It has not yet been precisely determined how much of the 290,000 acres of grassland suitable for timber production is owned by the State.

5. Ibid., Table II, p. 36. The distribution of commercial forest land in Hawaii is as follows: 948,000 acres on Hawaii; 150,800 on Kauai; 131,000 on Maui; 115,100 on Oahu; and 29,300 acres on Molokai.

6. Gerald D. Pickford, Opportunities for Timber Production in Hawaii, U. S. Forest Service, Pacific Southwest Forest and Range Experiment Station, Miscellaneous Paper No. 67 (Berkeley, Calif.: 1962), p. 1. Eucalyptus saligna growing in the Hamakua forest reserve on Hawaii grows as much as 3,800 board feet per acre per year.

7. An acre of land planted to a stand of Eucalyptus saligna of about 35 years of age can support more than 100,000 board feet of saw timber. Most other varieties of hardwoods growing in Hawaii produce about 40,000 and 60,000 board feet of timber per acre in 35 years; an annual growth rate of 1,500 board feet per acre. See Hawaii, Division of Forestry, A Multiple Use Program for the State Forest Lands of Hawaii: Water, Wood, Forage, Recreation, Wild Life (Honolulu: 1962), p. 10. See also Norman K. Carlson and L. 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: Trustees of the Bernice P. Bishop Estate, 1959), p. 24. These figures exclude the 5 to 10 thousand board feet of timber that should be harvested from each acre of a closely planted stand at about 20 years in order to make room for greater growth of the best trees. If thinning is undertaken at this point it generally yields materials of salable size for poles, posts and the like. The return from these sales alone could be sufficient to cover the original cost of clearing and planting. On the other hand, should there appear to be an insufficient market for the products produced by thinning operations, it would be wise to explore measures designed to make this step unnecessary. Experiments in mainland forests suggest that thinning may be eliminated by the use of herbicides, short-lived weed trees, and the planting of varieties of dissimilar trees.

8. These figures are based on the following premises: (1) the realization of a minimum annual growth rate somewhat less than 1,500 board feet per year per acre of planted forest land, and (2) the removal by thinning or some alternative measure of about 7,000 board feet per acre at approximately 20 years. The remaining trees in the stand should then supply about 40,000 board feet of stumpage.

9. These estimates are based both on conservative estimates of growth rates (1,000 board feet per year) and on conservative estimates of the value of hardwood stumpage. Although some hardwoods that grow well in Hawaii might be worth as little as $20 a thousand board feet (assuming the availability of roads and milling facilities), others, such as tropical ash, Australian red cedar, and Queensland-maple are worth from $40 to $60 and may in 35 years' time be worth as much as $100 a thousand. Some of these figures are presented in Carlson and Bryan, pp. 39-81. On pages 24-25 of this work the authors report that J. J. Byrne, Director of Forest Products Research for the U. S. Forest Service, believes that a price of $100 per thousand board feet for tropical ash can be expected in about 30 years. Stumpage values depend, of course, on a variety of factors, including the difficulty of harvesting, the distance to a suitable mill, and demand in a given area.

10. U. S. Forest Service, Forest Industry Opportunities in Rural Development, Agriculture Information Bulletin No. 222 (Washington: 1960), p. 4. This work estimates that each dollar's worth of stumpage increases in value to $17.60 by the time it reaches the consumer in the form of finished products. An even better documented figure, indicating that stumpage increases 25 times between the forest and consumer, is provided in U. S. Forest Service, The Economic Importance of Timber, pp. 4-5. This latter figure computes value added to stumpage by forest management (4 per cent of the increase), harvesting (6 per cent), primary manufacturing (16 per cent), secondary manufacturing (22 per cent), construction (31 per cent), transportation and marketing (21 per cent). To each $1 worth of stumpage in 1958 $1.50 was added in harvesting, $3.85 in primary manufacturing, $5.45 in secondary manufacturing, $7.60 in construction, and $5.35 in transportation and marketing.

11. Trees originally imported from Australia and promising for local timber production are: silk-oak (Grevillea robusta) which is well established in Hawaii; Australian red cedar (Toona ciliata); robusta (Eucalyptus robusta); saligna (Eucalyptus saligna); and Queensland-maple (Flindersia brayleyana). Tropical ash (Fraxinus uhdei), an especially valuable hardwood that is doing well in Hawaii, was originally brought from Mexico. Most mainland lumber imports into Hawaii consist of conifers (softwoods).

12. Samples of these woods processed as lumber and veneer can be seen at the U. S. Forest Service Experiment Station, 400 South Beretania Street, Honolulu.

13. Egon Glesinger, "The Role of Forestry in World Economic Development," Multiple Use of Forest Lands, Proceedings, Fifth World Forestry Congress, Vol. I (Seattle, Wash.: 1960), p. 192. See also Colin Marshall, "Report on Forestry in American Samoa" (Pacific Science Board, Natural Resources Council, Washington).

14. Shipment of hardwoods from eastern U. S. mainland forests requires trucking, followed generally by rail shipment, and reloading onto ships which must take the cargo through the Panama Canal to the West Coast users. Shipment from the Big Island or Maui would require only a short truck haul from the processing plant (which, in fact, might be located on the water front) and then barging directly from Hawaii on an ocean-going barge directly to the West Coast consumers. Not only would the cost of transportation be cut considerably, but also the cost of handling as compared to shipment from eastern mills would be reduced.

15. George D. Frazier, Progress Report, Forest Products Market Research Program in Hawaii (Berkeley, Calif.: 1964), p. 26.

16. Frazier indicates that Hawaii could now ship about 500,000 board feet to the Los Angeles furniture market and could eventually sell 5 million board feet there. See George D. Frazier, "Restricted Distribution Report to the Legislature's Tree Planting Committee," February 25, 1964, p. 5. This estimate is based on the assumption that hardwood consumption will increase in this market as long as sufficient supplies are available. The fact is that mainland hardwood supplies are decreasing while the market, especially on the West Coast, is expanding. One reason for Frazier's rather conservative estimates is that they are calculated on an annual average growth rate for most hardwood species in Hawaii of less than 1,000 board feet. This appears to be unduly low.

17. There is a widely held opinion of long-standing in the Islands that robusta presents so many difficulties in milling and in use by carpenters that it is of little or no commercial value. This opinion may be based on the fact that during milling it checks and warps easily. It has been demonstrated that it can be effectively and economically milled if suitable machinery and proper techniques are employed. In spite of its inadequate mill facilities, Hawaiian Fern-Wood on the island of Hawaii has been producing robusta flooring. According to one account, "the robusta flooring which the firm specializes in is popular, and has been proved in eight years of limited production. Sales have been primarily on the Big Island, although there has been an increasing demand from Honolulu--a demand which the mill's present capacity has not allowed it to exploit." "Lumber Business is Growing Rapidly in Hilo," Hawaii Business and Industry, January, 1965, pp. 54-55. See also Lester W. Bryan and Myron L. Wold, Exploitation of Hawaii's Timber Resources, Final Report, EPCA Grant No. 19 (Honolulu: Board of Commissioners of Agriculture and Forestry, 1957), illustrations 21 and 22, p. 86.

18. A notable exception to this generalization may be seen in the program of the Bishop Estate, which owns a great deal of land suitable for commercial forestry. The estate is currently spending about $10,000 a year to develop commercial timber in its 10,500 acre Honaunau forest. About 1,500 acres have already been planted to cedar, ash, eucalyptus, etc., with an additional 150-200 additional acres being planted annually. Under the direction of its able forester, Norman K. Carlson, detailed soil maps have been prepared and a two-way logging road developed. A 35-year forestry plan is currently being developed. It envisions an annual production of 6 to 10 million board feet per year, with the development of a mill to process this timber. Inasmuch as substantial portions of the Bishop Estate's forest lands are in scattered, small acreages, the Trustees have sought to secure cooperation from other landowners in furthering forestry experiments and development. As has been emphasized, however, a persistent difficulty which presents itself for relatively small private investors is that capital must be tied up for a 30 to 35 year period while seedlings reach cutting maturity. See "Big Island Timber Seeks Way Out of the Woods," Hawaii Business and Industry, July, 1963, pp. 72-73. See also Princess Bernice Pauahi Bishop Estate, Honaunau Forest, The Promise of a Timber Industry (Honolulu: 1963).

19. Conner Piper Otteson, "A Study of Lumber Distribution in Hawaii" (unpublished Master of Business Administration thesis, University of Hawaii, 1961), p. 39. The author reports that local lumber dealers feel they must carry about 3 or 4 months' inventory. They claim that an absolute minimum of 30 days is required after ordering to receive lumber shipments from the West Coast.

20. C. S. Wo and Sons, Ltd. and Twentieth Century Furniture, Inc. are the source of nearly all furniture manufactured in Hawaii. The products of these companies compare favorably with mainland-produced furniture. Both firms manufacture several lines which they market by grade through outlets in Honolulu. For pertinent wood consumption figures, see Ernesto dela Cruz Lucas, "Evaluation of Market Data As a Guide for Forest Development in Hawaii" (unpublished Master of Science thesis, University of Hawaii, 1963), Table VI, p. 29. Furniture manufacturers consume a variety of forest products, such as veneers and hard and soft wood lumber. The conversion of these materials into furniture greatly enhances the worth of the raw materials, as does the transportation and marketing of the finished product.

21. Based on products harvested and hauled from Hawaii's forests but processed no further, the estimated total value of craftwood declined from $121,000 in 1958 to $20,000 in 1960. Robert E. Nelson, Forest Products Harvested in Hawaii: 1958 and 1960, U. S. Forest Service, Pacific Southwest Forest and Range Experiment Station, Miscellaneous Paper No. 71 (Berkeley, Calif.: 1962), p. 2.

22. Between 1957 and 1960 the importation of hardwood logs from Fiji grew from 87,000 to 426,000 board feet. Most of it consisted of monkeypod. Lucas, Table XI, p. 40.

23. See especially Thomas C. Thrum, "The Sandalwood Trade of Early Hawaii," Hawaiian Almanac and Annual, 1905 (Honolulu: 1905), pp. 43-74 and also Ralph S. Kuykendall, The Hawaiian Kingdom, 1778-1854, Foundation and Transformation (Honolulu: University of Hawaii Press, 1947), pp. 85-92, which describe the "pitiless exploitation" not merely of the sandalwood forests, but also of the labor of the common people who were forced to collect it.

24. Lucas, p. 12. The author reports that Philippine mahogany exported from the Philippines or Japan is manufactured into furniture and other items, including face veneer, and then shipped to Hawaii.

25. Sess. Laws of Hawaii 1963, Act 141. This act provides in section 3 that "Any property of not less than thirty acres is eligible for classification as tree farm property if it is suited for the raising of trees of commercial specie in quantity sufficient to establish a business in the sale thereof and not suited for some higher and better use. Property on which the owner is already growing trees of commercial specie (in quantity sufficient to establish a business in the sale thereof) under good forestry management practices and which the owner agrees to manage in accordance with rules and regulations prescribed

by the board may also be classified as tree farm property. . . ."

Section 8 provides that "Any property classified as tree farm property . . . shall not, as long as the agreement described in section 6 is in effect, be subject to the real property tax. . . ."

Section 10 provides that "Upon harvesting of the trees for commercial purposes, the owner shall, . . . file monthly returns showing the total stumpage value of the trees cut during the preceding month, together with such other information as may be required." This yield tax is to be "equal to five per cent of the stumpage value of the merchantable trees cut. This tax shall be in lieu of all real property taxes and all general excise taxes. . . ."

26. Sess. Laws of Hawaii 1965, Act 239.

27. On this point see also footnote no. 13, chapter II, and especially reference to the constructive position set forth by Mr. E. J. Morgan in his letter of August 25, 1965, addressed to the Legislative Reference Bureau. The resolution of formerly sharp differences of opinion between administrative agencies on the advisability of adopting multiple-use programs should be fostered by the practice of the Department of Land and Natural Resources in circulating applications for multiple use of public lands to affected agencies. Throughout this study we have emphasized the importance of preventing contamination of water supplies, an objective emphasized by the legislature in the current statute dealing with forest and water reserve zones, Rev. Laws of Hawaii, sec. 19-70(a) (Suppl. 1963). This section stresses that in establishing "subzones within the forest and water reserve zones," the Department of Land and Natural Resources "shall give full consideration to all available data as to soil classification and physical use capabilities of the land so as to allow and encourage the highest economic use thereof consonant with requirements for the conservation and maintenance of the purity of the water supplies arising in or running or percolating through such land."

CHAPTER VI

1. Comprehensive figures on the extent of these problems in Hawaii at the present time do not appear to be available. The rate of unemployment in recent years has remained fairly stable, ranging from 3 to 4 per cent, with the rate sometimes rising slightly above 4 per cent on the Neighbor Islands. The continuing "boom" in tourism, construction trades, and military spending has been an important factor in keeping unemployment down, but does not provide any guarantee for the future. It is, of course, the unskilled and semi-skilled workers who are most immediately affected by cut-backs in service industries.

2. The percentage of "drop-outs," grades 9-12, was roughly 3 per cent for the State as a whole in 1964, while Oahu's percentage was 3.4. This figure is considerably lower than many mainland states. It is somewhat less assuring, however, when one adds to it the percentage of youngsters whose educational achievement is so low as to leave them poorly equipped to compete in the job market. Far too many youngsters are simply "sitting it out" in school until they receive a diploma.

3. See Honolulu Star-Bulletin, September 9, 1965, p. A-9, which reports that:

"If all goes well, Hawaii may have a $1 million-plus Job Corps Center at Koko Head Park with several satellite centers on the Neighbor Islands. . . .

"If approved as planned, . . . the Koko Head center could begin operations in February on a limited basis. . . .

". . . the program is expected to include an eventual total of 200 youths. An evaluation would be made later on expansion possibilities."

4. Many private owners of land suited for commercial forestry have holdings which adjoin public timber lands. Interesting possibilities for productive public-private cooperation present themselves. For example, sawmills constructed by private capital may, if they are to be of economic size, have to depend on supplies of stumpage secured from both private and public forest lands. Mill operators could lease or purchase timber land from private owners, while entering into long-term leases for development of public forest land and also making use of stumpage-cutting agreements. All of these possibilities require careful exploration, for considerable flexibility exists in developing operations of varying scope and size.

CHAPTER VII

1. Consult the final report of the Land Laws Revision Commission, which was created by Governor Ingram Stainback. Its final report was submitted in December, 1946. It found that "The factual history of the public domain of Hawaii admits of the following conclusions: (1) the public domain has been sacrificed to avidity and political expediency; (2) conservation has been notably absent in the administration of the land laws."

APPENDIX*

Entries in this annotated bibliography are grouped under five categories as follows:

I. Commercial Forestry -- works dealing primarily with the commercial uses of timber, including information on costs and potential profits in commercial forestry and wood processing.

II. Technical Reports -- works dealing with wood quality, timber growth rates, and related information.

III. Research Inventories and Planning -- research proposals and works summarizing research in forestry and watershed management.

IV. Tree Names and Forest Descriptions -- works which name and describe various genera and species of forest plants in Hawaii.

V. General Works -- histories of forestry in Hawaii and those dealing with forest policies and problems.

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*William V. Frame prepared this bibliography, which was checked and supplemented by Roger G. Skolmen. It takes account of the bulk of published writing and research on forestry in Hawaii, and includes some unpublished items. The U.S. Forest Service's Pacific Southwest Forest and Range Experiment Station at Berkeley is cited throughout as the Pacific Experiment Station.

I. COMMERCIAL FORESTRY

Arnold, Keith, and Ericksen, L.N. Letter to Walter W.Holt, June 15, 1961. 8pp.

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, prepared for Economic Planning and Coordination Authority, Territory of Hawaii. Honolulu: 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.

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

This short article discusses the 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 estate's trustees are cautiously optimistic.

Princess Bernice Pauahi Bishop Estate. Honaunau Forest, the Promise of a Timber Industry. Honolulu: 1963. 17pp.

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 support the view that the State has a potential timber producing industry.

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

This article includes a brief survey of timber use 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 the island of 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, Bryan estimates that annual production would be 200 million board feet per year. He advocates the local production of utility poles, and suggests that instead of the continued planting of an almost infinite number of species only a few of the most valuable commercial species should be planted, such as Australian toon, tropical ash, several eucalypti, monkeypod, 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 Wold, Myron L. Exploitation of Hawaii's Timber Resources, Final Report. Honolulu: Territorial Board of Commissioners of Agriculture and Forestry, 1957. 100pp. EPCA Grant No.19.

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 Bryan, Lester W. "Hawaiian Timber for the Coming Generations," from a Report on the Honaunau Forest, South Kona, Hawaii; Its Present Condition and Its Potential. Honolulu: Trustees of the Bernice P. Bishop Estate, 1959. 112pp.

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. The report cites problems in clearing lands and those encountered with respect to tree growth are also discussed. Data concerning clearing and planting costs in the reserve, as well as estimated maintenance costs until harvest time--30 to 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, pp.643-647.

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." [Honolulu] 1950.

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

_____. "Commercial Forestry on Marginal Land." [Honolulu] 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 Company, Ltd.)

"Cork Oaks Grown for Possible Isle Industry." Honolulu Advertiser, April 9, 1950; and "Cork Tree Plantings Being Discontinued." Honolulu Advertiser, 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 grow well.

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

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, pp.6-7.

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. Honolulu: State Department of Planning and Economic Development, 1964. 25pp.

This study, which was carried out in response 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. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1964. 33pp.

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.

_____. The Market Potential for Hawaii Timber Resources, A Summary Report, prepared for Forestry Division, Department of Land and Natural Resources, State of

Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1964. 14pp.

_____. The Markets for Hawaii's Timber Resource and the State's Tree-Planting Program. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1964. 9pp.

(A preliminary report, not for publication, on file at the Pacific Experiment Station.)

Frazier, George D., Mackenzie, K.D., and Weber, J.H. The Market Potential for Hawaii Timber Resources. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1964. Various pagings.

Additional and more comprehensive information than in report above, Forest Products Market Research Program in Hawaii. (Unpublished report, given limited distribution, on file at the Pacific Experiment Station.)

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

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.

Hawaii. Department of Agriculture and Conservation. Division of Forestry. Five-Year State Planting Plan for the State of Hawaii 1962-66. Honolulu: 1961. 20pp.

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.

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

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.

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

This article discusses the operations of Hawaiian Fern-Wood, Ltd., and the outlook 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 foresees a large and viable timber industry in the Islands which can easily supply the State's needs within 30 years.

"Hawaii's Forests Hold Promise for Future." Western Conservation Journal, 21:4&5, October-November 1964, pp.84-87, 89-91, 109.

A condensation of "Forest Resources of Hawaii--1961," by R.E. Nelson and Philip R. Wheeler.

Hawaiian Electric Company, Ltd. Hawaii Cuts into a Growing Future. Honolulu: 1959. 8pp. 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 outline an 8-point research program to make capital investment less risky.

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

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 problems which have been solved. He predicts that a timber industry is possible in the near future (after 1930) for such items as poles and fencing.

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

This article discusses the commercial uses of mesquite (algaroba or kiawe), which was brought to Hawaii 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, pp.19-20.

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, pp.6-7.

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; and The Lihue Plantation Co., Ltd.

LeBarron, Russell K. Forest Products Harvested in Hawaii--1963. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1964. 4pp. Research Note PSW-51.

Very little change had occurred since a similar survey made in 1960. Koa, Eucalyptus robusta, and tree fern are main products harvested.

Lucas, Ernesto de la Cruz. "Evaluation of Market Data as a Guide for Forest Development in Hawaii." Unpublished Master of Science thesis, University of Hawaii, 1963. 61pp.

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, pp.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. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1960. 22pp. Rept.No.2190.

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 with production designed primarily for prison use.

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

Products milled from Hawaii's forests account for about one 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 monkeypod. 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 off-shore sources for monkeypod; (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. Honolulu: University of Hawaii Press, 1963. pp.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? Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1960. 5pp. Misc.Paper No.47.

Ranchers in Hawaii have gone to considerable 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 land use for range and forest purposes 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 the ease with which it can be handled. Some silk-oak is milled by Hawaiian Fern-Wood, Ltd., Hilo.

Nelson, Robert E., and Hornibrook, E.M. Commercial Uses and Volume of Hawaiian Tree Fern. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1962. 10pp. Tech.Paper No.73.

Several tree fern species grow quite large in Hawaii, and almost every part of these plants 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 Wheeler, Philip R. Forest Resources of Hawaii--1961 [prepared for] Forestry Division, Department of Land and Natural Resources, State of Hawaii, in cooperation with Pacific Experiment Station, U.S. Forest Service. Honolulu: 1963. 48pp.

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 produce 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 non-native 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 furnish 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.

Nelson, Robert E., Whitesell, C.D., and LeBarron, R.K. Forest Resources of the County of Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1964. 5pp.+

Using data extracted from above report, presents figures and comments only for the Big Island. (Dittoed office report).

Otteson, Conner Piper. "A Study of Lumber Distribution in Hawaii." Unpublished Master of Business Administration thesis, University of Hawaii, 1961. 90pp.

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

Pickford, Gerald D. "Hawaii Forest Futures." 1p.

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. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1962. 11pp. Misc.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. Washington, D.C.: Govt.Print.Off., 1924. 16pp. Hawaii Agricultural Experiment Station, Bull.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. 9pp.

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. (On file at the Forestry Division, State Department of Land and Natural Resources.)

Schwartz, S.O. Hardboard from Ohia. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1960. 10pp. Rept.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. 3pp.

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, pp.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 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 easily be grown locally.

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

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.

"Tree Ferns Have Commercial Value." Western Conservation Journal, 21:4&5, October-November 1964, pp.88-89.

Highlights of "Commercial Uses and Volume of Hawaiian Tree Fern," by R.E. Nelson and E.M. Hornibrook.

U.S. Forest Service. Pacific Experiment Station. "Robusta." Honolulu: 1964. 1p.

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. Honolulu: Agricultural Extension Service, University of Hawaii, 1931. 15pp. Extension Bull.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

Baechler, R.H., and Gjovik, L.R. The Chemical Analyses of Posts of Hawaiian Species Treated in Tanks by Double Diffusion. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1962. 3pp.+

Retention of chemical preservatives achieved in treating twelve Hawaii-grown species is given. (Unpublished report on file at Forest Products Laboratory, U.S. Forest Service, Madison, Wis.)

Bryan, Lester W. "Timber Qualities of Some Exotic Timber Trees in Hawaii--a Preliminary Report," in 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. pp.106-109.

This article contains the results of a timber survey on 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 non-native species. An examination of the milling characteristics of some of these and other species is contained in an 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.

Carpenter, S.B., and Richmond, G.B. Five-Year Measurements of Unit 3, Waiakea Arboretum, Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1965. 5pp. Research Note PSW 63.

Some species are good and some are poor at this location. All plantings have been handicapped in their growth by the area's shallow soil and the competition of wild vegetation.

Clark, J.W. The Natural Decay Resistance of Four Hawaiian Hardwood Species. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1961. 5pp.+

Results of laboratory tests of ohia, Eucalyptus robusta, Eucalyptus saligna, and Australian toon showed robusta to be most durable and ohia least durable of the four. (Unpublished report on file at Forest Products Laboratory, U.S. Forest Service, Madison, Wis.)

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

This is a discussion of the Kamuela tree nursery.

Drow, John T., and Ali, Omar M. Mechanical Properties of Green Ohia from Hawaii. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1958. 35pp. Rept.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. A Limited Evaluation of a Few Strength Properties for Acacia Koa, Metrosideros Collina, and Eucalyptus Robusta Grown in Hawaii. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1963. 7pp.+

Previous data find support in these recent figures, and the previously limited engineering data on koa are increased. (Unpublished report on file at Forest Products Laboratory, U.S. Forest Service, Madison, Wis.)

_____. Limited Evaluation of Physical and Mechanical Properties of Nepal Alder Grown in Hawaii. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1964. 4pp.+ Research Note FPL-036.

Nepal alder proved to be quite similar to red alder from the Pacific Northwest, and should be suitable for the same uses--furniture, core stock, boxes and crates, etc.

_____. Physical and Mechanical Properties of Saligna Eucalyptus Grown in Hawaii. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1965. 12pp. Research Paper FPL 23.

Saligna grown in Hawaii is lighter, shrinks less, is equal in most strength properties, and is stiffer than that grown in Australia. It is stiffer than any mainland wood, but is otherwise about average for its density as compared with mainland woods.

_____. Some Strength and Related Properties of Green Wood of Hawaiian Eucalyptus Saligna. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1963. 8pp.+

This report furnishes an evaluation of the properties of this eucalyptus based on observations of trees grown near Pahala and Honokaa on Hawaii. The green wood 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, pp.48-55.

This article considers the methodology and some findings of engineering tests carried out on 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.

James, William L. Calibration of Electric Moisture Meters for Some Wood Species Grown in Hawaii. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1964. 18pp.+ Rept.FPL-061.

Provides calibration data necessary to enable use of moisture meters with more important.Hawaii species.

Lanner, Ronald M. Adventitious Rooting--a Response to Hawaii's Environment. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1964. 3pp. Research Note PSW-54.

Adventitious rooting occurs on some species in Hawaii that do not have such roots in their native habitat.

_____. "Clones of Nepal Alder in Hawaii." Journal of Forestry, 62:9, September 1964, pp.636-637.

Natural clones of this species offer a good source of material for genetic research and outplanting of superior stock.

_____. "Modifications in the Growth Habit of Exotic Trees in Hawaii." Reprinted from Proceedings, Society of American Foresters, Denver, 1964.

A number of introduced species respond in unusual ways to the Hawaiian environment.

Lutz, J.F., and Roessler, C.G. Veneer and Plywood Characteristics of Nepal Alder. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1964. 6pp.+

There are no inherent problems with the species. Due to lack of figure it is best suited for core stock. (Unpublished report on file at Forest Products Laboratory, U.S. Forest Service, Madison, Wis.)

McAlister, R.H. "Hawaiian-Grown Woods for Face Veneer." Reprinted from Plywood Magazine, Mid-January, 1962. [2pp.]

A popularized statement based on the above reports.

_____. A Study of the Veneer Cutting and Drying Properties of Shamel Ash. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1961. 8pp.+

Tropical ash (shamel ash) is a good face veneer species if good veneer logs can be produced.

McAlister, R.H., and Olson, W.Z. A Study of the Veneer Cutting and Drying Properties of Hawaiian-Grown Silk-Oak (Grevillea robusta, A. Cunn). Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1961. 8pp.+

Silk-oak can be made into attractive plywood by slicing or peeling veneer. Gluing problems are easily overcome. May cause dermatitis during manufacturing operations. (Unpublished report on file at Forest Products Laboratory, U.S. Forest Service, Madison, Wis.)

Malcolm, F.B. Quality Evaluation of Hawaiian Timber. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1961. 13pp.+ Rept.2226.

Provides preliminary data on the grade recovery of lumber that can be achieved in sawing robusta eucalyptus. Also discusses natural defects in ohia and silk-oak.

Margolin, Louis. Eucalyptus Culture in Hawaii. Honolulu: Division of Forestry, Territorial Board of Commissioners of Agriculture and Forestry, 1911. 80pp. Bull.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, G.D. "Forest Plantations for Timber Production in Hawaii" [Paper presented at] Symposium on Forest Growth Studies, Tenth Pacific Science Congress, August 29, 1961. Honolulu: Forestry Division, State Department of Land and Natural Resources, 1961. 7pp.

Discusses astounding growth achieved by various species in Hawaii and the possibilities of trying still others that have excellent commercial utilization prospects.

Pickford, Gerald D., and LeBarron, Russell K. A Study of Forest Plantations for Timber Production on the Island of Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1960. 17pp. Tech.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.

Richmond, George B. Species Trials at the Waiakea Arboretum, Hilo, Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1963. 21pp. 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, R.G. Air-Drying of Robusta Eucalyptus Lumber. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1964. 8pp. Research Note PSW-49.

Results of this study show that robusta can be successfully dried in Hilo, Hawaii, but that considerable degrade will occur unless various remedial measures are taken.

_____. "Brittleheart in Eucalyptus Robusta Grown in Hawaii." Reprinted from Forest Products Journal, 14:12, December 1964, pp.549-554.

Brittleheart, brash wood in the core of eucalypt logs, must be segregated from good outer wood. This can be done by methods outlined in this report.

_____. A Durability Test of Wood Posts in Hawaii--First Progress Report. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1963. 2pp.+ Tech.Paper 65.

Early results of durability tests of double-diffusion treated and untreated posts are given.

_____. Preservation Treatments for Eucalyptus Fence Posts. Honolulu: Hawaii Agricultural Experiment Station, 1957. 19pp. Bull.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.

_____. Robusta Eucalyptus Wood: Its Properties and Uses. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1963. 12pp. 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.

_____. Treating Costs and Durability Tests of Hawaii-Grown Wood Posts Treated by Double-Diffusion. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1962. 5pp. Research Note 198.

Discusses the costs of treating posts of ten species which were used for a durability test.

_____. Wood Density and Growth of Some Conifers Introduced to Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1963. 20pp. 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 other information provided in some detail are for 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, Rogert G., and Smith, Harvey. Drying of Silk-Oak in Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1962. 11pp. Tech.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 apart 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 in the yard.

Smith, H.H. Wood Quality Studies to Guide Hawaiian Forest Industries. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1960. 19pp. Misc.Paper No.48.

This report discusses the high quality of wood consumed in the Hawaiian market because of shipping prices, remanufacturing costs, and construction practices in the Islands. Lumber used in single-wall houses may be seen from both sides. Since Hawaii has no well developed wood processing industry, lumber is imported in essentially ready-to-use form. The author suggests that more studies be conducted comparing promising Hawaiian hardwoods with imported woods to obtain authoritative information about the feasibility of substituting domestic hardwoods for imported species. He reviews what is known about the hardness, strength, and natural resistance to termites of nine species growing in the Islands, and suggests further studies to complete this information. The trees discussed are: ohia, Eucalyptus robusta, Australian toon, shamel ash, cigarbox cedrela, redwood, silk-oak, Nepal alder, and Brayley flindersia (Queensland-maple).

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

Twelve wood species were tested with this inexpensive, non-pressurized 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.

Strong, C.C., and Skolmen, R.G. "Origin of Drift-Logs on the Beaches of Hawaii." Nature, 197:4870, p.890.

_____. "Pacific Floats Logs to Hawaiian Shores from Pacific Northwest and British Columbia." Western Conservation Journal, 19:4&5, July-October 1962, pp.24-25 and pp.32-33.

These two articles discuss findings of the kinds, origin, and amounts of logs that drift in to Hawaii beaches. Utilization possibilities and potential use of such data by oceanographers are discussed.

U.S. Army. Forces in Middle Pacific. Army Activities Resulting in Benefits to the Territory of Hawaii, Series D: Conservation of Resources, Subject 1: Reforestation. Honolulu: 1946. 8pp.

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.

Whitesell, C.D. "Forestry and Research Activities on the Mauna Kea Soil and Water Conservation District, 1962," in Seventh Annual Report of the Mauna Kea Soil Conservation District. Honokaa, Hawaii: 1963(?). pp.31-32.

Describes research needs and progress and forestry potentials in this area, which comprises some of the State's best timberlands.

_____. A Problem Analysis for Koa (Acacia Koa Gray). Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1963.

Discusses what is known and what needs to be known about koa. Office report given limited distribution.

_____. Silvical Characteristics of Koa (Acacia Koa Gray). Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1964. 12pp. Research Paper PSW-16.

Describes the tree, its growth habit, flowering and seeding, potentials for management, and reasons for present lack of young trees.

Wold, Myron L. Forest Utilization for Lumber--Seven Selected Hawaiian Hardwoods, Special Report. Hilo, Hawaii: 1958. 6pp.

This report rates seven Hawaiian hardwoods useful for commercial lumbering. 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 by these criteria and Spanish cedar is rated highest.

_____. Utilization of Exotic Hardwoods of Hawaii, Progress Report. Hilo, Hawaii: 1955. 15pp.

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 australis,

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.

Yamamoto, Teruo. Soil Moisture and Soil Strength Characteristics of Five Hawaiian Soils. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1961. 8pp.+ Research Note 184.

This study relates to the trafficability of these soils; that is, how they will respond when traversed by vehicles.

_____. Soil Moisture Constants and Physical Properties of Selected Soils in Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1963. 8pp.+ Research Paper PSW-2.

Provides the water holding capacity and basic physical properties of some important wildland soils.

Yamamoto, Teruo, and Duffy, P.D. Water Storage Capacities of Soil under Four Different Land Uses in Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1963. 4pp. Research Note PSW-5.

Relates the water storage capacities of several soils to the land use to which they are put. Forest soils have a much higher water storage capacity than soils under grass, or soils that are cultivated.

Youngs, Robert L. Hardness, Density, and Shrinkage Characteristics of Silk-Oak from Hawaii. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1964. 14pp. Rept.FPL-074.

Silk-oak proved quite similar to black cherry in most properties.

_____. Physical, Mechanical and Other Properties of Five Hawaiian Woods. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1960. 34pp. Rept.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 PLANNING

Anderson, Henry W., Hopkins, Walt, and Nelson, Robert E. A Program for Watershed Management Research in Hawaii Wildlands [prepared] in cooperation with the Forestry Division, Department of Land and Natural Resources, State of Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1962. 15pp. Tech.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. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1961. Various pagings.

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 dealing with Hawaiian forests. (The movie is at the U.S. Forest Experiment Station, 400 S. Beretania, Honolulu.)

Bentley, J.R., and Graham, C.A. Plant Control Problems in Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1964. 7pp.

Discusses problems and research approaches toward forest stand improvement and elimination of undesirable vegetation using chemical herbicides. (Preliminary office report on file at Pacific Forest and Range Experiment Station, Berkeley, California.)

Hawaii. Department of Agriculture and Conservation. A Wildland Research Plan for Hawaii. Honolulu: 1960. 71pp.

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 recommended projects have already been carried out.

Hawaii. Department of Land and Natural Resources. Division of Forestry. A Multiple Use Program for the State Forest Lands of Hawaii: Water, Wood, Forage, Recreation, Wildlife. Honolulu: 1962. 50pp.

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 recommends that 300,000 acres of state forest lands should be planted with tree species of established 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.

Holt, W.W., and Nelson, R.E. A Timber Resource Survey for Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1959. 12pp. Forest Survey Release 36.

Discusses the procedures to be used in, and the need for, the forest survey of Hawaii.

LeBarron, R.K. Eucalypts in Hawaii: A Survey of Practices and Research Programs. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1962. 24pp. Misc.Paper 64.

Discusses the eucalypts from both silvical and utilization standpoints.

Roberts, E.V. "Forest Survey, General, Hawaii." Berkeley, Calif.: California Forest and Range Experiment Station, 1957. 10pp. Memorandum to Director.

Recommends that a forest survey be established in Hawaii. Establishes need on the basis of apparent excellent growth potential and utilization prospects.

"Ten-Year Program for Forest Work on Oahu." Hawaiian Forester and Agriculturist, 26:1, January-March 1929, entire issue.

This report presents a number of recommendations for a forestry program on Oahu. It 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. Pacific Experiment Station. Forest Research in Hawaii, 1957-1962. Berkeley, Calif.: 1963. 9pp.

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

_____. Forestry Research in Hawaii, 1963. Berkeley, Calif.: 1964. 11pp.

A progress report.

_____. Forestry Research Progress in Hawaii, 1964. Berkeley, Calif.: 1965. 10pp.

Progress report--includes bibliography and 1965 plans.

_____. Forestry Research in Hawaii: Program and Progress [prepared] in cooperation with the Division of Forestry, Department of Land and Natural Resources, State of Hawaii. Berkeley, Calif.: 1963. Various pagings.

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 Walker, Clyde M. A Provisional Check List of Some Common Native and Introduced Forest Plants in Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1962. 36pp. Misc.Paper No.69.

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

Honda, N., and Klingensmith, J.D. "Hawaii Forest Type Map, Island of Hawaii" [prepared] in cooperation with the Division of Forestry, Department of Land and Natural Resources, State of Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1962-1963.

Blueline prints showing land use, forest type, density, and size class of timber stand. Twenty-two quandrangle units (15-minute). Scale 1:62,500.

_____. "Hawaii Forest Type Map, Island of Molokai" [prepared] in cooperation with the Division of Forestry, Department of Land and Natural Resources, State of Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1964.

See description above. Three sheets (15-minute). Scale 1:62,500.

Honda, N., Cheatham, D., and Klingensmith, J.D. "Hawaii Forest Type Map, Island of Maui" [prepared] in cooperation with the Division of Forestry, Department of Land and Natural Resources, State of Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1964.

See description above. Four sheets (15-minute). Scale 1:62,500.

Hosaka, Edward Y., and Thistle, T. Noxious Plants of the Hawaiian Ranges. Honolulu: Agricultural Extension Service, University of Hawaii, 1954. 39pp. Bull.62.

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

Richmond, G.B. Guide to the Waiakea Arboretum, Hilo, Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1964. Unpaged.

Tells visitors about the trees in the arboretum and where the various species are located.

Rock, Joseph F. Indigenous Trees of the Hawaiian Islands. Honolulu: 1913. 518pp.

This is a rather technical description of native trees.

_____. The Ohia Lehua Trees of Hawaii. Honolulu: Division of Forestry, Territorial Board of Commissioners of Agriculture and Forestry, 1917. 76pp. Botanical Bull.No.4.

This is a technical article describing various species of ohia.

_____. A Revision of the Hawaiian Species of the Genus Santalum. Honolulu: Division of Forestry, Territorial Board of Commissioners of Agriculture and Forestry, 1931. 43pp. Botanical Bull.No.3.

This is a technical work listing various species of sandalwood.

Swezey, Otto Herman. Forest Entomology in Hawaii. Honolulu: Bishop Museum, 1954. 26pp. Special Pub.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. Honolulu: Agricultural Extension Service, University of Hawaii, 1930. 50pp. Bull.5.

This is a rather technical discussion of tree planting and growing in the Territory of Hawaii.

V. GENERAL WORKS

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

The author contends that Hawaii is experiencing increasing demands for the broader 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 S. Beretania, Honolulu.)

_____. "Developing a Wildland Research Plan for Hawaii," Paper presented at Tenth Pacific Science Congress, August 1961. Honolulu: Pacific Experiment Station, U.S. Forest Service, 1961. 6pp.

Discusses how the State's "Wildland Research Plan" was developed.

Bryan, Lester W. "The Big Fence on the Big Island." Paradise of the Pacific, 49:4, April 1937, pp.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." Reprinted from Hawaiian Planters' Record, 51:1, 1st Quarter 1947, pp.1-80.

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 trees survived.

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

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

Hall, William L. The Forests of the Hawaiian Islands. Washington, D.C.: U.S. Bureau of Forestry, 1904. 29pp. Bull.No.48.

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

Hawaii (Ter.). Board of Commissioners of Agriculture and Forestry. Report of the . . . for the Biennial Period Ending . . . Honolulu: 1900-1958.

These reports frequently include summaries of technical forestry matters as well as discussion of forestry and forest reserve policy.

_____. "Underlying Principles of Hawaiian Forest Policy" in Report of the . . . for the Year Ending December 31, 1908. Honolulu: 1909, pp.19-20.

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

Hawaiian Forester and Agriculturist; a quarterly magazine of forestry, entomology, plant inspection, and animal industry, Vol.1-30, January 1904--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 Forester." Honolulu: University of Hawaii, 1931. 25pp. (Unpublished).

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

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

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, pp.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, pp.137-147.

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.

Nelson, R.E. A Record of Forest Plantings in Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1965. 18pp. Resource Bull.PSW-1.

A listing of all known species planted on the forest reserves. Some 800 tree species are included among the total of 1,100 species.

Whitesell, C.D., and Daehler, R.E. "Forests--A Natural Defense Against Seismic Waves." American Forests, 70:11, November 1964, pp.38-39.

Describes how the Japanese have protected their beaches and homes against tidal waves by planting forests. Recommends this as a method suitable for Hilo. A map of the proposed "tsunami forest" and a list of suitable species is included.

SUPPLEMENTARY BIBLIOGRAPHY: 1965-69

I. COMMERCIAL FORESTRY

Fraizer, George D. Estimated Demand for Lumber and Plywood in Hawaii by the Year 2000. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1965. 9pp. Research Paper PSW-23.

By the year 2000, the author expects total lumber consumption in Hawaii to be between 78 and 128 million board feet. He predicts that hardwood lumber consumption will exceed 16 million board feet--an increase of nearly 2 1/2 times the present level of use--while softwood lumber use will remain at about the present level of 79 million board feet. Plywood consumption may be about 40 million square feet (3/8-inch basis). These estimates are based on the author's expectation that Hawaii's population will grow at the rate sustained between 1955 and 1962. Below, see Zinnikas and Boone, this section.

Honda, Nobuo, Wong, Wesley H.C., Jr., and Nelson, Robert E. Plantation Timber on the Island of Kauai--1965. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1967. 34pp. Resource Bull. PSW-6.

Timber stands totaling 43 million board feet are located cartographically and identified by species on 25,000 acres of forest land on the island. Native stands of ohia and koa, and naturally regenerated stands of silk-oak distributed over 25,000 acres of forest land constituted only 16 million board feet of sawtimber while 2,000 acres planted to various eucalypti and other introduced species contained 27 million board feet of sawtimber.

LeBarron, Russell K. Growing Norfolk Island Pine Christmas Trees in Hawaii. Cooperative Extension Service, University of Hawaii, September 1965. Misc. Pub. 23.

Norfolk Island pine has most of the qualities that are desirable in a Christmas tree. It grows well in Hawaii and appears capable of yielding large profits if grown as a Christmas tree.

Nelson, Robert E., and Honda, Nobuo. Plantation Timber on the Island of Hawaii--1965. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1966. Forestry Division, Department of Land and Natural Resources, State of Hawaii. 52pp. Resource Bull. PSW-3.

This is the first report to comprehensively identify by species and location timber plantations on the island of Hawaii. The authors note that 13,300 acres support commercial timber plantations on Hawaii of which the State owns 65 per cent.

Nelson, Robert E., Wong, Wesley H.C., Jr., and Wick, Herbert L. Plantation Timber on the Island of Oahu--1966. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1968. 52pp. Research Bull. PSW-10.

About 5,000 acres supporting commercial forest plantations on Oahu contain 46 million board feet of sawtimber. The island is capable of supporting 97,000 acres of commercial forest plantations which could yield 75 million board feet of sawtimber annually.

Wick, Herbert L. Forest Products Harvested in Hawaii--1967. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1968. 5pp. Research Note PSW-179.

A survey of the primary forest products harvested in Hawaii in 1967 showed a total value of $334,000, a 24 per cent increase over the value in the 1958 survey. Compared with the earlier survey, the volume of sawlogs and treefern harvested has gone up while the volume of fuelwood and posts harvested has declined.

Wong, Wesley H.C., Jr., Honda, Nobuo, and Nelson, Robert E. Plantation Timber on the Island of Lanai--1966. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1967. 18pp. Resource Bull. PSW-7.

Commercial forest plantations cover only about 400 acres of the island in stands 2 acres or larger. About 150 acres of this supports Eucalyptus robusta which, together with other mature plantations, constitutes 2.9 million board feet of sawtimber. Both sawtimber and sapling and pole-size stands of pine are identified by species and located cartographically.

Wong, Wesley H.C., Jr., Nelson, Robert E., and Wick, Herbert L. Plantation Timber on the Island of Molokai--1967. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1968. 25pp. Resource Bull. PSW-9.

Only about 2,000 acres support commercial timber plantations on the island, containing 12.6 million board feet of sawtimber. About 24,000 acres on Molokai which is presently unproductive could support commercial timber crops yielding 20 million board feet of sawtimber annually.

Zinnikas, John D. The Pacific Basin Market for Wood Products for Military Support Activities. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1966. 6pp. Research Paper PSW-27.

The author finds that the heaviest military demand in the Pacific is for softwoods, but that Hawaii should gain easy access to the military hardwood market which involved about 2.5 million board feet in the Pacific in 1964.

Zinnikas, John D., and Boone, R. Sidney. Market for Hawaii Hardwood Lumber in New Single-Family Houses on Oahu, Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1967. 10pp. Research Paper PSW-41.

The total potential market for flooring, siding, and cabinet and millwork in new single-family houses on Oahu was between 10.5 and 11 million board feet of lumber in 1963. The total possible market for lumber in new single-family house construction from 1965 to 1970 is estimated at 18 to 23 million square feet of flooring, 28 to 36 million square feet of siding, and 7 to 9.5 million square feet in cabinets. These estimates indicate a far larger market for Hawaii-grown hardwoods than supposed by George D. Fraizer, cited above, this section.

Zinnikas, John D., and Boone, R. Sidney. Requirements for New Housing in Hawaii, 1965-70: A Forecast. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1967. 6pp. Research Paper PSW-40.

An estimated 44,300 new housing units will be required in Hawaii during the period 1965-70. Single family houses are expected to comprise 20-26,000 of these units. Housing demand is related to population growth, age of existing housing units, and disposable income of potential home buyers.

II. TECHNICAL REPORTS

Anderson, Henry W., Duffy, Paul D., and Yamamoto, Teruo. Rainfall and Streamflow from Small Tree-Covered and Fern-Covered and Burned Watersheds in Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1966. 10pp. Research Paper PSW-34.

Streamflow from two 30-acre watersheds near Honolulu was studied by using principal components regression analysis. Models using data on monthly, storm, and peak discharges were tested against several variables expressing amount and intensity of rainfall, and against variables expressing antecedent rainfall. Explained variation ranged from 78 to 94 per cent. The analysis provided some clues as to the dominant hydrologic processes under three different watershed conditions.

Boone, R. Sidney. "Dry-Wood Termite Attacks in a 55-Year-Old Display of Hawaii-Grown Wood." 20:4, October 1966, pp.524-527.

Display racks built in 1909 to exhibit various woods grown in Hawaii provided some unique observations on dry-wood termite infections. Of 79 wood samples, including 76 species, 54 samples were not attached. It is quite likely that this may be the only record of dry-wood termite resistance for many of these species.

_____. Moisture Content of Wood for Interior Use: Douglas-Fir and Robusta Eucalyptus Samples Studies. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1967. 5pp. Research Note PSW-152.

Panels of Douglas fir and Eucalyptus robusta blocks showed little seasonal variation in Equilibrium Moisture Content (EMC) of wood at 19 indoor locations on Oahu. Differences in EMC between locations were more variable. Minimum EMC at nonair-conditioned locations was 10 per cent; at air-conditioned locations, 8 per cent. Maximum EMC at nonair-conditioned locations was 16 per cent; at air-conditioned locations, 12 per cent.

_____. Paintability of Two Hawaii-Grown Woods: First Progress Report. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1966. 6pp. Research Note PSW-116.

In a test of simulated vertical house siding, Eucalyptus robusta and Australian toon panels appear to hold paint as adequately as redwood and Douglas fir panels after 1-year exposure. The addition of anti-mildew agents to paints seems advisable--particularly in higher rainfall areas. Of the four systems of paint being tested, the self-primed latex appears to be the best to date.

Boone, R. Sidney. Service Life of Telephone Poles on the Island of Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1965. 6pp. Research Note PSW-96.

Records on service life of telephone poles showed that after 20 years, untreated redwood poles averaged 94 per cent still serviceable, pressure-treated Douglas fir 84 per cent serviceable, and pressure-treated southern pine 74 per cent serviceable. Seventy-five per cent of the untreated western redcedar remained serviceable after 20 years. Non-pressure treated ohia and eucalyptus had a much shorter service life.

Carpenter, Stanley B. "Brushkiller Stimulates Adventitious Rooting of Tropical Ash in Hawaii." Reprinted from the Journal of Forestry, 65:6, June 1967, p. 421.

Brushkiller (2,4-D/2,4,5-T) applied by a turbine blower in mist form caused the development of adventitious roots on the stems of seven-year-old tropical ash on the island of Hawaii. The nature and extent of the adventitious roots are described.

_____. Controlling Cull Ohia Trees by Injecting Herbicides. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1966. 5pp. Research Note PSW-125.

Ohia trees less than 6 inches d.b.h. on the island of Hawaii were killed by injection of undiluted 2, 4, 5-Tester. This chemical was less effective on larger trees. Injections applied in September and January were more effective than the May applications. Injections of 2, 4-D were relatively ineffective any season of the year, even for small trees. Tordon 22K proved 100 per cent effective in a single, unreplicated trial.

_____. Herbicides for Site Preparation: Broadcast Spray by Mist Blower Tested Against Understory in Hawaii Rain Forest. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1966. 8pp. Research Note PSW-115.

Two studies started in 1964 tested control of dense understory vegetation in Hawaii rain forests with herbicides applied by a large turbine blower spraying from widely spaced bulldozer lines. Brushkiller and Tordon 101 were effective on shrubs. Results on treefern were poor, but encouraging enough to merit additional study.

_____. Survival and Five-Year Growth in Unit 4, Waiakea Arboretum, Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1965. 4pp. Research Note PSW-88.

The report discusses the performance of 9 tree species planted in this unit in 1960 and indicates that slash pine does remarkably well on pahoehoe lava.

Gerhards, C.C. Physical and Mechanical Properties of Blackbutt Eucalyptus Grown in Hawaii. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1966. 8pp. Research Paper FPL 65.

Logs from trees about 40 years old, growing on the Hamakua Forest Reserve on Hawaii were tested at the Madison laboratory and found to be exceedingly stiff and strong in bending and (compression) but it is very heavy and it shrinks a great deal while drying.

Gerhards, C.C. Physical and Mechanical Properties of "Norforlk-Island-Pine" Grown in Hawaii. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1967. 8pp. Research Paper FPL 73.

Sample logs from five trees felled near Haiku, Maui were tested by the Forest Products Laboratory at Madison, Wisconsin and the wood was found to be comparable to Douglas fir in bending and compression strength, stiffness and hardness. It shrinks less during drying than Douglas fir.

_____. Physical and Mechanical Properties of Molucca Albizzia Grown in Hawaii. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1966. 8pp. Research Paper FPL 55.

Sample logs from a grove planted near Pahala, Hawaii were tested at the Madison laboratory and the wood proved roughly comparable in several properties to ponderosa pine, black cottonwood, and American basswood. Also, see Peters and Lutz, below.

Lanner, Ronald M. Phenology of Acacia Koa on Mauna Loa, Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1965. 10pp. Research Note PSW-89.

Flowering of koa was strongly seasonal on the Mauna Loa Strip. At 4,000 feet heavy flowering began in early December and lasted until early March. At 6,700 feet it extended from early March until mid-May. Heaviest flower losses occurred during anthesis, and were due to wind, rain, and possible the dropping of unpollinated heads. Large insects were important as pollinators. Shoot growth was cyclic, being most rapid from April to August, and much slower from September to March, or April.

Null, William S. "Photographic Interpretation of Canopy Density--A Different Approach." Reprinted from Journal of Forestry, 67:3, March 1969, pp. 175-177.

Projecting 35mm negatives through a microfilm reader provides a simple and inexpensive picture upon which dot counts can be made to determine canopy density. A 12-fold enlargement creates a desirable dot/area ratio because dots on the grid are small in relation to the image of foliage and branch material upon which they do or do not fall.

Peters, C.C. and Lutz, J.F. Some Machining Properties of Two Wood Species Grown in Hawaii--Molucca Albizzia and Nepal Alder. Madison, Wis.: Forest Products Laboratory, U.S. Forest Service, 1966. 18pp. Research Note FPL-0117.

Boards cut from Hawaii-grown trees were tested at the Madison laboratory by planning, shaping, turning, boring and mortising. Both species were found to perform as well as several hardwoods of about the same density grown on the mainland.

Richmond, G.B. Naturalization of Java Podocarpus in Hawaii Rain Forest. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1965. 5pp. Research Note PSW-76.

Podocarpus cupressina, a tropical conifer, is naturalized in the rain forest near Hilo, Hawaii. After describing the plantings existing on Hawaii, the author recommends research to determine the timber bearing potential of this tree.

Sharpnack, David A. Predicting Volumes in Four Hawaii Hardwoods. . .First Multivariate Equations Developed. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1968. 15pp. Research Note PSW-121.

Multivariate regression equations were developed for predicting board-foot (Int. 1/4-inch log rule) and cubic-foot volumes in each 8.15-foot section of trees of four Hawaii hardwood species. The species are koa (Acacia koa), ohia (Metrosideros polymorpha), robusta eucalyptus (Eucalyptus robusta), and saligna (E. saligna). The four independent variables used are d.b.h., merchantable length, form class, and the diameter at the tope of the merchantable length.

Skolmen, Roger G. A Durability Test of Wood Posts in Hawaii: Second Progress Report. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1965. 3pp. Research Note PSW-91.

Exposure of double-diffusion treated and untreated round posts of Hawaii-grown wood showed that untreated 3- to 5-inch posts of 10 species will last from less than a year to 3 years, depending on species, and that the treatment did not afford a service life long enough to justify using it except, perhaps, for Norfolk-Island pine, sugi, and Eucalyptus saligna.

Skolmen, R.G. "Heating Logs to Relieve Growth Stresses." Reprinted from Forest Products Journal, 17:7, July 1967, pp. 41-42.

Growth stresses in Hawaii-grown eucalyptus logs cause severe problems in sawing. More than half the stress contained in 6- to 8-inch, 4-year-old Eucalyptus saligna logs was relieved by boiling them in water for 24 hours. The apparent stress relief was not increased by steaming similar logs for 48 hours.

_____. Water Spray Protects Stored Logs in Hilo, Hawaii. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1965. 6pp. Research Note PSW-84.

Eucalyptus robusta logs continuously sprayed with water for 3 1/2 months were compared with logs left unsprayed. Water spraying greatly reduced damage from end splitting, stain, and insect attacks--even though Hilo, Hawaii, has a very high annual rainfall. Coating log ends with a wax emulsion reduced end splitting, but was not as effective a protective treatment as keeping logs continuously wet.

Walters, Gerald A. and Schubert, Thomas H. "Saligna Eucalyptus Growth in a Five-Year-Old Spacing Study in Hawaii." Reprinted from Journal of Forestry, 67:4, April 1969, pp.232-234.

Saligna eucalyptus trees planted at spacings of 8 by 8 feet, 10 by 10 feet, 12 by 12 feet, and 14 by 14 feet have all made very rapid height and diameter growth. In five years, trees in all spacings averaged over 72 feet in height, dominant and codominant trees averaged over 85 feet. Diameter growth rate, unlike height growth rate, increased with spacing. Average d.b.h. ranged from 6.2 inches in the 8- by 8-foot spacing to 7.9 inches in the 14- by 14-foot spacing. For the same spacings the average d.b.h. of the dominant and codominant trees was 7.5 and 8.9 inches, respectively.

Whitesell, Craig D. and Landgraf, Marx F. "Growing Queensland-Maple on Lava Rocklands in Hawaii." Reprinted from Tree Planters' Notes, August 1966. pp.1-3. No.77.

About 80 per cent of the seedlings planted in a rain forest on Hawaii in the shallow soil of a rain forest on Hawaii survived after 3 years of growth.

Whitesell, Craig D. and Rogers Bruce J. Queensland-Maple Seedlings in Hawaii: Growth Accelerated After First Year. Berkeley, Calif.: Pacific Experiment Station, U.S. Forest Service, 1966. 5pp. Research Note PSW-127.

Queensland-maple seedlings planted on lava rockland in Hawaii grew slowly in the first year. Growth rates accelerated during the next 3 years, although fertilizer treatments were ineffective. The trees averaged 17 feet in height after 4 years. Early growth of Queensland-maple in Hawaii compares favorably with that in young plantations in Australia and in Central Malaya.

Wold, Myron L., and Lanner, Ronald M. "New Stool Shoots from a 20-Year-Old Swamp-Mahogany Eucalyptus Stump." Reprinted from Ecology, 46:5, Summer 1965. pp. 755-756.

The authors seek to explain why a stump of Eucalyptus robusta near Hilo, Hawaii produced sprouts more than 20 years after it was cut.

Yamamoto, Teruo and Anderson, Henry W. "Erodibility Indices for Wildland Soils of Oahu, Hawaii, as Related to Soil Forming Factors." Reprinted from Water Resources Research, 3:3, Third Quarter 1967, pp.785-798.

Soil samples collected in the watersheds of the Koolau and Waianae ranges on Oahu were analyzed in the laboratory for the size distribution of water-stable aggregates and suspension per cent. Soil erodibility was related to 7 soil-forming factors: parent material, rainfall, elevation, vegetation type, slope, aspects, and zone. Although parent rock material was the most important factor in explaining variation of water-stable aggregates, differences in vegetation type and other soil-forming factors also affected the water conserving capacity of the soil. The authors recommend the conversion of the native koa and ohia shrubby forests by planting paperbark or silk-oak trees in order to improve erodible soils and to develop forest products.

III. RESEARCH INVENTORIES AND PLANNING

Duffy, Paul D. "Water Becomes the Most Important Forest Crop." Reprinted from Western Conservation Journal, 21:6, 1965, pp.58-59.

The author summarizes the results of some of the watershed management research conducted in Hawaii.

Institute of Pacific Islands Forestry, Research Highlights, 1967. Berkeley, Calif., 1968. 11pp.

This reports research in progress and planned by the U.S. Forest Service and the State Division of Forestry. In 1967, the U.S. Forest Service's research unit in Hawaii was designated "Institute of Pacific Islands Forestry" and has undertaken research into forestry and watershed management in Guam and American Samoa as well as Hawaii.

Nelson, Robert E. "Watersheds Assume Important Role in Forest Management in Hawaii." Reprinted from Western Conservation Journal, 21:6, 1965, pp.56-57.

The author summarizes the results of some of the forest management research conducted in Hawaii.

U.S. Forest Service. Pacific Experiment Station. Forestry Research in Hawaii--1966. Honolulu, Hawaii: 1967. 12pp.

A progress report.