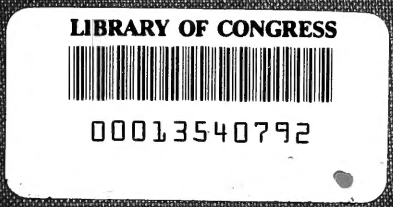

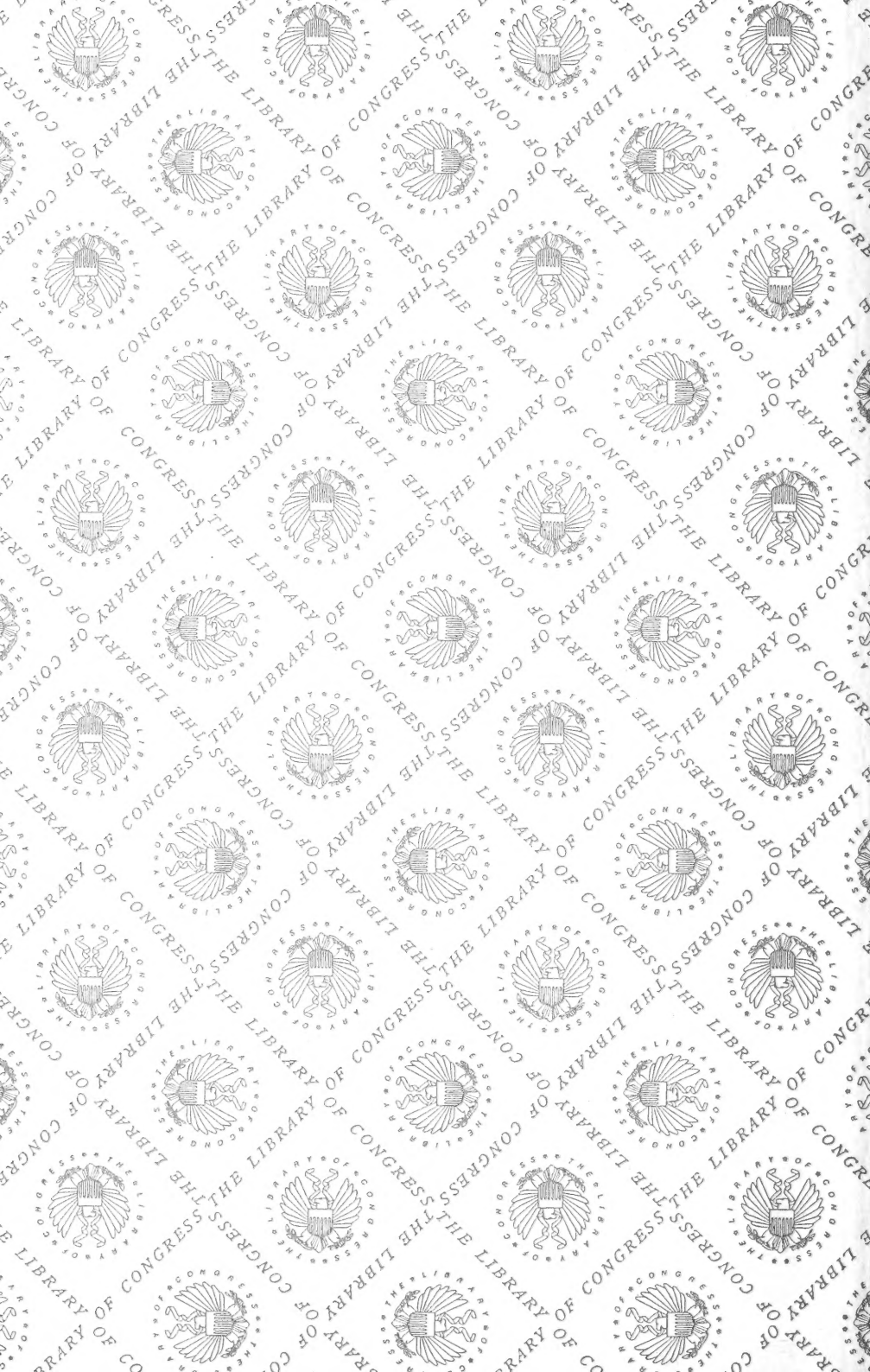
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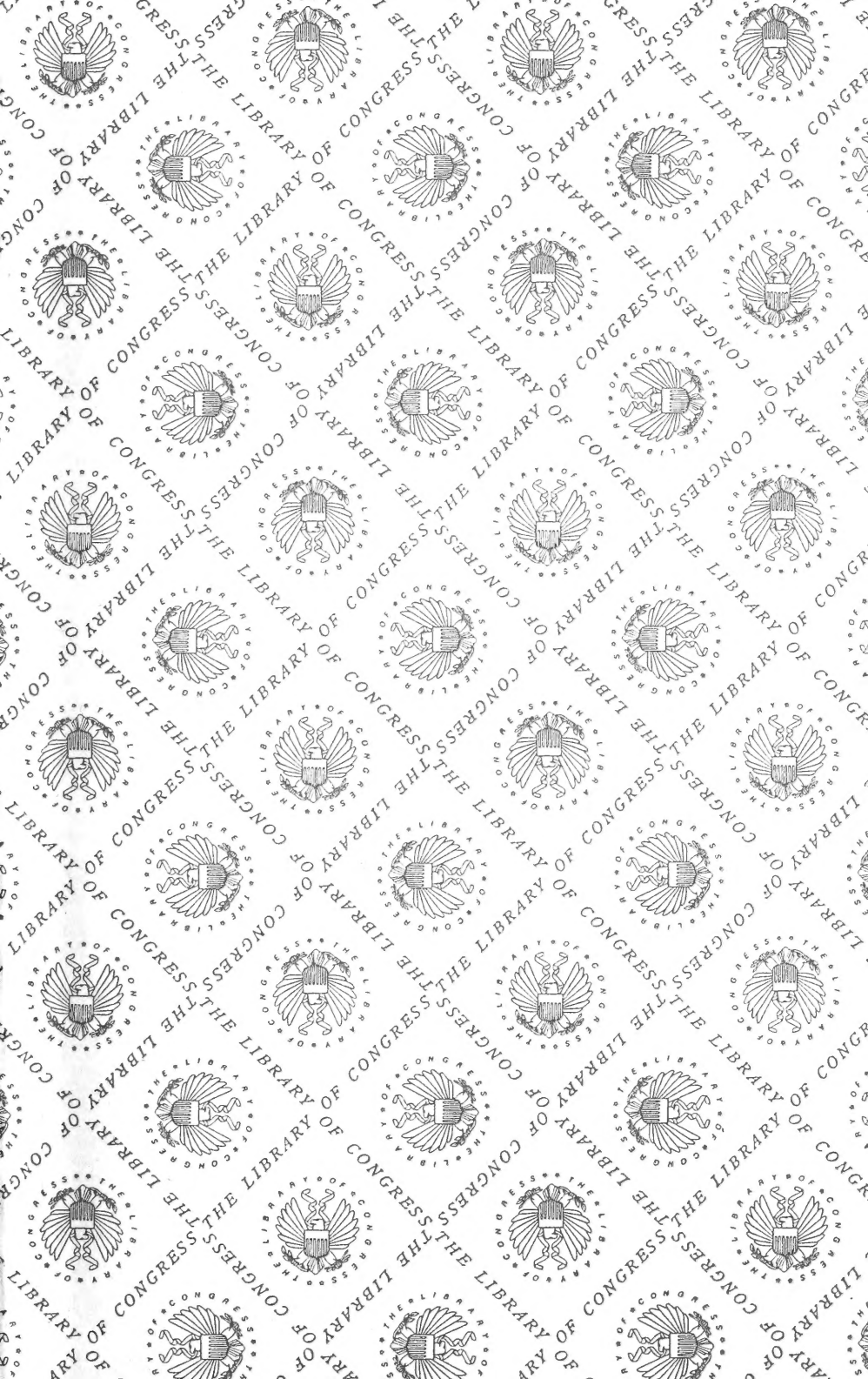
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BULLETIN NO. 1 DIVISION OF FORESTRY

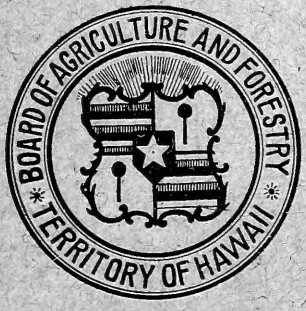
TERRITORY OF HAWAII
BOARD OF AGRICULTURE AND FORESTRY
DIVISION OF FORESTRY
RALPH S. HOSMER, Superintendent

In Cooperation with the

FOREST SERVICE
UNITED STATES DEPARTMENT OF AGRICULTURE
HENRY S. GRAVES, Forester

EUCALYPTUS CULTURE IN HAWAII

By
LOUIS MARGOLIN
Forest Examiner, Forest Service
United States Department of Agriculture



HONOLULU:
HAWAIIAN GAZETTE CO., LTD.
1911

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Walter D. McBryde, *in charge of Sub-Nursery at Homestead, Kauai,*
David Kapihe, *Forest Ranger for Tantalus.*

ASSISTANCE IN FOREST WORK.

Attention is called to the fact that the Division of Forestry stands ready at all times to give advice and assistance to tree planters and forest owners throughout the Territory on all phases of forest work. Upon payment of the traveling expenses, an agent of the Division of Forestry will be sent anywhere within the Territory to examine areas to be planted, following which there will be drawn up a detailed planting plan showing what species should be used and how the trees should be planted to secure the desired results. Owners of planted or native forests desiring advice as to the care and management of their properties can obtain it on similar terms. At the Government Nursery in Honolulu and its sub-stations on the other islands, the Division of Forestry keeps constantly on hand for sale, at cost price, seed and seedlings of the trees most in demand for local planting. Applications for assistance should be addressed to the Superintendent of Forestry, Box 207, Honolulu, Hawaii.

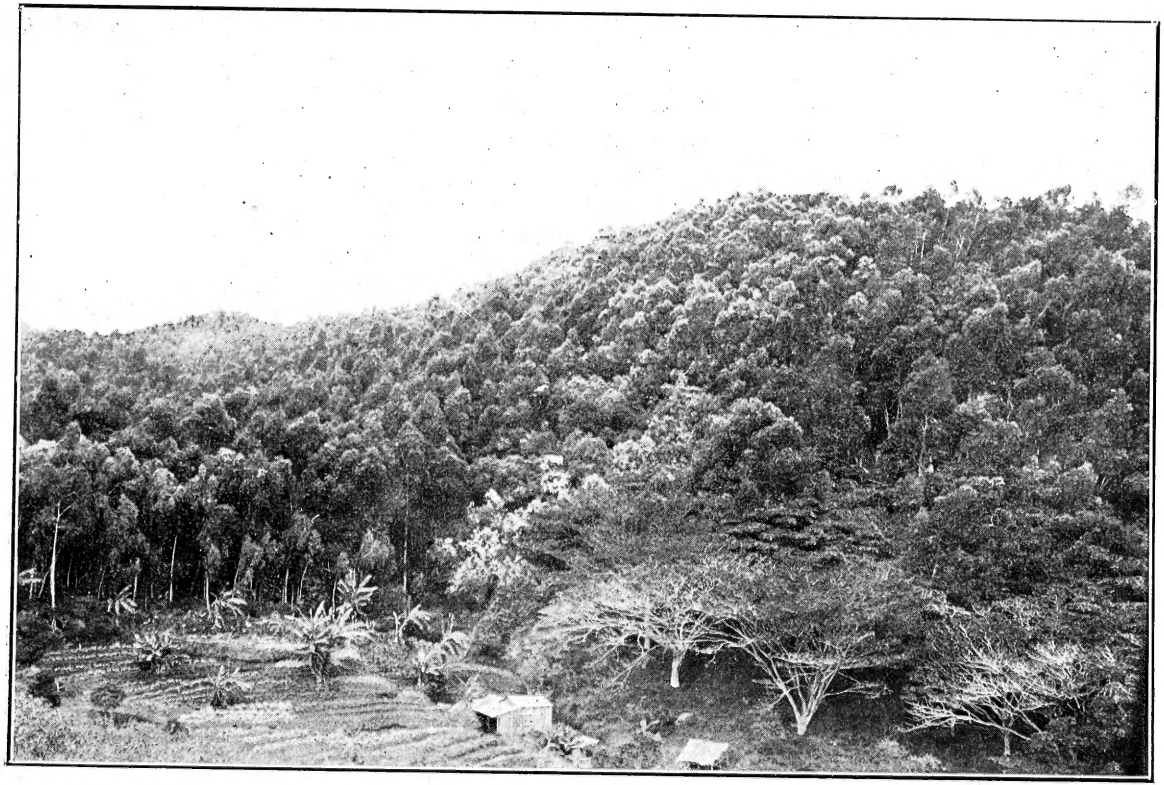

Plate 1. Eucalyptus Forest on Tantalus, Honolulu, Hawaii.

TERRITORY OF HAWAII
BOARD OF AGRICULTURE AND FORESTRY
DIVISION OF FORESTRY
RALPH S. HOSMER, Superintendent

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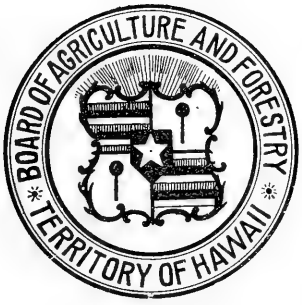

HONOLULU:
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1911

LETTER OF TRANSMITTAL.

Honolulu, Hawaii,

May 10, 1910.

The Board of Commissioners of
Agriculture and Forestry
Honolulu, Hawaii.

Gentlemen:—I have the honor to transmit herewith a manuscript entitled "Eucalyptus Culture in Hawaii," by Mr. Louis Margolin, Forest Examiner in the Forest Service, United States Department of Agriculture, which I recommend be published as Bulletin No. 1 of the Division of Forestry.

This report is the result of a study of Eucalyptus plantations in Hawaii carried on through coöperation between the Forest Service and the Territorial Board of Agriculture and Forestry. The field expenses incident to the investigation were borne jointly by the Forest Service and the Board; the cost of publication wholly by the latter.

The object of the report is to put before land owners in Hawaii comprehensive suggestions and definite recommendations in regard to growing and managing Eucalyptus forests. In view of the demand for such information and the difficulty in getting hold of it, the report has been made to include much general information in regard to the uses and value of Eucalypts, as well as some observations on the principles underlying forest management.

Sincere acknowledgment is here made to all those, plantation and ranch managers and others, who have given aid and encouragement in the investigation, particularly to the manager of the Maui Agricultural Company, to whom special thanks are due.

Very respectfully,

RALPH S. HOSMER,
Superintendent of Forestry.

APPROVED:

MARSTON CAMPBELL,
President, Board of Commissioners
of Agriculture and Forestry.

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Eucalypts 40-50 years old.

EUCALYPTUS CULTURE IN HAWAII.

The study of the eucalypts in the Hawaiian Islands, the results of which are now presented, was made in coöperation between the Forest Service of the United States Department of Agriculture and the Territorial Board of Commissioners of Agriculture and Forestry, at the request of the Superintendent of Forestry.

The field work extended over a period of four months (December 1909-March 1910), during which time practically all the important groves of Eucalyptus on the Islands of Hawaii, Maui, Oahu and Kauai were visited and examined. Complete measurements were made on 500 felled trees for the purpose of constructing volume tables. Wherever the groves were old enough sample plots were established, which should serve as a basis for studying future growth.

The object of this report is to bring together and correlate the information obtained in regard to Eucalyptus on the various islands, and to outline a system of forest management for planted groves. Since most of the systematic tree planting on these islands has been done only during the last decade, and few stands are now more than five or six years old, not enough definite data are available at present to forecast with any degree of certainty the exact financial returns that may be expected, but the information obtained indicates very clearly that a number of species of the eucalypts can be grown at a good profit in many places on the Hawaiian Islands.

NEED OF LOCAL TIMBER SUPPLY.

The Territory of Hawaii, with its extensive sugar plantations, camps, flumes, tunnels, and irrigation ditches, uses large quantities of timber and lumber. No complete statistics on this subject are available, but the following figures may be considered as quite conservative. There were during the last three or four years used annually in Hawaii over forty million board feet of sawed lumber and timber, 75,000 cords of firewood, 20,000 to 25,000 railroad ties, 25,000,000 shingles and 40,000 to 50,000 fence posts. This annual consumption of wood represents a value to the consumer of at least one and one-half million dol-

lars. With the more intensive development of the plantations, the increase in population, the development of irrigation systems, homesteads, and small farming, and the further extension of roads and power lines, the consumption of lumber will constantly increase. The problem of finding an adequate source of supply of wood becomes, therefore, of paramount importance to the future growth of the country.

The native Hawaiian forest is entirely inadequate to meet the demand for lumber consumed in the Territory. Although the Islands have an extremely rich and varied flora, there are few native trees of commercial value. Few native trees average more than 10 to 12 inches in diameter or more than 50 feet in height, and the clear merchantable length of such trees is too small to be of any practical use for lumber. A dozen or more different species of native trees are used locally for various purposes, but the ohia lehua (*Metrosideros polymorpha*) and the koa (*Acacia koa*) are the only two timber trees in the Territory which, because of their size and abundance, have any commercial importance. Of these two species, koa is primarily a cabinet wood, leaving ohia lehua as the only all-around native timber tree; and there is not enough of this tree to affect the situation materially. With few exceptions the chief use of the native forests is to conserve the water supply and regulate the stream flow, and their importance as a source of timber supply, except in a few restricted districts, is entirely negligible.

The timber supply of the continental United States at the present rate of consumption can not last for a long time. As the supply of timber diminishes, export lumber from the United States may be expected to reach practically prohibitive prices for many uses. The trees native to the continental United States are all of comparatively slow growth. The more valuable pines and hardwoods require not less than 75 to 100 years to form trees big enough for lumber. It takes at least 30 to 35 years to grow tie timber, and even this rate of growth is restricted to only a few species. The rapid-growing Eucalyptus can be grown in the continental United States on only comparatively small areas in central and southern California, Arizona, southern Texas, and southern Florida.

The Territory of Hawaii can not, therefore, depend indefinitely on the rest of the United States for its supply of lumber. Neither can it depend to any large extent on foreign countries. On the contrary, located as the islands are, and with a climate favorable to rapid growth, Hawaii, in course of time, should be

able to export to the United States an ever-increasing supply of hardwood.

Fuel wood of a low grade can be grown in Hawaii in five or six years, but trees of this age have very little value. Trees suitable for fence posts, railroad ties, and lumber, as well as for the better grades of firewood, require a much longer period to mature. Even the more rapid-growing species of eucalyptus and ironwoods, although growing faster than most hardwoods, require a number of years to reach a size which renders them fit for use as timber trees. The mistake in the past has been that trees were cut which were too young. Systematic tree planting in Hawaii can not, therefore, begin too soon, for the earlier the forests are established the less hardship will be experienced when the supply of timber becomes less abundant.

In short, an increasing supply of inexpensive lumber is essential to the proper growth and development of the Hawaiian Islands. The native forests are entirely inadequate both in extent and character to furnish this supply. The continental United States is approaching a time when it will be no longer in a position to export cheap lumber to Hawaii. The Islands can grow their own lumber supply before the timber scarcity comes, provided immediate planting is done on a commercial scale.

FOREST PLANTING IN HAWAII IN THE PAST.

In the past, more or less sporadic tree planting was done in the Hawaiian Islands, which at first was confined mainly to the introduction of exotic fruit trees, such as mango, alligator pear, and similar plants, but later included many valuable ornamental and timber trees. The introduction of exotic plants received especial impetus in 1881, as a result of a tour of the world by King Kalakaua, who sent back to the islands seed and cuttings of many important plants, some of which may now be found growing on almost every island in the group.

The early planting was largely without any system and was purely for ornamental purposes. Little attempt has been made to utilize the information obtained by this experimental planting, and outside of the eucalypts, ironwood (*Casuarina*), acacias, silk oak (*Grevillea*), and three or four other species, the introduced trees occur singly, and are rarely seen in groves or forests. It is not at all uncommon to find an old home surrounded by a grove containing from twenty to sixty different kinds of trees. Such planting, of course, is of little commercial value.

What is probably the oldest systematic forest planting is found

at Ulupalakua on the Island of Maui, where, on Prospect Hill, at an elevation of 2,800 feet, may be seen a grove of eucalypts 40 to 50 years old. Although the trees were planted for ornamental purposes, and are not properly spaced, they have shown remarkably good growth and clearly indicate the adaptability of the eucalypts to certain localities in Hawaii. Trees three or four feet in diameter and 75 to 100 feet in height are not uncommon.

Next in point of age is a grove of ironwood (*Casuarina equisetifolia*), about four acres in extent, planted in 1874 near Lihue, Island of Kauai, on the land of Grove Farm. Here may also be found various younger groves of ironwood, as well as groves of eucalypts and silk oak (*Grevillea robusta*).

The Lihue Plantation on the Island of Kauai was the first to begin the systematic planting of forests for purely commercial purposes. The native forest had been destroyed and a scarcity of wood was imminent. Accordingly, a German forester was employed in 1882 to plant trees for the purpose of supplying the plantation with fuel. The forester remained for fifteen years, during which time a large tract of land was replanted, mostly with ironwoods. Forest planting is regarded at Lihue as a regular part of the plantation program, new groves being started every year.

About the same time, 1880, the Government began the systematic reforestation of the slopes of Tantalus, back of Honolulu. More than thirty different species of eucalypts were here planted, besides a number of other kinds of trees. One of the most promising commercial groves of trees may be found on the land of the Paauhau Plantation, in the Hamakua district, on the Island of Hawaii. On an area of about 40 acres two species of eucalypts were planted, *E. globulus,* the blue gum, and *E. citriodora,* the lemon-scented gum. A more complete description of this grove is given later on.

The most extensive planting of Eucalyptus on a commercial scale was begun in 1896 on the Island of Maui by the Maui Agricultural Company. This planting has continued almost without a break to the present time. A number of species have been thoroughly tried, and the results obtained are most encouraging.

The planting in the past has shown that of the many kinds of trees so far tried, the various species of Eucalyptus are the most promising, and are best suited to the purposes for which planting is done on the islands. Other trees, like ironwoods, are particularly good for certain uses, as for windbreaks, and for certain localities, such as sandy sea beaches, but the eucalypts are

the best all-around trees in most situations. This report will concern itself exclusively with the eucalypts.

THE EUCALYPTS.

The genus Eucalyptus belongs to the Myrtle family, the *Myrtaceae,* to which family also belong the native ohia lehua (*Metrosideros polymorpha*) and the introduced Java plum (*Eugenia jambolana*). The genus Eucalyptus includes about 200 different species, but the specific differences are frequently slight, and are in many cases based on the structure of the stamen of the flower, and especially of the anther. In many cases, too, the different species grade into each other so imperceptibly that it is necessary to have not only the flowers and fruit but also the leaves, bark, and wood of a tree to determine the species to which it belongs. No attempt will be made in the present report to give a botanical description of any of the trees.

The various species of eucalypts differ from each other not only in size and form but also in their physical and climatic requirements of moisture, temperature, soil, etc. Many eucalypts are straight, cylindrical, and clear of branches for a great height, while others are crooked, forked and branchy. The wood of some trees is soft and brittle, while that of others is hard and tough and very durable. Some eucalypts can thrive on poor soils and can stand much drought, while others require rich, moist soils and plenty of rainfall. By a judicious selection it is thus possible to choose species of eucalypts suitable to almost any situation in Hawaii and fit for almost any use to which wood is put.

PHYSICAL REQUIREMENTS.

There are two main natural factors which determine the possibility of introducing eucalypts in any new region—namely, (a) climate, including temperature, precipitation and wind, and (b) soil.

Climate.

The native home of the valuable eucalypts is in the warmer portion of Australia and a few of the adjoining islands. The question of hardiness to frost is of paramount importance to the growing of Eucalyptus on the continental United States, because the range of the tree is there determined by its ability to endure cold. In Hawaii, however, the question of frost hardiness is not

of great consequence because outside of the summits of the three highest mountains on the Islands the temperature everywhere in the Territory is sufficiently warm for the growth of Eucalyptus.

Several species of eucalypts have been planted within the last three years on the west slope of Haleakala, on the Island of Maui, at an elevation of between 6,000 and 6,500 feet, and a number of them are doing very well, notably the peppermint gum (*E. amygdalina*), the blue gum (*E. globulus*), the mountain ash (*E. siberiana*), and the broad-leaved ironbark (*E. siderophloia*). Here the temperature is almost never lower than 35° F. How much higher than 6,500 feet these trees would grow it is difficult to state, but there is no reason to believe that the temperature would be too low for a proper growth of the eucalypts at elevations as high as 7,000 or 8,500 feet, since the thermometer rarely drops below 32° F.

The temperature and moisture conditions most favorable to the growth of Eucalyptus in Hawaii are an abundant rainfall, say between 50 and 100 inches per year, and a rainy season alternating with plenty of strong, warm sunshine. Prolonged rain suddenly followed by intense sunshine and heat is injurious, especially to seedlings.

The eucalypts are intolerant of shade and require plenty of light for their proper development. When given too much light, however, the eucalypts will branch out immoderately and will then not be of much value as timber trees. The trees in their seedling stage can endure more shade than the older trees, and the very young seedlings require a certain amount of shade for their growth. When all planted at the same time, the eucalypts can grow in dense stands, and the trees will then form straight, cylindrical trunks. They will not grow, however, planted in the shade of other trees.

Most of the eucalypts have well-developed root-systems, and as a rule are not easily thrown by ordinary winds, but the foliage of many of the gums is affected by strong winds, and few species can therefore thrive in windy situations. The trees seem to suffer more by constant than by unusually strong winds, and the ordinary trade wind in an exposed situation will be more harmful than an occasional kona storm. The foliage of blue gum (*E. globulus*) and red gum (*E. rostrata*) is particularly sensitive to strong winds. Sugar gum (*E. corynocalyx*) and peppermint gum (*E. amygdalina*) can stand much wind, though the trees will often lean to leeward and are then unfit for straight timber. The swamp mahogany (*E. robusta*) is gen-

erally considered sensitive to strong winds in California, but in Hawaii it is found to grow straight and of good form even in the most exposed situations.

The eucalypts, as a rule, prefer a very moist soil and respond readily to irrigation on dry situations. Swampy land, however, is not favorable to good growth, especially if the roots of the trees are constantly flooded. The red gum (*E. rostrata*) is probably the least exacting in this respect, and will thrive in wet swamps. Swamp mahogany (*E. robusta*), blue gum (*E. globulus*), and the bastard mahogany (*E. botryoides*) will also endure excessive moisture. The sugar gum (*E. corynocalyx*), on the other hand, is the most intolerant in this respect.

Soil.

Unlike agricultural crops, trees are not fastidious as to the quality of the soil on which they grow. There is hardly a soil so poor as not to be able to support some tree growth. The chemical composition of the soil is of little importance, provided its physical composition is favorable. The physical composition of the soil is important because it determines to a large extent the amount of available soil moisture. A deep, loose, moderately fine-grained, sandy loam is the best for most species of eucalypts, as it is for almost all other forest trees.

The following trees require good soil for their proper growth: Blackbutt (*E. pilularis*), red gum (*E. rostrata*), manna gum (*E. viminalis*).

The trees which are least fastidious as to their soil requirements are peppermint gum (*E. amygdalina*), yate (*E. cornuta*), red mahogany (*E. resinifera*), swamp mahogany (*E. robusta*), and red ironbark (*E. sideroxylon*).

HABIT OF GROWTH.

Form and Size.

There are two general classes of eucalypts recognized in Australia, the tall timber trees, collectively known as "gums," and the scrubby species, known as "mallees." There is no reason for planting the mallees in this country except for forest cover and water protection, and even for this purpose some of the faster-growing gum trees would be preferable, both because of their more rapid rate of growth and because of their greater value.

As a rule the timber eucalypts, when grown under forest con-

ditions, are tall, straight, cylindrical, and of symmetrical form and development, though species vary greatly in this respect. Trees grown in the wind are apt to be very much twisted in grain and gnarled in appearance.

Some of the eucalypts are among the tallest trees in the world. A variety of the peppermint gum or messmate (*E. amygdalina* var. *regnans* F. v M., or *E. regnans* F. v M.) has been considered to be the tallest tree in the world, specimens 400 to 500 feet and more in height having been reported. More recent investigations have proved that many of the reports as to the height of these trees are exaggerated. A tree reported by one observer to be 525 feet, and by another as 464 feet in height, was found to be barely 220 feet by actual measurement. A standing reward of £100 offered by the Premier of Victoria to any one discovering a Victoria tree 400 feet or more in height has as yet been left unclaimed. The highest tree authentically measured is 326 feet 1 inch. This height is exceeded by the California coast redwood (*Sequoia sempervirens*), which attains a height of about 400 feet. The tallest redwood authentically measured (by Sargent) was 340 feet high. The greatest diameter of any eucalypts authentically measured (*E. regnans* F. v M.) was 17 feet 8 inches, measured six feet from the ground. Mr. John Muir measured a California bigtree (*Sequoia washingtoniana*) which had a diameter of 35 feet 8 inches, measured four feet from the ground. This is equivalent to a diameter of at least 33 feet if measured six feet from the ground. California thus has the distinction of being the home of both the tallest and the largest trees in the world.*

Root System.

All the eucalypts have deep root systems to supply their demand for plenty of soil moisture. The young trees have well-developed taproots, which disappear, however, in most cases, as the trees grow older. When grown on a shallow soil underlain by an impenetrable layer of rock, the trees are liable to be stunted and scrubby.

The roots of the eucalypts will spread to a great distance in search of water, and roots 100 feet or more in length are frequently found. It is this habit of root-spreading which has given the tree a bad reputation with many, because it is claimed

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* See The Forest Flora of New South Wales, Vol. II, Part 8, Pages 159 to 165. By J. H. Maiden.

Plate 3. Fig. 1. Blue Gum Stand 8 Years Old.
Showing bad effect of wide planting.

Fig. 2. Blue Gum Stand 8 Years Old in Need of a Thinning.
Kaluanui, Maui.

that a Eucalyptus plantation or a windbreak of these trees will sap the moisture from the ground and prevent the growth of agricultural crops or grass in the immediate vicinity. There is no denying that the ground cover in the immediate proximity of a Eucalyptus grove or windbreak is not as luxuriant as it is some distance away from the trees, but observation will show that the damage done is greatly exaggerated. Furthermore, the benefit derived from the tree plantation, either as a windbreak or in other ways, more than compensates for the injury.

To reduce the damage from superficially spreading roots, a scheme has been recommended for California which may be of equal value in this Territory. As soon as it is noticed that the roots are spreading too widely, a trench is run 3 or 4 feet deep, parallel to the row of trees, and about 10 feet away from it. This cuts the surface roots. The trench is then immediately refilled to prevent the roots from making their way under the trench. Every two or three years thereafter the trench is reopened, the surface roots cut and the trench refilled. In this way it is possible, at a small expense, to keep the surface roots of the trees as limited in extent as desired.

Another charge that is sometimes brought against Eucalyptus plantations is that the trees pump so much water from the ground as to interfere with springs and small streams by lowering the general water table of the soil. This may be true in certain cases, especially in situations where the air is dry. On the other hand, the condensation of air moisture in the humid atmosphere by the tall eucalypts is more than enough to compensate for the water used by the tree in its growth. In the fog belt of California where eucalypts are planted the trees are almost constantly dripping with moisture. At upper Paauhau, on the Island of Hawaii, at an elevation of about 3,000 feet, a grove of blue gum condenses so much moisture from the air that troughs have been placed under the trees to catch the water for domestic purposes.

Reproduction.

The eucalypts reproduce prolifically both from seed and from sprouts. The trees begin to bear flowers and seed at a very early age, but the first few crops of seed are not fertile. At Umikoa, on the Kukaiau Ranch, on the Island of Hawaii, at an elevation of 3,700 feet, a line of blue gum trees eight years old has naturally seeded up a dry, rocky piece of land. At Olinda, on the Island of Maui, at an elevation of 4,000 feet, a planted

line of blue gum 35 years old is surrounded by several acres of younger trees which started from the seed dropped by the planted trees. The young trees are of excellent form and are growing rapidly, the largest being 16 inches or more in diameter and 70 to 80 feet in height. In another place near Olinda blue gum trees 12 years of age have produced fertile seed.

The swamp mahogany (*E. robusta*) is probably not much inferior to the blue gum so far as age of seed bearing is concerned. In Makawao, on the Island of Maui, at an elevation of 3,000 feet, swamp mahogany 20 to 25 years old produced fertile seed which has covered a small rocky ledge with young seedlings.

No naturally sown seedlings of other species of Eucalyptus were observed in Hawaii; but this is probably due to the fact that few other species have been planted long enough under such conditions as favor the germination of the seed when dropped from the tree. The seed will not, as a rule, germinate in turf or litter, but requires pure mineral soil. Most of the older eucalypts on the Islands, having been planted for ornamental purposes, are surrounded by lawns.

The ability of Eucalyptus to reproduce itself naturally by seed is unimportant commercially, when compared with its capacity to grow from sprouts (or ratoons). All the trees of this genus reproduce themselves very rapidly from the stump when cut. If injured by cattle, wind, or fire, young shoots are ever ready to take the place of the injured parts. A tree blown down by the wind and partly uprooted will send out numerous shoots from the prostrate trunk, which may eventually form trees of desirable form and quality. A grove of blue gum at Kailiili, on Maui, was planted on a very windy hillside. The trees were spaced 10 by 15 feet, and many were blown down by subsequent storms. From the trunks thus bent to the ground numerous sprouts appeared, forming a comparatively dense growth, which developed into a remarkably good stand of trees. When the trees were about ten years old, the grove was thinned, with the result that the stand is now in excellent producing condition. In this case the wind had a decidedly beneficial effect. However, it is extremely unsafe to depend on the wind as a silvicultural tool, and the instance is mentioned here only to illustrate the wonderful sprouting capacity of blue gum.

Other eucalypts than the blue gum have this power to an equal degree. A grove of mixed eucalypts, mostly of blue gum and red mahogany (*E. resinifera*) at Haiku Hill, on Maui, at an elevation of 500 feet, produced trees 30 to 40 feet high and 3 to 10 inches in diameter in less than three years after the first crop

was cut. In this case the red mahogany sprouts showed a more rapid rate of growth than the blue gum.

Trees of blue gum (*E. globulus*), swamp mahogany, (*E. robusta*) and yate (*E. cornuta*), cut on Tantalus, near Honolulu, early in December, showed numerous vigorous sprouts in the following April. Red gum (*E. rostrata*), manna gum (*E. viminalis*) and other species of eucalypts in California are found to sprout readily after cutting, and there is every reason to believe that most of the other species will sprout equally well.

It is this ability of the Eucalyptus to sprout which makes it such a desirable tree for firewood, for as soon as one crop is cut off a new growth of trees takes its place. A ratoon crop normally grows much faster than the original stand for a time, because no time is lost in establishing a root system, the sprouts deriving their nourishment from the roots already in existence. The number of successive crops that may be obtained from one set of trees has never been determined. Groves where five or six successive crops of trees have been cut may be found in California; and in Hawaii, in a grove about half a mile from the Makawao postoffice, on Maui, four or five successive crops of blue gum have been cut without apparently injuring the reproductive capacity of the trees.

It is not to be presumed, however, that this process can be repeated indefinitely. Judging by all that we know of other trees, sooner or later the vitality of the present root system will decline until eventually sprouts will no longer be produced. Generally speaking, trees from sprouts do not reach dimensions equal to those of seedlings. The time of the year when the trees are cut seems to have a great influence on their sprouting capacity, and it is asserted that trees cut in the summer or late spring will not ratoon readily. All who have had experience in cutting the eucalypts in Hawaii are unanimous in opinion that the rainy season from early November to about the middle of March is the most favorable time for cutting the trees to obtain a good sprout forest, though trees will ratoon if cut in other seasons.

ENEMIES.

The eucalypts in Hawaii, so far as observed, are remarkably free from insect and fungous enemies. In particularly dry locations and in unusual drought a Eucalyptus plantation may be in danger from fire, since the dry leaves and twigs and the fallen shreds of bark are quite inflammable. The danger from fire is further increased by the rank growth of weeds found in the more

widely spaced plantations. The damage done would depend, of course, on the intensity of the fire and the age of the trees. A light ground fire in an old grove of trees will cause little injury aside from scorching the bases of the trunks, while even a moderately light fire will completely destroy a young plantation. In most cases even a very severe fire will destroy only the portions of the trees above ground, and the roots will then send out a second crop of sprouts. However, a plantation is always set back by a fire, no matter how light, and every precaution should be taken to guard against fire, especially during unfavorable seasons. In extreme cases it may even be necessary to prohibit trespass through the plantation so as to avoid the danger from unextinguished matches and cigarette and cigar butts.

The main precautionary methods to be adopted against fire are close planting to prevent the growth of weeds and brush, care in burning grass on adjoining land, and a fire guard or patrol for a short time during unusually dry and dangerous seasons. With a moderate amount of care and vigilance the fire danger should not be a great deterrent to the successful cultivation of Eucalyptus in Hawaii.

Cattle, horses and pigs must be kept out of a young tree plantation. The animals bite off the young shoots, injure the bark, and trample down the trees without great benefit to themselves, for the Eucalyptus, at best, is but poor fodder, and there is nothing gained in letting the animals roam at will in young growth. After the trees have reached some size the harm done is greatly reduced, but even when they are 4 or 5 inches in diameter and 25 or 30 feet high cattle may cause considerable damage by tramping and packing the soil and exposing the roots, especially during the rainy weather, when the soil is wet and easily packed.

On some stock ranches in Hawaii eucalypts are planted for the express purpose of furnishing shade to cattle during the hot season, and shelter against rain and cold. Under such circumstances the value of the trees for timber and fuel is a secondary consideration, and it is only necessary to protect the trees long enough to insure their successful establishment. A cattle-proof fence for the first five or six years will usually accomplish this object. At the end of that time the fence may be taken down and moved to a place where a new plantation is to be established.

Where the primary object of a plantation is to raise timber trees, cattle should be kept out until the trees have reached a diameter of a least 4 inches.

USES OF EUCALYPTUS.

The main objects in planting trees in Hawaii may be enumerated as follows: For the production of fuel, fence posts, lumber and timber; for the protection of watersheds; for windbreaks and shade; for esthetic purposes. It will be found that the various species of eucalyptus are admirably adapted to the above uses. Not all of the eucalypts are equally well suited to the various purposes for which trees are planted, but among the long list of species some are best adapted for one use, some for another. A tree which may yield an excellent fuel wood may not rank high as a fence post tree, because its wood may not be durable; and so with the other uses. The selection of the proper species for the desired purpose will require a knowledge of the qualities of the different eucalypts. A brief description of the uses of the leading species is given in the appendix.

Fuel.

The most immediate need for planting trees in Hawaii is to furnish the extensive plantations with an adequate supply of fuel. The sugar mills are invariably run with the bagasse or cane pulp left after the juice has been pressed out. In a few cases there is a slight excess of cane refuse which is bundled up and used as domestic fuel, but with this unimportant exception all the fuel used for domestic purposes is either wood or coal.

The plantations usually agree to furnish their laborers with the necessary shelter and firewood. The fuel thus consumed averages, roughly, about half a cord of wood per person per year, counting not only the laborers, but also their families. With the average population on a plantation figured at 2,000 persons, the annual consumption is about 1,000 cords of wood. The present price of cordwood delivered at the plantation varies from about $5.50 per cord for kiawe or algaroba and young blue gum to $12.00 or more per cord for slabs of ohia lehua, the fuel value of the latter being ranked very high. The fuel expense to the average plantation amounts, therefore, to at least $5,500, and may run as high as $10,000 per year. On some plantations it is impossible to obtain wood at a reasonable price, and the laborers are supplied with coal or oil for fuel. The problem of obtaining an adequate fuel supply is therefore of great importance to the plantations, and deserves careful consideration, for it must be remembered that the price of wood is constantly rising.

There are a number of trees grown on the Islands which yield good fuel wood, notably the ironwoods (*Casuarina*), the black wattle (*Acacia decurrens*), and silk oak (*Grevillea robusta*). Many of the eucalypts, however, are superior to the above-mentioned trees not only in their actual fuel value but also because they can grow in places and at elevations where the other trees can not thrive, and especially because of the ease with which the eucalypts reproduce themselves by sprouts, or ratoons. With a reasonable amount of care in cutting down the trees, one planting of Eucalyptus should suffice for an indefinite number of crops of fuel wood, while with many other trees it may be necessary to replant the area each time the trees are cut. Furthermore, in a properly-grown Eucalyptus forest, the fuel wood may be obtained as a by-product by thinning out the main stand, or from the tops and branches of trees cut for more useful purposes, such as poles, lumber, etc., while in many of the other trees planted, fuel wood is the main crop. If for no other reason than its rapid rate of growth, Eucalyptus should receive favorable attention as a fuel wood.

Of the more common eucalypts the following four species are considered of high fuel value: Red box (*E. polyanthemos*), leather jacket (*E. punctata*), red gum (*E. rostrata*), and red ironbark (*E. sideroxylon*). The common species of Eucalyptus planted in Hawaii, namely, blue gum (*E. globulus*), swamp mahogany (*E. robusta*), red mahogany (*E. resinifera*), and lemon-scented gum (*E. citriodora*), though all furnishing good fuel wood, are inferior in this respect to the eucalypts mentioned above. In all cases the heartwood is of higher fuel value than the sapwood, and for this reason young trees, which have a high per cent. of sap, yield but indifferent firewood.

Fence Posts and Ties.

Next to the need for fuel the greatest need for wood on the Islands is for fence posts and ties. A considerable proportion of the fence posts and almost all the railroad ties used in the Territory are at present imported from the coast, at a cost averaging about 30 cents per post and 60 to 75 cents per tie. There is no reason why the demand for this material should not be supplied locally. Many of the eucalypts, because of the great durability of their wood when in contact with the soil, are well suited for ties and posts. The following species deserve especial attention in this respect: White mahogany (*E. acmenoides*), bloodwood (*E. corymbosa*), Victoria gum (*E. leucoxylon*),

jarrah (*E. marginata*), leather jacket (*E. punctata*), red mahogany (*E. resinifera*), and gray gum (*E. tereticornis*). Of the other commonly planted species, red gum (*E. rostrata*), swamp mahogany (*E. robusta*), and blue gum (*E. globulus*), in the order mentioned, will last in the ground well, provided the heartwood is used, and provided the wood is allowed to season for some time before it is used.

In a number of instances Eucalyptus, especially blue gum as well as ironwood, has been used for fence posts and ties with poor results, it being found that the wood went to pieces at the end of three or four years. In almost every case this was due to the fact that young green saplings, consisting mainly of sapwood, had been used. All woods last longer after they are seasoned, and the heartwood is almost invariably superior to the sapwood in this respect. No wood should therefore be condemned until after the seasoned wood of fairly old trees has been tried. The kind of soil and its moisture content have also a decided influence on the durability of the wood.

Lumber and Timber.

The greatest value of the eucalypts lies in the general usefulness of their timber which, with the gradual disappearance of the American hardwoods, is becoming of ever greater importance. Among the eucalypts may be found some of the most valuable timber in the world, though the species differ in the strength, weight and durability of their woods. The timber and lumber can be used for general construction purposes, for wharves, bridges, tunnels, mining shafts, culverts, street paving blocks, flooring, interior finish, furniture, car construction, wheelwright work, wagon construction, tool handles, cooperage, and, in brief, for all purposes for which hardwoods are ordinarily employed.

In addition to fuel wood, posts and ties, the chief demand for wood in Hawaii is for general construction purposes, for flume and tunnel timbers and for piling and wharf construction. There are a number of eucalypts admirably suited for these purposes.

The three species considered of the highest value in Australia for construction purposes and for general all-around timber are the jarrah (*E. marginata*), the karri (*E. diversicolor*), and the tooart (*E. gomphocephala*). In addition to the above the white mahogany (*E. acmenoides*) and the flooded gum (*E. saligna*) are of the highest value for general construction, while the following eucalypts are excellent for general saw timber: Sugar

gum (*E. corynocalyx*), blackbutt (*E. pilularis*), and red mahogany (*E. resinifera*). The jarrah and the red mahogany are especially highly esteemed for furniture. The blue gum (*E. globulus*), and the swamp mahogany (*E. robusta*), and the lemon-scented gum (*E. citriodora*) are good all-around timber trees, but they are inferior to the trees mentioned above. The blackbutt and the blue gum are especially liable to warp and twist unless carefully seasoned, and are objectionable for this reason. The blue gum (*E. globulus*), the jarrah (*E. marginata*), and the red mahogany (*E. resinifera*) are especially well adapted for wharves and piling because they resist to a large extent the attack of the teredo, which destroys many other kinds of timber.

A more complete table of the uses of wood of the various eucalypts may be found in the Appendix.

Watershed Protection.

An abundant and regular flow of water is essential to the successful raising of crops in Hawaii, since, in spite of heavy rainfall in certain localities in the Islands, a large proportion of the cultivated land is under irrigation. Many of the richest sugar cane fields are absolutely dependent on an adequate supply of water during the dry season.

There are few places in the world where the relation between forests and waterflow is so intimate as it is in certain parts of Hawaii. Because of the climatic conditions, the physiographic features, and the geologic formation prevailing here the destruction of the forest, especially on the steeper slopes and at the higher elevations, is almost immediately followed by a marked decrease in surface run-off during dry seasons, while in heavy rains the water runs down in torrents, washing and gulleying the mountain sides. The native forest which once covered the mountains with its numerous ferns, moss, vines and brush, was an ideal watershed protection, acting as a sponge in catching the rain and retaining the water for a long time. No matter how dry the air, the floor of the forest was always damp and the springs were always full. In many places, however, the forest maintained itself with great difficulty; and in consequence of the introduction by the white man of cattle, Hilo grass, lantana and other animals and obnoxious plants the native forest is rapidly disappearing and the denudation of the mountain slopes is becoming more and more serious.

A systematic artificial reforestation of denuded slopes on im-

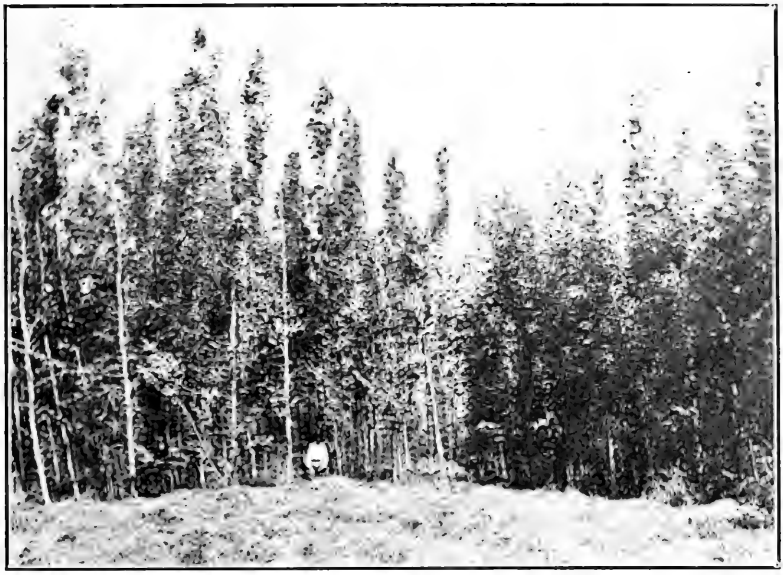

Plate 4. Fig. 1. Eucalypts Not Yet 4 Years Old. Kailiili, Maui.
Swamp Mahogany on the right, Blue Gum on the left.

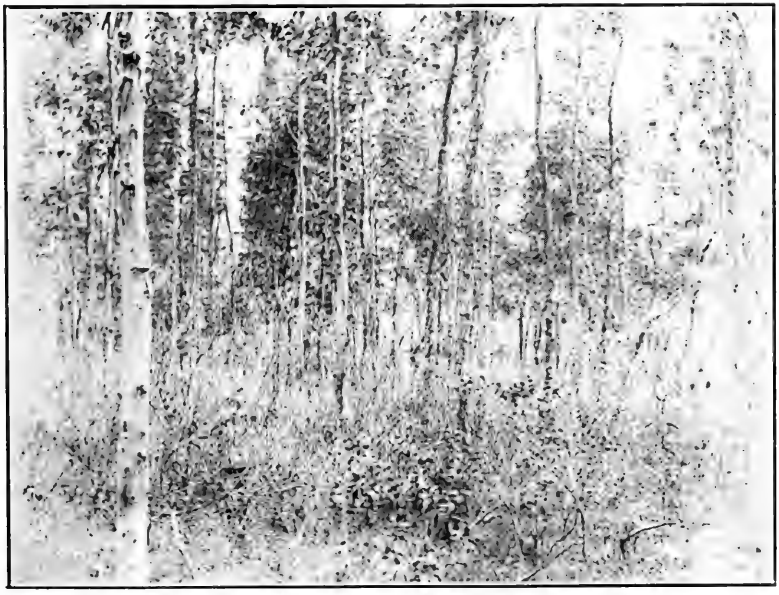

Fig. 2. Eight Year Old Blue Gums with a Dense Stand of Lantana and Guava, Kaluanui, Maui.

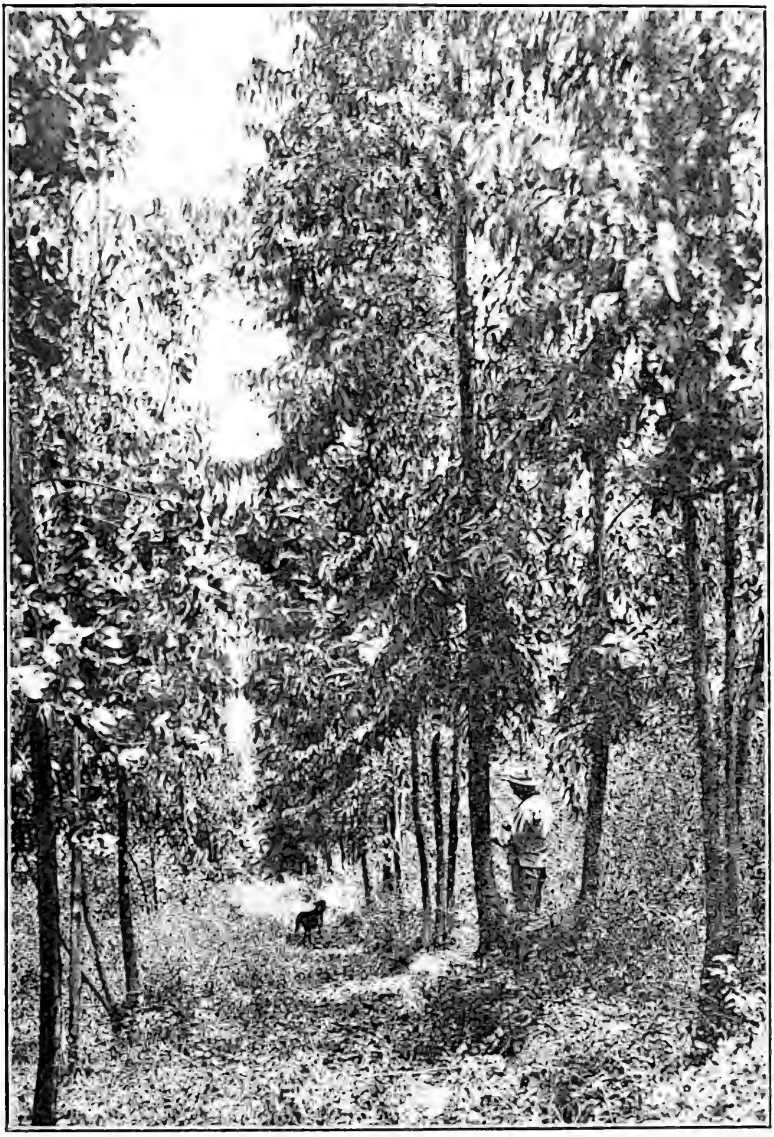

Plate 5. A Sprout Forest on Maui, Eucalyptus resinifera.

portant watersheds is already receiving attention, and the interest in this work will become more marked as time goes on. Planting trees to protect watersheds will be considered by many to be more important than planting them for lumber and fuel production, though under proper management one forest may be made to serve both purposes. Many eucalypts are well suited for the purpose of water protection if planted closely together or if under-planted with some undergrowth to afford protection to the soil. A properly-managed Eucalyptus protection forest should pay for itself in course of time.

Other Uses.

Because of their rapid growth, flexible trunks, and ability to grow in exposed situations, a number of the eucalypts make excellent windbreaks, deflecting the wind upward and thus exerting their influence for a comparatively long distance. The planting of Eucalyptus groves to protect cattle has already been mentioned. In California the eucalypts are extensively planted to protect orange groves and other fruit orchards from blasting winds. In Hawaii, especially at the lower elevations, the ironwood (*Casuarina equisetifolia*) is a better windbreak tree than most of the eucalypts, because of its ability to grow on sandy soils, to stand the salt ocean spray, and to form straight trunks under conditions extremely adverse to the growth of other trees. At higher elevations, where the ironwoods do not thrive, Eucalyptus was found to be advisable. The following species are considered particularly wind resistant: messmate (*E. amygdalina*), sugar gum (*E. corynocalyx*), and swamp gum (*E. rudis*). In California swamp mahogany (*E. robusta*) is considered to be a poor tree for windy situations because of its liability to breakage. In Hawaii, however, it is found to grow well in the most windy localities and apparently thrives in places where no other trees can exist. The blue gum (*E. globulus*) will grow in windy situations, but when growing under such conditions the trees are crooked and twisted, and (although valuable to some extent for a windbreak) the trees are therefore not good for timber.

From the fact that the eucalypts are evergreen, they are excellent shade trees for ornamental planting, and if properly grouped present a very pleasing appearance. The lemon-scented gum (*E. citriodora*), with its tall trunk and slender, often pendulous branches, deserves special mention for ornamental purposes. Blue gum is an effective tree if grown in a clump or

grove. Messmate (*E. amygdalina*) is particularly valuable as a shade and ornamental tree, not only because of its attractive form but also because it exhales a delicious fragrance. The scarlet-flowered gum (*E. ficifolia*) is a favorite ornamental tree on account of its beautiful red flowers. The orange-flowered gum (*E. calophylla*), red gum (*E. rostrata*) and sugar gum (*E. corynocalyx*) are also valuable shade trees. The blue gum is sometimes called the fever tree and has been used successfully to improve the health conditions in the swampy places around Rome. Messmate is frequently planted on hospital and sanitarium grounds.

From the leaves and young twigs of the eucalypts are distilled many different kinds of oil, which are used as non-poisonous antiseptics, for perfumery, and for scenting soap. An extract made by steeping the leaves of Eucalyptus, particularly blue gum, in water is used for bathing in the treatment of certain skin diseases. The medicinal properties are probably more ameliorative than curative in their effect. Some of the oils are the best known solvents for amber and other gums, and are therefore of particular value for the manufacture of high-grade varnishes. The distillation of eucalyptol and other oils is a growing industry in Australia and California, though the market for these products is rather limited.

ESTABLISHING A EUCALYPTUS PLANTATION.

CHOICE OF SPECIES.

The first point to be considered in establishing a plantation is to decide what species to grow. With the long list of eucalypts available there is a wide choice, and the selection is not an easy matter. The species selected must depend on two considerations: first, the purpose for which the trees are grown, and, second, the physical conditions under which the trees are expected to grow—that is, the soil, elevation, climate, etc. With soil and climate conditions as variable as they are in Hawaii, even in the same locality, no general rules as to species can be given. This is particularly true in view of the fact that few of the eucalypts have been grown here for any length of time, and most of the planting must therefore still be in the nature of an experiment. The species best suited for different uses have already been mentioned, and the various trees best adapted to the different physical factors have also been discussed. With these as a guide it should be possible to decide in a general way what trees to plant in a given place and for a given purpose.

Three species of Eucalyptus have so far been grown in Hawaii with signal success. Blue gum (*E. globulus*), in general, has been found to do excellently at elevations higher than 1,000 feet above sea level, reaching its best development and most rapid growth at elevations between 3,000 and 4,500 feet, especially on the windward side. Red mahogany (*E. resinifera*) has been found to grow well at elevations between 500 and 1,500 feet. Swamp mahogany (*E. robusta*) grows well in almost any place and thrives on poor soils and in windy situations, and under conditions which few other eucalypts can endure. It prefers, however, low, swampy land and elevations below 2,000 feet. Lemon-scented gum (*E. citriodora*) also calls for mention here. At Paauhau, in the Hamakua district on Hawaii, at an elevation of 1,600 feet, lemon-scented gum 20 years old is doing well, and it also thrives at lower elevations.

Red mahogany (*E. resinifera*) is of the greatest commercial value, and is one of the best all-around eucalypts that can be grown. The other three species, though not of the highest value, are very desirable trees, and the blue gum is particularly rapid in rate of growth. No serious mistake can be made in planting these trees. Experimental planting to ascertain the suitability of other eucalypts to various conditions and localities is greatly to be desired, but it would be wise to confine planting on a commercial scale to the above species until results of the experimental planting undertaken in the last five years become apparent.

To be of the greatest value, most of the experimental planting should be in pure groves—that is, groves consisting of only one species, of at least one acre each. Planting on a commercial scale also should be pure rather than mixed, unless expert knowledge is available to utilize the different site qualities for different species of trees and to regulate the future reproduction of the forest. Mixed forests, on the whole, are desirable, but they require more skilled management than forests of only one species.

NURSERY METHODS.

Two methods of growing trees are in general practice: first, growing the young trees in beds in the nursery and transplanting them directly to the ground where they are to grow; second, growing the seedlings in flats or boxes and eventually transplanting the trees in pots or bags of one kind or another. In the first case the soil is carefully prepared in beds in the nursery, the beds being usually three to four feet wide and as long as desir-

able. The seed is planted directly on these beds. In Hawaii this method has been found to give satisfactory results only in localities favorable to tree growth, at elevations of 2,000 feet or more, and where there is an abundant rainfall. It has proved particularly successful in the nursery of the Maui Agricultural Company, Kailiili, at an elevation of about 2,500 feet. In less favorable situations the seedlings as a rule are grown in boxes or flats of convenient size, usually 12 x 18 inches and 3 to 4 inches deep. In either case the soil in the seed bed should be light and friable, so that the seedlings may be readily transplanted. A garden loam mixed with an equal quantity of sand and put through a sieve with a mesh as fine as coarse mosquito netting is the best. The soil is first made smooth; then the seed is scattered evenly over the surface and pressed down lightly with a piece of board to imbed it in the soil, after which it is covered with a thin layer of pure sand or finely-sifted soil to a depth approximately equal to the thickness of the seed. To prevent the growth of weeds in the seed-bed, it is often desirable to sterilize both the soil and the sand.

The seed will sprout and the young shoots will appear above ground in from three to ten days. The soil should be watered and kept moist with a very fine sprinkler, held close to the seed-bed. Unless great care is taken in watering, the seed may be washed out and the tender stems of the young trees broken by the force of the falling water. If the soil is kept too wet, the trees will be killed by a fungus disease known as "damping-off." This disease is most serious during times when there is little evaporation taking place, as on damp, cloudy days and during still, warm evenings. Very little watering should therefore be done on cloudy days, and even on clear days the sprinkling should take place in the morning.

For the first few weeks of their life the young seedlings are injured by excessive heat and light, and it is necessary to protect them from the direct rays of the midday sun. Various devices are in use for shading the beds or boxes of seedlings, lath houses and lath screens being the most common. The lath in the screens are spaced their own width apart, and the screens are so arranged that they can be readily moved. If a lath house is used, the various panels composing the lath house are made removable. This is necessary because the screens must be moved in cloudy and humid weather in order to prevent "damping-off" in excess shade. In many nurseries in Hawaii the shade afforded by the large trees growing about the nursery is sufficient to protect the young seedlings, and no lath screens are necessary.

The seed boxes must not, however, be kept directly under the big trees, where the seedlings would be injured by the drip from the leaves.

When the seedlings grow to be two or three inches high, they are transplanted in the nursery. This is done in order to give the young trees more room for growth and to encourage the development of a strong root system. The little trees are taken out from the seed boxes or beds and are set out either in other beds in the nursery or in other boxes. In transplanting, the trees, as a rule, are spaced about two inches apart, the ordinary box or flat containing 100 trees. The holes for the transplants are usually made with a small cylindrical stick or with the finger, and great care must be taken to spread out the roots in the holes and to press the soil around them. The roots should not be exposed to the air any more than is absolutely necessary, and the work of transplanting should be done during cloudy weather when there is little danger of the roots drying up and dying.

After the trees have been transplanted they should be watered well and shaded from the sun. The trees are left in the nursery until they are from eight to fourteen inches in height, when they are ready to be set out in the place where they are to grow.

An extremely efficient but somewhat more expensive method of raising young trees is to transplant them in the nursery into pots, bags or bottomless tin cans, about 4 or 5 inches deep and 2 to four inches wide, before they are set out in the ground where they are to grow. The pots are usually made of hollow sections of bamboo or of ti leaves (*Cordylina terminalis*), while the bags are made from fertilizer sacks. They are left in the nursery for two months or more and are then set in the ground, the pot or bag eventually rotting away, and the trees soon becoming well established in their home.

METHODS OF PLANTING.

Clearing the Land.

The heaviest expense in planting forest in Hawaii is entailed in clearing the land of the rank growth of Hilo grass, guava and lantana, which is often six feet or more in height. The ground cover is frequently so heavy that any attempt to grow trees without first getting rid of it is absolutely futile. Three methods of preparing the ground are in general vogue, as follows:

1. Where the ground cover is very tall and heavy, where sufficient money for proper planting is available, where the area

to be planted is not extensive, or where the ground cover is very light, consisting mostly of grass, the entire area is cleared with a scythe, cane knife, brush-hook or ax.

2. Where the above conditions do not exist, instead of clearing the entire area, only alternate strips are cleared wide enough to allow the trees planted in these strips room for growth and development, while the ground cover on the intermediate strips is left untouched.

3. Where the ground cover is not very heavy, the land is cleared only in patches immediately around the holes where the trees are to be set out, the space cleared depending on the nature of the cover and the kind of trees planted. A circle three to four feet in diameter is usually sufficient.

Transplanting Seedlings.

The method of transporting the seedlings from the nursery to the place where they are to be planted depends mainly on the way the trees were raised in the nursery and on the nature of the road or trail between the nursery and the plantation.

In one place on the Island of Hawaii the seedlings are raised in large flats about 6 or 7 feet square, and when the trees are 2½ to 3 inches high the soil in the flats is thoroughly moistened and the trees and soil are transferred into smaller boxes about 3 by 4 feet. Two of these boxes are then hung on a pole and so carried by Chinese laborers to the plantation.

When the transplant seedlings are grown directly in the nursery beds, it is customary to take them up, dip the roots in a very thick puddle, wrap the lower parts of the trees in wet gunny sacks, and load them on mules, which can transport them in this manner for comparatively long distances without injury. If the transplants are grown in flats or boxes, it is usual to load as many flats as possible on bullock, horse or mule wagons and so transport them. Pack saddles specially devised for carrying seedling boxes are also in use.

After the land is cleared of the undesirable ground cover, three methods are in common use for preparing the holes to receive the trees:

1. The land is plowed one or more times and the holes are dug in the plow furrows with a kipikua or mattock.

2. The land is not plowed, but circular holes are dug 1½ to 2 feet in diameter and the soil is loosened to a depth of 10 to 18 inches.

3. Where the climate and soil conditions are favorable for tree growth and the nature of the cover will permit it, the land is not plowed and no holes are dug. The land is simply broken with a kipikua or mattock, the tree is set in the slit, and the soil is pressed back around the tree.

Spacing the Trees.

The question of spacing the trees properly is a very important one, and deserves close attention, since the success of the plantation for the purpose for which it was intended may depend on the distance apart at which the trees were set out. Wide spacing favors diameter growth and wide branching, while close spacing stimulates good height growth, favors the development of straight trunks free from branches, decreases the danger from windfall, and interferes with the growth of weeds and obnoxious undergrowth. If, however, the trees are planted too close together, proper growth is interfered with and the trees tend to become tall and spindling. Between these two extremes there is what may be termed an optimum spacing, which will result in the most desirable height and form of a tree as well as in the best diameter growth. Such spacing utilizes the land to the greatest advantage.

If trees are to be grown in windy situations, it is essential that they should be planted close together, the spacing recommended being 5 by 5 or at most 5 by 6. In case of exposure to very strong winds, or if the planting is done in a narrow strip, still closer spacing may be desirable, depending on the number of rows of trees planted. Spacing the trees 3 feet apart may not be too close if only one row of trees is planted; if two, three or four rows are planted, the trees may be set out 4 feet apart, placing the trees in the alternate rows in the middle of the space between the trees in the immediately adjacent rows. Wide spacing in windy situations will result not only in poor growth but in a high percentage of windfall.

The purpose for which the planting is done will also have to be taken into consideration in deciding on the proper spacing of the trees. A grove planted to shelter cattle will be much wider spaced than one established primarily for the purpose of growing the best quality of lumber or for watershed protection. In general, it has been found that most of the planting done in Hawaii has been too widely spaced. If there is any doubt as to proper spacing, it is better to set out the trees too closely than too wide apart, especially in the more windy situations, for if it

is found eventually that the spacing is too close the stand may be thinned and the trees cut used for fuel or for other purposes. On the other hand, if it is found that the trees have been planted too wide apart, it is difficult, and often impossible, to plant additional trees and make them grow in the shade of the trees already established. It is better to plant a small area properly than to spread an insufficient number of trees over a large area.

While it is risky to lay down hard and fast rules, the following general guide may be used in spacing blue gum.

Trees on good soil and in favorable situations can stand wider spacing than groves on poor soils and grown in unfavorable situations.

For a windbreak or shelter belt, plant the trees 3 to 5 feet apart, depending on the width of the belt.

For the production of clear lumber and good quality of timber, plant the trees 6 by 6 feet apart. In especially windy situations or in very poor soils the spacing may be 5 by 5 or 5 by 6 feet.

For the production of fuel, plant the trees 6 by 8 or 8 by 8 feet.

For sheltering cattle from the hot sun or from wind and cold, space the trees 9 by 9 or 10 by 10 feet.

When undergrowth is dense and it is desirable to get rid of it, plant the trees 5 by 5 to 5 by 6 feet.

For watershed protection, plant the trees 6 by 6 or 6 by 8 feet. If the trees are to be underplanted by a shrub, they may be spread 8 by 8 or 8 by 10 feet.

TENDING THE GROVE.

Fertilizing, Irrigating and Cultivating.

In their seedling stage almost all the eucalypts respond readily to soil fertilization and cultivation. In a particular plantation at Waipio, Island of Oahu, at an elevation of 1,000 feet, blue gum (*E. globulus*) eight months old showed a maximum height growth of 20 feet, while ten other species of eucalypts growing on the same plantation and treated in the same way all showed greatly stimulated growth as compared with the same species growing on an adjoining plantation, apparently under similar conditions, but not fertilized and not cultivated. Stable manure is the best for this purpose, though ordinary commercial fertilizer similar to the kind used in cane fields and pineapple plantations can be used with great advantage. It is very doubtful, however,

Plate 6. Fig. 1. Sprouts, Blue Gum Forest.
Kaluanui, Maui. Two years old.

Fig. 2. Natural Reproduction of Blue Gum.
Olinda, Maui.

whether it would pay to fertilize trees grown for commercial purposes.

When grown in particularly dry localities, or if there should happen to come an extended drought immediately after the trees are planted, it may be necessary to resort to artificial irrigation in order to save the plantation. Where water is available and irrigation is inexpensive, the additional growth of the young trees due to artificial watering will more than make up for the expense involved. As a rule, however, irrigation is probably impracticable for commercial Eucalyptus plantations.

Because of the rank weed growth in most places in Hawaii it is usually necessary to cultivate one or more times or cut back the grass and weeds in recently established tree plantations. This may be done with a scythe or a hoe, or an ordinary cultivator may be used where the trees are planted sufficiently far apart. At the end of the first year, after the trees are 5 or 6 feet high, they can take care of themselves and as a rule need no other attention, except that they must be protected against fire and cattle, as has already been described.

Thinning.

If the trees are planted close enough together, they will make a rapid height growth, each tree endeavoring to overtop the others to a sufficient amount of light. As a result height growth is made at the expense of increase in diameter. In this struggle of the trees to obtain a sufficient amount of light a point is soon reached when certain trees fall too far behind, become overtopped, suppressed, and stunted and become a hindrance to the better and more vigorous trees. It is then a good plan to cull out the suppressed trees in order to give the better individuals a chance to grow in diameter. This process of cutting out the poor trees is known as a thinning.

The first thinning in a blue gum forest grown for timber or poles may be made, as a rule, when the plantation is seven to nine years old, the vigorous or dominant trees at that time being 7 to 12 inches in diameter and 40 to 60 feet high. The rule for thinning stands is to thin lightly and to thin often. If too many trees are taken out at one time and the stand is opened up too much the remaining trees will begin to branch, the danger from windfall is increased, the ground may dry out, and weeds and grass may come in. As a rule the crown cover of the forest should not be broken more than can be filled by the growth of the remaining trees within three or four years. Ten to fifteen

per cent. of the total number of trees may be taken out in the first thinning. In addition to the suppressed trees, poor-shaped, forked, and diseased trees should be taken.

At the time the first thinning is made about 200 or 250 of the best developed and most promising trees on each acre are selected for the final crop. The trees surrounding these selected individuals are not all cut, but are thinned out sufficiently to give the crown of each selected tree a chance to spread slightly. This operation is repeated as often as the space thus provided becomes filled by the growth of the crowns. If this is done carefully, a final stand of 200 or 250 large, well-formed trees is obtained.

The material obtained from thinnings may be used for fuel, and the trees cut in the later thinnings may even be large enough for fence posts or for railroad ties. In most cases the wood thus obtained should bring more than enough to pay for the cost of cutting the trees, and the benefit to the trees of the main crop is thus obtained free of cost or even at a profit.

CUTTING THE FOREST.

Age.

A forest crop differs from an ordinary agricultural crop in that there is a wide choice in the time when the forest crop may be harvested. Whether a forest is ripe enough to be cut or not is in most cases a purely financial consideration, and not a matter of simple judgment as in the case of a farm crop. The standing trees in the forest may be considered as capital, and the yearly growth of the trees as the interest on the capital. Considered from a purely financial point of view, whenever this growth (or interest) falls below the rate which may be earned by the money into which the timber can be converted, the forest should be cut. Thus, if the trees grow in value at the rate of 6 per cent. per year while money is worth 8 per cent., and the trees can be cut and sold, there is a loss entailed in letting the forest grow. This consideration, however, does not definitely determine when the trees should be cut. It simply indicates the age beyond which it is unprofitable to let the forest grow. To find the proper rotation—that is, the age at which the trees should be cut, it is necessary to know the value of the tree at different ages, all the items entering into the cost of producing the crop, and the rate of interest demanded on the money invested. This, in turn, involves the construction of yield tables showing the

contents and value of the forest at different periods of its growth.

Unfortunately, there are not enough groves in Hawaii of the necessary age to be used for the construction of yield tables, and all that can be done at the present time is to indicate in a general way the age at which the Eucalyptus plantation may be cut.

It should be remembered that the first few years in the life of a tree are spent in forming roots and crown, during which time very little merchantable wood is grown. In the case of the rapid-growing blue gum, this period covers at least five or six years, and it is only at the end of that time that it begins to produce valuable wood. To cut the trees at that time is like drawing out money deposited in a bank just before the interest on it becomes due. Therefore, if it is at all possible to avoid it, no young trees should be cut.

As a tree grows in age and size, the percentage of sapwood decreases rapidly and the lumber becomes more valuable. Further than as determined by this general principle, the age of the trees to be cut must depend on the purpose for which the wood is to be used. If fuel wood is the main crop, the trees may be cut in rotations of eight or nine years, but it must be remembered that sapwood makes poor fuel and that the young trees therefore make inferior firewood.

If fence posts are desired, the plantation may be cut when the majority of the trees are 10 to 13 inches in diameter or larger. The stand at that time would be nine to twelve years of age.

If railroad ties or telephone and telegraph poles are to be the main consideration, the trees should be at least 15 or 16 inches in diameter measured 4½ feet from the ground. The stand would then be 12 to 20 years of age, according to the locality.

If the forest is grown for the production of wharf piles, lumber or large timbers, it is best to keep the trees for at least 25 or 30 years, at which time, if grown on favorable situations, the trees may be more than 20 inches in diameter and 100 feet high.

Methods.

If a second crop is expected, it is necessary to take certain precautions when cutting the first stand of trees. The ability of the stumps to ratoon has already been discussed, and it was mentioned that the time of the year when the trees are cut has a decided influence on their sprouting capacity, the months from November to March being the most favorable in this respect.

Whenever possible the trees should be cut with a saw. If they are cut with an ax, the choppers should be cautioned against leaving ragged stumps unable to shed water. To prevent still further the collection of moisture, the stumps should be cut slantwise, sloping away from the center like the roof of a house. Low stumps are preferable to high ones, first because more wood is utilized, and second because it gives the young sprouts a chance to establish independent root systems of their own in case the old stump should rot away.

GROWTH AND YIELD OF EUCALYPTUS.

Most of the eucalypts are rapid-growing trees, and of these the blue gum (*E. globulus*) is the most rapid. A distinction must here be made between a rapid-growing tree and a persistently-growing tree. Many eucalypts make very fast growth in the first few years of their life, but slacken the rate of growth in about eight or ten years. Such trees make an excellent showing in a young plantation, but are often a disappointment later on. Blue gum is both fast growing and fairly persistent. The following table, prepared from notes taken in various parts of Hawaii, shows in a general way the size of blue gum trees at different ages and grown under different conditions. Particular attention is called to the trees fourteen years of age growing at Umikoa, on the Island of Hawaii. The growth made by this small clump of trees compares favorably with trees grown under the best conditions in California:

TABLE I.

GROWTH OF EUCALYPTUS

Blue Gum (*E. globulus*).

Age	Average		Maximum		REMARKS.
	Diameter breasthigh	Height	Diameter breasthigh	Height	
Years.	Inches.	Feet.	Inches.	Feet.	
2½	...	5–10	4	25	Hawaii, Hamakua; Elevation 3000 ft. Spacing 6x6.
2½	2–4	30	5	40	Hawaii, Hamakua; Elevation 3900 ft. Spacig 6x6. Corn planted between the trees.
3	3	30	5	40	Hawaii, Hamakua; Elevation 3700 ft. Spacing 25x25. Land was formerly cultivated.
3	4–6	40	7	50	Maui, Makawao; Elevation 4500 ft. Spacing 15x15.
5	9	45	13	60	Maui, Makawao; Elevation 4200 ft. Spacing 12x15.
5	8	35	13	50	Maui, Makawao; Elevation 4500 ft. Spacing 15x18.
6	8	45	13	60	Maui, Makawao; Elevation 4200 ft. Spacing 12x15.
7	10	45	15	60	Maui, Makawao; Elevation 2500 ft. Spacing 15x15.
8	6	50	9	70	Maui, Makawao; Elevation 1500 ft. Spacing 9x9.
8	13–14	60	17	75	Hawaii, Hamakua; Elevation 3700 ft. Annual rainfall about 60 inches.
11	10	65	17	90	Maui, Makawao; Elevation 2400 ft. Spacing 10x15.
14	15	100	24	130	Hawaii, Hamakua, Umikoa; Elevation 3700 ft. No regular spacing, about 6x8.
15	11	70	16	90	Hawaii, Waimea; Elevation 2700 ft. Roadside planting.
20	10	70	18	90	Hawaii, Hamakua; Elevation 1600 ft. Spacing 10x10.
25	17	80	22	100	Hawaii, Hamakua; Elevation 900 ft. Ornamental trees about houses. Spacing about 20 ft. apart.
35	30	65	36	75	Maui, Makawao; Elevation 4000 ft. Row of trees 4 ft. apart.

Detailed tables similar to the above can not be made for the other species of eucalypts, but the field notes of the trees given in the Appendix state the age and size of a number of species found growing in various places in the Islands.

The yield of wood or lumber to be obtained from a grove of a given age will depend, of course, not only on the size of the trees but also on the number of trees per acre. This, in turn, depends on the spacing of the trees in the plantation and the age of the stand. As a rule the older the grove the fewer trees to the acre, since more individuals are crowded out and killed in the struggle for existence. When trees are grown in comparatively open stands, it sometimes happens that the number of trees at the end of eight or ten years is greater than the number of trees planted, in spite of the trees killed. This is due to the fact that a number of trees blown over send out numerous sprouts, some of which develop into good trees.

To measure the yield of the various groves examined it was necessary to construct volume tables which show the average volume or contents of trees of various sizes. The volume of a tree of a given species depends on its diameter, height and age. Of two trees having the same diameter and the same height, the older tree has a slightly greater volume, because an older tree is fuller in form and more cylindrical. If very accurate results are desired, all the three factors must be known, but for practical purposes two factors, such as diameter and height, or diameter and age, are sufficient.

Table II shows the average volume in cubic feet of different sized blue gum trees.*

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* The left hand vertical column in this next table shows the diameter of the tree at breast height; the uppermost horizontal line shows the total height of the tree from the ground to the top of the crown. To find the volume of a tree of any given diameter and height, as for example 10 inches in diameter and 70 feet high, look in the left hand column for the diameter (10), and under the height (70) find the volume of the tree (14.6 cubic feet).

TABLE II.

VOLUME TABLE.

Blue Gum (*Eucalyptus globulus*)—Seedlings.

Diameter Breasthigh Inches.	Total Height—Feet. 20	30	40	50	60	70	80	Basis Trees.
	Volume of used length with bark—Cubic ft.							
2	.2	.3	.5	...	...	...	...	1
3	.6	.7	.9	...	...	...	...	3
4	1.1	1.3	1.6	2.1	3.0	...	...	12
5	1.7	2.0	2.4	3.1	4.0	5.2	...	20
6	2.5	3.0	3.5	4.1	5.2	6.5	8.2	27
7	..	4.0	4.5	5.4	6.5	8.1	9.9	48
8	..	5.2	5.9	6.9	8.2	10.0	11.9	57
9	..	6.4	7.3	8.5	10.1	12.1	14.2	64
10	..	..	8.9	10.4	12.4	14.6	17.2	61
11	..	..	10.6	12.5	14.8	17.3	20.4	44
12	..	..	12.5	14.8	17.3	20.2	23.8	32
13	..	..	14.4	17.0	19.9	23.1	27.2	24
14	..	..	16.5	19.4	22.5	26.1	30.7	12
15	..	..	18.6	21.9	25.4	29.2	34.5	4
16	..	..	20.6	24.4	28.3	32.6	38.7	6
17	..	..	...	26.9	31.3	35.9	42.8	..
								415

To construct the above table 415 felled trees were measured, the diameter being taken at intervals of eight feet along the stem of the tree. The volume of each tree was then computed and the data were plotted on cross-section paper, curves drawn, and the figures for the table read from these curves. The volume of the stump and of the top of the tree was not included. The stump as a rule was 6 to 12 inches high and the top was the portion of the tree above a point where the diameter outside the bark was less than two inches. Big limbs or branches were included if the diameter at the small end of an eight-foot section measured two inches or more.

The volume table can not be safely used to measure the volume of single trees. The more trees measured, the closer the average volume will approach the values given in the table. The diameter of the trees refers to the diameter outside the bark, measured at a point 4½ feet above the ground. This is known as the breast-high diameter.

Volume tables for yate (*E. cornuta*) and for swamp mahogany (*E. robusta*), based on diameter measurements alone, are given in the Appendix.

To convert the volume of a tree in cubic feet to its equivalent in cords it was assumed that on the average 90 cubic feet of solid wood will equal one cord of 128 cubic feet. The values of Table II were, therefore, divided by 90. The resulting Table III shows the volume of different sized trees expressed in decimals of a cord.

TABLE III.

VOLUME TABLE.

Blue Gum (*Eucalyptus globulus*)—Seedlings.

Diameter Breasthigh Inches.	Total Height—Feet. 20	30	40	50	60	70	80	Basis Trees.
	Volume of used length with bark—Cords.*							
2	.002	.003	.006	...	...	...	...	1
3	.007	.008	.010	...	...	...	...	3
4	.012	.014	.018	.023	.033	...	...	12
5	.019	.022	.027	.034	.044	.058	...	20
6	.027	.033	.038	.046	.058	.072	.091	27
7	...	.044	.050	.060	.072	.090	.110	48
8	...	.058	.066	.077	.091	.111	.132	57
9	...	.071	.081	.094	.112	.134	.158	64
10	...	...	.099	.116	.138	.162	.191	61
11	...	...	.118	.139	.162	.192	.227	44
12	...	...	.139	.162	.192	.224	.264	32
13	...	...	.160	.189	.221	.257	.302	24
14	...	...	.183	.216	.250	.290	.330	12
15	...	...	.201	.243	.282	.324	.383	4
16	...	...	.229	.271	.314	.362	.430	6
17	...	...	...	.299	.348	.399	.476	..
								415

* 1 cord = 90 cubic feet.

The above tables show the volume of trees expressed in cubic feet or in cords. Lumber trees, however, are usually measured in board feet, the board foot being a board one foot square and an inch thick. Since few of the trees measured were large enough to be scaled by the board foot, no table was constructed for Hawaii to show the lumber contents of various sized trees.

YIELD.

Because of the insufficiency of old groves it has been found impossible, as already stated, to construct tables showing the yield of wood from various plantations. Seven groves, however, varying in age from 5 to 20 years, were found growing under conditions regular enough to allow the measurement of sample plots, the results of which are summarized in Table IV.

TABLE IV.

YIELD OF BLUE GUM PLANTATIONS.

Age Years.	No. trees per acre.	Volume per acre. (cu. ft.)	Volume per acre. (cords)	REMARKS.
5	244	1363	15.1	Makawao, Maui; Elev. 4500 ft. Spacing irregular about 12x18. Many trees wind-thrown.
5	180	1568	17.4	Makawao, Maui; Elev. 4200 ft. Spacing 12x15.
6	236	1853	20.6	Makawao, Maui; Elev. 4200 ft. Spacing 12x15.
7	176	1861	20.7	Makawao, Maui; Elev. 2400 ft. Spacing 15x15.
8	570	2039	22.6	Kaluanui, Maui; Elev. 1500 ft. Spacing 9x9.
11	216	3725	41.4	Kailiili, Maui; Elevation 2400 Spacing 10x15.
20	382	5292	58.8	Paauhau, Hawaii; Elev. 1600 ft. Spacing 10x10.

None of the groves in which the measurements were made for the above table were grown under ideal conditions or under proper spacing, and the yield of properly-regulated groves should have made a much more favorable showing. But imperfect as the above table is, it shows the disadvantage in cutting young trees. Thus while the yield of the seven-year-old grove was 20.7 cords to the acre, and of the eight-year-old grove 22.6 cords to

the acre, the yield of the eleven-year-old grove ran as high as 41.4 cords to the acre, in spite of the wide spacing, thus showing how fast the trees grow after they once establish their root systems. The above table, being based on very meager data, can not be very reliable. It shows merely what a few groves have done rather than what regularly-spaced, carefully-tended plantations will do. As soon as there are enough old groves in the Islands to justify the work new and more complete yield tables should be constructed.

FINANCIAL RETURNS FROM EUCALYPTUS.

When trees are grown for water protection, shelter for cattle, windbreaks, etc., the relation between the cost of establishing a plantation and the value of the wood or lumber that may be cut from the forest is of secondary importance. When forests are grown solely for the commercial purpose of wood or lumber production, then the value of the forest products balanced against the expense incurred in obtaining the products will determine the practicability of growing the forest. Thus, it is manifest that an expenditure of $100 an acre to grow Eucalyptus will not be justified if the returns in wood and lumber amounts to only $75 an acre, unless in addition to the wood material certain indirect benefits are enjoyed. It is, therefore, of the first importance to balance the cost of a plantation with the returns expected. Furthermore, since most of the expenses are incurred at the time when the forest is planted, while the returns may not be obtained for years to come, it is necessary to carry forward all expenses with compound interest at an acceptable rate to the time when the crop is harvested. The cost of starting a plantation and the probable returns will, therefore, be examined next.

COSTS.

The cost of starting and maintaining a forest may be divided into three parts: (a) the cost of raising the trees in the nursery, (b) the cost of planting the trees, including the clearing of the land, and (c) the cost of tending and of protecting the grove.

(a) The cost of raising the trees in the nursery varies from place to place, and is highest, of course, where conditions for tree growth are most unfavorable and where the trees, therefore, require most attention. In Hawaii it has been found that the cost of transplant trees in the nursery varies from $1.50 per thousand, where the trees are grown without boxes or flats, to

$35.00 or $40.00 a thousand where great care is necessary. The average figure would probably be between $20.00 and $25.00 per thousand trees, but this average cost is unnecessarily high. This may be due to inexperience on the part of the planters, excessive care, the limited extent of the majority of the nurseries, or faulty bookkeeping. One or two men, usually Japanese, are employed to do the nursery work, and the entire wages of these Japanese are credited to the nursery account. Frequently these laborers do other work than raising trees, such as keeping the grounds in order, general gardening, tending to irrigation ditches, etc., and this, of course, is reflected in increased figures for the value of young seedlings. In many cases the nursery men could raise twice as many sedlings with practically the same outlay if the nursery were managed on a wholesale basis. Since, however, the planting done on most of the plantations is rather limited in extent, there is no demand for large quantities of trees, and the cost of the smaller number is proportionately increased.

After careful figuring, the conclusion is reached that with few exceptions trees can be raised in Hawaii for $10.00 a thousand for commercial planting. This includes the raising of seedlings in beds or boxes in the nursery and transplanting them in flats or boxes when the trees are 2 or 3 inches high. Under exceptionally favorable conditions of tree growth this cost can be materially reduced.

(b) The cost of planting trees will depend on the character of the ground cover to be cleared, on the distance the plantation is from the nursery, the ease with which trees may be grown in a given locality, and on the extensiveness of the plantation. It has been found to vary from $10 to $75 an acre. Under average conditions it should be possible to clear the land and set out the plants for $17 an acre, planted to 1,000 trees. This will include a charge of $8 per acre to clear the land and plow, $8 per acre to dig holes and plant the trees, and $1 per acre to transport the seedlings from the nursery to the plantation.

In many cases these figures will be found too low, especially the figure for clearing the land and plowing it, in case of unusually heavy lantana, while in other cases the figures will be much too high, but it is believed that planting on a commercial scale can be done for these figures if proper care and economy is exercised.

(c) The expense involved in tending the grove after it is once established consists of the cost of weeding or cultivating for the first year or two after the trees are planted. The ex-

pense will vary, but on an average it should not exceed $3.00 an acre.

Adding up the average cost of the three items of expense, it appears that $30 an acre on an average should cover the expense of establishing a Eucalyptus plantation on a commercial scale. In addition to this initial outlay, there will be a slight expense incurred in taxes on the land.

RETURNS.

The returns obtained from the plantation will vary with the species of trees planted and with the class of wood cut. The following statements apply only to blue gum.

If cordwood is to be the main crop, the entire grove will be cut over every eight years, at which time it should be possible to obtain at least 22 cords to the acre. Assuming a stumpage value of $2.50 a cord, the crop would bring at the end of the first eight years a return of $55 per acre, which is equivalent to a return of 8 per cent. compound interest on the original investment of $30 per acre. However, in addition to this satisfactory return on the original investment it will be possible to obtain wood to the value of $55 per acre at the end of every eight years for an almost indefinite time from the stumps of the trees cut down, all of which would be clear gain, in addition to the interest on the money invested. This calculation, however, does not take into account the value of the land.

In the absence of reliable yield tables, it can not be stated with any degree of accuracy what returns could be obtained from a forest grown for the production of lumber and timber. However, all indications seem to point to the conclusion that on waste land unfit for other uses, the Eucalyptus should prove a remunerative crop. In addition to the final crop certain immediate as a rule not only pay for itself but would leave a wide margin of profit. This will be especially true of the later thinnings returns may be obtained from the forest through thinnings. The cost of thinning the stand to produce the desired final crop would when material will be obtained suitable not only for firewood but also for fence posts and perhaps for railroad ties. A thinning made in an eight-year-old stand on Maui, in the District of Makawao, originally spaced 9 by 9, yielded 2.2 cords per acre.

No data are available to show what the returns would be for plantations of Eucalyptus other than blue gum. Most of the species are slower-growing than blue gum, but many of them make up in higher value what they lose in the slower rate of

growth. One specific example of yield may here be mentioned. A nine-year-old stand of Eucalyptus, consisting mainly of red mahogany (*E. resinifera*), on Maui, yielded 723 cords of fuel wood and 1800 fence posts on an area of 33.16 acres, or an average of 21.8 cords of wood and 55 fence posts to the acre, which at a value of $2.50 per cord of firewood and 10 cents apiece for the posts amounts to $60 per acre—a very good showing.

A Eucalyptus forest is a valuable and remunerative crop provided the owner is willing to wait some years for the returns on his investment. The business of raising Eucalyptus is, therefore, particularly well adapted to long-lived corporations and companies. That the forest has a value before the crop matures goes without saying. This value can be quite accurately figured in the assets of a plantation by discounting back to present date at an acceptable rate of compound interest, the prospective or expected value of the forest at the time when it will be cut. Thus if it is expected to cut the forest at the end of eight years and obtain cordwood to the value of $55 per acre, and money is valued at 8 per cent., the value of the grove at the end of seven years is $50.92, at the end of six years $47.15, at the end of five years $43.65, and so on. A lumber forest may be discounted in the same way. This should be borne in mind by plantation managers who hesitate to invest money in forest planting because no showing is made of the money expended until the forest is cut. In this connection it may not be out of place to state that there is hardly anything on a plantation or ranch which shows the foresight and thrift of the manager and is a more enduring monument to his wise management than a well-regulated, rapidly-growing forest.

FOREST MANAGEMENT FOR SUGAR PLANTATIONS.

It has been shown in the early part of the report that the fuel supply is becoming a serious problem with many plantations in Hawaii, that the fuel bill of the average plantation amounts to from $5,000 to $10,000 a year, and that there are a number of places where firewood can not be obtained at any reasonable price. The fuel question in many cases can be solved only by the plantations devoting a part of their land to forest planting in a systematic way. On almost every plantation in the Islands, pineapple and coffee as well as sugar plantations, there are pieces of land, small in themselves, but aggregating a large total area, unfit for the main crop, either because the land is too steep,

the situation too windy, the soil too poor, or for other reasons, but which can support a good forest. The trees may be made frequently to serve as a windbreak to the main crop. In addition to these small, scattered areas there is always some land on the edge of the plantation, frequently on the mauka or upper edge, which can not be used for growing the main crop because it is too high for irrigation or because the product can not be brought down at a profit, which is now lying idle, but which can be made to grow the annual fuel supply of the plantation. On the more extensive belts perhaps a few head of cattle graze now, but the land can probably be used to better advantage by growing forest trees. A wise plantation management will utilize every square foot of ground to the best advantage, and so, while it is not expected that land fit for sugar or pineapples, or for growing agricultural crops, will be planted to trees, land not suitable for any more useful purpose should be covered with forest. To be of the greatest value all such planting should be systematically planned and carried out.

Two general schemes of forest management are open to the plantation.

1. If the plantation desires to raise its own supply of fuel but does not care to raise forests of large trees for lumber, ties, or dimension timber, the following plan may be adopted: Figure out the annual demand for firewood and plant an area sufficiently large so that the required quantity of wood may be cut in successive areas, returning to the first area when the ratoon crop on that area is large enough to be cut a second time. To take a specific case: Suppose the demand for firewood on the plantation is 1,000 cords per year, that it takes eight years to grow a crop of 22 cords to the acre, and that successive ratoon crops may be cut at the end of every eight years. In this case it would take about 45 acres of forest to supply the annual demand for firewood. Since it takes eight years for the ratoon crop to grow to sufficient size to be cut again, an area of 8 times 45 acres, or 360 acres, will have to be planted. If, now, 45 acres are cut every year, the entire area of 360 acres will be cut over in eight years, but at the end of that time a second crop may be obtained from the 45 acres cut the first year. The next year it will be possible to cut again the portion of the forest which was cut the second year, and so on successively until the entire tract is cut over a second time, when the first area can be cut a third time, and the operation thus repeated many times, provided care is taken to cut the forest at the proper time of the year (from November to March), and provided the stumps are left in a good condition to

shed water. The necessary outlay for the plantation would be $30 an acre, or $10,800 for the entire 360 acres, not necessarily spent in one year, and at the end of eight years it would be possible to reap a harvest of at least $5,000 each succeeding year for a long time to come. Already the more progressive plantation managers are beginning to see the wisdom and economy of this policy, and it will not be long before most of the plantations will grow their own fuel supply.

2. When there is much land available unfit for any better purpose, a good return may be obtained on an investment in forest planting on this waste land for the purpose of producing lumber and timber. In this case most of the fuel wood necessary for the plantation may be obtained practically without cost by thinning out the main crop, and by using the tops and branches of the trees when eventually cut for lumber. It may be necessary, however, to devote at least a portion of the land to raising firewood exclusively, unless a very extensive area is planted in forest. The first thinning at the end of eight years will yield probably 3 cords to the acre; subsequent thinnings should yield more. On an average it may be figured that 5 cords to the acre can be obtained every eight years through thinnings. When the annual demand is 1,000 cords of wood, it will be necessary to thin 200 acres annually, and to allow for a rotation of eight years it will be necessary to have a planted forest of at least 1,600 acres. Here the firewood would be incidental, since the main crop is the production of valuable lumber trees. The practicability of this plan will depend on the amount of money that is available for investment in forest planting. There is little doubt that a good market can be secured for the product when the forest finally matures.

On many plantations there are already more or less extensive planted forests, some of which are in excellent condition. In a number of places, however, the planted forest is not in the best producing state and can be greatly improved with a little attention. These latter plantations are faulty in one or two particulars: First, the trees are planted too wide apart, and, second, inferior trees are planted in places capable of supporting a more valuable forest. The following remedies are suggested:

Where the spacing is very wide, or where the trees already planted are not large and their shade will not interfere with the growth of new trees on the same area, then plant additional trees between the trees already growing, in order to form a fully-stocked forest. In this case shade-enduring trees should be selected for the new planting. The Japanese cedar or sugi

Plate 7. Fig. 1. Growth of Blue Gum, 5 Years Old.
On the slope of Mt. Haleakala, Maui.

Fig. 2. Blue Gum Trees, Olinda, Maui.

Plate 8. Eucalyptus Seedlings.

Box on the left contains seedlings 6 weeks old. That on the right seedlings two months transplanted. Pot grown plants are 3 months old from seed.

(*Cryptomeria japonica*) and Monterey cypress may be tried for underplanting on elevations above 800 feet, while at the lower elevations one of the tolerant eucalypts like swamp mahogany may be tried. If the spacing or the size of the originally planted trees will interfere with the ready growth of additional trees, it may be necessary to cut off the present forest as soon as it is large enough to be utilized, and to plant additional trees between the stumps so that the sprouts of the stumps and the new trees planted will form a fully-stocked stand.

Where the present forest consists of inferior species or poorly-developed trees, it is desirable to convert the entire stand into a more valuable forest with the least loss of time in order to utilize the land to the best advantage. It would be poor policy, however, to cut off the entire forest at once until it is ascertained that more valuable trees can be made to grow there. Furthermore, the forest already growing can be made to serve as a windbreak for the new plantation. Accordingly, a belt of the old forest, 100 to 200 yards in width, should be left on the windward side, and behind this belt a few acres at a time should be cut and replanted with the more desirable trees until the entire stand back of the windbreak is restocked. Except in places where there is little danger from windfall it would probably be best to allow the strip of old forest to grow indefinitely and act as a windbreak or shelter belt for the more valuable stand.

ROADSIDE PLANTING OF EUCALYPTUS.

Many thousands of trees are planted along the roads in Hawaii, as well as along fence lines and lot boundaries, and such planting can be made an important source of firewood and fence posts, if carefully managed. The eucalypts, as has already been stated, are excellent shade trees and make desirable roadside trees, especially the blue, red, and lemon-scented gums, the messmate (*E. amygdalina*), and the swamp mahogany. Complaints are sometimes heard that roadside planting keeps the roads in poor condition because it does not allow the surface to dry readily. If proper care is used in setting out the trees, this difficulty can be obviated to a large extent. Planting on the windward side of the road should be either wide spaced or entirely omitted so that the wind may have free access to the road. On both sides of the road the trees should be spaced in such a way as to allow the sunlight to strike the road at some time during the day, successive parts of the road being in turn kept in shade. If these simple precautions are taken, there should not be diffi-

culty in keeping the road dry, while at the same time securing the benefits of the shade trees.

The yield of wood from roadside trees is considerable. The main road leading east from Waimea on the Island of Hawaii is lined with blue gum trees for several miles, spaced eight feet apart, and planted in 1894 and 1896. The trees, fifteen years old, average 11 inches in diameter and 70 feet in height. It will be found by referring to the volume table (Table III) that a tree 11 inches in diameter and 70 feet high contains on an average .192 cords of wood. Trees planted 8 feet apart will run 660 trees to the mile on each side of the road, or a total of 1,320 trees for both sides. The roadside trees along the Waimea road, now fifteen years old, thus contain 253 cords of wood per mile, which, at a value of $2.50 a cord, amounts to $632.50.

When planted on private land, the trees may be grown in two or more rows and managed in such a way that the rows are cut successively, at definite intervals, to supply the necessary firewood and fence posts without destroying the value of the trees for the main purposes for which they were planted.

KEEPING RECORDS.

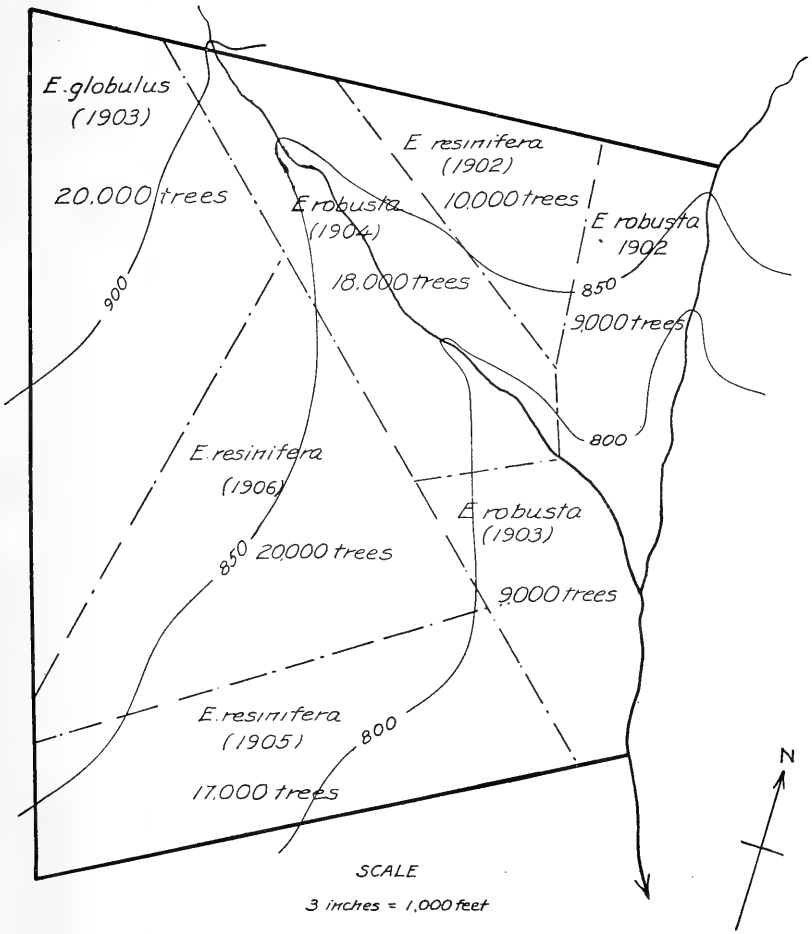
If forest planting is to be done systematically and in a businesslike manner, business methods should be used. It is very important that a record be kept of the trees planted, of the costs of the operations, and of the returns obtained. This does not involve complicated bookkeeping, a simple record of the different operations being sufficient. An occasional half hour spent in this work will keep the history of the plantation up to date. Following is a suggested form for keeping a record of the plantation:

SAMPLE FORM FOR KEEPING RECORD OF PLANTATION.

Lot No. 3, Puu Ululaau Plantation.
Species, *E. globulus*. Spacing, 6 x 8. Area, 40 Acres.

Year.	Month.	No. of trees planted per acre.	Cost of planting per acre.	Cost of tending per acre.	RETURNS				Total value returns per acre.
					Cordwood per acre.		Posts per acre.		
					No. Cords	Value	No. Posts	Value	
1902	*February*	*900*	*$24.00*	$	$	$	..	$	$ .....
1903	*January*	*200*	*2.00*	*2.00*	....	.....	..	....	.....
1904	*March*	...	.....	*1.00*	....	.....	..	...	.....
1910	*March*	...	.....	....	*25.5*	*204.00*	*35*	*10.50*	*214.50*

A map of the forest, showing the location of the trees, the time when the trees were set out, and the number planted, is almost indispensable. The map is particularly desirable in case of a Eucalyptus plantation, because, if track is once lost of the trees planted, many species can not be identified until the trees begin to bear flowers and seed, which often takes several years, and even at that time it will frequently require the services of an expert botanist. The attached diagram (Plate 9) shows the manner in which a simple map of the plantations may be made without much effort. The suggested form for keeping records, as well as the attached map, are intended merely as guides, and there is no doubt that many of the plantation managers can devise better plans of their own. The form of record is not important, but only that a record should be kept.



SAMPLE MAP OF EUCALYPTUS PLANTATION

Plate 9.

APPENDIX

Timber valuable for spokes, tool handles, and is taking the place of hickory.

E. capitellata, Smith. Brown stringybark.

Tree occasionally 200 feet but usually not more than 50 feet high and 2 to 2½ feet in diameter. Prefers moist soils.

Wood tough, strong and durable; splits very readily. Used for shingles, fuel and rough construction.

E. citriodora, Hook. Lemon-scented gum.

A rapid growing tree sometimes 125 feet high and 4 feet in diameter. Rapid growing.

Wood flexible, strong and durable. Used instead of hickory in coach factories.

E. cordata, Labill.

A tree rarely more than 50 feet high. Uses of wood none.

E. coriacea, A. Cunn. White gum.

A medium sized tree, rarely 75 to 100 feet high and 3 to 5 feet in diameter. Tree can not stand drought. Very hardy to climate and probably suitable to high elevations.

Wood soft, fairly durable in the ground, splits well but is brittle and warps easily. Good fuel; occasionally used for fence posts.

E. cornuta, Labill. Yate.

A large tree in its native home but is apt to be spreading and branchy. Endures much rain. Prefers rich moist soil, but will grow in poor soil.

Wood heavy, hard, tough and elastic. Used for shafts and wagon work.

E. corymbosa, Smith. Bloodwood.

A tree occasionally 100 to 150 feet high, but usually much smaller and sometimes stunted and shrubby.

Tree unsuited for lumber on account of kino or gum which it contains. Wood lasts well under ground and is valuable for fence posts even when the tree is young. Not very good for fuel except in furnaces.

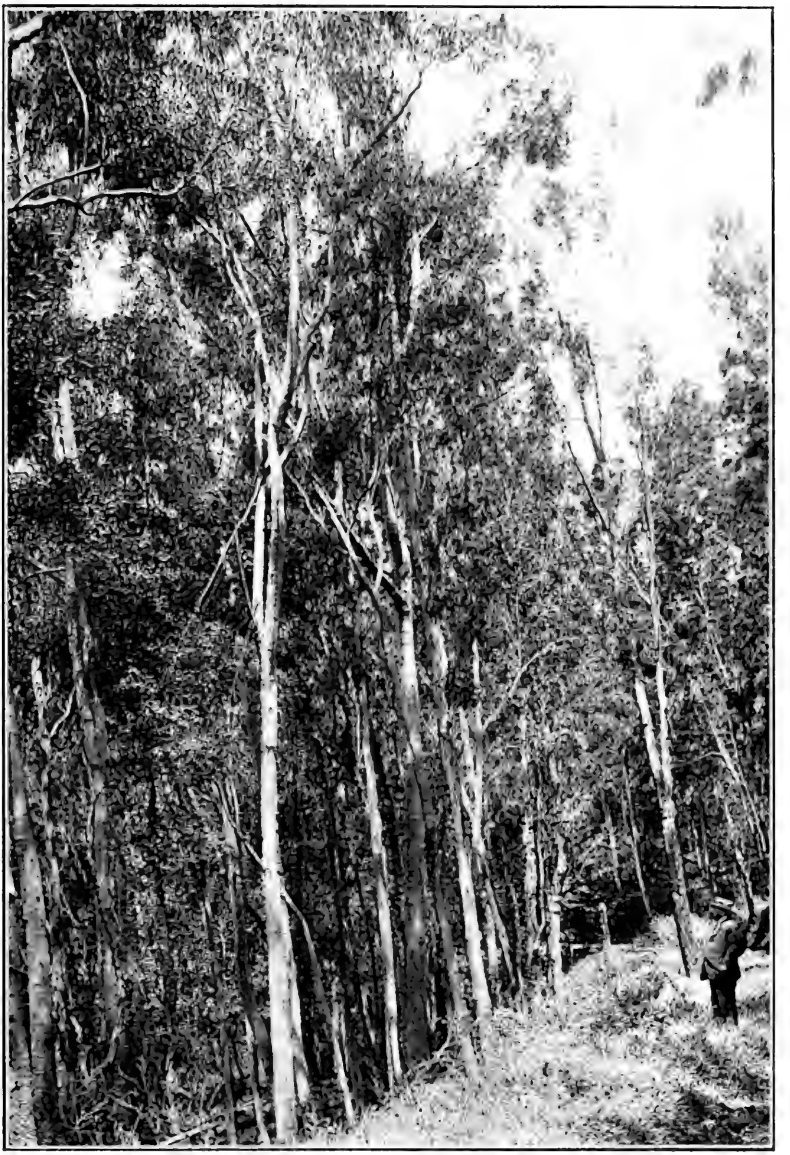


Plate 10. Eucalyptus Forest on Tantalus.

E. corynocalyx, F. v M. Sugar gum.

A tree of good timber form reaching a height of from 50 to 100 feet, and a diameter of from 5 to 6 feet. It is of slower growth than blue gum but is a persistent grower. One of the most drought enduring trees, but prefers moisture.

One of the best all around trees. Timber straight and even grained, durable in contact with the soil. Lumber does not warp much in drying. One of the strongest eucalypts; the seasoned wood is better than the best grade of second-growth hickory.

E. crebra, F. v M. Narrow-leaved ironbark.

A slender tree 100 feet high and 2 to 3 feet in diameter. Not particular as to character of soil on which it grows.

Wood durable under ground, and used for posts, ties, piles, bridges and wagon stock. A valuable timber tree.

E. diversicolor, F. v M. Karri.

This tree is among the tallest eucalypts, easily reaching a height of over 300 feet and diameter of 15 feet or more. Trunk usually straight and symetrical. Grows faster than *Eucalyptus amygdalina.* Does not endure dry heat, but likes moist climate.

Wood straight grained, not very durable under ground but lasts in water and is good for piling. The timber is superior to that of blue gum. Used for masts, wheelwright work, ship building, spokes, shafts, felloes and rails.

E. eugenioides, Sieb. White stringybark.

A tree 150 to 200 feet high. Prefers moist climate, which is not too hot. Tree is not fastidious as to soil requirements.

Wood strong and durable, not very hard, easily worked, splits easily, and does not warp badly in drying. Used for fence posts, ties, flooring and paving blocks. Fairly good fuel.

E. eximia, Schau. White bloodwood.

A medium sized tree, rarely 80 feet tall, resembling *E. corymbosa.*

Wood soft and not durable. Good fuel.

E. redunca, Schau. Wandoo.

A very large tree, sometimes 17 feet in diameter. Will grow on poor soil, but requires moisture.

Wood hard, heavy, durable. Used for wheelwright work.

E. regnans, F. v M. See *E. amygdalina.*

E. resinifera, Smith. Red mahogany.

A medium sized tree, occasionally reaching a height of 100 feet. It prefers moist, semitropical climate, but will grow on hard, gravelly soils. It is a hardy tree and can stand much drought.

Wood very hard, strong and very durable. Used for fence posts, piles, paving blocks, shingles and general construction. It makes an excellent furniture wood. This is one of the most valuable hardwoods in Australia. It lasts a long time in salt water.

E. robusta, Smith. Swamp mahogany.

A tree 100 feet high and 4 feet in diameter. It prefers moist situations but will grow under almost any condition, where no other eucalypts can exist.

Wood fairly durable under ground. Used for posts, railroad ties and ship building.

E. rostrata, Schl. Red gum.

A tree 100, sometimes 200 feet high, and 6 to 12 feet in diameter. Crooked and irregular in form, even when closely planted. It prefers low, moist, clayey soils, but can stand much heat. It makes fairly rapid growth but does not grow so rapidly, except in the seedling stage, as blue gum. It can withstand hurricanes, but will not thrive in a steady wind, unless cultivated and cared for in the early stages of its growth.

Wood durable in the soil and water; makes good fence posts, piles and railroad ties. It resists the attacks of teredo and white ants. It is used for ship building, piles, posts, paving blocks and street curbing; and is an exceptionally good fuel wood.

E. rudis, Endl. Swamp gum.

A tree 75 to 100 feet high. It requires a good deal of moisture for its proper growth.

Good for fuel.

E. saligna, Smith. Flooded gum.

A tall straight tree 100 to 200 feet high and 3 to 6 feet in diameter. It prefers rich alluvial soils.

Wood strong, straight grained, easily worked. One of the lightest eucalypts in weight. Very durable under ground. Used for piles, beams, fence posts and railroad ties. This is a good lumber tree and the wood is extensively used by carpenters.

E. siderophloia, Benth. Broad-leaved ironbark.

A tree 100 to 150 feet in height and 3 to 4 feet in diameter.

Wood hard, strong and durable. Used for bridges, posts and railroad ties. Fair fuel, but burns slowly.

E. sideroxylon, A. Cunn. Red ironbark.

A rather branchy tree, usually short, but sometimes 100 feet high and 4 feet in diameter. It grows naturally on poor soil, but makes rather slow growth.

Wood hard, heavy, strong and durable under ground. Used for ties, spokes and shafts. This is one of the best fuel woods.

E. sieberiana, F. v M. Mountain ash.

Straight tall tree 100 to 150 feet high and 5 feet in diameter. It will grow on poor soils.

Wood strong, elastic, splits easily and is used for shipbuilding and for tool handles. It makes second grade timber and the wood is attacked by white ants. Excellent fuel wood. Contradictory statements in regard to the durability of the wood.

E. tereticornis, Smith. Gray gum.

A tree 100 to 125 feet high and 3 to 4 feet in diameter. It makes a slower growth than blue gum. It frequently grows a straight trunk of larger dimensions. The tree can stand more drought than *Eucalyptus rostrata,* which it resembles, but is not so good.

Timber strong, hard, heavy, quite durable when the wood is well seasoned. Used for ties, posts and wheelwright work. The lumber is liable to warp and twist in seasoning. It makes poor fuel.

E. viminalis, Labill. Manna gum.

A tree sometimes 300 feet high, and 15 feet or more in diameter, but often of irregular and poor form. The tree will not stand much wind and will not thrive on poor soil.

The timber is not valuable, but is sometimes used for shingles, fence rails and ship construction. It is not a very good fuel wood.

Plate 11. Eucalyptus citriodora in the Tantalus Forest.

SUMMARY OF USES OF EUCALYPTS IN AUSTRALIA.

Species.	Fuel Wood.	Posts.	Ties.	Piles.	All Around Saw Timber.
E. acmenoides	Poor	Excellent	Excellent	Excellent	Poor
E. amygdalina	Poor	Poor	Poor		Poor
E. botryoides		Good	Good		Poor
E. calophylla		Poor	Poor		Good
E. capitellata	Good	Good	Good		Good
E. citriodora		Fair	Fair		Good
E. coriacea	Good	Good	Good		
E. cornuta					Good
E. corymbosa	Poor	Excellent	Good	Good	Poor
E. corynocalyx		Good	Good		Excellent
E. crebra		Good	Good	Good	Excellent
E. diversicolor		Poor	Poor	Good	Excellent
E. eugenioides	Fair	Good	Good		Good
E. eximia	Good	Poor	Poor		
E. globulus	Good	Fair	Fair	Excellent	Good
E. gomphocephala		Excellent	Excellent		Excellent
E. goniocalyx	Good	Good	Good		Good
E. gunnii	Fair	Poor	Poor		Poor
E. haemastoma	Fair	Fair			
E. hemiphloia	Excellent	Poor	Fair	Good	Good
E. leucoxylon	Good	Excellent	Good	Excellent	Excellent
E. longifolia	Good	Excellent	Excellent		Good
E. macrorhyncha	Fair	Good	Good		Good
E. maculata		Good	Good		Good
E. marginata		Excellent	Excellent	Excellent	Excellent
E. obliqua	Poor				Good
E. obtusiflora		Good			Good
E. paniculata		Good	Excellent		Good
E. pilularis		Excellent			
E. polyanthemos	Excellent		Good		Good
E. punctata	Excellent		Good		Good
E. redunca		Good			Good
E. resinifera	Fair	Excellent	Excellent	Excellent	Excellent
E. robusta		Good	Good		Good
E. rostrata	Excellent	Good	Good	Good	Good
E. rudis	Good				
E. saligna		Good	Good	Good	Excellent
E. siderophloia	Fair	Good	Good		
E. sideroxylon	Excellent	Good	Good		Good
E. sieberiana	Good	Fair	Good		Good
E. tereticornis	Poor	Good	Good		Poor
E. viminalis	Fair				Poor

SIZE OF EUCALYPTS.

TALL EUCALYPTS, USUALLY MORE THAN 100 FEET IN HEIGHT.

E. amygdalina	Messmate. Peppermint gum
E. calophylla	Orange-flowered gum.
E. cornuta	Yate.
E. diversicolor	Karri.
E. eugenioides	White stringybark.
E. globulus	Blue gum.
E. goniocalyx	Mountain gum.
E. gunnii	Cider gum.
E. longifolia	Woolybutt.
E. obliqua	Stringybark.
E. pilularis	Blackbutt.
E. polyanthemos	Red box.
E. redunca	Wandoo.
E. saligna	Flooded gum.
E. siderophloia	Broad-leaved ironbark.
E. sieberiana	Mountain ash.
E. tereticornis	Gray gum.
E. viminalis	Manna gum.

MEDIUM-SIZED EUCALYPTS, USUALLY 50 TO 100 FEET IN HEIGHT.

E. acmenoides	White mahogany.
E. bicolor	Black box.
E. botryoides	Bastard mahogany.
E. capitellata	Brown stringybark.
E. citriodora	Lemon-scented gum.
E. coriacea	White gum.
E. corymbosa	Bloodwood.
E. corynocalyx	Sugar gum.
E .crebra	Narrow-leaved ironbark.
E. eximia	White bloodwood.
E. gomphocephala	Tooart.
E. haemastoma	Scribbly gum.
E. hemiphloia	Gray box.
E. leucoxylon	Victoria gum.
E. macarthuri	River box.
E. macrorhyncha	Red stringybark.
E. maculata	Spotted gum.
E. marginata	Jarrah.
E. melliodora	Yellow box.
E. occidentalis	Flat-topped yate.

E. paniculata	White ironbark.
E. piperita	Sydney peppermint.
E. punctata	Leatherjacket.
E. resinifera	Red mahogany.
E. robusta	Swamp mahogany.
E. rostrata	Red gum.
E. rudis	Swamp gum.
E. sideroxylon	Red ironbark.

SMALL EUCALYPTS, USUALLY LESS THAN 50 FEET IN HEIGHT.

E. cordata	
E. ficifolia	Scarlet-flowered gum.
E. obtusiflora	
E. pulverulenta	Silver-leaved stringybark.

LIST OF EUCALYPTS PLANTED IN HAWAII.

Trees marked thus (*) were identified by Dr. J. H. Maiden.

Eucalyptus	acmenoides, Schau.	White mahogany.
"	alba, Rein.	
"	amygdalina, Labill.	Messmate. Peppermint gum.
"	bicolor, A. Cunn.	Black box.
"	botryoides, Sm.	Bastard mahogany.
"	calophylla, R. Br.*	Orange-flowered gum.
"	capitellata, Smith.*	Brown stringybark.
"	citriodora, Hook.	Lemon-scented gum.
"	cordata, Labill.	
"	coriacea, A. Cunn.	White gum.
"	cornuta, Labill.	Yate.
"	corymbosa, Smith.	Bloodwood.
"	corynocalyx, F. v M.	Sugar gum.
"	crebra, F. v M.	Narrow-leaved ironbark.
"	diversicolor, F. v M.	Karri.
"	eugenioides, Sieb.*	White stringybark.
"	eximia, Schau.	White bloodwood.
"	ficifolia, F. v M.	Scarlet-flowered gum.
"	globulus, Labill.	Blue gum.
"	gomphocephala, D. C.	Tooart.
"	goniocalyx, F. v M.	Mountain gum.
"	gunnii, Hook.	Cider gum.
"	haemastoma, Smith	Scribbly gum.
"	haemastoma var. micrantha, D. C.*	
"	hemiphloia, F. v M.*	Gray box.
"	hemiphloia var. microcarpa.*	
"	lehmanni, Preiss.	
"	leucoxylon, F. v M.	Victoria gum.
"	longifolia, Link & Otto	Woolybutt.
"	macarthuri, H. D. & J. H. M.	River box.
"	macrorhyncha, F. v M.	Red stringybark.
"	maculata, Hook.	Spotted gum.
"	marginata, Smith.	Jarrah.
"	obliqua, L'Her.	Stringybark.
"	obtusiflora, D. C.	
"	occidentalis, Endl.	Flat-topped yate.
"	paniculata, Smith.*	White ironbark.

Eucalyptus	pilularis, Smith.	Blackbutt.
"	piperita, Smith.*	Sydney peppermint.
"	polyanthemos, Schau.*	Red box.
"	pulverulenta, Smith.	Silver-leaved stringybark.
"	punctata, D. C.	Leatherjacket.
"	redunca, Schau.	Wandoo.
"	resinifera, Smith.	Red mahogany.
"	resinifera var. grandiflora, Benth.	
"	robusta, Smith.	Swamp mahogany.
"	rostrata, Schl.*	Red gum.
"	rudis, Endl.	Swamp gum.
"	saligna, Smith.	Flooded gum.
"	siderophloia, Benth.*	Broad-leaved ironbark.
"	sideroxylon, A. Cunn.*	Red ironbark.
"	sieberiana, F. v M.	Mountain ash.
"	tereticornis, Smith.	Gray gum.
"	viminalis, Labill.	Manna gum.

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FIELD NOTES ON THE EUCALYPTS FOUND PLANTED IN HAWAII.

The following notes on the eucalypts were collected in various parts of the four islands visited. The names of the trees are based mostly on the names supplied by Eucalyptus seed dealers in Australia and California, and may not be authentic. Specimens of certain eucalypts growing on Tantalus on Oahu were sent to Dr. J. H. Maiden, the Government Botanist of New South Wales for identification. The species named by Dr. Maiden from these specimens are starred (*) in the following list:

Where no detailed description is given about a tree it is because the seed has been planted so recently that little information about it is available.

E. acmenoides, Schau. White Mahogany.

Kauai—

Planted at Kalaheo, at an elevation of between 900 and 1,000 feet.

E. alba, Rein.

Kauai—

Planted at Kalaheo, at an elevation of between 900 and 1,000 feet. The tree grows quite well.

E. amygdalina, Labill. Messmate—Peppermint gum.

Maui—

Found growing in Makawao, at an elevation of 2,500 feet. Trees 12 years old are 75 feet high and 10 to 12 inches in diameter. Trees doing well.

Makawao. At an elevation of 800 feet, trees 9 years old are 50 to 60 feet high and 10 inches in diameter.

Kauai—

Kalaheo. At an elevation of between 900 and 1,000 feet the tree does fairly well, but the altitude is probably too low here.

Kilohana. At an elevation of 1,000 feet the tree is growing quite well.

E. bicolor, A. Cunn. Black box.

Maui—

Planted at elevations of between 500 and 2,000 feet.

E. botryoides, Sm. Bastard mahogany.

Plate 12. Eucalyptus robusta on Tantalus.

Maui—

Makawao. At elevations of 2,000 feet and higher. This seems to be the fastest growing of all the eucalypts at higher elevations, but no old trees were seen.

Oahu—

Waipio. At an elevation of 1,000 feet. Trees 5 months old are 4 to 7 feet high. Land was fertilized and cultivated.

Kauai—

Kalaheo. Planted at an elevation of between 900 and 1,000 feet.

Hawaii—

Waimea. At an elevation of 2,700 feet the trees did not grow well in the nursery.

*E. calophylla**, R. Br. Orange-flowered gum.

Maui—

Makawao. At elevations of between 2,500 and 3,000 feet the trees are growing quite well.

Haiku. Trees at an elevation of 1,600 feet are growing well.

Oahu—

Waipio. At an elevation of 1,000 feet trees one year old are 10 to 15 feet high. Land cultivated and fertilized.

Tantalus. At an elevation of about 1,000 feet trees 25 to 30 years old are 55 feet high and 12 inches in diameter.

Kauai—

Kalaheo. At an elevation of between 900 and 1,000 feet the seedlings did not do very well.

*E. capitellata**, Smith. Brown stringybark.

Maui—

Makawao. At an elevation of between 2,500 and 3,000 feet trees three years old are about 10 feet high. Small bush.

Oahu—

Tantalus. At an elevation of about 1,000 feet trees 25 to 30 years old are 35 feet high and 10 inches in diameter.

E. citriodora, Hook. Lemon-scented gum.

Maui—

Makawao. Trees doing well in nursery at an elevation of about 2,500 feet. Seedlings have not yet been planted but indications are that the tree will do well.

At an elevation of 2,000 feet and higher the tree does very well.

Haiku. Trees planted at elevations of between 500 and 2,000 feet.

Hawaii—

Paauhau. At an elevation of 1,600 feet trees 20 years old are 60 to 75 feet high and 8 to 10 inches in diameter.

Pahala. At an elevation of 2,000 feet trees 2 years old are 6 to 10 feet high.

Waimea. At an elevation of 2,700 feet trees do not grow well in the nursery. Probably too windy.

Oahu—

Nuuanu Valley. Trees planted on poor soil and in windy situations at an elevation of 1,000 feet are not growing well.

Waipio. Trees 10 months old at an elevation of 1,000 feet are 10 to 15 feet high. Land cultivated and fertilized.

Kauai—

Kalaheo. At an elevation of between 900 and 1,000 feet trees are growing quite well.

Lihue. Trees 7 years old, growing near sea level, are 40 to 50 feet high and 8 to 10 inches in diameter.

Kilohana. At an elevation of 1,000 feet the trees are growing well.

E. cordata, Labill.

Maui—

Makawao. Trees planted at elevations of 2,000 feet and higher.

E. coriacea, A. Cunn. White gum.

Maui—

Makawao. At an elevation of between 2,500 and 3,000 feet the trees are not growing very well, being tall and spindling.

At elevations of 2,000 feet and higher, the trees are doing very well.

Kauai—

Kalaheo. At an elevation of between 900 and 1,000 feet the trees are rather slow growing. Trees 3 years old are from 4 to 5 feet high.

E. cornuta, Labill. Yate.

Maui—

Makawao. At an elevation of between 2,500 and 3,000 feet the trees are growing fairly well.

Oahu—

Waipio. At an elevation of 1,000 feet trees 10 months old are from 8 to 10 feet tall. Land is cultivated and fertilized. Trees grow rather bushy.

Tantalus. At an elevation of about 1,000 feet trees 25 to 30 years old are 15 to 16 inches in diameter and about 60 feet high.

Kauai—

Kalaheo. Trees are planted at an elevation of between 900 and 1,000 feet.

E. corymbosa, Smith. Bloodwood.

Maui—

Makawao. At elevations of between 2,000 and 3,000 feet trees grow rather slowly.

At an elevation of 1,500 feet trees are growing fairly well.

Oahu—

Waipio. At an elevation of 1,000 feet trees 10 months old are 8 to 10 feet high. Land was fertilized and cultivated. Trees do not stand the wind very well.

Kauai—

Kalaheo. Trees planted between 900 and 1,000 feet elevation.

Hawaii—

Waimea. At an elevation of 2,700 feet the seedlings did not grow very well.

E. corynocalyx, F. v M. Sugar gum.

Maui—

Makawao. At elevations of 2,500 to 3,000 feet the trees seem to be growing very well. Trees 80 feet high and 8 to 10 inches in diameter were found, but the age of these trees is not known.

At elevations of 2,000 feet and higher seedling trees are making very rapid growth.

Haiku. Trees are planted at elevations between 500 and 2,000 feet.

Oahu—

Waipio. At an elevation of 1,000 feet trees 6 months old are 3 to 5 feet high. Land cultivated and fertilized.

Kauai—

Kalaheo. At an elevation of between 900 and 1,000 feet trees are making good growth. Trees 6 years old are 30 to 35 feet high and 4 to 6 inches in diameter. Trees 3 years old are 8 feet high.

Kukuiolono. Trees planted at an elevation of 1,000 feet.

Hawaii—

Waimea. Seedlings did not grow well at an elevation of 2,700 feet.

E. crebra, F. v M. Narrow-leaved ironbark.

Maui—

Makawao. At an elevation of 2,000 feet the seedling trees are doing very well. Stand transplanting.

Kauai—

Kalaheo. Trees planted at an elevation of between 900 and 1,000 feet.

E. diversicolor, F. v M. Karri.

Maui—

Haiku. Trees planted at elevations from 500 to 2,000 feet.

Kauai—

Kalaheo. Trees 3 to 4 years old are doing well at an elevation of between 900 and 1,000 feet.

Kukuiolono. At an elevation of 1,000 feet trees one year old are from 6 to 7 feet high. They do not stand up to the wind, leaning to leeward.

*E. eugenioides**, Sieb. White stringybark.

Kauai—

Kalaheo. Trees planted at an elevation of between 900 and 1,000 feet.

Oahu—

Tantalus. At an elevation of about 1,000 feet trees 25 to 30 years old are 40 feet high and 10 inches in diameter.

E. eximia, Schau. White bloodwood.

Kauai—

Kalaheo. Trees planted at an elevation of between 900 and 1,000 feet.

E. ficifolia, F. v M. Scarlet-flowered gum.

Maui—

Makawao. At elevations between 2,000 and 4,000 feet. Trees are rather slow growing, 40 to 50 feet in from 15 to 20 years.

Kauai—

Kalaheo. Trees planted at an elevation of between 900 and 1,000 feet.

E. globulus, Labill. Blue gum.

The tree grows well in practically all parts of all the islands at almost all elevations but does particularly well at altitudes higher than 1,000 feet. The tree grows in windy localities but in such places it is of very poor shape.

Maui—

Makawao. At an elevation of from 2,500 to 3,000 feet trees are growing very well. Trees 4 years old are now about 25 feet high.

At elevations of between 500 and 2,000 feet trees are growing rapidly.

At an elevation of 4,000 feet trees 35 years old are 30 to 36 inches in diameter and 65 to 75 feet high.

At an elevation of 5,300 feet trees 5 years old are 4 to 9 inches in diameter and 40 to 45 feet high.

For additional notes and diameters at different ages see Table I.

Blue gum produced fertile seed when 25 years old at an elevation of 4,000 feet. In the same place fertile seed was produced by a tree only 12 years old.

Hawaii—

Kukaiau. Trees 14 years of age at an elevation of 4,000 feet are 15 to 24 inches in diameter and 100 to 130 feet high.

Pahala. At an elevation of 1,800 feet shade trees near the "Stone Field" are remarkably tall and straight and from 20 to 35 inches in diameter. Age unknown.

Waimea. Trees can not stand the strong wind. At an elevation of 2,700 feet trees 5 to 6 years old are only 3 to 15 feet high.

Oahu—

Nuuanu Valley. At an elevation of 1,000 feet in very windy places, growing in poor soil, blue gum 12 years old is only 20 to 25 feet high and 4 inches in diameter.

Waipio. At an elevation of 1,000 feet trees 10 months old are 15 to 20 feet high, and are the best of eleven different species planted. The land was cultivated and fertilized.

Kauai—

Kalaheo. At an elevation of from 900 to 1,000 feet trees are doing quite well.

E. gomphocephala, D. C. Tooart.

Kauai—

Kalaheo. At an elevation of between 900 and 1,00 feet trees 3 to 4 years old are growing quite well.

E. goniocalyx, F. v M. Mountain gum.

Hawaii—

Waimea. At an elevation of 2,700 feet seedlings were growing quite well.

Kauai—

Kalaheo. At an elevation of between 900 and 1,000 feet trees 3½ years old are 20 feet high.

E. gunnii, Hook. Cider gum.

Maui—

Makawao. At an elevation of between 2,500 and 3,000 feet trees 3 years old are growing quite well. The seedlings are difficult to raise in the nursery. At elevations of 2,000 feet and higher trees are growing very rapidly.

Kauai—

Kalaheo. Trees planted at an elevation of between 900 and 1,000 feet.

E. haemastoma, Smith. Scribbly gum.

Hawaii—

Waimea. At an elevation of 2,700 feet seedlings were growing quite well.

Kalaheo. At an elevation of between 900 and 1,000 feet trees 3 years old were growing well, but not rapidly, being 4 to 8 feet high. The tree does not stand the wind here.

Oahu—
Waipio. Trees planted at an elevation of 1,000 feet.

E. haemastoma, var. *micrantha** D. C.

Oahu—
Tantalus. At an elevation of about 1,000 feet trees 25 to 30 years old are 45 feet high and 15.5 inches in diameter.

*E. hemiphloia,** F. v M. Gray box.

Kauai—
Kalaheo. Trees planted at an elevation of between 900 and 1,000 feet.

Oahu—
Tantalus. At an elevation of about 1,000 feet trees 25 to 30 years old are 45 feet high and 12 inches in diameter.

Hawaii—
Waimea. At an elevation of 2,700 feet seedlings were growing quite well.

E. hemiphloia, var. *microcarpa.**

Oahu—
Tantalus. At an elevation of about 1,000 feet trees are 50 feet high and 16 inches in diameter.

E. lehmanni, Preiss.

Kauai—
Kalaheo. Low shrub at an elevation of between 900 and 1,000 feet.

E. leucoxylon, F. v M. Victoria gum.

Maui—
Makawao. At an elevation of between 2,500 and 3,000 feet seedlings are growing fairly well. The trees are hard to raise in the nursery.

At elevations from 2,000 to 4,000 feet the trees are making very rapid growth.

E. longifolia, Link and Otto. Woolybutt.

Maui—
Makawao. The tree does well at elevations of 2,000 feet and higher.

Haiku. The tree is planted at elevations of from 500 to 2,000 feet.

Kauai—

Kalaheo. Trees planted at an elevation of from 900 to 1,000 feet.

E. macarthuri, H. D. & J. H. M. River box.

Maui—

Makawao. Young trees are growing well at elevations of 2,000 feet and up.

E. macrorhyncha, F. v M. Red stringybark.

Maui—

Makawao. Young trees are doing well at an elevation of between 2,500 and 3,000 feet. The seedlings are hard to raise in the nursery.

E. maculata, Hook. Spotted gum.

Maui—

Haiku. Trees planted at elevations of between 500 and 2,000 feet.

E. marginata, Smith. Jarrah.

Maui—

Makawao. Young trees are growing well at elevations of 2,000 feet and up.

Haiku. Trees planted at elevations of between 500 and 2,000 feet.

Kauai—

Kalaheo. Trees 3 years old at an elevation of between 900 and 1,000 feet are growing slowly, being 4 to 5 feet high.

E. obliqua, L'Her. Stringybark.

Maui—

Makawao. At an elevation of between 2,500 and 3,000 feet seedlings of this tree did well in the nursery, but died when transplanted. This may have been due to an exceedingly rainy season.

Kauai—

Kalaheo. Trees planted at an elevation between 900 and 1,000 feet.

E. obtusiflora, D. C.

Maui—

Makawao. Young trees growing fairly well at an elevation of between 2,500 and 3,000 feet.

E. occidentalis, Endl. Flat-topped yate.

Kauai—
Haiku. Trees planted at elevations of between 500 and 1,500 feet.
Kauai—
Kalaheo. Trees 6 years old growing at an elevation of 900 feet are not doing well. Crooked and poor.

*E. paniculata,** Smith. White ironbark.

Maui—
Makawao. Young trees growing rapidly at elevations of 2,000 feet and higher.
Kauai—
Kukuiolono. Trees planted at an elevation of 1,000 feet.
Oahu—
Tantalus. At an elevation of about 1,000 feet are trees 25 to 30 years old.

E. pilularis, Smith. Blackbutt.

Maui—
Makawao. Young trees are growing well at elevations of 2,000 feet and higher.
Kauai—
Kalaheo. Trees growing at an elevation of between 900 and 1,000 feet 3½ years old are 20 feet high. Trees 6 years old are 30 to 40 feet high and 3 to 6 inches in diameter. Trees stand wind quite well.
Kukuiolono. Trees growing at an elevation of 1,000 feet are 4 to 5 feet high in one year.

*E. piperita,** Smith. Sydney peppermint.

Oahu—
Tantalus. At an elevation of about 1,000 feet trees 25 to 30 years old are 60 feet high and 14.5 inches in diameter.

*E. polyanthemos,** Schau. Red box.

Maui—
Makawao. Young trees are growing quite well at elevations of 2,000 feet and higher.
Kauai—
Kalaheo. Trees 4 years old at an elevation of 900 feet are 15 to 20 feet high.
Oahu—
Government Nursery. Tree 40 feet high and 17.5 inches in diameter. Age unknown.

Hawaii—

Waimea. Young seedlings are growing well at an elevation of 2,700 feet.

E. pulverulenta, Smith. Silver-leaved stringybark.

Maui—

Makawao. At an elevation of 3,000 feet the trees are growing quite well. Seedlings do not stand transplanting readily.

E. punctata, D. C. Leatherjacket.

Kauai—

Kalaheo. Trees planted at an elevation of between 900 and 1,000 feet.

E. redunca, Schau. Wandoo.

Maui—

Haiku. Trees planted at elevations of between 500 and 2,000 feet.

E. resinifera, Smith. Red mahogany.

Maui—

Makawao. At an elevation of 3,000 feet the tree does not grow well; apparently it is too cool.

Haiku. At elevations of between 500 and 800 feet trees 9 years old were 50 to 75 feet high and 9 to 11 inches in diameter. The tree grows well also at an elevation of 1,500 feet. Sprouts from trees cut 3 years ago are now 30 to 40 feet high and 5 inches in diameter.

Grove Ranch. At an elevation of 900 feet trees 3 years old are 35 to 40 feet high and 8 inches in diameter.

Oahu—

Waipio. Trees a few months old are planted at an elevation of 1,000 feet.

Kauai—

Kukuiolono. Young trees are growing well at an elevation of 1,000 feet.

Hawaii—

Waimea. Seedlings were growing at an elevation of 2,700 feet.

E. resinifera var. *grandiflora,* Benth.

Kauai—

Kalaheo. Elevation 900 to 1,000 feet. The trees are making excellent growth. Trees 3 years old are 25 feet high.

E. robusta, Smith. Swamp mahogany.

Maui—

Makawao. Elevation 2,500 to 3,000 feet. The tree grows well but is hard to start in the nursery at this elevation.

At an elevation of 3,000 feet seedlings came up naturally on a very poor, rocky soil.

At an elevation of 2,400 feet trees 5 years old are 2 to 6 inches in diameter and 15 to 20 feet high.

Oahu—

Wahiawa. At an elevation of 1,000 feet roadside trees 5 to 6 years old are 50 feet high and 7 to 9 inches in diameter.

Waipio. At an elevation of 1,000 feet trees 9 months old are 10 feet high. Land fertilized and cultivated.

Tantalus. At an elevation of about 1,000 feet trees 25 to 30 years old are 15 to 20 inches in diameter and 60 to 80 feet high.

Hawaii—

Pahala. Elevation 2,000 feet. Trees 2 years old are 3 to 4 feet high.

Kauai—

Kalaheo. Elevation 900 to 1,000 feet. Trees 3 years old are 30 feet high and 4 inches in diameter.

Lihue. Trees growing in the bottom of a gulch about 500 feet elevation, 25 years old, are 16 to 20 inches in diameter and 80 to 100 feet high.

*E. rostrata,** Schl. Red gum.

Maui—

Makawao. Elevation 2,500 to 3,000 feet. Trees do not do well; probably too windy.

With elevations of between 2,000 and 3,000 feet, trees make rapid growth.

Haiku. Elevations between 500 and 2,000 feet. Trees make fairly good growth.

Wailuku. Elevation 700 feet. Trees on exposed ridge, 14 months old, are doing well, but are bent with the wind.

Ulupalakua. Elevation 2,000 feet. Trees 30 to 40 years old are doing very well. Some of the older trees are dying.

Oahu—

Waipio. Elevation 1,000 feet. Trees 6 months old are 5 feet high. Land fertilized and cultivated.

Tantalus. At an elevation of about 1,000 feet trees 25 to 30 years old are 60 feet high and 20 inches in diameter.

Hawaii—

Waimea. Trees planted at an elevation of 2,700 feet.

Kauai—

Kalaheo. Elevation 900 to 1,000 feet. Trees growing very well, but do not stand the wind.

Puhi Valley, Lihue. Grove 4 years old; where protected from wind the trees are 40 feet high and 4 to 6 inches in diameter. The trees clean themselves of branches quite readily.

Kilohana. Elevation 1,000 feet. Young trees are doing very well.

E. rudis, Endl. Swamp gum.

Maui—

Makawao. Young trees are growing rapidly at elevations of 2,000 feet and up.

Haiku. Trees planted at elevations of between 500 and 2,000 feet.

Oahu—

Waipio. Elevation 1,000 feet. Trees 6 months old are 5 feet high. Land fertilized and cultivated.

Kauai—

Kukuiolono. Elevation 1,000 feet. Young trees are growing very well.

Kalaheo. Elevation 900 to 1,000 feet. Trees 3½ years old are 25 feet high.

E. saligna, Smith. Flooded gum.

Maui—

Makawao. Elevation 2,500 to 3,000 feet. Trees 3 to 4 years old are doing very well.

Trees planted at elevations of 2,000 feet and higher.

Kalaheo. Elevation 900 to 1,000 feet. Trees 3 years old are 10 to 15 feet high.

Hawaii—

Waimea. Young seedlings doing well at an elevation of 2,700 feet.

*E. siderophloia,** Benth. Broad-leaved ironbark.

Maui—

Makawao. Elevation 2,500 to 3,000 feet. Young trees are growing well but seedlings are hard to raise in nursery. Elevation 2,500 feet; young trees growing rapidly. Elevation 6,500 feet; trees grow quite well.

Kauai—

Kalaheo. Trees planted at an elevation of between 900 and 1,000 feet.

Oahu—

Tantalus. At an elevation of about 1,000 feet trees 25 to 30 years old are 70 feet high and 19.5 inches in diameter.

Hawaii—

Waimea. Young seedlings are doing well at an elevation of 2,700 feet.

*E. sideroxylon,** A. Cunn. Red ironbark.

Kauai—

Kalaheo. Trees planted at an elevation of between 900 and 1,000 feet.

Oahu—

Tantalus. At an elevation of about 1,000 feet trees 25 to 30 years old are 45 feet high and 15 inches in diameter.

E. sieberiana, F. v M. Mountain ash.

Maui—

Makawao. Elevation 6,500 feet. Young trees growing well.

E. tereticornis, Smith. Gray gum.

Oahu—

Waipio. Elevation 1,000 feet. Trees 6 months old are 3 to 5 feet high. Land fertilized and cultivated.

Kauai—

Kalaheo. Elevation 900 to 1,000 feet. Trees 3½ years old are 10 to 15 feet high.

Hawaii—

Waimea. Elevation 2,700 feet. Seedlings are growing quite well.

E. viminalis, Labill. Manna gum.

Maui—

Makawao. Elevation 2,500 to 3,000 feet. Trees growing very well.

Haiku. Trees planted at elevations of between 500 and 2,000 feet.

Kauai—

Kalaheo. Elevation 900 to 1,000 feet. Trees 3 years old are 8 to 10 feet high.

Hawaii—

Waimea. Elevation 2,700 feet. Young seedlings are doing well.

TABLE V.

VOLUME TABLE.

Blue Gum (*Eucalyptus globulus*).

Kokomo, Maui. Age 11 Years. Basis 315 Trees.

Diameter Breasthigh.	Used volume with bark.	Diameter Breasthigh.	Used volume with bark.
Inches.	Cubic feet.	Inches.	Cubic feet.
2	.3	10	11.8
3	.7	11	14.0
4	1.3	12	16.6
5	2.4	13	19.7
6	3.7	14	23.1
7	5.5	15	26.5
8	7.4	16	30.0
9	9.5	17	33.4

TABLE VI.

VOLUME TABLE.

Blue Gum (*Eucalyptus globulus*).

Tantalus, Oahu. Age 30 Years. Basis 75 Trees.

Diameter Breasthigh.	Used volume with bark.	Diameter Breasthigh.	Used volume with bark.
Inches.	Cubic feet.	Inches.	Cubic feet.
5	2.7	11	16.6
6	4.2	12	20.2
7	5.9	13	24.0
8	7.9	14	28.1
9	10.4	15	32.4
10	13.4	..	...

TABLE VII.

VOLUME TABLE.

Yate (*Eucalyptus cornuta*).

Tantalus, Oahu. Age 25 Years. Basis 50 Trees.

Diameter Breasthigh.	Used volume with bark.	Diameter Breasthigh.	Used volume with bark.
Inches.	Cubic feet.	Inches.	Cubic feet.
5	5.2	12	21.4
6	6.7	13	25.6
7	8.4	14	30.5
8	10.2	15	35.8
9	12.3	16	41.1
10	14.8.	17	46.5
11	17.7	..	...

TABLE VIII.

VOLUME TABLE.

Swamp Mahogany (*Eucalyptus robusta*).

Tantalus, Oahu. Age 25 Years. Basis 25 Trees.

Diameter Breasthigh.	Used volume with bark.	Diameter Breasthigh.	Used volume with bark.
Inches.	Cubic feet.	Inches.	Cubic feet.
5	3.1	10	18.5
6	4.9	11	23.4
7	7.3	12	28.4
8	10.3	13	33.6
9	14.0	14	39.0

PUBLICATIONS FOR DISTRIBUTION.

Any one or all of the publications listed below (except those marked *) will be sent to residents of this Territory, free, upon application to Mailing Clerk, P. O. Box 207, Honolulu.

BOARD.

Report of the Commissioner of Agriculture and Forestry for 1900; 66 pp.
Report of the Commissioner of Agriculture and Forestry for 1902; 88 pp.
* First Report of the Board of Commissioners of Agriculture and Forestry, from July 1, 1903, to December 31, 1904; 170 pp.
Second Report of the Board of Commissioners of Agriculture and Forestry, for the year ending December 31, 1905; 240 pp.; 8 plates; 10 text figures.
Third Report of the Board of Commissioners of Agriculture and Forestry, for the year ending December 31, 1906; 212 pp.; 3 plates; 4 maps; 7 text figures.
Fourth Report of the Board of Commissioners of Agriculture and Forestry, for the calendar year ending December 31, 1907; 202 pp.; 7 plates.
Fifth Report of the Board of Commissioners of Agriculture and Forestry, for the calendar year ending December 31, 1908; 218 pp.; 34 plates.
Report of the Board of Commissioners of Agriculture and Forestry, for the biennial period ending December 31, 1910; 240 pp.; 45 plates.
"Notice to Importers," by H. E. Cooper; 4 pp.; 1903.
"Digest of the Statutes Relating to Importation, Soils, Plants, Fruits, Vegetables, etc., into the Territory of Hawaii." General Circular No. 1; 6 pp.
"Important Notice to Ship Owners, Fruit Importers and Others. Rules and Regulations Prohibiting the Introduction of Certain Pests and Animals into the Territory of Hawaii." General Circular No. 2; 3 pp.; 1904.
"Law and Regulations, Importation and Inspection of Honey Bees and Honey." General Circular No. 3; 7 pp.; 1908.

"The Hawaiian Forester and Agriculturist," a monthly magazine. Vols. I to VII; 1904-1910. To be obtained from the Hawaiian Gazette Co., Honolulu. Price $1 a year.

DIVISION OF FORESTRY.

* "Forest and Ornamental Tree Seed for Sale at Government Nursery." Press Bulletin No. 1; 3 pp.; 1905.
* "Suggestions in Regard to the Arbor Day Tree Planting Contest." Press Bulletin No. 2; 7 pp.; 1905.
"An Offer of Practical Assistance to Tree Planters." Circular No. 1; 6 pp.; 1905.
"Revised List of Forest and Ornamental Tree Seed for Sale at the Government Nursery." Press Bulletin No. 3; 4 pp.; 1906.
* "Instructions for Propagating and Planting Forest Trees." Press Bulletin No. 4; 4 pp.; 1906.
"Instructions for Planting Forest, Shade and Ornamental Trees." Press Bulletin No. 5; 7 pp.; 1909.
"Na Hoakaka no ke Kanu Ana i na Laau Malumalu ame na Laau Hoohiwahiwa." Press Bulletin No. 6; 8 pp.; 1909.
"Eucalyptus Culture in Hawaii," by Louis Margolin. Bulletin No. 1; 88 pp.; 12 plates; 1911.
Report of the Division of Forestry, for the year ending December 31, 1905. Reprint from Second Report of the Board; 77 pp.; 5 plates.
* Report of the Division of Forestry, for the year ending December 31, 1906. Reprint from Third Report of the Board; 123 pp.; 4 maps.
Report of the Division of Forestry, for the year ending December 31, 1907. Reprint from Fourth Report of the Board; 70 pp.
Report of the Division of Forestry, for the year ending December 31, 1908. Reprint from Fifth Report of the Board; 85 pp.
Report of the Division of Forestry, for the biennial period ending December 31, 1910. Reprint from Report of the Board; 86 pp.; 22 plates.


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