

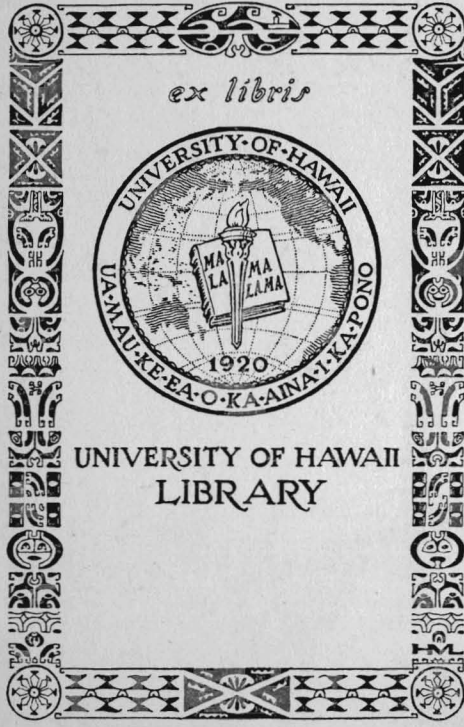
*SOME OBSERVATIONS ON HAWAIIAN
FORESTS AND FOREST COVER IN THEIR
RELATION TO WATER SUPPLY*

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Some Observations on Hawaiian
Forests and Forest Cover in
Their Relation to Water
Supply

BY WALTER M. GIFFARD

HONOLULU, HAWAII
JANUARY, 1913

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LETTER OF TRANSMITTAL.

To the Joint Committee on Forestry,
Hawaiian Sugar Planters' Association and
Board of Agriculture and Forestry.

DEAR SIRs:—I beg to submit you for your consideration a
paper entitled "Some Observations on Hawaiian Forests and
Forest Cover in Their Relation to Water Supply."

Respectfully,

W. M. GIFFARD.

Honolulu, January 20, 1913.

JOINT COMMITTEE ON FORESTRY.

H. S. P. A.
Albert Horner, Chairman,
E. D. Tenney,
E. F. Bishop.

Bd. of A. & F.
W. M. Giffard, Chairman,
H. M. von Holt,
A. H. Rice.

SOME OBSERVATIONS ON HAWAIIAN FORESTS AND FOREST COVER IN THEIR RELATION TO WATER SUPPLY.

A paper by W. M. Giffard read before the Joint Committee on Forestry of the Hawaiian Sugar Planters' Association and the Territorial Board of Agriculture and Forestry.

The Nature and Peculiarities of the Wet Forests of Hawaii and the Cause of Their Deterioration and Decline.

Much has been written on this subject and at first thought it may appear quite unnecessary that further explanation be made of the composition and nature of the Hawaiian forests that are needed for drainage or the conservation of water supply. It is, however, very apparent that there are still a number of individuals in the Territory that up to the present have ignorantly, carelessly or wantonly disregarded the oft repeated warnings of foresters and botanists as to the necessity for protecting these forests. Clearings continue to be opened up through the encroachment of man and beast, and the forest in places is still being pushed back by the making of clearings and roads to these that ought never to have been permitted. Elsewhere, the cutting of the forest for posts and for firewood is still going on, and again, where wild cattle and hogs are at large in the forest, general destruction is caused by their roaming around grubbing and feeding on and trampling down the herbaceous undergrowth so necessary for soil and water protection.

It is well understood by all having knowledge of the peculiar nature of these virgin forests that much of their natural undergrowth, composed as it is of climbing vines (lianes) and herbaceous plants, ferns and mosses, not only protects the soil from erosion but furnishes a protective cover for the surface growing roots of our indigenous trees.

Take for instance the native Ohia Lehua, which attains such fine growth in these wet forests and of which they are in the main composed. No observing person passing through such a forest can have failed to notice the peculiar stilt-like roots of the Ohia. This characteristic habit of growth is explained by the epiphytic habits of the Ohia. The tree has developed from

seed, which dropped on the stem of some stately tree fern or Cibotium, germinated there and sent down its own roots, surrounding the fern, until both for a time became as it were, one. Later, the fern stump having decayed, the Ohia stands supported by its own roots.

Further, it will be noticed that not only the Ohia, but also several other species of trees peculiar to these forests have only surface roots, and that these are not altogether dependent on the usually thin layer of rich but boggy humus, but as well, rely on the ground cover of mosses and roots of ferns with which their own roots are intermingled.

Very many of our land owners, or those having the use or care of such forests, have the idea that if the trees themselves are not destroyed or disturbed, the forest will continue in its virgin state. These people forget that the very act of disturbing or destroying the undergrowth is in itself the main factor in causing the trees themselves eventually to die back. The loss of numbers of trees from one cause and another naturally admits more sunshine to the undergrowth than the latter has ever been accustomed to or can stand. The natural consequence is its death, which in turn leads to the dying back of more trees, and to the still further destruction of the forest.

Under such conditions it then becomes merely a matter of a short time, especially if animals are allowed to range in the forest, or if clearings are made for any purpose, before the Hilo grass or other rank growing introduced plant pests get a foothold. By the crowding out and prevention of the reproduction of the native flora, there follows either the general destruction of the forest outright or its degeneration to such an extent that it ceases longer to be of use for the purpose which it originally served, viz—the retention and conservation of our water supply.

As regards the encroachment of grasses into the forests and their effect on trees and other growths, it has been scientifically demonstrated by a long series of experiments in Europe and elsewhere, that the injury is not altogether due to the grass crowding out and mechanically interfering with the roots of other plants, but to a toxin excreted from, or resulting from the growth of the grass. However, as both effects are injurious to the forest it is clear that such pests must be excluded.

From what has been said above the following can be scientifically and therefore safely deduced, viz:

- (1). That to keep our forests and sources of water supply in a natural condition the jungle of woodland and undergrowth therein must be left altogether undisturbed by man or beast.
- (2). That preventive measures for safeguarding the existing forests by fencing, ranging and policing as well as destroying wild cattle, hogs and goats, should be systematically undertaken by the Forestry Division of the Territorial Board of Agriculture and Forestry.
- (3). That in order effectively to undertake such important work the privately owned areas within the water-bearing forest reserves should be brought under the same system of management that is here recommended for the Government lands, in such manner as is already provided for by law. A proper system of forest protection having been established by the Government, failure to assign forest lands to the Territory for the specific purpose of protection might, as a last resort, be followed by condemnation proceedings, it being understood that any neglect on the part of the Government properly to protect and police such acquired reserves would forfeit the latter's right to the ownership; and
- (4). That the Legislature appropriate sufficient funds for the special purpose of fencing and policing the forests above referred to, and excluding therefrom wild cattle, etc.

The Intermediate Forest Areas and Their Relation to the Water Sheds.

From an economic point of view the so-called intermediate forests, i. e. the areas of woodland between the agricultural and mountain zones and the wet forests on the water sheds are of as much importance for the protection and preservation of the areas forming the virgin wet forests as these latter are in helping to control the drainage, retention and conservation of water for the supply of agricultural lands, or such other purposes as the water may be needed for. The close observer of our natural forests and water sheds will at once notice that where the wet forests are still in their virgin condition, the areas both above and below the wet forest are of somewhat different nature than those from which we expect to and do receive our water supply.

Taking Hawaii and Maui as examples, one finds that the extreme upper sections of the middle forest zone, above the true wet forest, are composed of a more or less scrubby growth of indigenous trees with an undergrowth of dry district ferns and raspberries, technically described as semi-xerophytic in character.

This upper belt of rather open forest gradually increases in density as one descends into the true wet forest zone, until it intermingles with the latter. The undergrowth also becomes thicker and composed of a greater number of species, until it reaches the ideal wet forest conditions, which are so necessary for a continued water supply at all periods of the year. Technically this type of forest is said to be mesophytic in character.

Again, taking the same islands for an example we find on the lower edge of the wet forest belt a similar state of things. There also the typical wet forest merges into a transition type which may or may not be composed of the same species that are to be found in the wet forest, but which in character is different from the wet forest above. In places also the section between the wet forest and the area of land now under cultivation is covered by a scrub forest and the introduced guava.

The point to be made is that it is of paramount importance to protect, as necessary adjuncts of the forest system, not only the main wet forest but also these intermediate areas. Nature has provided that these so-called intermediate conditions of forest are requisite to the proper and natural protection of the flora contained in the wet forests on the water sheds.

Of course the formation, botanical composition and geographical position of some of our water sheds on other islands than those named, where they are not of the same general character as those described, are equally worthy of consideration when studying the natural conditions which are necessary to their proper protection. Let us take for instance Oahu. This Island has had all the lands adjacent to the mountains, i. e. the water shed areas, stocked with cattle, so that comparatively little is left of any forest other than what may be found on the high ridges and plateaus. Even in these places, which might be supposed to be almost inaccessible, cattle and also goats have trespassed more or less and damaged the forests on which so much depends in the way of water conservation. The result is that there are practically no intermediate or scattered forest areas existing on Oahu at this time, this section having been in the main given up to the graziers and others.

*The Oahu Water Sheds and Their Relation to the Water Supply
of the Honolulu and Ewa Basins.*

As to the Oahu water sheds, more can be said as to what has *not* been done than otherwise, when it comes to their protection and conservation for water supply. Take the Waianae mountains for instance, their present condition and what they were years ago when the forest extended down the slopes of the valleys and ridges adjacent to the Waialua plains.

A similar condition exists and tends to become worse on the slopes of the Koolau range, the backbone of Oahu, from the forest areas of which so much artesian water is drawn for agriculture and city uses. What do we find today on these slopes as protective cover in place of the indigenous vegetation so necessary for our important water sheds? Hilo grass and scrub guava is practically all that remains of what was once a valuable adjunct to the virgin forests which conserve our water supply. Even these latter, excepting perhaps sections on the western half of the range, are daily suffering from the hands of man.

Fortunately cattle are practically excluded from the forested slopes in the Ewa District, and so far goats are not much in evidence. But what do we find in the way of forest protection? The water sheds above the City of Honolulu, from Moanalua to Waialae, although mostly Government land are not yet even included in a forest reserve, and much less are they protected (with exception of portions of upper Nuuanu and Makiki valleys) by either the Government or private owners. So-called trails are being cut out of the face of the steep declivities on the mountains for the pleasure of those inclined to tramp, but outside of such pleasures no thought is taken of the forest ridges and wooded gorges which are simply allowed to take care of themselves.

As a result of the trails cut by pleasure seekers, and of the depredations committed by those apparently ignorant of the peculiarities of our forest growths and the disaster which follows interference with them by man or beast, we find that eroded slopes caused by land slides are fast taking the place of what not so long ago were ideal conditions for conserving the precipitation. It goes without saying that the construction and further maintenance of trails on the steep sides of these mountain areas should be forbidden. Those pleasure bent, if

allowed to trespass at all in our water sheds, should be altogether confined to the ridges where ran the ancient trails of the natives in olden days.

What are we to expect of Nature when man so wilfully, or is it ignorantly, defies and interferes with her course, especially when as in this particular instance the matter is of paramount importance to the City of Honolulu and its environs? What are we going to do in the very near future for a normal water supply if such lack of foresight on the part of the Government and of its citizens continues? Are we to trust to Providence in this as in other things?

It is quite certain that with the continued dying back of what little indigenous forest remains on the mountains back of Honolulu, and with the worse conditions of erosion which are taking place, the "run-off" from precipitation will be more than is now bargained for. In such case what is going to feed the springs and artesian wells upon which we absolutely depend for a normal supply of water? Even now the slightest appearance of dry weather indicates a great falling off in the water supply and this is immediately followed by a threatened curtailment for the time being of water rights.

If the agriculturists on this and the other islands are dependent on water for irrigation purposes, as they surely are, then it behooves them systematically to protect the forest and prevent disturbance of the conditions which conserve such supplies.

If the people of Honolulu desire to be assured of a constant future supply of water for domestic and other uses then similar protection must be enforced as to the mountains back of this city.

That this is by no means too highly colored a picture is proved by the following official figures, compiled by the Territorial Department of Public Works:

"It is estimated that about 350,000,000 gallons of water are delivered daily from all the artesian waters on Oahu, making an annual consumption of about 127,000,000,000 gallons.

"The annual consumption of artesian water between Fort Shafter and Diamond Head (Honolulu) from flowing and pumped wells is more or less 12,700,000,000 gallons, the daily consumption being about 35,000,000 gallons. We believe the amount of water actually leaving the artesian basin is more than this, owing to leakage through defective casing, etc.

"It is almost impossible at the present time to give anywhere near approximate figures on the average annual consumption of water as it is only recently that stream measurements have been taken up by the Hydrographic Survey. The Nuuanu dam, with the spring water used by the Water Works, probably amounts to about 1,450,000,000 gallons annually or 4,000,000 gallons per day. As a very rough estimate, the springs that are delivering water at the surface of the ground, may be placed at about 80,000,000 gallons per day, or 29,000,000,000 gallons per year. The flowing streams, are of course, also great sources of water supply. In accounting for the distribution of the rainfall, however, the underground springs which show themselves at the sea, and the evaporation, must be taken into consideration.

"As to the levels in artesian wells, about 1889 there was a drought, in which the artesian wells fell about $2\frac{1}{2}$ feet. The following season there were heavy rains and the wells in Honolulu again rose to the $42\frac{1}{2}$ ft. level. There have been no available records showing the exact height fifteen years ago, but from our knowledge of conditions of the wells at that time, we place it at about 38 feet.

"Ten years ago the maximum was 34.50 feet, the minimum 32.55, and the average 33.62.

"In 1908, say five years ago, the maximum was 31.81, the minimum 30.41, average 30.74.

"The lowest during the present year has been 28.25. In 1910 the level fell to 29.5 feet then rose during the winter season to 32.5 feet, giving us a total fall of over 4 feet. The recent rains have caused the wells in Honolulu to rise a little. Under normal conditions, we will get a seasonable rise of $1\frac{1}{2}$ to 2 feet. This year's level is the lowest on record.

"It has been estimated that there annually falls on the Island of Oahu, which is roughly 600 square miles in area, enough rain to cover the island to a depth of five feet. Of the total precipitation it is estimated that there reaches the sea, or is lost through evaporation, the equivalent of a depth of $3\frac{3}{4}$ feet, leaving $1\frac{1}{4}$ feet of water over the 600 square miles to be the flow of the artesian wells and surface springs together."

With so large a percentage of the water coming to the surface in this way, under conditions where it can at least in part be controlled, the need is brought home of enforcing greater care than is now used in looking after this source of

supply. Any one who knows anything at all about artesian wells in Hawaii, knows that frightful waste of water is constantly going on. It has been stated that the waste alone from uncapped artesian wells in the Honolulu basin amounts to 10,000,000 gallons of water per day. This water, now permitted to flow away to the ocean, might be stored for future use. In other ways, too, reasonable measures of economy as to the use of water are not now enforced as they should be. At present there appears to be no legislation under which abuses of this kind can be checked.

We have reached a stage of economic development in this Territory when we can no longer afford to allow such reckless and unwarranted carelessness. Water itself, as well as the forest that clothes the catchment areas, must be conserved, and what is more, action must be taken at once. The people of this island face a serious condition, one that can no longer brook delay.

The Need for Hydrographic Investigations in Conjunction With Systematic Forest Work in Hawaii.

Since writing the main portion of this paper the author has received a communication from G. K. Larrison, the local district engineer of the Hydrographic Service of the United States Geological Survey, from which the following is quoted relative to Hawaiian forest conditions and their relation to the hydrographic work which he is at present conducting and which he is desirous of extending:

“The direct and beneficial relation of forest cover to surface, stream and underground water regulation has been so thoroughly demonstrated and widely accepted by the world’s water users that it may seem superfluous to invite attention to this relation again. However, the writer has observed an atmosphere of indifference on this subject in the Hawaiian Islands, which is all the more remarkable, because the supply and regulation of fresh water is, by far, the most important factor in the material life and development of Hawaii.

“The Hawaiian Islands are primarily agricultural, and for the greater part dependent on irrigation. While the rainfall is heavy, the catchment areas are comparatively small, the stream gradients very high, and the run-off from deforested and barren regions very rapid, with resulting heavy erosion and

damage to agricultural lands and property. Further, there are very few natural storage sites in the Territory, and the run-off of barren regions may be likened to the run-off from a roof without gutters or rainspouts. In a great many locations porous or fissured conditions of the drainage areas result in a light surface run-off, and a heavy absorption of the rainfall. This water may sometimes be picked up by water tunnels or wells, but as a rule it appears in springs near or below sea level. The comparative cost of irrigating by pumping against the cost of surface gravity supplies is too well known to be discussed here. With the intermittent rainfall of the Territory, without regulation of some kind, the resultant run-off of surface streams would consist of short periods of high erosive and destructive floods followed by long periods of drought. Underground supplies would be similarly affected to a less degree.

“There is but one way by which Hawaiian streams may be economically regulated, and that is by retaining or developing a heavy blanket of forest cover over as much of the streams’ catchment areas as may be consistent with the demand for water from these areas. The heaviest rainfall is, with few exceptions, above the levels at which agriculture is carried on and it is at these upper levels that the heaviest forest cover is needed as a water supply regulator. This spongelike cover receives and retains the rainfall, and feeds it gradually to the surface and underground water sources, serving as a regulator to decrease floods and to increase dry season discharge.

“The United States Geological Survey in collaboration with the National Bureau of Forestry, is now making careful and detailed experiments in the White Mountains of New Hampshire on the effect of deforestation and reforestation in its relation to surface stream regulation. While these experiments have not been completed, the results so far have proved conclusively that forest cover is a most important factor in the regulation of stream run-off. In the Hawaiian Islands and under tropical conditions, the forest cover is much more dense, and the beneficial or destructive effects of forest cover or the lack of it is much greater than in the White Mountains.

“The Territory of Hawaii, has, since 1910 maintained a hydrographic survey in cooperation with the United States Geological Survey. Limited funds have restricted operations to low level accessible localities with insufficient and temporary equipment. The 1911 and 1912 reports of this Survey are

now being prepared, and should be given to the public within the next few months. These data will give the daily, monthly, and annual discharge of such streams as have been under investigation, and should furnish abundant proof of the necessity of forest cover as a stream discharge regulator. These reports will also show the amount of water that is being utilized, and the amount being wasted at a number of localities. In a number of cases seepage loss of irrigation ditches is also given.

"It is estimated that, during the drought of the past year on Kauai, enough water was wasted through lack of proper regulations to have increased the value of the sugar output of that island by more than one million dollars.

"From rainfall records available it is believed that sufficient rainfall is precipitated on the Hawaiian Islands to supply all possible needs, if the forests are properly maintained to regulate the run-off of this rainfall.

"The forestry and hydrographic operations are so closely related that the two services should be maintained in the closest possible form of cooperation.

"The development and conservation of Hawaii's water resources demand the following operations:

1. The maintenance of the forests over the heavy rainfall catchment areas to regulate streams and to prevent erosion.
2. The construction and maintenance of stream discharge measuring stations at points at which water supplies may be diverted for irrigation, city supply, power or other purposes. This means that these stations should be installed at points now inaccessible by most of the roads and trails, and that clock registers, which give continuous records of stream fluctuations, should be installed. Trails should also be built in order that the stations are accessible at all times, and cable or foot bridges should be constructed for flood measurements.
3. Climatological and meteorological stations should be constructed and maintained at different elevations in the rainfall and forest cover areas to measure the rainfall, evaporation, temperature, mud, sunshine, etc. These will also require the construction of many miles of trails.
4. After the surface water investigation is well under way an investigation of underground water resources should be made."

It will be made apparent from the above communication that the Hydrographic work and that of Forestry as already or-

ganized under the Division of Forestry of the Board of Agriculture and Forestry are closely associated, and should, as Mr. Larrison states, be maintained in the closest possible form of cooperation. It is believed that such cooperation as will produce the best practical results would be the creation of a Division of Hydrography under the Board of Agriculture and Forestry. This Division, if created, should consist of the present Hawaii District organization of the Water Resources Branch of the U. S. Geological Survey, in so far as the expenditure of the Territorial appropriation or allotment for this purpose is concerned. This organization is now indirectly reporting to the Department of Public Works.

This arrangement would also eliminate the additional expense of maintaining separate offices, as is now being done by the Hydrographic Survey, and would keep the Divisions of Forestry and Hydrography directly in touch with each other, and under one administrative head.

Additional reasons why the forestry and hydrographic operations in the Territory should be maintained in the closest possible cooperation are:

(1) The data collected by the hydrographic survey show directly the effects of forestry operations.

(2) In the routine field work of each service there is much work that will be duplicated by employees of both services, if it is not done in cooperation. The larger part of the time of field men of either service is consumed in traveling. A considerable portion of the field work done by the hydrographic service consists of stream and rain gage reading which requires that both classes of stations shall be visited at regular intervals. This duty does not require the services of an especially trained man, and a large part of this work could be done, and on the mainland is done, by forest rangers. On the other hand field men of the hydrographic service could, in the rounds of their duties, assist in exterminating wild cattle and goats, inspect fences, report depredations, fires, etc. It is believed that the cooperation of the two services would eliminate the cost of at least one field assistant or ranger in each island.

Indigenous Forests in Hawaii Not Essentially Needed for Conservation Purposes.

Of these there are several important areas, notably among which are those of the lower forest zone of Puna and certain

sections of Kau and Kona, all on the Island of Hawaii. Of these in particular a word may be said and will suffice for a few similar areas in certain other districts or sections on other Islands.

It has been contended that our indigenous forests not essentially needed for water conservation, might well be used for other purposes, such as agriculture, lumbering, etc. This is quite true insofar as agriculture is concerned, provided that these areas after being cleared are found to contain soil in such chemical condition as will permit of intensive cultivation. This condition can better be ascertained and a policy arrived at as to whether it is right or wrong to clear off these forests, by first opening up an experimental area and testing the cultivable conditions of the soil.

To have done this on portions of the upper Oloa lands would have decided the question as to their adaptability for growing coffee. It is well known that after sacrificing thousands upon thousands of indigenous forest trees in the upper Oloa section it was found that the land was not suitable for the crops intended to be placed thereon by the homesteaders. Had the Government first experimented with the upper Oloa lands and found out that they could not be made of good economic use for coffee, not only would very many thousands of dollars have been saved to the many homesteaders who took up the lands in large areas, but tens of thousands of trees might have been spared the axe or been left to die of themselves because of the disturbance to their natural surroundings.

Fortunately for some of the homesteaders a corporation undertook, also at some loss to itself, as well as to those who planted these upper forest lands, to grow sugar cane on some of the areas cleared. This Company may, later on, by adapting certain varieties of cane to the land, redeem much which has been so far apparently wasted. Should success attain the efforts of these planters an unnecessary loss of sections of a large forest area will have been averted. Today may be seen in these upper areas thousands of acres, of what 15 years or so ago was an impenetrable forest, now covered with dead or dying trees and a thick growth of Hilo grass.

As to the lumbering proposition, it may be said that although heroic efforts have been put forth to make it pay, it has so far failed. This is perfectly natural in view of the fact that forests on these islands adaptable to the full growth of mar-

marketable lumber are extremely limited. The head of a lumber concern on the Coast once told me that he would hesitate to tackle any lumbering proposition on such comparatively small forest areas as we have in this Territory. The clear marketable lumber would be so limited in quantity that it would and could not pay. What has been done thus far on these lines has caused but little harm and it is hardly likely that further operations will be undertaken for a long while to come, if ever, unless it be by the saw mills now in Puna which still have limited areas of forest trees at their command.

I have in the previous section referred to the protective effect which intermediate or adjacent forest cover has on the water forests. Much more might also be said as to the modification of climate and rainfall which wholesale denudation of indigenous forest areas, such as those existing in the upper sections of Puna, Kau and Kona might eventually bring about. It is not only the large agriculturists who suffer from a lack of water supply. The smaller farmers, the graziers and residents generally are all more or less effected when such modifications of climate take place as bring about long and protracted droughts in certain sections or districts where there are no springs or running streams.

It would be well to study the reasons for such protracted droughts in sections where in old days these were never known. One certain conclusion, however, is apparent and that is, that the less we disturb natural forest conditions the better. When such disturbance appears necessary for the purposes of agriculture, experimental work extending over a reasonable period should first be undertaken, lest there result an altogether unnecessary destruction of forest growth and a further disturbance of climatic conditions. Surely there are sufficient cultivable and grazing lands for all without our taking such chances as the jeopardizing of our sources of water supply or changing our climatic conditions.

Forests Intended for Purely Economic Uses.

Of these there are practically none in this Territory beyond the small areas which have been planted in recent years. The fuel so necessary for our plantation laborers and other country residents has been mostly derived from these planted stands, or where no such plantings existed, from wild guava or other adjacent indigenous forest areas.

The old time practice of denuding the native forest areas in proximity to sugar mills, in order to secure fuel for the factories, has practically ceased, but there are many sections on some of the islands where the native forests are still used as a source of fuel supplies, regardless of the disturbance and subsequent harm it does to them.

The modern practice of planting, with introduced trees for fuel and fence post purposes, areas in close proximity to agricultural and grazing estates is to be highly commended. Much has been done in such work by private individuals or corporations, as well as under the auspices of the Board of Agriculture and Forestry. The time is past for our indigenous forests to be used for such wholesale slaughter as once prevailed. Local agriculturists and others are now alive to the fact that it is far more reasonable, and better for their own interests, to plant bare areas with large copses of Eucalyptus and other quick growing and fuel-producing timber trees, rather than to make further unwarranted onslaughts on the native forests.

For plantings in copses, wind breaks and fence rows such introduced trees as the Silk Oak, various species of Eucalyptus and many others are admirably adapted in this tropical climate. The practice however of reforesting or regenerating our indigenous forests with such trees as these is not to be recommended. Their habits and our requirements from such forests are inimical. What we require in forests intended for water conservation, or in those which are adjacent and contributory to them, are plantings, when necessary, of either some of our quick growing indigenous trees, such as Koa, or else of other trees which are closely associated allies in other tropical countries, which will admit of a thick, indigenous forest undergrowth to cover and protect the soil from erosion, as well as to retain the free percolating qualities which the constant moisture under such conditions brings about.

Introduced trees from temperate climates will not admit of such qualities and even those from tropical countries unless carefully selected are liable to be worse than useless. As far as Eucalyptus are concerned they are as previously stated, admirable for certain purposes but not for those of water conservation. Their roots are great feeders of moisture and but little undergrowth will mature where numbers of these are planted. Neither of these characters are suitable for the special conditions required in indigenous forest areas, and the practice of using them for such purpose should, if possible be deprecated.

Forest Plantings on Areas Above the Wet Forest Zones on Certain Islands.

Here we have an opportunity of testing what such trees as the Conifers may do in reclaiming areas which have never to our knowledge been under forest cover. The altitude from 6,000 feet upwards, and the consequent climatic conditions obtainable at these high elevations, make it quite possible to have some of our upper mountain slopes on Haleakala, Manna Kea and Mauna Loa planted with species of Pines, etc., which are so admirably suited for lumbering purposes in other countries.

There is no known reason why some of the Conifers which attain such size and height in Southern California and Mexico could not be made to thrive at those very high altitudes, provided that nurseries were started and maintained and the plantings conducted under systematic supervision. It is to be hoped that the finances of the Board of Agriculture and Forestry will be such in the near future as will admit of the establishment of several of these nurseries on the mountains named. This could no doubt be undertaken in cooperation with some of the adjacent graziers or large land owners. The work of these high altitude stations should not be confined to the growing of introduced pines, etc. alone, but also should include the raising of many of our valuable high elevation indigenous trees. Such stations should be convenient to both upper indigenous forests and also to the unforested areas intended to be planted on the mountain slopes.

Appended to this paper is a list by Mr. J. F. Rock, Consulting Botanist of the Board of Agriculture and Forestry, giving the scientific names of certain quick growing exotic trees from other tropical climates, all of which he suggests may be of use in reforesting areas in our wet forest zones.

Besides being indebted to Mr. Rock for the compilation of the list above referred to, I have also to thank the Department of Public Works, the local branch of the U. S. Hydrographic Service, Mr. Ralph S. Hosmer, the Territorial Forester and Dr. H. L. Lyon of the H. S. P. A. Experimental Station for data besides much valuable information and assistance.

LIST OF TREE-SEEDS ADAPTABLE FOR PLANTING IN HAWAIIAN
FORESTS, WITH ESPECIAL ADAPTATION TO ALTITUDE,
CLIMATE AND SOIL CONDITIONS.

(Victoria, Kamerun, Africa)

African species adapted for the lower rain forest zone in
the Hawaiian Islands.

FAM. MYRISTICACEAE.

Coelocaryon Preussii.

Staudtia kamerunensis.

FAM. LEGUMINOSAE.

Cassia Mannii. (Lower forest zone, rain forest 1500 feet
elev.).

Azelia africana. (Lower forest zone, rain forest 1500 feet
elev.).

Erythrina excelsa. (Lower forest zone, rain forest 1500 feet
elev.).

FAM. GUTTIFERAE.

Mammea ebboro.

FAM. BURSERACEAE.

Canarium auriculatum.

FAM. LILIACEAE.

Dracaena kamerunensis.

Dracaena Deisteliana. (Elev. 4500-5000 feet).

FAM. RUTACEAE.

Clausena anisata. (Rain forest 2400-3000 feet).

FAM. EUPHORBIACEAE.

Macaranga Preussii.

Treculia africana.

FAM. ARALIACEAE.

Polyscias Preussii.

Schefflera Barteri. (1500 feet elev.).

Schefflera Mannii.

FAM. LEGUMINOSAE.

*Albizzia adiantophylla.**Erythrina lanata.***Sokode District, Togo, West Africa***Limonia Warneckei.**Diospyros mespiliformis.**Strophantus sarmentosus.**Strophantus hispidus.*} (Beautiful shade trees of the
lower rain forests used for re-
forestation).**German East Africa.****Amani, East Usambara. (2800 feet elev.)***Allanblackia Stuhlmannii.**Dracaena papahu.**Morinda asteroscepe.**Sapium Abyssinicum.*

Especially noteworthy are the following trees:

Anthocleista orientalis. (Native name *mbogo*).*Strombosia Scheffleri.*

FAM. LEGUMINOSAE.

*Schefflerodendron usambarense.**Englerodendron usambarense.**Pterocarpus Holtzii.**Milletia ferruginea.*

FAM. MELIANTHACEAE.

Bersama usambarensis.

FAM. EUPHORBIACEAE.

Crotogynopsis usambarica.

Cape Town, South Africa

The following trees are very common and form the major part of the forests of the table mountain.

FAM. OLEACEAE.

Olea laurifolia.

FAM. APOCYNACEAE.

Gonioma Kamassi.

FAM. CONIFERAE.

Podocarpus Thunbergii. (Common name Yellow wood).

Central American Trees of the Rain Forest Type.

Cuban rain forests.

Swietenia Mahagoni.

Cedrela odorata. (The Spanish Cedar. elev. 2000 feet).

Hibiscus elatus. (Dense rain forest).

Calophyllum calaba.

Ochroma lagopus.

Genipa americana.

Jamaica.

Dense tropical rain forests.

Ceiba pentandra—*Eriodendron anfractuosum.*

Podocarpus Urbanii. (Well adapted for the rain forests of the higher elevation).

Santo Domingo.

Guaiacum officinale. (Lignum vitae).

Zanthoxylum flavum or satin wood.

Porto Rico.

Coccoloba macrophylla. (2000 feet elev. rain forest).

Dacryodes hexandra. (Native name tabanuco tree one of the most common forest trees reproducing very freely, growing in the U. S. Luguillo Forest Reserve).

Bucida capitata.

Andira inermis.

Ternstroemia luguillensis.

Hura crepitans.

Mammea americana.

Orizaba, Mexico.*Quercus polymorpha.**Quercus tomentosa.**Quercus jalapensis.**Quercus calophylla.**Quercus galeottii.* (4000-5000 feet and higher).*Quercus germana.**Dendropanax arboreum.**Banara mexicana.**Platanus mexicanus.* (Along stream beds, 4000-5000 feet).**Yucatan.***Inga xylocarpa.* (Most common tropical rain forest tree).**Guatemalan Rain Forests.***Haematoxylon campechiana.**Liquidambar styraciflua.* (2400-5700 feet).*Perymenium Tuerckheimii.* (Native name *Taxico* tree, elev. 2100-5400 feet, in tropical and subtropical rain forests.

Mention may be made of the following trees which may be obtained from **Buitenzorg, Java.**

*Stercutia spectabilis.**Dysoxylum mollissimum.**Vitex timorensis.**Vitex leucoxylon.**Schizolobium excelsum.*

Of value for the Hawaiian forests may also be the introduction of some of the **Fijian Conifers.**

Dammara vitiensis. (Native name *Dakua* tree, adapted for the more mixed forest).*Podocarpus vitiensis.* (Native name *Kau solo*, one of the finest Conifers found on Viti Levu).*Dacrydium elatum.* (Native name *Leweninini*, a medium sized tree found in mixed forests; adapts itself to almost any environment. Found in Fiji from the sea shore to the highest peaks, (4000 ft.).

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