Forests
Instruction

File No. 1

MAUI FOREST PROJECT.

The lands which it is proposed to reforest lie on the north east slope of Mount Haleakala, on the Island of Maui, within the area bounded by 156° - 06' and 156° - 15' west longitude, and 20° - 46' and 20° - 55' north latitude. They extend from an elevation of 1000 feet up to 5000 feet above sea level.

From cliffs of varying heights at the seaside, this slope of the mountain rises on a ten to fifteen per cent grade until it reaches an altitude of four to five thousand feet, when by a much steeper grade it rises abruptly to the rim of the crater, 8000 to 10000 feet.

This face of the mountain is cut by innumerable gulches, which, in many places, unite in their lower portions to form formidable gorges. Thus this face of the mountain presents a series of sloping ridges separated by gulches of varying depths. Some of these ridges have broad tops, while others are more or less sharp, dropping off abruptly into a gulch on either side.

This slope of the mountain directly faces the north east trade winds which prevail for at least ten months of the year. During this time it is subject to heavy precipitation from the trade wind clouds. The annual rainfall varies in different parts of the area from 200 inches to 400 inches. The velocity of the trade wind is usually between ten and twenty miles per hour, but occasionally it reaches 35 miles per hour. The temperature within the area to be reforested is subject to very little variation at any one elevation, and throughout the entire area the maximum will not exceed 90° Fahrenheit, and the minimum will be not less than 45° Fahrenheit.

Until 1906 this area was covered by a heavy growth of trees, ferns, and climbing plants which formed a compact and almost impassable jungle. In this forest Metrosideros polymorpha Gaud. was the dominant tree, specimens of this tree comprising over half of the forest. Its more common tree associates were Eugenia sandwicensis Gray, Straussia mariniana Gray, Acacia koa Gray, Pisonia umbellifera Seem., and Byronia sandwicensis Endl.

The more common undershrubs and small tree forms were Cordyline terminalis Kunth., Broussaisia arguta Gaud., Clermontia macrocarpa Gaud., Perottetia sandwicensis Gray, and various species of Pelea Gray.

A straggling pandanaceous climber, Freycinetia arnotti Gaud., occurred in abundance throughout the forest, climbing to the top of nearly every tree, while its tangled woody branches formed a barrier beneath the trees through which one could force a passage only with great difficulty and after much use of knife or ax. Cibotium menziesii Hook. and C.chamissoi Kaulf. occurred frequently in well developed specimens, while Elaphoglossum gorgoneum (Klf) Brack. completely covered the forest floor in many places.

In 1906 this forest began to die out, all the trees and Freycinetia vines dying off as though affected by a rapidly spreading and quickly fatal disease. A very noticeable fact about the disease was that it spread rapidly along the broad topped ridges, but did not affect the vegetation on the steep Slopes of the adjacent gulches.

The death of the trees and vines was directly due to the killing of the roots which penetrated the soil to a depth of two inches or more. In areas recently affected, where the trees still looked healthy it was found, on uprooting the trees, that those roots which penetrated deeply into the soil had been killed back to the surface of the ground. Such as remained entirely within the first inch or two of soil were still alive and able to function. Of course no large roots could be restricted to this thin stratum. The tissue of the dead roots was colored a deep purple or bluish black. The color was quite characteristic, and always the same, no matter to what species of tree the roots belonged. If a fresh living trunk of a tree was buried in the soil its tissue would, in a very short time, be stained to the characteristic color.

The prevailing type of Metrosideros tree in this region is one with an abundance of stilt roots, i.e., instead of having the roots entirely buried in the soil, and a single trunk emanating from the ground, the trunk proper begins at some distance above the surface of the ground, and is supported by numerous stilt roots, which arch out like flying buttresses (see photograph). An examination of dying trees of this type showed invariably that the tissue of the stilt roots was alive and apparently healthy above ground, but entirely dead from the surface of the ground downward. Such shrubs and plants as are able to restrict their roots to the very top soil can grow here without serious trouble, but if they chance to root deeply their roots are sure to be killed. This was found to be true of such sturdy plants as Cordyline, Psidium, and Lantana.

A carefully conducted field and laboratory study demonstrated with absolute certainty that the death of the trees was not due to parasitic fungi or insects, while further investigations proved that the trees and vines died as the result of the killing of their roots by poisonous chemical compounds in the soil.

The soil of this district is formed, as it is throughout the Hawaiian Islands, by the disintegration of basaltic lavas rich in iron. The upper portion has the consistency of a fine sticky clay, while the deeper portion is much stiffer. The mechanical condition of the soil is such that it permits of very slow movement of water through its interstices. The soil is more or less acid, and when the deeper soil is exposed it liberates hydrogen sulphide to such a extent that its odor is very noticeable and the gas is readily detected chemically. This gas, itself a plant poison, has changed the ferric compounds of the soil to poisonous ferrous compounds.

The hydrogen sulphide and ferrous compounds are quickly oxidized into non-poisonous compounds when they come in contact with the air, and hence they are so changed in the upper inch or two of soil as to render a thin stratum habitable to the roots of various mesophytes. The well drained soil on the steeper slopes of the gulches is for like reasons kept sufficiently free from the harmful compounds to permit of the growth of the native trees.

A chemical analysis of a sample of soil taken from among dying trees is given below. This sample included the upper three inches of soil.

Analysis of Hydrochloric acid (1.115 sp. gr.) extract.

Insoluble matter	71.32
Potash	.48
Soluble silica	.78
Soda	.25
Lime	.04
Magnesia	.98
Manganese oxide	.02
Ferric oxide	1.48
Ferrous oxide	5.75
Alumina	5.70
Phosphorus pentoxide	.02
Sulphur trioxide	.00
Chlorine	.04
Volatile matter	12.54
	99.40
Nitrogen, moisture free	.292
Reaction, acid	

Of 28.08 parts of soluble matter it will be noticed that 5.75 parts are ferrous oxide; or in other words, 20% of the soluble matter in this soil is ferrous iron. The relatively enormous quantities in which this

plant poison occurs in the soil should absolutely prohibit the growth of any ordinary upland forest tree.

From such knowledge as we have been able to obtain of Hawaiian forests and forest trees it would seem that the majority of these trees require a well drained and well aerated soil, and when located in such a soil they delight in a moist atmosphere and heavy rainfall. The growth which native trees have made on the more recent lava flows of windward Hawaii is most remarkable, and testifies strongly to the correctness of this view. In this region the rainfall is very heavy, but the underground drainage is good, as evidenced by the absence of surface streams.

It would seem that at one time windward Maui must have presented ideal conditions for the growth of the native trees, but the gradual changes in the substratum have been constantly rendering it less suitable for their growth. The upper basaltic lavas have disintegrated to a fine grained soil, and under the constant soaking and leaching effects of a heavy rainfall, the interstices of the lower strata have become clogged with fine material, while there remains at the surface the washed-out impervious top soil that we have already noted.

There can be no circulation of air in this soil, since it is always saturated with water. The hydrogen sulphide liberated through the fermentation of the organic matter by bacteria reduces the abundant ferric compounds to ferrous compounds. The poisonous compounds have gradually increased in the soil until now the native upland trees are no longer able to maintain themselves upon it. Evidence has been deduced which shows that the trees of this forest have made no growth for many years past, and have, in reality, been slowly dying. The excessively moist atmosphere has enabled the trunks and leaves of the trees to remain green, although most of their roots were dead. The limit of their endurance having been passed, however, a disturbance of the ecological factors brought on the sudden and simultaneous death of all the trees of the region.

REFORESTATION.

The only possible way to correct the trouble and make the soil again suitable for the growth of the native trees is to drain it. This, of course, is entirely out of the question. The broad crests of the ridges are already veritable swamps so far as their soil and drainage are concerned, and it should be possible to build up on these a formation of plants adapted to swamp life and immune to its ills. Such a plant formation, to be effective, must consist of trees, shrubs, vines, ferns, and mosses. These islands are devoid of swamps, and the local flora offers no tree which can be of use in a swamp formation. It will therefore be necessary to obtain plants inhabiting swamps and lowlands in other countries. These will be carefully tested under the conditions prevailing on Maui, and it is hoped that we may, in this manner, secure suitable trees which will form a permanent part of a new forest.

(250—7/09.)

OFFICE OF
Government Analyst,
STRAITS SETTLEMENTS,

It is requested that the following number be quoted in reply to this letter.

No. ....

Singapore, 29. 3. , 1910.

Dear Ridley

Iron exists in solution as ferrous carbonate dissolved in excess of carbonic acid and I take it, that the bacteria in question simply cause the oxidation of the iron by precipitating it in the form of hydrated ferric oxide.

I do not think the data given in the paper is complete enough to enable me to arrive at a proper solution of the problem. It would have been much better to give the ferrous & ferric compounds, soluble & insoluble in rain water & not hydrochloric acid.

The sulphuretted hydrogen may be formed by the decomposition of the lava as well as by that of the vegetable matter, and if present in large amount would tend to keep the iron in the reduced condition, but the amount of this soluble would depend on the quantity of carbonic acid present.

The soil is said to be acid, which I suppose must be due to carbonic acid, as the analysis gives sulphuric - nil. but this I do not understand, considering the amount of SH_2 present. If sulphuric acid were present in even very small amount it would dissolve quite sufficient ferrous salts to poison most or all plants.

[illegible]

[illegible]