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REFORESTATION IN THE REPUBLIC OF HONDURAS CENTRAL AMERICA

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GENERAL CONSIDERATIONS

The present paper is a review of the reforestation operations of the United Fruit Company in northwestern Honduras, Central America.[2] This reforestation program was set up to establish, maintain, and utilize the products of selected areas on company lands which have been allocated to the growth of future saw timber. In line with this go many biological problems in nursery and planting practice, protection, soil and drainage relationships of tree species, and the development of silvicultural techniques and management practices for large areas of coastal plantations and natural stands of pine and hardwood in the interior. The program has also been concerned with the improvement of wood quality and growth rates in existing stands by the studied removal of inferior stock and with the economical and favorable utilization of wood products. The aim of this report is to summarize observations regarding silvicultural characteristics of plantation hardwoods and naturally regenerated pine stands gained during the course of this study. It is to be hoped that this might serve as a guide in future operations and prevent the duplication of field procedures which our experience has shown to be faulty.

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2 EDITOR'S NOTE

Although originally prepared for limited release, some 12 years ago, this report, covering the research activities of the United Fruit Company in the field of reforestation and forest management in Honduras, is so unique in its scope, even today, that the editors feel it should have much wider circulation.

The rational use of Honduras' great national resource, its forests, is still a valid issue and many efforts are being directed toward that goal.

Both the author and editor wish to express their sincere appreciation to the Research Department, United Fruit Company, New Orleans, U. S. A. for special permission granted to publish this work.

HISTORY

The early work of the United Fruit Company in Honduras in reforestation experiments was carried out at the Lancetilla Experiment Station near Tela. Seven species were planted here in 1927 including *Swietenia macrophylla, Swietenia mahagoni, Cedrela mexicana, Cedrela odorata, Tectona grandis, Pterocarpus indicus* and *Vitex parviflora*. These were in small plantings ranging from 0.4 to 0.8 acre in area and at present are more important from the standpoint of their growth rate than from any commercial value. From the outset this station has served as a center for plant introduction and distribution and some of the early experiments in nursery practice, propagation, and movement of planting material were worked out here. The groundwork was laid here for the larger plantings which were to follow later on the north coast.

In 1941 the earliest planned plantings of cedar and macuelizo were made at Tacamiche near La Lima. The following year larger plantings of teak and Burmese rosewood were put in at Zapote and Lancetilla. By the end of 1943, the timber tree acreage had reached 81.3 acres. It was during the period between January, 1943 and December, 1945 that the greatest strides in the development of reforestation techniques were made. Nursery practices were refined to a very satisfactory degree. Problems such as the prevention of insect and fungus attack, irrigation procedure, nursery planting from germination beds, and lifting and planting techniques were worked out. In addition to this, replications of field plantings were made in Lancetilla, San Alejo, and the La Lima area to study the soil and drainage requirements of the selected timber tree species. Improved methods of field planting were put into use and the timber tree acreage had risen to 1,724.7 acres by December, 1945. Most of the plantings were made in abandoned banana areas and were divided into three classes: 1. Pure stands; 2. mixed reforestation in which several species were planted in row-wise or group-wise mixtures; and 3. windbreaks and shelter plantings.

Pilot experiments indicated that the reforestation program warranted further expansion, and plantings in five new areas were made during the latter part of 1945 and during 1946. These areas were the Los Dragos tract in the upper Chamelecon valley, the Amapa and Agua Azul tracts near Lake Yojoa, and the Trincheras and Siguatepeque tracts in the interior highlands. Protection was started in this year by building fences and making firelanes around these properties. During the early part of 1947, labor barracks and administration quarters were built to house the personnel used for fire protection and the planting program which was set up to regenerate artificially the degraded broadleaf zones in these areas. These plantings were made as pure stands, with few exceptions, and the most generally used spacing was 30 x 15 feet, making a population of 97 trees per acre.

During the next two years the planting program was stepped up in all areas and by December, 1949, there were 10,134 acres in reforestation, windbreak, and firewood plantings. In addition, 4,810 acres were established as natural pine and hardwood reserves. At this point the planting program was slowed down to take stock of results and to begin gathering information on growth rates and management principles.

Little new planting was done in any of the projects between January, 1951, and December, 1953. A replanting program was carried out each year during the rains to fill in areas that had failed and all projects were given periodical cleanings during the season of greatest bush competition. The protected pine acreage increased considerably during this period by the addition of the Potosi property, in the upper Chamelecon valley, which has one common boundary with Los Dragos. At the end of 1953 there was a total of 10,514 acres in timber tree plantations and 14,524 acres of protected pine and hardwood forests, making a total of 25,038 acres under management in this program. Distribution by species and projects is outlined in Appendix I while in Appendix II are listed the scientific and the principal common names of the most important species planted in the course of this work in Honduras.

Role of the United Fruit Company in the Development of a Forest Policy

The reforestation program of the United Fruit Company is an important step in the stabilization of a sound national economy for a country such as Honduras which is primarily an agricultural region and in all probability will remain so for a long time to come. The production of food, clothing, and other cultural needs must come directly from the soil to be used in place of, or in the form of, some product that can be sold in world markets in exchange for such items. There are no large reserves of oil or industrial minerals as far as is now known. The establishment of a land-use program on a long-term basis must be built around the proper utilization of the soil cover for agriculture, grazing, and forest products.

The need for a forest economy was recognized 400 years ago in the heavily populated areas of Central and Western Europe. It was not recognized until about 1900 in the United States. In both cases there was no cause for alarm until the reserves were in danger of running out and then it was a long trail back to normal supply. This region has not reached that stage and it can be avoided by proper land use.

The utilization of forest products has been going on for about 200 years on the north coast of Honduras. The first small-scale cuttings here were made by British Honduras mahogany cutters after the accessible stands were cut out in their region. Large-scale mahogany logging was carried out in the Ulua-Chamelecon, Lean, Patuca, and Segovia valleys about 100 years ago. More recently, extensive operations were carried out in these regions with the appearance of the crawler-type tractor. Most of the accessible lowland forest has now been highgraded to the point that it is not producing many saleable products. On the other hand, there was hardly any market for pine timber in this region until about 1944. Since that time, with better road systems, accessible stands are being cut out rapidly. Aproximately 25,000,000 board feet of pine was cut in Honduras in 1951 of which about 10,000,000 board feet was exported.

It has been estimated that less than 25 per cent of the surface area of Honduras is suitable for agriculture and livestock. The remainder is made up of forest lands that have been mismanaged for generations by shifting rural farmers and those who graze livestock on the pine hills.

The outcome of this is the widespread occurrence of low-grade second growth hardwood forest following shifting agriculture and the sparsely stocked pine stands caused by overgrazing and annual burning to promote better forage plants. The carrying capacity of the pine hills is low and in all probability could perhaps better be utilized for the production of wood products.

The United Fruit Company occupies a unique position in the development of a forest policy in these regions. With increasing specialization in the banana industry, the company is giving more consideration to the classification of lands for bananas, livestock, miscellaneous crops, and finally, for forests. In this way, it has developed a land-use program that may well serve as a model to the people of the country. There is a pressing need that national as well as large private landholders be encouraged and induced to put their land to work to produce those items which are best suited to it. Such production should either enter into the domestic economy or be used as exchange items in outside markets.

The reforestation program is an attempt to put some of these land-use principles into operation. In addition to bringing back into full utilization over 25,000 acres of the surface area, it has been a means of livelihood for many coastal and rural families who are learning by doing. The company has the land at its disposal and the trained personnel and facilities for bringing such lands into full production of a saleable product. The complete possibilities for a dual managed forest-open range for livestock relationship have not been explored fully but offer a promising outlook.

In regard to present and future employment for native labor on these projects, there is good reason to believe that a well organized forest management program will continue to use a permanent labor force. During 1953, nearly 300 men were given employment in all of the reforestation projects throughout the division. During the experimental stage, there is a seasonal fluctuation in the labor needs, the peaks coming during the middle of the rainy season when replanting and cleaning crews are in the field at the same time and during the dry season when additional labor is needed to make firelanes and to serve as fire suppression crews. After these plantations and protected forests have become established, the labor trained in the ways of management, protection, and suppression will still be needed although requirements will decrease. It is difficult to estimate, in the light of changing methods and policy, the future labor needs when these stands reach maturity. In the large-scale mahogany operations of 100 years ago about 6,000 men were employed during each dry season in the Ulua-Chamelecon valley alone.

In all the projects now in operation, the overseers, watchmen, and laborers are provided suitable pine lumber living quarters. This encourages the development of a permanent trained labor force.

The monetary return from these crops will depend upon world markets and future policy at the time these stands reach maturity. Any prediction of timber prices 30 years hence would be pure guesswork but at least two of our major plantings, i. e., teak and mahogany, have been prized for centuries and the chances are very good that they will remain so.

ENVIRONMENTAL FACTORS

An excellent discussion of the factors shaping the biotic environment of Honduras has been made by Carr (3). Carr's subdivision of factors shaping the environment are discussed here in view of their relationship to the problem of reforestation. Regional differences will be discussed in individual projects.

Geographical Position

The selected forest areas under study are located in the northwestern quadrant of the Republic of Honduras. With the exception of the two Caribbean littoral plantations at San Alejo and Lancetilla, the whole area falls within the Ulua-Chamelecon drainage basin. These two rivers emerge from their locally restricted canyons near the towns of Pimienta and Chamelecon and flow separately to the sea across the great Sula plain. This valley, long famous in the banana industry, is roughly triangular in shape with its apex to the south 85 kilometers from the sea near the town of Rio Lindo and its base 34 kilometers in width, lying along the north coast. The areas under study range from 33 to 50 feet elevation at San Alejo and Lancetilla on the Caribbean coast to 3,500 to 4,000 feet at Siguatepeque and Trincheras in the interior highlands. Map I shows the geographical relationship of this region to North and South America and the Caribbean area. Map II shows the locations of the various projects in northwestern Honduras.

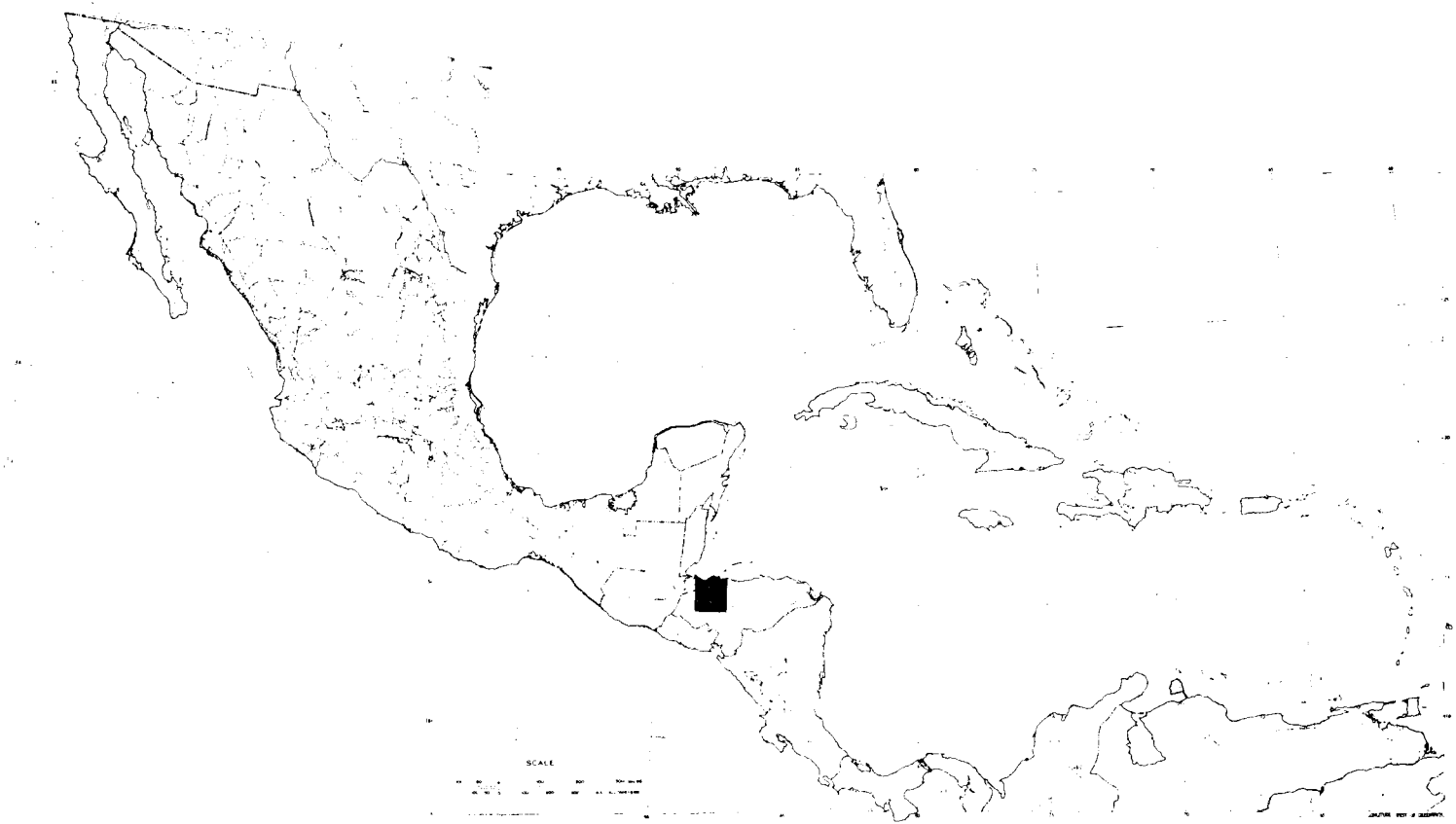
Physiography

The areas now being actively reforested include representative areas in two of the major topographic divisions of Honduras. These are the Caribbean lowlands and the interior highlands. The lowlands reach their greatest development in northern Honduras in the Ulua-Chamelecon valley and in the Department of Colon. They extend inland to some distance from the coastal plain to find expression in locally developed alluvial flood plains in low interior valleys.

The Ulua and Chamelecón rivers rise from a long and extensive drainage system in interior Honduras. Affluent streams flow over a wide variety of parent materials that are rich in nitrogen, phosphorus, and potassium. The resultant soils laid down in the lower Ulua-Chamelecon valley are some of the best banana soils known.

The interior highlands which relate to this study are comprised of the northern coastal range and the Sierra de Omoa-Espiritu Santo mountain massif which separates the Ulua drainage from that of the Motagua river in Guatemala.

The Yojoa basin is separated from the coastal lowlands by a series of eastwest trending volcanic mountains. This high basin forms a lake which drains to the south and by a circuitous route to the Ulua river. The northern and eastern shores are composed of volcanic materials consisting of lava flows, volcanic ejecta, and ash. The southern and western shores are composed mainly of limestone.



Map I - Shaded area represents geographical location of reforestation operations in Northwestern Honduras showing relationship with the United States, Caribbean area and South America

The timber tree plantations and natural forest tracts are widely scattered throughout the area. Soil variations will be discussed in connection with the individual projects.

One of the most important factors in the development of artificial stands in the lowlands is the species tolerance to drainage variables. Beard (2) has put forth the following drainage classification based on natural vegetation studies in Trinidad which seems to be admirably adapted to our local reforestation operations:

1. Drainage excessive - Completely tree internal drainage and external drainage strongly affected by steepness of slope. It is typical of shallow soils over highly fissured tabular limestone in Trinidad and is not actually represented in our projects. It is most closely related to the porous, highly permeable soils of the Los Dragos-Potosi pine hills.

2. Drainage free - Sands, loams, friable granular silts and some clays. High porosity and permeability and very low water table, soil drainage conditions being probably adequate to carry off the prevailing rainfall. This type is characteristic of the better plantation sites in the Ulua valley.

3. Drainage partially impeded - Loams, marly silts, marly clays, and sandy clays. Medium porosity and permeability through partial compaction, restricted perviousness of parent material or depressed topography. Intermittently high water table. Locally distributed in all projects. Much of the Amapa tract falls within this classification.

4. Drainage impeded - Heavy clays. Low porosity and permeability through compaction, restricted perviousness of topsoil or subsoil or depressed topography. Locally distributed in all projects and has been avoided where possible.

    a. No true water table. Heavy clays in which water penetration is never sufficient to promote a water table.

    b. Perennially high water table. Due to low relief and generally found in swamps and marine sand flats.

It is outside the scope of this study to attempt to delimit the natural vegetation zones in this region. The variations in climate, topography, permeability and retentivity of the soil, exposure, and past land use have all contributed to the physiography of the present vegetation. The limits imposed by these factors separately and collectively must necessarily enter into the treatment and management of the reforested areas. Listed below are the outstanding parent materials which underlie the study areas. The classification is modified from Carr (3) for local use.

1. Very old, probably pre-Permian metamorphic mica schists with granite outcrops in the Los Dragos-Potosi mountain pine region.

2. Pliocene volcanics.

a. Deep red clay soils derived from deeply weathered lava flows, ash deposits, and ejecta in the vicinity of Agua Azul. Pine is probably artifact and montane rain forest is climax.

b. Shallow soils developed on acid lavas and tuffs in the Trincheras and Siguatepeque pine region. *Pinus oocarpa* is dominant.

3. Recent valley soils derived from alluvial or colluvial deposits, found in the Ulua-Chamelecon valley, San Alejo-Tela plain, Los Dragos vega, Amapa valley, and the apparent old lake bed in the Siguatepeque valley.

Climate

In an area where reforestation operations are being considered, the local climate of the selected area and the effectiveness of rainfall are of primary importance in the initial planning. Plantations are so artificial that annual rainfall alone will not fulfill all of the requirements for success. In many cases, plantations are made in areas that have not evolved into, or have passed, the optimum stage for the development of the tree species introduced.

The climate of northwestern Honduras is classified according to rainfall and the seasons are appropriately divided into wet and dry periods. This monsoon climate, characterized by moderate to high rainfall followed by a period of high insolation, rapid evaporation, and a distinct reainless interval, can have totally different effects on newly abandoned land and on a high graded forest underlain by the same soils. The planting program must be gauged to the seasonal water availability with proper regard for the natural growth periods of the plants.

The rainfall regime follows a general pattern which exhibits local variations resulting from the influences of elevation, exposure, distance from the coast, and prevailing winds. The dry season may vary in duration and intensity from year to year but generally occurs from February to May. The early rains which can begin in late May and build up to a peak in June or July are mainly convectional and orographic with the former generally accompanied by thunder and lightning. Rainfall decreases in August or September and a rainless period during this interval is called *the canicula*. This is followed by the winter norther season from October to March which, augmented by orographic and convectional rain, produces more than half of the annual rainfall.

The winter northers are a conspicuous feature of the climate in this region. They can be expected at any time from October to February although conditions favoring their occurrence can last until March. Northers are accompanied by heavy rains, lowering temperatures, and gusty winds. Their intensity is abated somewhat as they progress inland from the coast. The greater part of winter rain from October to March is due to this phenomenon.

Another feature of the climate, although of infrequent occurrence, is the tropical hurricane. In 1935 and 1954, intense and widespread rainfall accompanying tropical disturbances caused two serious floods in northwestern Honduras.

Appendix III shows the monthly rainfall distribution by projects for 1953 and gives average rainfall figures for the years records have been kept in the various projects.

Four basic types of climate can be recognized on the basis of rainfall distribution in the areas where reforestation practices are in effect. They are:

1. Caribbean littoral — 90-130 inches annual rainfall.

   San Alejo with 89.25 inches and Lancetilla with 126.78 inches average annual rainfall; highest rainfall between October and January. The wettest month is November and driest May at Lancetilla; the wettest, October, and driest, February at San Alejo. Characterized by a high annual rainfall with more than half falling between October and January with relatively dry months from March to May.

2. Interior valley — 45-75 inches annual rainfall.

   This type of climate prevails in the La Lima area, Los Dragos, and the Amapa region. The Chamelecon valley which includes La Lima and Los Dragos has an annual rainfall near the low figure in this range with moderate rains in June and July, a short dry spell in August, and 35% of the total rainfall occurring between September and November. September is the wettest month and March or April the driest. The Amapa rainfall is close to the top of the range but the indurate soils of this area reduce the effectiveness of available rainfall. Over 60% of the rain falls between June and September but much of this is lost by runoff. Late winter rain is moderate and a rigorous dry season prevails between January and May.

3. Yojoa basin — over 100 inches annual rainfall.
   A separate category must be set up for this region due to a set of influences giving rise to a local climate distinct from that of contiguous areas. The region is characterized by an average rainfall annually of 105 inches for the period 1943-53. The climatic region is comprised of an interior lake basin, 24.000 acres in water surface area, located at 2,100 feet elevation. It is bounded on the east and west by high mountain ranges, to the south by smaller mountains, and is separated from the Ulua to the south by a string of low hills.

   Seventy per cent of the total rainfall occurs between May and September and is both orographic and convectional. September is the wettest month and the *canicula* is scarcely felt. There is moderate rain from October through December due to norther influence but on a much milder scale than in the coastal areas. The dry season extends from January to April with April being the driest month.

4. Interior highlands — 45-60 inches annual rainfall.
   Prevalent over most of interior Honduras. It occurs on leeward slopes and high interior valleys in the rain shadow of higher ranges. Topography and elevation affect the distribution and intensity of rainfall. The rains, mainly orographic in nature, begin in late May and continue until October,

often with a distinct *canicula* in July or early August. The rains decrease in November and a severe dry season prevails from December to April. Siguatepeque, Trincheras, and the Potosi pine hills area fall within this classification.

BROADLEAF PLANTATIONS — REGIONAL

General

The development of timber tree plantations in northwestern Honduras came about as the result of the impact of the war years on timber demands. Company owned lands which were available were either marginal or unsuited for banana agriculture and other economic crops or were located so far away from the north coast transportation facilities that they were not utilized. Such lands had been acquired in earlier purchases with fertile lowland properties. Until this program was started, they had supported only subsistence agriculture, high grade logging, and forest grazing. The reforestation program was the first permanent, organized attempt to produce a saleable crop on these lands.

From the outset, the organization and administration of this program was carried out by the Research department of the United Fruit Company. At the height of the program, properties were being developed at 1, Siguatepeque and Trincheras in the interior highlands; 2, Agua Azul, Amapa, La Lima, and Los Dragos-Potosi in the interior valley and lake region; and 3, San Alejo and Lancetilla on the coast. The first group was sold at the end of December, 1953, the second placed under the administration of the Cortes division in La Lima at the end of 1954, and the third placed under the administration of the Tela division earlier in 1954.

For the sake of completeness in this report, all of the above projects will be considered as one program as of December, 1953. For location of general area and projects discussed in the following section, refer to Maps I and II.

Coastal Lowlands

Lancetilla Reforestation Project

This project has been administered jointly with the Lancetilla Experiment Station which has been the propagation center and proving ground for plant introductions, fruit trees, ornamental and economic plants, and timber trees.

Lancetilla has a littoral climate characterized by a high rainfall which is relatively well distributed throughout the year with a mild dry season from March to May. Elevation at the headquarters area is between 50 and 60 feet and the property extends up the hillsides on both sides of the valley to an elevation of 400-500 feet.

A wide variety of soil and drainage conditions is found within the limits of this station, hence its importance as an experimental planting area for timber trees.

In the various arboretums of this station, 132 native and exotic tree species, including 42 species of *Eucalyptus*, have been planted in collections. Of these, 30 species have been planted on a plantation or field trial basis.

There are 801 acres of land devoted to timber tree plantings in Lancetilla. Honduras mahogany is by far the most important species with a total of 421 acres, the greater part of which is planted in lanes in low second growth on hillsides. Other important plantings are: cedar, 84 acres; Honduras rosewood, 38 acres; Burmese rosewood, 31 acres; primavera, 31 acres; ciruelillo, 29 acres; frijolillo, 27 acres; teak, 23 acres; and *Eucalyptus* spp; 15 acres. The remaining acreage is made up of experimental plantings on various sites to study species preferences in soils and drainage.

San Alejo Reforestation Project

San Alejo resembles Lancetilla in its littoral climate, moderately high rainfall, and relatively mild dry season. All of the plantations have been put in on flat land ranging from 30-50 feet elevations.

The soils in this area vary from sandy loams and sandy clay loams to red clay patches and sand belts. In general, timber trees been planted on land that was unsuitable for African oil palm. Topography is of the depressed, low relief type and the water table is often quite high during the rainy season. Superficial drainage is performed by numerous creek systems but there is a lag in runoff after periods of heavy rain.

The most important feature of this project is the large planting of teak. This species now occupies 2,158 acres of which the major part, about 1,900 acres, is (in 1955) 5½ years of age. The remainder is about evenly divided between 8 to 9 year old stands and several experimental age classes on different sites.

Other important timber plantings in this project are: Honduras mahogany, 998 acres; primavera, 164 acres; Burmese rosewood, 116 acres; frijolillo, 115 acres; cedar, 69 acres; Honduras rosewood, 67 acres; ciruelillo, 59 acres; West Indian mahogany, 28 acres; and *Eucalyptus* spp., 12 acres.

Aside from the teak and eucalyptus, most of the plantings before 1949 were established in lanes through rather heavy bush. This led to intense competition for root room and light and generally poor growth ensued. These underplantings have been released gradually during the past 5 years and better growth conditions have now developed.

Of all species planted in San Alejo, primavera has exhibited the poorest development. In some places, it has been planted on soils heavier than its optimum range. However, the seasonally high water table and acid soils may account for the failure of this species to develop normally on a variety of planting sites.

The largest single block of teak is located on the southern edge of the property nearest the hills. Soils in this block are generally of the lighter textured series and internal drainage is fair to good. Surface drainage from the many small creeks that cross the plantation is ample to carry off most

of the water during the season of heaviest rains. In any plantation of this size, however, some poorly drained spots are bound to exist and San Alejo is by no means an exception. Such spots are easily apparent from the air in flight over this project and generally occur at stream junctions or at the point where several small creeks come together in a depressed area to make up a larger stream. Waterlogged areas have not been replanted after the initial loss and acreage has been made up in more favorable parts.

Interior Valley

Los Dragos-Potosi Reforestation Project

In recent years, these two projects have been combined for convenience in administration. The pine hill region in Los Dragos and all of Potosi have been managed from the outset for natural regeneration of pine which will be discussed in another section of this report.

The Los Dragos broadleaf plantings are located on a strip of alluvial land between the hills and the Chamelecon river. The property is crossed by the Carretera del Occidente and the headquarters are located about 74 kilometers west of La Lima in the Department of Santa Barbara.

This area falls in the dry interior valley climatic group with an average rainfall of 45-50 inches per year. There is an intense dry season and evaporation rates are high.

The soils range from light sandy and silt loam soils on the lower *vegas* to heavy clays on the higher and oldest third terrace level of the river.

The Los Dragos plantations comprise 557 acres of which the most important are: primavera, 174 acres; Honduras mahogany, 138 acres; cedar, 109 acres; frijolillo, 37 acres; ciruelillo, 33 acres; and teak, 9 acres. The remainder is made up of experimental plantings.

Primavera has exhibited excellent growth rates in this project. Apparently the Chamelecón valley is an optimum habitat for the species for it is found growing wild as a pioneer on abandoned lands throughout the region. Cedar which has been planted on the sandier soils has developed slowly. This is due to borer damage and to flood damage at the higher river stages. Mahogany has been planted on the areas of heavier soils and, discounting borer damage, is developing at a satisfactory rate.

La Lima Reforestation Project

The widely scattered small-scale plantings in the vicinity of La Lima have been experimental in nature. The purpose of these plantings was to fulfill the need for a nearby source of plantation material for studies in propagation, planting sites, soil and drainage. Experiments in spacing, pruning, and management have been set up in this area.

Amapa Reforestation Project

This property contains 5,500 acres of practically level land at about 300 feet elevation which was derived from old alluvial or colluvial material. Average rainfall is over 70 inches per year but its effectiveness is decreased due to a long dry season, high evaporation rates, and indurate soils.

The area was formerly covered with degraded high forest and local areas of second growth from which the valuable timber had been removed. There are several areas of swamp land and the region is drained by Río Chiquito, Río Blanco, Río Amapa, and several small creeks. In general the soils are quite heavy with the exception of some areas of well drained sandy loams along the larger streams and some areas of volcanic stone in the northeastern section of the tract.

This project has 3,475 acres of the better land in timber plantations. The largest portion, 2,179 acres, is in Honduras mahogany. Primavera is next in importance with 903 acres. Smaller acreages are in teak, 173; cedar, 160; and frijolillo, 28. The remaining part is devoted to small experimental plantings.

Tree growth on the locally restricted areas of well drained sandy loam has been exceptionally good for primavera, cedar, and teak. Some of the best teak growth rates and tree form in Honduras plantings have been recorded in an 11 acre planting in this tract. Most of the heavy soil areas have been planted to mahogany and in spite of its slow growth due to the ravages of the shoot borer and leaf defoliator, it is the tree most ideally suited to the widespread areas of heavy soils in this tract.

The original planting in Amapa was begun as a lane planting in lines cut through the high second growth or degraded forest. Growth was slow and mortality was high due to shade and root competition. During the past six years this overwood has been gradually reduced and the plantation is now characterized by an underplanting protected by a widely spaced high shelterwood. Aside from the poorly drained sections which have been avoided, there have been two problem areas in this property. One of these has been a stand of native bamboo, *Guadua* sp., which has been difficult to eradicate or control by hand methods. It is recommended that such areas should not be underplanted if it can be avoided. The second problem area has been an almost pure stand of caulote, *Guazuma ulmifolia*, interspersed with Panama berry, *Muntingia calabura*. These two species form a low permanent shade which is more harmful to developing plantations than the moving high shade of large forest trees. Caulote has the remarkable ability to withstand girdling operations and many trees have been observed to recover. Clear felling of such areas is perhaps the cheapest procedure in the long run if some use can be found for the wood.

Interior Highlands

Siguatepeque and Trincheras Projects

Siguatepeque Agricultural Station was located on the outskirts of the town of Siguatepeque, in a small valley in the interior highlands, in the Department of Comayagua. The area has about 45 inches of annual rainfall and is at 3,560 feet elevation. The primary purpose of the station was the development and demonstration of improved agricultural methods in this remote dry interior valley with poor heavy clay soils. Part of the property still had a small stand of pine and this was set up as a farm woodlot demonstration to show the favorable results of fire protection on natural regeneration. Introduction of temperate zone fruit and nut trees and selected timber species as a rule gave better results than lowland tropical timber trees planted at this elevation on poor soils. Some of the best introductions have been several species of eucalyptus which have thrived in this parsimonious environment. Given below are the most promising species:

Eucalyptus tereticornis
Eucalyptus hemiphloia
Eucalyptus maidenii
Eucalyptus paniculatus
Eucalyptus botryoides
Eucalyptus polyanthemus
Eucalyptus robusta
Eucalyptus pilularis

Other promising introductions are:

Araucaria Bidwilii
Araucaria angustifolia
Cupressus Lindleyi
Araucaria excelsa
Cupressus macrocarpa
Chamaecyparis Lawsoniana

The Trincheras project of 194 acres is located on the main highway to Tegucigalpa, 14 kilometers north of Siguatepeque. Annual rainfall is approximately the same as at Siguatepeque and the area lies at 3,900 feet elevation.

This area was set up along the highway as a demonstration plot to show the beneficial results of fire protection.

Soils in this area are very thin and are found overlying tuffs and acid lavas. Results of pine regeneration will be discussed in another section.

Yojoa Basin

Agua Azul Reforestation Project

The Agua Azul property comprising about 7,000 acres is divided into three blocks: A, B, and Cienego. The first two are traversed by the Interoceanic Highway on the northeast shore of the lake. The area is characterized by a high annual rainfall with lower evaporation rates than the interior valleys to the north. The property lies between 2,000 and 3,000 feet in elevation.

The soil cover is a deeply weathered red volcanic soil, rather heavy in texture but possessing good surface drainage. The medium to strong acid soils show no indication of a lack of nitrogen or phosphorus but there is a deficiency of potassium, magnesium, and calcium. The values for free aluminum are high while those of free iron are low, indicating a point in the decomposition of tropical soils affected by high rainfall which has not yet become true laterite.

The land is rolling on the south slope toward Lake Yojoa in blocks A and B but steep and badly broken on the north slope in the Cienego block. The south slope formerly had a heavy stand of pine with a ground cover of grass and bracken fern on the ridges and physiologically dry exposed parts. The concave slopes and seepage areas between ridges support a luxurious broadleaf vegetation. The north slope is comprised almost entirely of high broadleaf evergreen forest with an understory of palmiche palm, *Euterpe sp.*

There are 3,836 acres of managed forest in this project: 1,045 acres of pine reserve; 1,655 acres of protected hardwood forest; and 1,136 acres of timber plantations. The plantations are comprised of 736 acres of Honduras mahogany, 191 acres of primavera, 106 acres of Spanish cedar, 45 acres of Guatemala cypress, 19 acres of *Eucalyptus* spp., and the remainder in noncommercial experimental plantings.

Most of the mahogany was underplanted in Cienego while other broadleaf species were planted on concave slopes of the more humid sites in lots A and B. Tree growth by north coast standards is poor due in part to poorer soil but also as a result of the intense competition from the fibrous root system of palmiche palm and fast growing bush. The incidence of shoot borer attack has also been extremely high.

FOREST TREE PROPAGATION AND PLANTING PROCEDURE

Selection of Site

The selection of a site for a permanent timber tree propagation center in any new land development is of utmost importance. It is worthy of considerable planning in advance because once the headquarters have been established and the propagation phase under way, the forces of seasonal time limits, cleaning operations, and fire suppression measures leave no time for a move to a better location. On the basis of experience gained during the developmental phase of this program, some of the primary requisites in the location of a headquarters camp are:

1. Accessibility to all-weather highways. The majority of the projects are located in the interior away from the north coast transportation facilities and labor centers. The amount of materials necessary to put in motion a 3,500-acre planting project is very great and all materials have to be hauled in by truck. Construction of an access road from the highway to the site is more economical in the long run if the chosen site fulfills all the other requisites.

2. Location near permanent water supply. Irrigation, cooking, washing, and drinking water must be available. Where possible, a suitable stream has been utilized. From the beginning, Los Dragos and Agua Azul have been supplied by a well since no natural water supply was at hand.

3. Fertile agricultural soil has always been an important criterion in the selection of a propagation center. The timing of the entire planting program is dependent upon the productivity of the nursery area and characteristically this has been located on the best soil available. Where possible, alluvial silt loam and clay loam soils have been utilized in areas that are free from flood damage and easy to drain. In the past, very little fertilization has been carried out in these flood plain soils although nurseries in continuous use for three years have been built up with nitrogen applications.

4. The availability of extra labor during the fluctuating seasonal demands must be considered. The labor force is more than doubled during the early part of the rains and again during the dry season. It is uneconomical to maintain a large crew during the slack season and a nearby source of labor is very important.

5. Location of the propagation headquarters near the center of the project will facilitate the future planting and management operation in the area.

Administration and Personnel

From the beginning, the organization and administration of the reforestation program was carried out by the director of research and his staff. Direct contact with the overseer or foreman of the individual projects was made through the assistant director and the superintendent of new crops.

The project overseer or foreman in most cases was a man trained in plant propagation work at Lancetilla, San Alejo, or La Lima. He was responsible for selection and training of a labor force for his particular project. In the initial phase, experienced labor from the banana plantation centers built the houses and installed the irrigation systems in the nurseries.

Seed Collection

Over fifty species of timber trees have been planted experimentally in the project but of these only fifteen have sufficient acreage to be considered commercial plantings. The most important species with which we are concerned are Honduras mahogany, *Swietenia macrophylla;* teak, *Tectona grandis;* primavera, *Tabebuia Donnell Smithii;* and Spanish cedar, *Cedrela mexicana.* Other less important species are Honduras rosewood, *Dalbergia cubilquitsensis;* frijolillo, *Pseudosamanea guachepele;* Burmese rosewood, *Pterocarpus indicus;* and ciruelillo, *Astronium graveolens.*

From the outset the Lancetilla Experimental Station has been a reliable source of forest tree seed. The first plantations were established here and the administrative personnel of this station have trained a highly efficient group

of native seed collectors. Permanent records have been kept on flowering and fruiting dates of all economic, ornamental, and plantation timbers as well as major native timber species found in the surrounding valley. The major portion of the teak seed used in the large-scale teak planting in the Ulua valley came from teak trees planted at Lancetilla in 1927. It is fortunate indeed that the initial seed trees were of good quality. Beard (1) has pointed out the importance of race in teak and has shown that the original Trinidad plantations were derived from seed of good growth form Burma teak from the moister regions. The first teak seed planted in Honduras came from plantations in Trinidad and the plantation material shows the deep red purple on the flush leaves which is characteristic of Burma teak.

Teak flowers during the rainy season and seedfall occurs during the early part of the dry season in February or March. Seed collection is normally done in a cleaned area at the base of the trees for economical reasons. This has the added advantage that the calyx and a part of the fuzzy coating of the seed has decayed before the seeds are ready for use. Storage is simple and seeds can be stored in sacks in any dry warehouse from one seed fall period to the next planting season. Teak retains a high percentage of viability stored in this manner.

In the early phases of this program mahogany seed was obtained from the Lancetilla valley in Honduras, the Caribbean lowland in Nicaragua, and the Pacific and Caribbean coast of Guatemala. In the later phase, most of the material came from the lower and middle Comayagua river valley in north central Honduras. With the exception of the Lancetilla material, all seeds were collected behind logging operations and it can be presumed that the seeds came from fair to excellent phenotypic parents. One disadvantage of collecting berind logging operations is that it is often delayed too long after felling. Seeds in partially opened pods lying on the ground are subject to fungus attack and penetration by borers.

A quick field check for good seed, although not altogether foolproof, is the external appearance of the individual seeds. They should be free of insect holes and possess a burnished copper luster on the seed coat and wings, free of discolorations. They should be firm to the touch, not spongy or mushy, and the seed coat must be brittle in texture. The seed should be firm and pale creamy white at the center, shading to a barely discernible pale green nearest the seed coat.

Storage of mahogany seed is much more difficult than teak. It is subject to dry rot and a great decrease in viability percentage if stored in sacks from one seed season to the next. Some degree of success has been achieved by storing selected seeds in 10-gallon demijohns sealed with paraffin. When storage facilities were available, some of these demijohns were kept in refrigerated banana ripening rooms at 68-70° F. and in this way it was possible to carry small amounts of selected seed through to the following season. This is very important in mahogany propagation since seedfall occurs later than the optimum period for beginning propagation operations for the coming season. Seed collected in February and March must be held in sealed containers until the end of October before beginning propagation of material for the coming year. In this way 6 to 8-month-old planting stock is ready at the beginning of the rains in late May or early June of the following year.

Cedar seed matures toward the end of the dry season in April or May and is best collected from the tree or immediately after felling operations. The capsule dehisces rapidly after becoming mature and a few critical warm dry days at this period can mean the difference between a sufficient seed supply and a bagful of empty capsules. Extraction is accomplished by drying on hardware cloth elevated above metal screen. Storage is much the same as for mahogany and here again there is a need for holding the seed to fit in with the timing of the planting season.

Primavera flowers in the middle of the dry season, generally in March and at the latest in April. The fruit matures early in the rainy season in June or July. The fruit consists of a long pod-like capsule sometimes a foot in length and ½ inch in diameter. The pods are sun dried until the seeds can be shaken out.

Table 1 contains data concerning the collection and handling of tree seed.

TABLE 1

Collection and Handling of Seed

Species	Collection Period	Approx. No. Seed/Lb.	Collection Method	Drying	Viability Period
Australian Pine	Feb.-May. Sept.-Nov.	96,000	Fruiting branches	Sun	1 yr.
Burmese rosewood	Nov.-Dec.	1,600	Under tree	Sun	1-2 yr.
Calan	Late April -early May		Fruiting branches	Sun	9-12 mos.
Cassia Siamea	Mar.-Apr.	16,000	Fruiting branches	Sun	1-2yr.
Ciruelillo	Mar.-Apr.	20,000 w/impurities	Fruiting branches	Sun	6-9 mos.
Eucalyptus spp.	All year	25,000 800,000	Fruiting branches	Half shade	Varies by species
Frijolillo	Mar.-May.	23,000	Fruiting branches	Sun	1-2yr.
Guatemala cypress	Mar.-May.	41,600	Fruiting branches	Sun	1-2 yr.
* Honduras mahogany	Feb.-Mar.	700-900	Logging operations	Sun	1 yr.
Honduras rosewood	May.-June	26,600	Fruiting branches	Sun	1-2 yr.
Laurel	May.-June		Fruiting branches	Sun	6-9 mos.
* Macuelizo	May.-June		Fruiting branches	Sun	6 mos.
Mora	August		Fruiting branches	Sun	1-2 yrs.
Pinus spp.	Mar.-Apr.	14,000-35,000	Logging operations	Cover in sun	1 yr.
* Primavera	May.-June	70,000	Fruiting branches	Half shade	6-9 mos.
* Spanish cedar	Mar.-Apr.	80,000	Fruiting branches	Sun	6-9 mos.
Teak	Jan.-Apr.	320w/ calyx 400 without	Under tree	Sun	2-3 yrs.

*** For long storage periods seeds must be kept in sealed bottles.**

Propagation Methods

In the course of propagation work with many different tree species it has been necessary to make use of several methods to fulfill the germination requirements of the individual species. Below are outlined three methods used in former propagation work:

1. *Soil germination beds*: This is a cheap method when large numbers of seedlings are needed. Beds must be located on light well drained soil and are best used with large heavy-seeded species that produce sardy, vigorous seedlings. Such seedlings are tolerant of open sunlight from germination onwards. These beds are prepared by turning the soil under, breaking it up, and leveling with rakes. Beds range from 4 to 6 feet in width to facilitate weeding and the spoil material from the small runoll runoff drains tween beds is added to the bed to elevate it for better drainage. Seed is sown and is then covered with a light topping of 60% sand and 40% loam. Formerly these beds were covered with temporary shade but this practice has been abandoned in recent years due to increased costs and retardation of germination and seedling vigor. This method has been elaborated during the past few years to reduce root damage at lifting time and has the added advantage that it can be used on heavy soil areas. In a temporary arrangement, beds are laid out in the open near the area selected for the transplant nursery. A frame of logs 6 to 7 inches in diameter is staked in place on the ground surface forming a bed 4 to 6 feet wide and of a convenient length. A walkway is left between frames. The enclosed space is then filled in with a 1:1 mixture of loam and sand and leveled off with rakes to the top edges of the logs. The seedbed is then ready for sowing. It has been found better to use several small beds with various sowing dates so that the transplant material reaches optimum planting size at staggered intervals. This has worked exceptionally well with teak and mahogany. Teak seeds are broadcast thickly in the bed which is then leveled until the seeds are well imbedded in the surface. They are then covered with about 1/4 inch of river sand applied through a wood frame shaker-sifter. Mahogany seed is stuck into the bed surface in rows 2 to 4 inches apart with the broken wing edge extending upwards, then covered with sand as above.

2. *Sand beds*: This method is most useful for large quantities of seedlings of species susceptible to damping off. The beds are prepared by side boarding or soil banking the required area of well drained ground and filling in with screened and washed medium-sized river sand to a depth of 4 to 6 inches. Temporary shade is erected and beds are watered twice weekly. Shading and watering must be carefully controlled to eliminate the damping off of young seedlings. Damping off has been controlled to a satisfactory degree in such beds by drenching the soil with a 1% formaldehyde solution and covering it with sacks for 2 to 3 days several days before planting. For larger beds, soil treatments with Dithane before and after sowing have been very effective in reducing losses. This type of bed has been used satisfactorily for germinating Australian pine, native

pine, primavera, laurel (*Cordia colliodora*), and many other species having delicate seedlings. The light shade used in this method serves to reduce rain beating and sun scald.

3. *Flats*: This method is used only when a small sample of seeds is to be germinated or if a small valuable seed collection needs special care. Boxes are constructed from 1/2 x 4-inch rough lumber, the most convenient size for subsequent handling being 20 x 14 x 4 inches. Two 6-inch widths of lumber are nailed lengthwise across the bottom of each box, leaving sufficient space on both sides and in the center to allow adequate drainage. Inside each box is placed a layer of semi-decayed leaves which is covered by a layer of small stones. The box is then filled to a depth of 3 inches with sandy loam or clay loam soil. Flats can be sterilized in the same manner as sand beds. Seed is then sprinkled over the soil and lightly covered with screened and washed sand applied with a shaker-sifter. Boxes are then placed on benches in potting shed and watered as required until the young seedlings are ready for hardening off prior to transplanting to nurseries or pots. Good results have been obtained in the reduction of losses from damping off by spraying seedlings and soil once a week with a 5-5-50 Bordeaux mixture.

Transplanting to Nursery

The majority of the timber species which have been discussed here can be successfully transplanted with bare roots or balled in earth. Other plants, especially *Eucalyptus* spp., must be transferred to tarpaper pots from which they can later be transplanted in the field without disturbing the root system. These are available in two sizes: No. 1 small, 100 to carton, 6 inches in diameter, 6 inches tall, and No. 2 large, 50 to carton, 6 inches in diameter, 10 inches tall. When these are not available they can be made with an improvised cutting jig to cut the tarpaper to dimension and then stapled.

Teak and mahogany seedlings are moved with the cotyledons still attached. Teak is best transplanted in the four-leaf stage at 1 to 3 inches in height. Mahogany is transplanted at 3 to 4 inches in height while the shoot leaves are still small. It is advantageous with all species to transplant to nursery before crowding produces spindly, suppressed seedlings. The seedlings are lifted with a wooden spatula and placed in trays and carried to the nursery for transplanting. Care should be taken while moving the small plants to insure that the roots are not damaged or exposed to full sun but are protected by a piece of moistened burlap or other suitable material.

Table 2 gives the propagation characteristics of the most important timber species.

TABLE 2

Propagation Characteristics of Timber Tree Species

Species	Germination Method	Transplant Size	Move to	Field Planting Age	Field Planting Size	Field Planting Method
* Australian pine	Soil beds	2-3"	Nursery	6-8mo.	10-12"	Balled
Burmese rosewood	Soil beds	3-4"	,,	6-8mo.	5-6'	Leaf prune bare root
Calan	Flats	3-4"	,,	8-10mo.	18-24"	Leaf prune bare root
Cassia	Soil beds	3-4"	,,	6-9mo.	3-4"	Stumps
Siamea						
Ciruelillo	Flats	3-4"	,,	8-10mo.	2-3'	Leaf prune bare root
Eucalyptus	Flats	1-2"	Pots	4-6mo.	1'	Pots
Frijolillo	Soil beds	3-4"	Nursery	8-10mo.	2-3'	Leaf prune bare root
* Guatemala cypress	Flats	2-3"	Pots	8-10mo.	1'	Pots
Honduras mahogany	Soil beds	3-4"	Nursery	8-10mo.	3-4'	Leaf prune bare root
Honduras rosewood	Soil beds	3-4"	,,	8-10mo.	3-4'	Leaf prune bare root
Laurel	Flats	3-4"	,,	6-9mo.	2-3'	Leaf prune bare root
Macuelizo	Flats	3-4"	,,	8-10mo.	2-3'	Leaf prune bare root
Mora	Soil beds	3-4"	,,	8-10mo.	12-18"	Leaf prune bare root
* **Pinus** spp.	Sand beds	2-3"	,,	15-18mo.	12-15"	Balled
Primavera	Sand beds	2"	,,	8-10mo.	3-4'	Stump
Spanish cedar	Sand beds	3-4"	,,	8-10mo.	3-4'	Leaf prune bare root
Teak	Soil beds	2-3"	,,	6-8mo.	4-5'	Stumps

*** Where small quantities are required it is advisable to use pots.**

Honduras mahogany, Spanish cedar, teak, and primavera are transplanted in the nursery at 18 x 18 inches for more rapid development. Other species with less luxuriant growth are transplanted at 12 x 12-inch spacing.

Nursery Methods

To set up a large-scale permanent nursery in a new area requires time and it should be organized in a way that will fit into the annual planting schedule.

The nursery should be located on an area of good surface drainage near a permanent water supply, utilizing the best soil available. The loam soils in Honduras have produced excellent nursery stock with a minimum of fertilization.

If the area selected is in forest or second growth, it should be cleared and stumped to determine the best natural drainage. The area should be disc-harrowed and the primary drainage and irrigation system put in. Since a great deal of the nursery work is done during the dry season to fit in with field planting schedules during the rains, some form of irrigation is necessary. Good results have been obtained using a 6 hp., 95 gpm. Fairbanks-Morse

engine and water pump. A pump of this size can maintain irrigation cycles in 5 to 8 acres of nursery containing material of varying ages with varying water requirements. This pump has a 3-inch intake and 2-inch outlet main line. Pipe laterals 1 1/4 inches in diameter take off from the main with risers on 3/4-inch sublaterals at a spacing of 60 feet square. Use of laterals and sublaterals is designed according to the size of the area to be cultivated. This is the maximum spacing with which complete water coverage can be obtained using the large size Rainbird sprinklers on 3 to 3 foot risers. Moderl No. 40, 3/4-inch male connection, full circle, with nozzles 9/32 x 7/32 inch, has worked out very well. Only one sprinkler per lateral is used at one time. If the pump is located 400 feet or less from the end of the main, as many as 6 sprinklers can be operated at once.

Nursery beds are laid out so that they will not interfere with irrigation line repair and movement. These beds are generally made 12 x 60 feet with four beds between irrigation laterals. Beds are soil banked and elevated slightly by break-up and addition of spoil from shallow drains. Walkways are left between beds and at the head of each bed to facilitate sprinkler moves.

The beds after being leveled with rakes are ready for planting. A simple lining procedure which most native laborers can use has worked very successfully here. In this system, the two outer rows in each bed are marked with cord stretched the length of the bed. This serves as a guide for the planting board on which the cross bed planting distance is marked by saw cuts. Three men plant in each bed with the outer two men keeping correct spacing between moves. The spacing generally used has been 12 x 12 inches in the nursery. Large-leaf, luxurious-growth seedlings such as teak and primavera should be planted at 18 x 18 inches to insure a greater percentage of robust plants and avoid a residue of spindly cull plants. A greater percentage of usable plants reduces nursery costs.

Nursery maintenance, after the initial planting and prompt replanting of failures has been completed, involves proper care in watering and keeping the nursery free of competing weeds. In order to keep stock growing vigorously during the dry season, the nursery must be irrigated regularly. Cycles may be reduced considerably in May so that the tender flush growth will harden up before planting time.

It has been found that 6 to 8-month-old nursery stock is at the optimum stage for field planting for most species. The best time for field planting is shortly before the beginning of the rains which in Honduras is in late May or early June. This means that nursery layout and seedling propagation should be commenced no later than October in order to meet the planting schedule for the following year. This allows good planting weather for transplanting from seedbed to nursery and a favorable period for establishment in the field before the dry season begins.

Field Planting

This is by far the most important phase and one in which the greatest amount of supervision is necessary. Land preparation is the first step in this operation. In degraded cut-over areas and second growth following subsistence

agriculture, the land is prepared by cutting lanes 30 feet apart through the planting area. In the north coast plantations, the spacing generally used has been 30 x 15 feet. This spacing, which makes up a population of 97 trees per acre, is wider than that generally used in plantation establishment elsewhere. Here an attempt has been made to use the second growth as side pressure and avoid costly precommercial thinnings from which there is no saleable product.

The opened lanes are lined with planting stakes at 15-foot intervals in lines as straight as field conditions permit to facilitate finding the plants in subsequent cleanings. Planting holes are dug in advance to speed up the actual planting.

Lifting procedures vary with species but the operation is most conveniently separated into these two categories:

1. *Stump plants*: This method, known as the "root and shoot" method by Indian foresters, has been used very successfully with teak and primavera in Honduras. Several days before planting, the required amount of selected stock, 3 to 5 feet tall, having a hard woody stem at least 3/4 inch in diameter at the base, is cut back to a 4-inch stump. This is daily operation as the planting progresses and care should be exercised to move the stump before the first buds appear. Lifting is done with straight shovels (our experience has been that straight shovels do a better planting job and are preferred by the labor). Some root pruning is done at lifting and broken or bruised roots are pruned off. The roots are then dipped in an aqueous clay solution to put a protective layer on the roots and to prevent desiccation during the trip to the field. The stumps are wrapped in moist burlap or other suitable material, 25 to 50 to a bundle.

2. *Leaf pruned plants*: This method has been used successfully with the majority of the remaining timber trees that can be planted in the field with bare roots. One day before lifting time, the nursery is selectively graded for hardy, vigorous plants, 36 to 48 inches tall, 1/2 to 3/4 inch in diameter at the base, with as few flush leaves as possible, and a slowly growing bud. These plants are leaf pruned, seldom leaving more than 1/2 of the innermost leaf attached to the stem to help reduce transpiration. A tuft of young leaves is left at the top to protect the bud. Root pruning occurs with lifting and damaged roots are trimmed off. The roots are dipped in an aqueous clay solution and plants are then wrapped in damp burlap in bundles of 25 to 50. Most of the mahogany, cedar, rosewood, and ciruelillo has been planted in this manner with good results.

The actual planting in the field is carried out by experienced planting crews taken from the permanent labor force. It is hardly possible to have too much supervision at this time. Careful planting is the key to the success of the whole operation and disregard for the simple rules is most often the cause of plantation failure. Some of the mistakes most often repeated in field planting are:

1. Allowing plant roots to dry out by exposure to the sun.
2. Doubling of tap root and laterals by trying to force plants into undersized holes.

3. Failure to tamp earth firmly around the root system after plant has been placed in hole. Most leaning plants are caused by this and many plants die during dry spells due to loose planting.

4. Planting at improper depth, either too deep or too shallow.

5. Careless handling causing breakage of the tender bud in transport of leaf pruned plants.

Plantation Maintenance

The maintenance of broadleaf plantations in the lowlands falls into two developmental phases during the first ten years after establishment: Cleaning and pruning.

Cleaning begins a few weeks after planting and is continued until the plantation has developed sufficient height and crown closure to enable it to utilize the surface area to the best advantage. Cleaning includes weeding in the early stage, vine removal, and release from competing vegetation between lanes until the crown closes. The length of time this treatment continues depends upon growth conditions for different species and the spacing of the initial planting. Broadleaf plantations in Honduras have been established at wider spacings than are normally used in temperate regions or with tropical reforestation programs elsewhere. The majority of the field plantings have been put in at 30 x 15 feet. The relative merits of close and wide spacing in this area had to be weighed in the light of economic feasibility. Close spacing produces better formed trees with the ultimate production of more clear timber but periodic thinnings are necessary which make close spacing more costly in the initial stages. It seems probable that few if any Latin American governments or private enterprises will be able to reforest large areas by the use of closely spaced plantations. The prohibitive costs of establishing worthwhile acreages at close spacing from which there are no immediate proceeds from sale of thinnings would preclude this method. The wide spacing in Honduras is an attempt to reduce the cost of establishment and to use the bush between lanes to produce the side competition which is normally afforded by close planting. Some pruning will be necessary in this system but it will be repaid many times over. It is still felt that further study of optimum planting distances is necessary to suit the variety of conditions in the tropics.

Given below are some generalized cost figures for plantation establishment from the beginning of this program until the end of 1953 in the interior projects. Cost for establishment of new plantings on the north coast would now be about double the figures given below and about 35% more in the interior due to wage increases given during 1954. These figures compare costs in the generally used 6 x 6-foot spacing and our field planting distance of 30 x 15 feet. It can be seen that savings in the wider spacing fully justify a small investment in pruning to produce trees of better quality.

Costs per Acre

	1210 plants/acre 6 x 6' spacing	97 plants/acre 30 x 15' spacing
Land preparation	$ 10.00	$ 6.00
Unit cost in nursery @ .06 cts	72.60	5.82
Unit cost in planting @ .02 cts	24.20	1.94
Cleaning, 1st yr., 3 cycles	12.00	6.00
Nursery cost, 2nd yr.	20.00	2.00
Replanting, 2nd yr.	8.00	1.50
Cleaning, 2nd yr., 3 cycles	12.00	6.00
Nursery costs, 3rd yr.	15.00	1.20
Replanting, 3rd yr.	2.00	.40
Cleaning, 3rd yr., 3 cycles	6.00	6.00
Nursery costs, 4th yr.	....	.40
Replanting costs, 4th yr.	....	.25
Cleaning, 4th yr., 3 cycles	....	4.50
Cleaning, 5th yr., 2 cycles	....	3.00
Cleaning, 6th yr., 2 cycles	....	2.00
Cleaning, 7th yr., 2 cycles	....	2.00
Pruning, 4th through 7th yr.	....	25.00
2 precommercial thinnings	20.00	....
T O T A L	$ 201.80	$ 74.01

Pruning is absolutely necessary for maintenance in the plantings where wide spacing has been used to avoid thinnings. In addition to the effects of planting distance, both Spanish cedar and Honduras mahogany are subject to recurrent attacks of the shoot borer, *Hypsipyla grandella*, Zeller. To date, this has been the greatest problem in cedar and mahogany silviculture and neither close spacing nor shelterwood planting has solved this problem here. Pruning has improved tree form and fortunately both species respond very favorably to treatment. Healing is rapid and clean and a definite improvement in tree form can be seen a year after treatment. Treatment should begin as early as possible and should be continued until the desired clear length is obtained. Teak responds the least favorably of any species due to the formation of callus tissue in wound area and susceptibility to heart rot infection from the wound.

Ladders have been needed to achieve the desired height of clear pruning and have proved more effective and economical than long pole saws which leave a ragged wound surface. The lightest and strongest ladders which we have used have been made of 2 x 3-inch laurel (*Cordia alliodora*) lumber with hard pine rungs. The upper rung is bound with burlap to prevent injury to the tree and a short section of rope is attached at one end of this rung to throw a hitch around the tree when sawing is begun. Forming-up pruning is begun as soon as possible in plantations of mahogany and cedar since these two species are so badly hit by the borer in the first three or four years of life. Treatments can be given from the ground at this stage using hand pruning saws and the Meylan saw which is a pole saw attached to an axe handle. Early pruning tends to force height growth and reduce the growth output to the best leader.

Some general rules for pruning which will hold for all species are given below.

1. Where possible, pruning should be done during the early part of the dry season when the trees are out of leaf or in a slow growing period. Wet season pruning has a tendecy to force suckers or water sprouts.

2. Pruning should be done with saws. Harvesting knives or machetes leave a ragged wound which is slow to heal and invites termite and fungus attack.

3. All pruned surfaces should be painted with outside damp-proof paint.

4. Cuts should be made as close to the main trunk as possible and should not leave a stub projecting from the general outline of the bole.

5. Limbs should be lopped off 15 to 18 inches from the trunk with a machete before saw cut is begun to prevent splitting out.

6. Large limbs should be undercut with a saw for about one third of the distance before the main cut is started at the top.

7. Multiple stems should be reduced to the straightest and most vigorous leader.

8. Forked trunks should be reduced to one stem, taking into consideration the leaf surface requirements of the tree.

9. An appraisal of the best potential tree form is the criterion in pruning. The live crown of the tree should be at least 35-40% of the total height.

10. It is better to underprune than overprune. Most trees cannot be formed up in one operation; a follow-up for one or more years will be necessary.

Pruning Recommendationes for Major Plantation Species.

Honduras Mahogany and Spanish Cedar

These two species may be discussed jointly because of the similarity in growth rates and insect damage during the first three or four years of development. The new growth flushes in both trees are attacked continuously by borers throughout the growing season and few if any terminal leaders survive these attacks. The lateral branches take over and these in turn are attacked by succeeding generations of larvae. At two years of age, the trees are 8 to 12 feet in height and 2 to 2 1/2 inches in diameter and have such a witches'-broom appearance that it is difficult to look upon them as timber trees. The initial improvement should be started at this time by a reduction of the number of multiple stems at the same time that routine cleaning is done. This should be duplicated the third year at cleaning time and a definite pruning program should be set up during the dry season of the fourth through seventh years to remove coarse side branches.

Teak

Pruning is of minor importance in the management of teak due to its inherent good growth form and freedom from insect enemies. As a matter of fact, some of the early plantings of teak were damaged due to overpruning which produced whippy stems that were extremely susceptible to wind bending and the subsequent development of negatively geotropic shoots from the upper side of the leaning stem. Pruning wounds heal slowly with a heavy callus formation that is very often the origin of later sprout growth. A high degree of heart rot infection has also been observed to originate from pruning wounds on teak.

Primavera

During the first few months of its life, a primavera seedling develops a straight stem with a dominant terminal leader. At the sapling stage between 6 and 12 feet in height, the terminal leader loses dominance and height growth is faster in the opposed pair of branchlets that develop below the bud. One of these paired leader generally achieves dominance over its twin but at the expense of tree form in the competition for growing space. This biological aspect of growth form is repeated at each new flush period and the consequent product of this double leader competition, in the late sapling or early pole stage, is a stem that is undulating or ziz-zag in outline. Pruning can be advantageous in the developmental phase of these stands in that it can accelerate the biological processes by removing one of the competing leaders before too much distortion has occurred. Moreover, quite often dominance is achieved twice in succeeding growth flushes on the same side of the stem and this produces a bow or curvature in the bole. Early and careful selection of the desired leader can produce well shaped stems in open grown plantings.

Laurel and Frijolillo

There are no pruning problems connected with these species. Some pruning is desirable to speed up the natural process which is relatively slow in open plantings.

Burmese Rosewood, Ciruelillo, Honduras Rosewood, and Mora

These four species are grouped together due to their common possession of poor growth form and coarse branching habits. To date no close spacing experiments have been carried out with any of these species but if it is ever desirable to make commercial plantings of them in all probability it will have to be established at the minimum spacing. Tree form in existing plantings has been improved considerably by pruning but the operation is costly in comparison to the potential return from these timbers.

SILVICULTURAL CHARACTERISTICS OF PLANTATION SPECIES

In past years many differential characteristics of species adaptability to plantation methods have been met in the field. It is felt that an appraisal of these features will be useful in future operations. Published results of plantation practice throughout the Caribbean area resemble in many ways the operations in this region. This is the first attempt, however, to collate the results of artificial reforestation on the north coast of Honduras.

The species discussed will be treated in order of decreasing acreage. In this way we can indicate our appraisal of the importance of each species to our program as well as the time and effort expended in its establishment.

Swietenia macrophylla King

Honduras Mahogany, Caoba

Local Distribution and Adaptability

Honduras mahogany has been the most widely used species in this operation. To date there are 4,570 acres planted in all projects. It has been planted on a wide variety of sites on soils ranging from almost pure sand to heavy clays, rainfall areas ranging between 40 and 140 inches annually, and at elevations between 30 and 3,500 feet. Only on the heavy clay at Siguatepeque, at an elevation of 3,500 feet in the interior highlands, can it be considered a failure and here it is obviously outside its optimum habitat. It is represented in the plantations by age classes as follows:

Group	Date Planted	Age	Acreage
1	1927	27 yrs.	0.4
2	1946-1947	8-9 yrs.	643.0
3	1948-1950	5-7 yrs.	3,803.0
4	1951-1953	2-4 yrs.	123.6
TOTAL ACREAGE			4,570.0

Silvicultural Characteristics

Light

We have come to look upon mahogany as a very intolerant species and for normal development in the field it must have plenty of overhead light. It has been planted in every degree of light and shade intensity grading from individual trees planted in the open to lane planting in heavily shaded tunnels in high bush. The best results have been obtained in low second growth 4 to 5 years after abandonment by *milpa* agriculture after the soils have had an opportunity to renew organic matter and nutrients. Too little cover results in poorly formed trees and overshading produces spindly, unthrifty trees that are unable to cope with vines, pests, and diseases.

A high moving shade of widely spaced dominants in the old overstory has been found to help reduce vine and weed competition without seriously retarding growth rate in young plantings. The shade from tall trees can be reduced considerably by cutting the ground attachments of all climbing vines, thereby allowing more light to enter after the vines die.

Diseases and Pests

Shoot borer: To date the biggest pest in mahogany silviculture has been the moth, *Hypsipyla grandella* Zell. Larvae of this insect make feeding tunnels in the stems of tender flush growth of species of the family Meliaceae. Mahogany, cedar, and introduced African varieties of *Khaya* and *Entandrophragma* belong to this family.

As the larva develops, the entire length of the new growth is hollowed out and the new shoot generally dies. In the course of the growing season virtually every new shoot that develops is attacked. Fortunately mahogany is seldom killed outright from this damage and puts out new growth. The result is a very bushy, unkempt sapling with very poor form.

It has been reported by Nelson-Smith (7) that shelterwood plantings reduce borer damage. We have yet to find conclusive proof that this is true in Honduras. Borer damage is complete and widespread regardless of whether the tree is located in the open or in heavy shade. Furthermore, borer attacks in shaded sites are accompanied by attacks of a leaf defoliator. The end result in such humid habitants is a plant with all new shoots damaged and a type of gummosis developing in the wounds. All new leaf surface, with the exception of the veins, is removed by the defoliator and the plant is in a state of stagnation from which it frequently does not revive.

Control of the borer by spraying or other conventional methods is impractical on a large scale. Tests are still in progress to determine the best silvicultural methods to counteract the injurious attacks of this pest. Our experience has been that mahogany grown in full overhead sunlight is much more vigorous and better able to withstand insect attacks.

It is noteworthy that exotic members of the family Meliaceae are attacked much less frequently than native species. Successful introductions with a minimum of borer attacks have been observed with:

Khaya nyassica	*Khaya ivorensis*
Cedrela toona	*Entandrophragma cederi*

As far as field records indicate, *Entandrophragma* has never been attacked. Curiously enough, this parallels results with East African mahoganies. Eggeling (4) reports that *Entandrophragma* was seemingly immune while *Khaya* was susceptible to borer attacks.

Leaf defoliator: A mahogany defoliator classified as *Egchireter nominus* Dyar is mentioned as attacking mahogany seedlings in British Honduras in the Annual Report of the Forest Trust of British Honduras for 1927. It was also reported by Nelson-Smith (7).

An unidentified defoliator, presumably the same one or closely related to it, has been abundant in some of our plantations. The attacks are seasonal and occur during the rainy period when new flush growth appears. The greatest damage is done in underplanted woodland for this insect is apparently confined to the humid forest understory and avoids the drier second growth habitats.

Attacks are coincident with those of the borer and the effects of both pests cause the loss of an entire season's growth. At Amapa, where damage was most critical, the attacks decreased perceptibly after underbrushing and felling operations which opened up the plantation to more sunlight.

Leaf cutter ant: This insect can be particularly troublesome at the time of new land planting. It strips the leaves off the young plants at a time when they can ill afford setbacks.

Control measures on colonies with carbon bisulfide, sodium cyanide, and chlordane have been standard operating procedure. The most spectacular results were obtained by the use of methyl bromide cartridges inserted into tunnels on metal poles with a spring activated cartridge-breaker on the end. One treatment has been observed to kill entire colonies and even the most difficult cases have usually been destroyed after the second treatment.

Soils and Drainage

Mahogany is the least exacting of the species studied with regard to soils and drainage. It has been planted in every soil type from sand to heavy clay; it can survive inundation during high flood stages; and it has been planted successfully in poorly drained areas where other species have failed.

As a rule, mahogany has done better in the littoral plantations at San Alejo and Lancetilla and interior valleys near the coast such as La Lima. Growth has been slow at Los Dragos and Amapa and the poorest development is at Agua Azul.

As would be expected, mahogany has done best on the well drained alluvial loams that are widespread in this valley. Development is particularly slow on the heavy soils that develop deep surface cracks during the dry season.

Cultural Practices

Due to the long period needed for mahogany to close its canopy, cleaning operations are somewhat longer than with most other species. Vines and competing bush in opened-up areas become such a problem that regular cleanings are necessary during each growing season for the first 6 years.

Pruning is generally carried out during the fourth, fifth, and sixth years after planting. This must be handled carefully because mahogany is very susceptible to epicormic shoot development. The entire stem during the first 7 to 8 years is closely spaced with dormant epicormic buds. This phenomenon is most pronounced while the bark on the sapling is still smooth. After fissures and oblong plates characterize the bark surface between 8 and 10 years of age, the tendency for epicorm development is negligible. Proper manipulation of shade and slow reduction of coarse branches is necessary to prevent excess formation of these sprouts.

There is a great need for further study in spacing requirements for this species. This would perhaps best be done as a combination of various spacings supplemented by pruning of potential crop trees. In the initial phase, between planting and 4 years of age, the closest planting, i. e., 6 x 6 feet, looks most promising.

Field experience indicates that the maximum spacing for mahogany on better soils should be about 15 feet with an optimum planting distance of 10 to 12 feet on average sites. This procedure, supplemented by judicious pruning, can produce well stocked stands with acceptable form in 8 to 10 years.

Tectona grandis L.
Teak, Teca

Local Distribution and Adaptability

The area of planted teak in Honduras totals 2,368.2 acres, concentrated at San Alejo with 2,158.5 acres. Some of the older experimental plantings are located at Lancetilla and La Lima and a commercial planting of 173.4 acres at Amapa. Field trial plots have been put in at Los Dragos and Agua Azul. The ease with which this species is propagated and its comparative freedom from disease and insect pests has made it one of our most promising timber trees. It is represented in the plantations by the following age classes:

Group	Age	Acreage
6	28 yrs.	0.7
1	11-13yrs.	27.5
2	8-9 yrs.	223.0
3	5 1/4 yrs.	1,900.0
4	2-3 yrs.	150.0
5	All ages (experimental)	67.0
TOTAL ACREAGE		2,368.2

Silvicultural Characteristics

The silvicultural characteristics of plantation teak in Honduras are at present the subject of a long-term study at San Alejo by Mr. Thomas Schubert who holds a United Fruit Company Fellowship in Tropical Forestry and is carrying out his research problem under the direction of the Harvard Forest of Harvard University.

Light

Teak is a strong light demander and our plantations are on cleared land. We have followed the practice used in India and Trinidad of preparing the land by felling and burning. There have been no attempts to put the "taungya" system into effect in this area. This system entails the renting out of government or privately owned land to native farmers. The land is used for two years for the production of subsistence crops. At the end of this period, the native farmers plant teak at prescribed distances in payment for their use of the land.

Diseases and Pests

To date there have been no disease problems with teak in Honduras and insect pests have caused very little damage. At Los Dragos there was one infestation by a lepidopterous larva stem borer which at maturity is 3 to 4 inches long but it was quickly controlled. This larva apparently develops from the egg deposited at some point of injury on the stem. Such injuries could be pruning wounds or machete cuts in which case entry would be made into the pith which would then be hollowed out back to the main stem. The caterpillar tunnels large holes 3/8 to 1/2 inch in diameter into the heart of the trees. Chaff from the tunnel is spun into a hard cup-shaped cap which covers the entrance hole, is visible for some distance, and is easily removed. The hole may be probed with a flexible wire and treated with insecticide. This caterpillar has also been found attacking a native species of *Vitex*, a member of the teak family, in the vicinity of the Los Dragos plantings.

The greatest pest problem in teak plantation development at San Alejo has been the pocket gopher. This rodent has caused recurrent damage by its selection of teak roots for food during the first three year after planting. Many plants are killed outright by the removal of the feeder root system and others are so seriously weakened that they are easily windthrown. The most serious attacks are concentrated on light friable soils and are seasonal due to the local restriction of the gopher population to the higher well drained area during the rainy season.

Control measures including trapping, poisoning, and digging have kept attacks from ruining the plantations. The local gopher hunters have become surprisingly adept at killing these animals as they bring soil to the surface.

Natural enemies also appear to be a factor in control. We have found weasels and snakes in the gopher tunnels. After three years of age, teak seems able to withstand gopher attacks and mortality drops off sharply after this point.

Soils and Drainage

Our experience has been that teak needs a well drained soil for best development. It has not done well on the red clay hills in San Alejo and Agua Azul or in the poorly drained areas at San Alejo. It has prospered on sites close to streams where the subsoil has been gravelly with good interior drainage.

Generally speaking, teak has done well in Honduras with the exception of plantings on very heavy soils and sites with depressed topography.

Cultural Practices

Our stump-and-root method of planting teak has made it necessary to prune soon after establishment to reduce sprout growth to one good leader. This is generally done in the first growing season after field planting although at times it may be necessary again during the second year.

A varying percentage of plants in the field will become deformed while the plantation is becoming established. Most growth deformities arise from animal injury or vine growth. Deformed trees should be cut back to a 4 inch stump as early as possible to force new sprout growth. A close check during the first two years will eliminate many potentially defective trees and yet maintain the even age character of the stand.

Some pruning will be necessary but it must be carried out very carefully. Teak does not heal rapidly or evenly and there is danger of heart rot infection. Necessary pruning should be done while the limbs are still small, preferably during the dry season of the year. A good preservative paint should be used on pruning wounds.

Marshall (6) recommends the encouragement of an evergreen understory in line with procedure in Indian plantations. The San Alejo plantings have developed a dense woody and herbaceous undergrowth five years after planting. On the light clay soil areas in the northeastern part of the tract, a fairly dense stand of Panama berry, *Muntingia calabura,* afforded good side pressure while the young trees were developing. This species has now been replaced by mahao, *Hibiscus tiliaceous;* balsa, *Ochroma limonensis;* and guaruma, *Cecropia hondurensis* which are growing faster than teak. Some release cutting has been necessary during the past growing season.

There have been no studies made of teak planted in mixture with other species. Teak growth rate is so far ahead of most other plantation species that we have never considered mixed plantings worthwhile.

Spacing experiments at 6. 8, 10, 12, and 15 feet have been put in at San Alejo and at 6 and 10 feet at Lancetilla. Preliminary studies indicate that the first thinnings in 6 x 6 foot spacing should be done before trees reach 5 years of age in Honduras. Growth rate of teak is faster here than in its native habitat. Excessive competition results in a high percentage of spindly trees during the fourth year. Some wind throw following improvement fellings in 3-year old stands at this spacing has pointed out the need for further study in thinning procedure.

Tabebuia Donnell-Smithii Rose

Blond Mahogany, Primavera, San Juan, Palo Blanco

Local Distribution and Adaptability

Primavera is the third most important timber tree under study. It grows naturally throughout the middle and upper reaches of the Ulua and Chamelecon river valleys. It thrives in the drier interior valley habitats and is abundant as a roadside or pasture tree in the Quimistan valley and the Amapa area. This species is more exacting in its site preference than mahogany and is not a common tree in the littoral zone or in the montane forests of the interior. It has been planted in all projects but the best results have been obtained at Los Dragos, La Lima, Amapa, and on sandy soils at Lancetilla. There are now 1,465 acres planted with primavera, represented in the plantations by the following age classes:

Group	Age	Acreage
1	8-9 yrs.	245
2	5-7 yrs.	1,220
TOTAL ACREAGE		1,465

Silvicultural Characteristics

Light

The habit of primavera to reseed on abandoned land, roadsides, and other disturbed areas indicates its preference for light. Seedlings are rarely found in high forest unless an opening has been formed in the canopy. Extremely rapid growth in open sunlight further indicates primavera's preference for this type of environment. Under the light shade afforded by guanacaste (*Enterolobium cycolcarpum* (Jacq.) (Griseb.) primavera can eventually become part of the canopy. In heavy shade primavera is suppressed by more shade tolerant neighboring species and seldom becomes a well formed tree.

Diseases and Pests

There have been no diseases or pests serious enough to warrant concern for this species.

Soils and Drainage

Primavera is one of the most exacting timber species studied in its soil and drainage requirements. For best growth primavera requires a light well drained soil in an area of medium rainfall. It has been planted in areas with rainfall ranging from 45 to 150 inches annually but the best growth occurs in the low rainfall areas. There is some indication that this species does better on alkaline than on acid soils.

Primavera has been a failure in poorly drained areas with impermeable subsoils and on clay and heavy clay soils. Light clay soils with natural surface drainage have produced some good stands.

Mortality from damping off is high in germination beds unless proper precautions have been taken. Field plantings are good indicators of site preference. If soil and drainage requirements are not completely fulfilled, high mortality occurs during the first year. Survivors are whippy, rachitic plants that never achieve vigorous growth. The best procedure in such areas is to replant with other species.

Cultural Practices

Aside from pruning during the first four years, primavera requires only a fraction of the maintenance that mahogany demands.

On good sites in open sunlight, primavera achieves dominance over competing bush species within two years. Woodland plantings require a longer period of cleaning and release from over-topping trees each year. Underplantings do not appreciably improve growth form. More often distortion is caused by trees growing in the direction of light openings in the canopy.

Close spacings at 6 x 6 feet and 7 1/2 x 7 1/2 feet have been made at La Lima and Lancetilla. There is some indication that the lateral branching habit of primavera is little affected by close spacing during the early years.

Cedrela mexicana Roem
Spanish Cedar, Cedro

Local Distribution and Adaptability

Spanish cedar has been planted on 596 acres and is represented in the plantations by the following age classes:

Group	Age	Acreage
1	27 yrs.	0.5
2	8-11 yrs.	157.0
3	5-6 yrs.	438.5
TOTAL ACREAGE		596.0

Silvicultural Characteristics

Light

Spanish cedar is considered to be intolerant of shade. It must have plenty of overhead light for optimum growth. One of the first phases of improvement before any planting was done was the liberation of cedar volunteers in the Los Dragos and Amapa projects. The response was marked and released trees have increased their diameter at an average of about 1 inch per year.

Once cedar is established it can survive rather intense competition from bush with a low percentage of mortality. Growth form and vigor are seriously retarded and best results have been obtained in plantations open to overhead sunlight.

Pests

Cedar, like mahogany, is subject to recurrent attacks by the shoot borer, *Hypsiphyla grandella* Zell. This insect has caused such poor form in cedar plantings that the species has not been planted extensively.

Another pest which has contributed to the loss of growth in cedar has been the mealy bug. Damage began in the nursery and continued after field planting. Often the attack became so severe in the early part of the dry season that young trees stagnated and remained in this condition until the new leaf growth of the following growing season. The most serious attack of this insect occurred at Agua Azul.

Soils and Drainage

Spanish cedar does best in Honduras on a moderately rich, well drained, light clay to clay loam soil. It has exhibited good growth on light clay soils on hillsides in high rainfall areas.

Growth on sands and fine sandy loams has been slower due to excessive dryness. Many failures have been observed on heavy clays and in depreseed areas with poor surface drainage.

Cedar is more exacting than mahogany but less so than primavera in its soil and drainage requirements. In general, cedar can be planted on a wider range of sites in low rainfall areas than can mahogany due to the ability of cedar to withstand drought better.

Cultural Practices

Cedar resembles mahogany in the long maintenance period and high pruning costs. The need for cleaning can continue for a longer period than for mahogany on the heavier texture soils due to the slow growth rate of cedar.

Pseudosamanea guachepele (H. B. K.) Harms

Frijolillo

Local Distribution and Adaptability

The most extensive field trial plantings of this species were made before 1948. There are now 245 acres in the 7-9 year age class. It was considered one of the better native secondary woods and many experimental plantings were made to study site preferences.

The ability of frijolillo to grow fairly well on the most adverse sites had led to its use as a fill-in on dry, rocky, or poor soil areas which were considered unfavorable for the major species.

Frijolillo is most abundant in the dry deciduous forests of the interior valleys at low elevations. It ranges inland by way of the water courses and often is found in the foothill areas as a gallery forest tree.

Silvicultural Characteristics

Frijolillo is intolerant of shade and is most often found as a roadside or pasture tree. It is resistant to drought and ground fires. Some of the most adverse rocky and exposed sites have been seeded naturally by this species in the Chamelecon valley. It apparently thrives best in the drier zones but where it has been planted in heavy rainfall areas it has done better on sandy or gravelly soils.

Open grown trees are generally of poor form and short merchantable length but where this tree has grown up in abandonments with sufficient side pressure it has developed an excellent bole form.

Plantation maintenance is relatively simple and inexpensive in the dry zones. Periodical cleanings are necessary to remove vines and competing bush for two years after which it is able to keep pace with surrounding bush. In the wetter zones, the luxurious growth of its competitors slows its development.

Some pruning is necessary during the first four years. This tree forms a light canopy and self pruning is slow. The limbs are widely spaced on the stem and relatively few pruning cycles can produce the desired clear lengths. Wounds heal rapidly and cleanly and there has been no indication of heart rot infection.

Frijolillo has not been attacked by any serious diseases or pests. Leaf cutter ants may cause some retardation of growth in the early years.

Dalbergia cubilquitzensis (D-Sm.) Pittier

Rosewood, Granadillo, Rosul, Junera

Local Distribution and Adaptability

The Honduras species is distinct from Honduras rosewood, *Dalbergia Stevensonii* Stand., which is found in British Honduras and is already established in the trade. Rosewood or granadillo as it is commonly known in Honduras is most abundant in the moist lowland tropical forests. It is found in the low interior valleys along streams and can extend into the foothill areas by way of the gallery forests.

There are about 202 acres in small-sized plantings distributed through the projects as field trial site studies. There is no definite age class since small plantings were made each year until 1951.

Silvicultural Characteristics

Rosewood is more tolerant of shade than the species previously discussed. It is frequently found as seedlings or saplings in old second growth or high forest. In mixed plantations it can support rather intense competition and suppression from primavera, cedar, and frijolillo and finally becomes a part of the canopy.

The best growth in rosewood is observed in moist alluvial soils of medium to heavy texture. In high rainfall areas, good growth has taken place on residual clay soils on hillsides.

The species can survive in poorly drained areas where waterlogging occurs. For this reason it has been planted on depressed topography and on heavier soils in high rainfall zones where most other species have failed.

Despite the ability of rosewood to utilize unfavorable sites, there is one main objection to its widespread use. It has an exceedingly poor growth form in plantations. Trees are consistently crooked or leaning, have many branches, and pruning wounds heal slowly. Leaning trees in the open frequently develop vertical sprouts along the upper surface of the inclined stem.

Pruning costs are high and the sale value of the timber is not high enough to return profits.

If the acreage of this species should be expanded, the following recommendations should be considered. First, rosewood should be planted under a light shelterwood. Second, the most favorable spacing would be 6 to 8 feet with the maximum not exceeding 10 to 12 feet. Due to the sprouting habit of this species, it could probably be planted faster and cheaper by "stump" plants.

Pterocarpus indicus Willd.

Burmese rosewood, Narra

Narra, or Burmese rosewood as it is known on the Honduras north coast, is an exotic that was planted on a wide variety of sites during the early part of this program. It is a native of the Philippines and the Malay peninsula where it is used as a cabinet wood (5).

There are 171 acres of the species in small-sized plantings in coastal and interior projects. It has done best in the moist tropical lowlands with high rainfall. In such areas there are cases where this tree has grown 2 inches in diameter per year during the first 10 year of life.

Narra will grow on the heaviest soils and can stand considerable periods of inundation by standing water on the lighter soils. Stake plantings of limbs or cuttings in swampy areas have rooted and prospered where all other live fence post species have failed. It has been widely planted on poorly drained areas for this reason.

Narra has a poor growth form in plantations due to its coarse and extensive branching habit. It does not prune itself well and lateral branches grow vigorously and soon become tree trunks in themselves. Some small-scale experimental pruning operations were carried out for a short time and then abandoned because of excessive costs.

This species is not looked upon here as a potential lumber producer. Due to the high volume production, it has been used as firewood and the wood is accepted gladly by native laborers. It has also been used experimentally for cacao shade but repeated thinning and pruning are necessary to maintain proper shade relations.

Cassia Siamea Lam.
No common name is used here.

This is another exotic, native to Ceylon, India, Burma, and Malaya. It was planted on a small scale during the early part of the program but since has been widely planted as a firewood species to be cut on a short rotation.

It will grow on a wide variety of soils including the heavy clays. Growth is better in the high rainfall zones than in the dry interior valleys.

Cassia Simaea coppices well after firewood fellings and excellent regeneration follows. The best results have been obtained by timing the fellings at the end of the dry season when the trees are in a resting condition. At the onset of the rains all of the stumps sprout readily and after one or two weedings the stand is free of any danger of suppression.

A discussion of firewood studies will be presented in another section of this report.

Astronium graveolens
Ciruelillo, Ron Ron, Goncalo Alves

Ciruelillo or Ron Ron as it is called in Honduras is known in the U. S. timber trade by the Brazilian name Goncalo Alves. It is one of the woods most widely used in northern Honduras for turnery articles and fine inlay work.

Ciruelillo is found naturally in this area in moist evergreen and semi-deciduous forest. In the dry interior valleys it is occasionally found in deciduous forest.

The total of 130 acres of this species has been distributed throughout the projects on difficult dry sites with poor soils. Growth is naturally slow in such places but ciruelillo can withstand drought much better than the primary species.

Ciruelillo is tolerant of shade and seedlings or saplings are often found in high forest. When grown in mixture with cedar, primavera, and frijolillo, it is overtopped rapidly but continues to grow and will eventually become a canopy species.

Eucalyptus spp.

A special study of planting results of introduced exotic species of *Eucalyptus* in northern Honduras is warranted. In this report only a brief summary of results will be given.

Work in the past has shown that of more than forty species of *Eucalyptus* in trial plots on various sites, soils, and rainfall zones, only five have given consistently good results at elevations below 2.000 feet. Biometric data from past studies in Lancetilla of these five species are given below.

Species	Age	DBH	Height
Eucalyptus deglupta	3 yrs.	5.9 in.	52.9 ft.
Eucalyptus rostrata	4 yrs.	6.5 in.	46.8 ft.
Eucalyptus hemiphloia	3 yrs.	3.2 in.	17.2 ft.
Eucalyptus viminalis	3 yrs.	4.3 in.	36.2 ft.
Eucalyptus citriodora	3 yrs.	3.7 in.	36.2 ft.

Eucalyptus degluta, or kamarere, is the only truly tropical species. It has developed exceptionally well in the tropical lowlands with high rainfall but is subject to wind damage. To date, most of the reports regarding its timber quality and susceptibility to termite attack have not been optimistic. Mr. J. R. McWilliam of the Australian Forest Service, Brisbane, Australia, has supplied us with information about *E. deglupta* which he obtained from his colleagues in the Australian and Colonial Forestry divisions. Without exception, from Malaya to Trinidad, *E. deglupta* has been seriously attacked by termites before the trees reach maturity.

Below is a rating on the adaptability of *Eucalyptus* species in Lancetilla as taken from research department records.

Group A .....Good

E. deglupta
E. hemiphloia
E. viminalis
E. eximia
E. camaldulensis
E. rostrata
E. citriodora
E. maculata
E. tereticornis var. *linearis* (seeana)

Group B .....Fairly Good

E. MacArthuri
E. diversicolor
E. resinifera
E. resinifera var. *grandiflora*
E. tereticornis
E. multiflora
E. saligna
E. microcorys
E. macrorhyncha
E. paniculata
E. maidenii (*N. I.*)
E. longifolia

Group C.....Poor

E. botryoides
E. smithii
E. collosea
E. rudis
E. acmenioides
E. dealbata
E. lactea
E. robusta
E. crebra
E. marginata
E. resinifera var. *jarrah*. Guat.
E. punctata

Group D.....Very Poor

E. affinis
E. stuartiana
E. ficifolia
E. piperita
E. cinerea
E. siderophloia
E. desconocida
E. gomphocephala

Not included in the above list are 19 unidentified species which were propagated from seed material obtained in Guatemala.

Chlorophora tinctoria (L.) Gaud.

Mora, Fustic

Mora is one of the favored secondary woods among the native people in this area. It is found growing throughout the valley, most often near streams. Most of the 73 acres of this species were put in before 1948 and no attempt was made to increase this acreage during the large-scale planting program.

The growth habit of this species with its coarse limbs has led to rather high pruning costs. The main stem sprouts badly after pruning and the wounds are slow to heal.

Mora does not seem to be adapted to our present plantation methods in Honduras.

Cupressus Lindleyi Klotsch (C. Benthami Endl.)

Guatemala Cypress, Cipres

This species was planted experimentally in all projects prior to 1948. It is found naturally in the highlands of Guatemala and on some of the highest peaks in northwestern Honduras near the Salvador-Guatemala border. A magnificent stand of this species is found on Santa Barbara mountain bordering the west side of Lake Yojoa. It is restricted to the upper 2,000 feet of this 9,100 foot mountain. It has not prospered in the tropical lowlands but has done well at Siguatepeque and Trincheras and, to a limited degree, at Agua Azul.

This tree has possibilities in the higher mountain regions of Honduras. In plantations it must be planted at a close spacing of 4 to 6 feet due to its excessive branching habit. It can maintain a favorable growth rate in the rockiest of sites. It does not seem to be as resistant to fire as pine and is subject to wind throw on deep, loose soils.

Casuarina equisetifolia Forst.

Australian Pine, Pino Australiano

In the early phase of this program, Australian pine was planted as a windbreak species and later as a source of firewood. It grows well in the Ulua valley and it is widely used as an ornamental. Tree form is usually very good. It has been utilized on littoral beach sites near Tela.

Swietenia mahagoni L.

West Indian Mahogany

In the early phase of this program, this species was planted on a field trial basis in all projects. Its failure on some sites and extremely slow growth on all sites led to its abandonment in many areas after 1948. There are still 40.5 acres of this species scattered throughout the different projects.

One of the most noteworthy features to come out of this early planting has been the development of 10 or 12 sport trees out of the many thousands that were originally propagated. Seed material for this planting came from Santo Domingo and in all probability originated near Puerto Libertador. The sports exhibit height and diameter growth that is much faster than either *S. macrophylla* or *S. mahogani*. Furthermore, the leaf sizes in this variety are intermediate between the two species and the bark characteristics resemble Honduras mahogany in its early stages. Bark fissures develop much earlier in *S. mahagoni* than in *S. macrophylla* and the intermediate variety more closely resembles the latter in this characteristic.

Comparison of the growth rates of the typical species and the intermediate is shown below.

Species	Age	DBH	Height	Spacing
S. macrophylla	6 1/3 yrs.	4.9 in.	34 ft.	10' x 10'
Intermediate var.	6 1/3 yrs.	6.1 in.	38 ft.	10' x 10'
S. mahagoni	6 1/3 yrs.	4.5 in.	28 ft.	10' x 10'

The intermediates are scattered throughout stands of *S. mahagoni* or in rowwise mixed planting. They quickly achieved dominance and have outgrown native mahogany in pure stands.

NATURAL REGENERATION OF PINE

General

This phase of reforestation in Honduras is one that holds the most promise in any long-term venture. More local people will benefit from the conservation and management of existing pine forests than from the lowland broadleaf plantations. The benefits that will accrue from pine forestry as regards conservation of soil and water resources far outweigh all other economic considerations.

According to Shank (8), the pine forest in Honduras covers 1,025,000 hectareas (2.47 acres) and constitutes approximately 15% of the gross forest area. Much of this interior highland zone is better suited for the production of pine timber as a saleable crop than for any other land use.

Three of the four species of pine found in Honduras are present in our projects. Caribbean pine, *Pinus caribaea* Mor., is the lowland form commonly found within the range of 1,000 to 2,500 feet elevation. In eastern Honduras this species is found on the coastal plain near sea level. In the interior highlands of Honduras, the mountain pine, *Pinus oocarpa* Scheide, is most commonly found at elevations between 2,500 and 4,800 feet. This species is replaced at higher elevations by pinabete, *Pinus pseudostrobus* Lindl., which grows in mixed stands with cloud forest hardwoods up to elevations of 9,000 feet. The fourth species, *Pinus ayacahuite* Ehrenb., is not found in our projects but has been seen growing between 6,800 and 9,000 feet on Santa Barbara mountain in the Department of Santa Barbara.

Regional

Three widely separated natural pine zones have been managed for natural regeneration since 1946-47. These have been the Siguatepeque-Trincheras region, Agua Azul, and the Los Dragos-Potosi properties.

The Siguatepeque and Trincheras tracts were located in the interior highlands between 3,500 and 4,000 feet elevation. Trincheras is a small demonstration block located near the Interoceanic highway. The terrain is broken up into numerous ridges and ravines. The soil mantle is very shallow, seldom being more than 10 to 12 inches deep and overlying a deep volvanic tuff parent material. The Trincheras property had been burned over for generations before the area was protected. There was a good stand of merchantable timber that was cut to a 16-inch diameter limit before the protection phase began. Numerous seed trees were left and within two years all open areas had been reseeded. One poorly drained area failed to regenerate. *Pinus oocarpa* was most commonly encountered although some *P. pseudostrobus* was growing along ridges. Reproduction at Siguatepeque has been much slower due to the intolerance of *P. oocarpa* to soils with impeded drainage.

The Agua Azul pine region, comprising 1,045 acres near Lake Yojoa, is located on deep red clay soils derived from volcanic ash and ejecta. Pine is probably a fireclimax in this area and broadleaf forest would eventually take over if fire were excluded entirely. The ground cover in much of this

area is comprised of bracken fern, *Pteridium aquilinum* L. Kuhn, in dense stands in burned over areas. It has been the major factor in the slow rate of regeneration in these hills. *P. caribaea* is the only species found here and fortunately it is more tolerant to shade and suppressión than the higland species. In spite of heavy ground cover, a fair to medium stocked stand of young pines has come in on the grassy areas. Little or no reproduction has occurred in the dense bracken fern sites. The future of pine as a permanent crop in this area does not hold the promise that Los Dragos-Potosi or Trincheras does.

The Los Dragos-Potosi pine region is located in northwestern Honduras near the Guatemalan borde. The total pine region under protection in this project covers 11,106 acres. The terrain is broken and hilly with elevations ranging from 900 to 2,800 feet. The soil is derived from a granite schist bedrock with occasional outcrops of granite. A limited area of transported hillwash soil located in the ravine bottoms and seepage areas supports broadleaf vegetation. The ground cover on the hills is made up mainly of grasses and a few leguminous shrubs. Bracken fern is rarely seen on the hills but is occasionally found near the seepage areas. Other tree species associated with pine but only as scattered individuals are chaparro, *Curatella americana* L., and nance, *Byrsonima crassifolia* L. Rich. *P. caribaea* is found between 900 and 2,400 feet but this is replaced on the 2,400 to 2,800-foot high ridges of the Potosi tract by *P. oocarpa*.

Los Dragos was put under protection during 1946. After 5 years most of the bare areas above 1,000 feet were covered with an excellent stand of young pine trees. In some cases, the population per acre ran as high as 12,000 to 15,000 plants and 8,000 young trees per acre was a common average. At this time, competition began to cause the growth rate to slow down. In some of the 5-year-old stands that reseeded the first year the best trees were 18 feet high and 4 inches in diameter at breast height.

The excellent reproduction that followed the protection phase was one of the most heartening sights of the reforestation program. It demonstrated in the course of a few years what might be expected of the pine region if it were protected and managed efficiently for a timber crop. Before this operation, the pine hills were characterized by poorly stocked stands, a considerable amount of cull trees due to butt damage from fires with little or no reproduction on the bare areas. The region had been used for open range grazing for many years and in all probability had been burned at least once in every three years for the preceding 25 years. Most of the existing standing timber above 1,200 feet is less than 35 years of age. These trees are probably the progeny of a few large old seed trees scattered through the area that survived a serious insect attack in this region between 1917 and 1920. This information is derived from accounts of inhabitants who have described the almost complete destruction of the old growth during this period by some unknown insect.

Complete protection was carried out in Los Dragos for seven years. A serious fire in 1953 pointed out the need for a prescribed burning program in future operations. The greatest damage from this fire was the loss of ground cover and organic matter and subsequent increased runoff. The loss of growing stock was no disadvantage and the remaining trees, after 2 to 3 years of reduced growth, will take advantage of the increased space and resume normal growth.

The Potosi property has been protected since 1950. With the exception of one area in which the first reproduction was lost by ground fires, the tract closely resembles the Los Dragos project after 5 years of protection.

In analysis, the two most important pines do best at elevations between 1,200 and 4,800 feet on the semi-arid hill lands that are underlain by acid tuffs and lavas or metamorphic schists. Such areas are better suited for sustained yield pine forestry operations than the deep soils in the Lake Yojoa region or the north slopes of the coastal mountains.

Fire Protection

This has been the chief tool used in the natural regeneration of the pine areas in this program. From the beginning, all pine reforestation projects were fenced to keep out open range cattle. Each year fence lines were cleared to the bare ground to a width of 8 meters. This served not only as a fire break but also protected the fence from being burned in ground fires. Fire lanes were also opened up at strategic points throughout the properties. Fire suppression crews lived in outlying stations during the period of greatest fire hazard from February to May.

Incendiarism has been a problem from the outset. This problem will continue in this region where woods burning is a national pastime. In view of this, any long-term pine reforestation program cannot be built around the principle of complete protection. Prescribed burning by competent personnel will become the best insurance for long-term protection.

In the beginning, all pine projects were set up for complete protection. This was especially necessary during the first 3 or 4 years. After the young stand was established, no prescribed burning was done since it was feared that a high degree of mortality might occur.

In April, 1953, a serious fire in the Los Dragos project served to point out some of the hazards involved in reliance upon a complete protection program. The area had been protected for 7 years and a magnificent stand of young pines, *P. caribaea*, had been established. The 7-year-old rough was composed of dry litter more than two feet thick and a waist-high grass and weed cover. This region was fired maliciously at several points after a severe dry season when the entire area was tinder dry. This was a wild fire from the beginning and 1,500 acres burned over before it was stopped at the highway.

Fortunately, the young pines were old enough to withstand a severe fire and about 60% of the initial stand of 1,500 acres still remains. After the fire, the young stand suffered between 25 and 100% scorch from ground fires which was the prevalent effect in the burned area. The fire did not reach crown height except in small local patches at the heads of ravines and ridge tops. All the needles were burned off and mortality was 100% in the approximately 80 to 100 acres which were completely destroyed.

Apart from this small area, the highest mortality occurred in the rolling hills and flat areas nearest the highway which traverses the property from east to west. The fire in this area burned during the middle of the day and did not travel as rapidly as on the slopes. Mortality on regeneration up to 20 feet in height was over 60% and 100% needle scorch was observed on trees 10 to 14 inches DBH and 70 feet tall.

In the burned-over area, there was an experimental prescribed burning sample plot that was set up in 1952. Nearby control and thinning plots that were not burned in the initial treatment suffered from 60 to 100% scorch whereas in the center of the prescribed burned plot, away from edge effect, the scorch was less than 5% or none at all.

About 60% of the old growth on the flats either died outright from the fire or succumbed later to flat-headed borer and termite attacks.

When these pine projects were first started, protection costs amounted to about one dollar per acre per year. This included fence building, fire lanes, mule trails, and fire suppression crews. Rising labor rates and construction and maintenance of fire access roads throughout these properties have increased costs to approximately $1.50 per acre per year.

Fire suppression crews are built up each dry season from local sources. These men are under the direction of permanent forest guards who have lived in these outlying stations since the projects were started. These men have had several years of fire suppression experience and the responsibility of training and organizing a new crew each season rests with them.

Backfiring has been the most economical tool in suppression work. One can safely say that the major part of the pine hill region will be burned off each dry season. If a menacing fire is approaching a protected area, the boundary is backfired and later patrolled for burning snags.

Sufficient water for extinguishing burning logs and stumps has always presented a supply problem. This has been alleviated somewhat by the use of Unox Penetrant, a wetting agent which has increased our water efficiency by about three times. It is used as a 1% solution in water or about 6 ounces added to the five-gallon tank of the Indian knapsack pump for extinguishing burning stumps and logs.

Regeneration Characteristics of Caribbean Pine

Life History and Seed Fall Studies of P. caribaea Mor.

Field studies carried out during 1951-1953 accumulated some information regarding natural reproduction of Caribbean pine, *P. caribaea* Mor., in this region.

Flowering occurs in late November or early December. Newly formed pistillate conelets are 1/4 to 3/8 inch long and nearly as broad. Development during the first year is very slow. At one year of age, the cones are only 1 to 1 1/8 inches long and 7/8 inch in diameter. This is followed by an extremly rapid period of development and 4 months later the cones are 4 to 5 inches long and 1 1/4 inches in diameter. The cones mature 16 months after flowering during the latter part of February and March.

Seed fall begins during the late dry season and in dry years continues through May. By this time, the majority of the seeds have been dispersed from the forward and middle thirds of the cone. The middle third possesses the greatest number of viable seeds. In the Lake Yojoa area, seed fall has been interrupted during May by the early advent of the rains and the cones remained so tightly closed that there was no seed dispersal during the remainder of the year.

In the Los Dragos region, the production of heavy crops of seed has been cyclical and resembles closely the production of heavy seed crops in slash pine in southeastern United States which occurs every 2 or 3 years. Field observations by the overseer and head watchman at Los Dragos since this project has been under way indicate a heavy seed crop every third year. Personal observation in this area since 1950 corroborate the latter part of the seed fall observations given below.

Heavy Seed Years	Light Seed Years	Very Light Seed Years
1946, 1949, 1952	1947, 1948	1950, 1951
(very heavy, 1952)	1953, 1954	

Pine cone enemies in the pine region have been beetles of the family Scolytidae while cones are small during the first year of development. When the cones are mature, they are also attacked by grey squirrels and red, blue, and yellow macaws. It is only during bumper crop years that satisfactory reproduction is obtained because then the terrific drain due to seedling mortality, insect enemies, and seed consumed by wildlife is overcome by heavy seed crops.

Seed trapping studies were conducted during 1952. Traps were shallow boxes 1/4000 acre in area (3.3 feet square inside dimensions), covered with chicken wire and hardware cloth. The traps were placed at random throughout the pine stands under study. Results in Table 3 may be considered representative of the seed fall per acre in individual areas.

TABLE 3

Seed Trapping Results under Honduras Pine Stands

1952

Species	Location		February	March	April	Total Viable Seed per trap	Total Viable Seed per acre
P. oocarpa	Siguatepeque	1	9	12	—	21	84,000
	Siguatepeque	2	4		2	6	24,000
	Siguatepeque	3	2	3	—	5	20,000
	Trincheras	4	—	—	—	0	0
P. pseudostrobus	Trincheras	5	1	3	—	4	16,000
P. caribaea	Agua Azul	1	10	6	4	20	80,000
	Agua Azul	2	5	10	5	20	80,000
	Agua Azul	3	9	3	6	18	72,000
	Los Dragos	1	—	1	—	1	4,000
	Los Dragos	2	—	1	—	1	4,000
	Los Dragos	3	—	—	—	0	0
TOTAL VIABLE SEED			40	39	17		

Comparison of Regeneration Characteristics of

Caribbean and Mountain Pine

Both of these pine species are prolific seeders and there seems to be a cyclical occurrence of heavy seed years. This is more noticeable with *P. caribaea* since appraisal is made difficult in *P. oocarpa* which has persistent cones.

The seedlings of *P. caribaea* are much more tolerant to shade and competition than the highland form. Both pines need well drained sites for favorable reproduction and *P. oocarpa* is so intolerant of poor drainage that it is seldom found in flat ground unless there is excellent internal drainage.

One outstanding silvicultural characteristic of *P. oocarpa* is its ability to sprout from the root collar region after the young sapling stem has been killed by fire. Cases have been seen in which young saplings were burned back for several years in succession. A dense fibrous root system develops after such setbacks and finally, during a series of favorable years, the saplings get past the stage where they can be killed back by fire. The occurrence of excellent young stands of *P. oocarpa* in the annually scorched highlands is due primarily to its ability to continue sprouting until a favorable year.

This sprouting ability is not shared by *P. caribaea* which is extremely vulnerable to ground fires during the first 3 to 5 years. It becomes very fire resistant after the stem needles have been shed and the sapling stem has developed a thick fibrous bark with deep fissures.

FUELWOOD OPERATIONS

In 1951 studies were begun to get information on the possibility of utilizing certain timber species for fuel. There was a pressing need for additional fuelwood supplies due to the heavy demand for fuel by the large labor force in this valley.

Firewood is sold in northern Honduras by a unit known as a "carga" --50 sticks of wood 31 inches long and 2 to 3 inches in diameter-- and is considered to weigh 200 pounds or 100 pounds each for two bundles on a pack mule. Various conversion factors have been tried to establish a stable volume figure for this unit. An actual count made near La Lima from several standard cords of *Cassia Siamea* wood produced an average of 1,400 sticks or 28 "cargas". *Cassia Siamea* has an average weight of about 50 pounds per cubic foot and one "carga" equals 4.57 cubic feet. The average cord would weigh about 228.5 pounds. It required four man-days to cut and split one cord into 1,400 sticks.

The first experimental firewood cutting was made in 4 1/2-year-old *Cassia Siamea* planted at 10 x 10-foot spacing. The average height was 37 feet and the average DBH was 5.2 inches. This cut produced 21.4 cords per acre with a cordwood increment of 4.75 cords per acre per year.

The following year a 3-year-old stand of the same species planted at 12 x 12 feet was cut. The average height was 34 feet and the average DBH was 3.4 inches. This stand produced 16.2 cords per acre with a cordwood increment of 5.4 cords per acre per year.

The increment per year was greater in the 3-year-old material than in the older planting but a better quality of wood was produced from the older material. About 20% of the firewood from the younger planting was composed of limb material with a maximum top diameter of 1 1/2 inches. This wood burns more rapidly than the heavy split wood from the 4 1/2-year-old planting. It appears that 3 years of age is the bottom limit at which *Cassia Siamea* could be cut for firewood at the 12 x 12-foot spacing.

Twelve months after the old stand was cut, 100% regeneration of the stumps had been accomplished by sprouting. These sprouts had attained an average height of 22 to 25 feet and 2.5 inches DBH. The stump sprouts were cut back to an average of three low sprouts per stump.

These plots were abandoned temporarily in 1953 due to flood-fallowing operations.

A comparative study of the volume production of *Eucalyptus deglupta* and *Cassia Siamea* was carried out at the same cutting rotation in Lancetilla. Comparative yields are given below.

Species	Spacing	Location	Age	Av. DBH	Av. Height	Yield per Acre
Cassia Siamea	12' x 12'	La Lima	3 yrs.	3.4 in.	34 ft.	16.2 cords
Eucalyptus deglupta	15' x 15'	Lancetilla	3 yrs.	5.9 in.	52.2 ft.	15.5 cords

It is probable that *E. deglupta* planted at 12 x 12 feet would produce at least 20 cords per acre at this rotation.

SUMMARY

The foregoing paper has been a review of the reforestation operations of the Tropical Research Department of the United Fruit Company in northern Honduras during the past fourteen years. The history and development of reforestation as well as the role of the company in the development of a forest policy has been discussed in the light of their social implications in the economy of Honduras.

The forestry program of this organization is a pioneer venture in a country which has much to gain from intelligent use and conservation of its existing forests. It has developed trees as a future crop on more than 25,000 acres of land not needed for agriculture. Approximately 300 families have been furnished a means of livelihood while the head of the household was learning a new occupation.

The material presented in this report can be divided into two major parts: 1) the development of broadleaf plantations in the lowlands including summary of propagation, field planting, and plantation maintenance methods and 2) natural regeneration of native pine in selected areas in interior Honduras with associated fire protection procedure and regeneration phenomena. Within these two broad subdivisions the following features are noteworthy:

Broadleaf Plantations

During this operation over 10,000 acres of land were planted with fourteen major species and more than sixty minor species in collections. Broadleaf plantings in any region during the initial phase have had their share of hardships and Honduras is no exception. Site preference field trials were first made in the lowlands for all major species and then extended to all of the projects. Some species were planted outside of their optimum habitat and now serve as reminders of this experience. On the other hand, much information has been gained concerning the adaptability of tree species to the soils and forest sites in this region.

The wide spacing used in this operation was an attempt to solve some of the problems that will be met in any endeavor to establish plantations in the tropics. These problems are: 1) high plantation costs; 2) shortage of seed supply; 3) utilization of bush growth as side pressure; and 4) avoidance of costly precommercial thinnings for which there is no market. This has worked out reasonably well for most species but pruning will have to be a necessary part of plantation maintenance. It is still felt that further studies of spacing requirements are necessary in this area.

Natural Regeneration of Pine

A total area of 12,349 acres of pine has been put under protection for natural regeneration. Excellent results have been obtained at the Los Dragos and Potosi properties and formerly at Trincheras. Reproduction has been plentiful and vigorous and has now been protected to the stage where it is quite fire resistant.

Prescribed burning will probably have to be resorted to as a tool to combat the wholesale incendiarism which takes place each year in the pine hills. Natural regeneration of pine has been a complete success and holds great promise for the future economy of Honduras if the national interest in this matter improves.

In conclusion it should be pointed out that the reforestation operations in Honduras have been highly satisfactory. It is not a history of failure but rather of progress in the build-up of information concerning the conservation and continuity of the natural resources of this country.

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APPENDIX I

Timber Tree Acreage by Projects and Species — December, 1953

Species	Agua Azul	Amapa	Los Dragos	Trincheras	Siguate-peque	Guace-rique	San Alejo	Lance-tilla	Research & Farms	Potosi	Total
Cassia Siamea			8.8		1.0			5.2	130.0		145.0
Ciruelillo	.4	5.6	33.3		.1	.1	59.4	29.2	1.9		130.0
Cedar	106.5	159.6	109.1	.2	.8	.2	68.7	83.9	67.0		596.0
Cypress	44.9		3.0	8.5	1.0	2.2		2.0	.1		61.7
Eucalyptus	19.0		7.9	2.1	3.8	1.4	11.6	15.2	13.6		74.6
Frijolillo	6.9	27.6	37.2		.1		115.2	27.2	31.1		245.3
Mahogany Hond., Guat.	736.1	2,179.0	137.6	.4	.1		997.8	421.4	97.3	.3	4,570.0
West Indian			4.6		.1		28.2	7.1	.5		40.5
Mora							4.6	2.5	66.0		73.1
Nurseries	2.7	5.5	3.0			.3	5.0	2.0			18.5
Pine, Australian						2.5			57.3		59.8
Primavera	191.4	903.5	173.7			.5	164.2	31.3	.6	.3	1,465.5
Rosewood, Burm		3.2					116.4	31.3	20.0		170.9
Rosewood, Hond.			1.9		.1		66.8	37.6	95.2		201.6
Teak		173.4	9.4		.1		2,158.5	22.6	3.4	.8	2,368.2
Miscellaneous	29.0	17.6	27.7	8.9	9.1	2.8	57.3	82.6	82.6		317.6
Total Planted	1,136.9	3,475.0	557.2	20.1	16.3	10.0	3,853.7	801.1	666.6	1.4	10,538.3
Prot. Natural Hardwood Forest	1,655.0									520.4	2,175.4
Pine Reserve	1.044.9		2,106.0	160.0	38.0					9.000.0	12,348.9
Total Protected Forest	2,699.9		2,106.0	160.0	38.0		3,853.7	801.1	666.6	9,520.4	14,524.3
GRAND TOTAL	3,836.8	3,475.0	2,663.2	180.1	54.3	10.0				9,521.8	25,062.6

APPENDIX II

Given below are the scientific and the principal common names of the most important species planted in the course of reforestation work in Honduras.

Scientific Name	Common Name
1. *Acacia arabica*	Gun Arabic
2. *Acacia catechu*	Cutch tree
3. *Acacia scleroxyla*	Candalon
4. *Achras sapota*	Chicle, nispero
5. *Adansonia digitata*	Boabab tree
6. *Adenanthera pavonina*	Red sandalwood
7. *Albizzia Lebbek*	Siris tree, woman's tongue
8. *Albizzia moluccana*	
9. *Albizzia procera*	
10. *Araucaria Bidwillii*	Bunya Bunya pine
11. *Araucaria excelsa*	Norfolk Island pine
12. *Astronium graveolens*	Ciruelillo, Ron-Ron
13. *Bucida buceras*	Bullet tree, jucaro comun
14. *Byrsonima crassifolia*	Nance
15. *Calycophyllum candidissimum*	Salamo, madrono, calan
16. *Cassia Siamea*	
17. *Casuarina equisetifolia*	Beefwood, Australian pine
18. *Casuarina lepidophloia*	
19. *Catalpa longissima*	
20. *Catalpa speciosa*	Hardy catalpa
21. *Cedrela mexicana*	Spanish cedar
22. *Cedrela toona*	Toon
23. *Cedrela tonduzii*	
24. *Chlorophora tinctoria*	Fustic, mora
25. *Chrysophyllum caimito*	Star apple, caimito
26. *Colubrina ferruginosa*	Black velvet, greenheart
27. *Coumarouna odorata*	Tonka bean
28. *Cordia alliodora*	Laurel blanco
29. *Cordia gerascanthus*	Laurel negro
30. *Cupressus Lindleyi*	Guatemalan cypress
31. *Dalbergia cubilquitzensis*	Honduras rosewood
32. *Dalbergia retusa*	Cocobolo
33. *Diospyros discolor*	Mabolo
34. *Dipysa Robinioides*	Guachipelin
35. *Dipterix panamensis*	Ibo
36. *Enterolobium cyclocarpum*	Ear tree, guanacaste
37. *Guaiacum officinale*	Lignum vitae
38. *Guainacum sanctum*	Lignum vitae
39. *Haematoxylon campechiarum*	Logwood
40. *Harpulia cupanoides*	Na-imbul
41. *Hura crepitans*	Sandbox tree, javillo
42. *Juglans neotropica*	Peruvian walnut
43. *Khaya ivorensis*	Lagos mahogany
44. *Khaya nyassica*	East African mahogany

Scientific Name	Common Name
45. *Liquidambar styraciflua*	Sweet gum
46. *Lonchocarpus guatemalensis*	Chapel
47. *Lonchocarpus latifolius*	Cincho
48. *Lysiloma bahamensis*	Sabicu
49. *Lysiloma sabicu*	Sabicu
50. *Michelia champaca*	Champac
51. *Peltogyne purpurea*	Nazareno, purple heart
52. *Pinus caribaea*	Caribbean pine
53. *Pinus palustris* (Mill)	Long leaf pine, pitch pine
54. *Pinus patula*	
55. *Pinus oocarpa*	Highland pine
56. *Pinus radiata*	Monterey pine
57. *Pinus pseudostrobus*	Pinabete
58. *Pithecolobium arborcum*	Barba de jolote
59. *Pseudosamanea guachepele*	Frijolillo
60. *Pterocarpus indicus*	Burmese rosewood, narra
61. *Samanea saman*	Rain tree
62. *Sarcocephalus Diderrichii*	Opepe
63. *Sideroxylon mastichodendron*	Mastic
64. *Swietenia macrophylla*	Central American mahogany, Honduras mahogany
65. *Swietenia mahagoni*	West Indian mahogany
66. *Sweetia panamensis*	Chichipate
67. *Tabebuia Donnell-Smithii*	San Juan, primavera
68. *Tabebuia guayacan*	Cortez
69. *Tabebuia pentaphylla*	Macuelizo, roble
70. *Tectona grandis*	Teak
71. *Terminalia arjuna*	Arjan
72. *Terminalia ivorensis*	Black afara
73. *Triplaris americana*	Palo santo, palo mulato
74. *Vatairea Lundellii*	Amargosa
75. *Vitex gigantea*	Cuajada, flor azul
76. *Vitex peruiflora*	Molave

APPENDIX III

Rainfall in Inches -- Research Department Plantings

Date & Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1953	Period Average
Lancetilla	5.94	6.61	2.61	.03	8.86	6.14	7.64	16.61	8.75	18.98	17.87	17.32	117.36	
22-year average	14.25	7.58	5.85	6.34	5.21	6.48	8.18	11.10	7.34	15.37	21.25	15.83		126.78
San Alejo	3.72	5.86	2.59	.47	8.14	4.58	7.88	16.46	6.30	26.32	15.75	13.61	111.68	
11-year average	6.96	6.00	2.08	3.98	3.61	4.96	6.34	7.74	6.54	14.45	13.83	12.76		89.25
La Lima	2.52	1.03	.53	..	6.73	5.70	4.79	5.58	3.41	7.97	6.54	3.54	48.64	
28-year average	3.07	1.82	1.54	1.29	3.21	4.90	4.89	4.46	6.82	6.57	6.77	4.44		49.78
Los Dragos	1.12	1.02	.54	..	7.83	8.82	4.83	4.79	5.90	4.15	2.37	.76	42.13	
7-year average	1.47	1.39	.70	1.11	2.73	8.10	6.68	6.40	8.93	4.90	2.30	2.75		47.46
Potosi	1.73	.88	1.11	.24	7.13	10.00	6.16	4.67	5.84	4.97	5.49	2.98	51.20	
2-year average	.86	.44	.56	.12	4.00	11.09	6.99	7.07	7.39	6.89	4.17	4.84		54.42
Amapa	2.73	.89	.14	.46	13.48	10.39	10.62	12.57	13.21	5.16	3.18	2.01	74.84	
15-year average	2.08	1.62	.58	1.36	5.03	11.51	10.58	10.38	13.95	7.65	5.12	3.21		73.07
Aqua Azul	3.60	1.12	.28	.14	10.00	14.48	21.68	14.56	14.51	8.36	5.23	2.81	96.77	
15-year average	3.41	2.08	.88	1.74	6.12	14.28	14.32	14.04	15.40	7.24	5.23	4.40		89.14
Siguatepeque	.75	.26	..	.76	2.92	8.99	4.79	3.40	14.19	7.58	1.83	.88	46.35	
7-year average	.97	.67	.29	.95	3.07	8.94	5.45	5.69	9.53	5.51	3.40	1.35		45.79