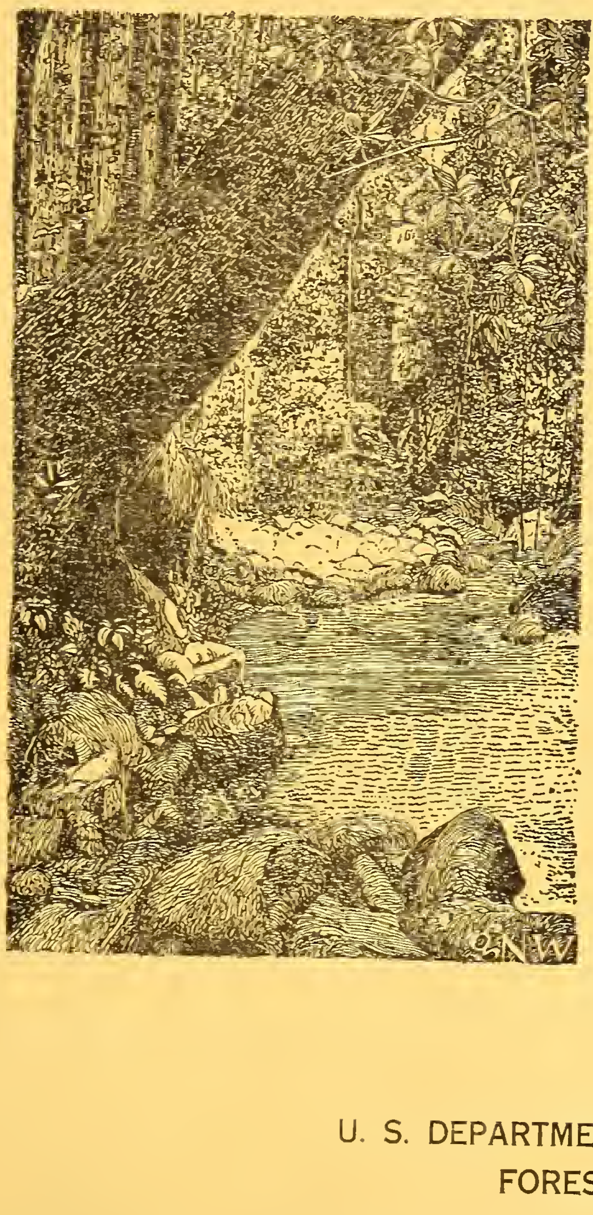
Caribbean Forester



U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

TROPICAL FOREST RESEARCH CENTER
RIO PIEDRAS, PUERTO RICO

VOLUME 20 NOS. 1 AND 2 JANUARY - JUNE, 1959

Caribbean Forester

El Caribbean Forester es una revista semestral gratuita publicada en Puerto Rico desde el año 1938 por el Centro Tropical de Investigaciones Forestales del Servicio Forestal del Departamento de Agricultura de los Estados Unidos. Esta publicación está dedicada a promover la mejor ordenación y utilización de los recursos forestales del trópico con especial énfasis a la región del Caribe.

Provee información a los que laboran en la dasonomía y ciencias afines sobre los problemas específicos que confrontan, las políticas forestales vigentes y el progreso del trabajo que se lleva a cabo para mejorar la ordenación y utilización de los recursos forestales tropicales. También sirve como medio informativo sobre los resultados y el progreso de los programas experimentales, en ordenación forestal tropical y utilización, que se llevan a cabo en el Centro de Investigaciones en Puerto Rico. También le brinda una oportunidad a otras personas interesadas en la dasonomía tropical para presentar el resultado de sus trabajos.

Se solicitan aportaciones de otras fuentes en el campo de la dasonomía tropical siempre que no estén considerándose para publicación en otras revistas. El manuscrito generalmente no debe exceder 20 páginas escritas a máquina a doble espacio, aunque ocasionalmente podría aceptarse un artículo más largo cuando tuviera un interés especial.

Los artículos deben someterse en la lengua vernácula del autor, deben incluir su título o posición que ocupa y un resumen corto. Deben estar escritos a máquina a doble espacio, solamente en un lado de la página, en papel blanco primera, tamaño 8½ por 11 pulgadas.

Las tablas deben numerarse consecutivamente, cada una en una hoja separada con su título. Las notas al pie usadas en las tablas deben escribirse a máquina como parte de la tabla y designarse por medio de números.

Las ilustraciones deben designarse con números y numerarse consecutivamente. Los títulos para cada ilustración deberán someterse en una página separada. Las fotografías sometidas como ilustraciones deben ser claras, bien definidas y en papel glaseado, preferiblemente 5 por 7 u 8 por 10 pulgadas en tamaño.

Las notas al pie deben numerarse consecutivamente con un número de llamada siguiendo la palabra en el texto a la cual hace referencia la nota al pie. La nota al pie debe aparecer en el texto en la línea siguiendo el número de referencia y separada del texto por medio de una línea corta hacia dentro desde el margen izquierdo del texto. Las notas al pie se usan para dar crédito a material no publicado y a comunicaciones. Si se hacen solamente unas pocas referencias a la literatura entonces dichas citas pueden aparecer como notas al pie. Las citas incluirán el nombre del autor, el año de publicación, el título del trabajo, y el nombre y páginas de la publicación.

Los manuscritos deben enviarse al Líder del Centro Tropical de Investigaciones Forestales, Río Piedras, Puerto Rico.

Las opiniones expresadas en esta revista no coinciden necesariamente con las del Servicio Forestal. Los artículos publicados en el Caribbean Forester pueden reproducirse siempre que se haga referencia a la fuente original.

●

The Caribbean Forester is a free semi-annual technical journal published since 1938 in Puerto Rico by the Tropical Forest Research Center, Forest Service, U. S. Department of Agriculture. This publication is devoted to the development of improved management and utilization of tropical forest resources, with special interest in the Caribbean region.

Through the pages of the journal tropical foresters and workers in allied scientific fields are informed of specific problems of tropical forestry, policies in effect in various countries, and progress of work being carried out for the improvement of the management and utilization of forest resources. It furnishes a means of distribution of information on the progress and results of the experimental programs of the Tropical Research Center in Puerto Rico. In addition, it affords an opportunity for other workers in the field of tropical forestry to make available the results of their work.

Contributions for the journal are solicited. However, material submitted should not be under consideration for publication elsewhere. Manuscripts should not ordinarily exceed 20

(Continúa en la portada #3)

The printing of this publication has been approved by Director of the Bureau of the Budget (June 26, 1958)
The Tropical Forest Research Center is operated in cooperation with the University of Puerto Rico.

Vol. 20, Nos. 1 and 2 January - June, 1959

Caribbean Forester

Contents

Sumario

Sixth Session of the Latin American Forestry Commission

At the Sixth Session of the Latin American Forestry Commission of FAO held at Antigua, Guatemala in November 1958 two working group were formed. One was the Long Forest Policy Committee the other Forest Research Committee.

The Long Term Forest Policy Group discussed and made recommendations regarding the following subjects:

(a) Colonization and related factors, (b) Shifting cultivation, (c) Reforestation.

The Forest Research Group heard brief report from the members on current research in the following fields: Dendrology, Botany, Ecology, Mensuration, Inventory, Silviculture, Management, Protection, Wood Utilization.

In addition three sections were established to continue work in the various assigned fields and report to the Forest Research Committee. The sections formed are the follows: (a) Forest Terminology, (b) Utilization of Tropical Hardwoods, (c) Planting.

The assigment of Leader of the Section on Planting was given to Dr. Frank H. Wadworth, Leader of the Tropical Forest Research Center in Puerto Rico. This Section was given the assigment of investigating forest plantations in Latin America. A preliminary report was requested at the end of the first year. Therefore a report on the work of Planting Section will be subitted early in 1960.

The date of Seventh Session of the Latin American Forestr Commission was not set but will be held sometime after the World Forestry Congress and will be announced by FAO.

1958 Annual Report Tropical Forest Research Center

The program of the Center during 1958 continued within six broad fields: forest management research, forest utilization research, forest administration, forestry assistance, forestry training, and the Virgin Islands program. Progress in each of these fields was equal to that of the past, and in some, it was accelerated.

With the appointment of a project leader in forest management research for half the year three new studies were begun: reforestation of the shallow loam area in eastern Puerto Rico, expanded testing of pines, and development of new techniques for poisoning undesirable trees.

Forest utilization research, concerned chiefly with preparation of equipment during the previous year, made full use of the new non-pressure treating plant in the testing of fence posts of 53 species.

In the Caribbean National Forest (including the Luquillo Experimental Forest), where a unique tropical example of multiple forest use is being maintained, the progress of stand improvement was accelerated, costs per acre were reduced, and the volume of timber sales increased. Progress was also made in the elimination of undesirable cultivation from within the forest and in more efficient administration of special uses of the forest under some 200 distinct permits, including a large recreation area, summer homes, and numerous electronic installations.

Cooperative assistance in forestry again emphasized potential industrial markets for local woods but also expanded into Commonwealth forest administration. Cost sharing with the Commonwealth continued for the production and distribution of planting stock and technical forestry assistance to farmers.

A forestry short course for training foreign students was held as in the past. A total of 21 students from 12 countries participated. A notable development in this course was more complete treatment of forest utilization.

In the Virgin Islands an outstanding accomplishment was the acceptance on the part of a large number of landowners that forest plantations are needed and their willingness to pay the costs of establishment.

In addition, major improvements were made in the production of mahogany planting stock.

FOREST MANAGEMENT RESEARCH

A total of 149 studies were active in the field of forest management research during the year. These were in the following projects: dendrology, environmental factors, regeneration cuttings, nursery practice, species adaptability, planting methods, growth of residual trees and stands, silvicides, and management units. Only those studies which produced results of special interest during the year are described here.

Reforestation of the Shallow Loam Area

The shallow loam soils on steep slopes within the eastern mountains cover an area of about 166,000 acres. Elevation ranges from 1000 to 2500 feet above sea level and annual precipitation from 50 to 80 inches. Most of this area is so steep that it needs forest protection yet it is almost completely deforested. Tests were started in 1958 to determine the adaptability of several tree species to reforestation of this area. The following fast-growing species with soft, light timbers were tested: *Spathodea campanulata* Beauv., *Erythrina poeppigiana* (Walp.) O. F. Cook, *Didymopanax morototoni* (Aubl.) Dec. & Planch., *Hernandia sonora* L., *Castilla elastica* Cerv., *Cecropia peltata* L., *Spondias* *mombin* L., *Eucalyptus kirtoniana* F. Muell., *Casuarina equisetifolia* Forst., and *Cupressus lusitanica Mill.*

This study entailed the use of seeds of tree species heretofore untried locally. It was found that for *Hernandia* there are 156 seeds per pound. Germination averaged only 17 percent. For *Erythrina* it was found that there are 2099 fresh seeds per pound and germination was 72 percent. For *Castilla* seed weighings showed 1850 per pound, and although interference prevented an exact germination count, it was high. For *Spathodea* the number of seeds per pod ranged from 550 to 730 and the seeds ran 52,000 per pound. Germination was poor but this was probably due to losses from washing by rains. It was found that for *Spondias* there are 400 fruits per pound. Production of nursery stock did not prove difficult, although the plant percentage was low.

A preliminary test of planting stock, started in November 1957, showed that wilding stock of *Hernandia* could be used satisfactorily (6-month survival was 75 percent). Survival of wildings of *Didymopanax* and *Cecropia*, however, was unsatisfactory, possibly due to poor stock. Cuttings were tried with *Spathodea*, *Spondias*, *Erythrina*, and *Castilla*. Surprisingly these species, which root abundantly in nature, did not respond well in the nursery, even with hormones. Therefore, nursery stock was used since no serious problem developed in producing it.

Field planting was tested in six locations ranging from 1500 to 2500 feet elevation. At each location 16 trees of each species were planted in each of two plots. At the end of the year these tests are still so recent that only indications of results are apparent. The most promising species appear to be *Spathodea*, *Cupressus*, *Casuarina*, and *Cecropia*.

Adaptability of Pine

The spectacular response of *Pinus elliottii*, Engelm. to inoculation with mycorrhizal fungi on poor laterite soil, reported previously, has led to several recent trials, the largest of which was undertaken this year. Failures to obtain seed of *P. occidentalis* Sw. and *P. caribaea* Mort. left the United States as the only remaining source of planting material this year. Three thousand seedlings each of **P.** *elliottii* and *P. taeda* L. were imported and planted at seven sites on the island. Elevations range from 500 to 3500 feet, rainfall from 50 to 120 inches annually, and soils from coarse sands to heavy clays. The work was done late in the year and no results are yet apparent. Future plans call for new tests with tropical species of pines.

Yagrumo Hembra Planting

Yagrumo hembra *(Cecropia peltata L.)* has recently attracted attention as a tree of rapid growth producing a light wood with many possible uses. Studies of natural regeneration after clear cutting have been started and artificial regeneration is being tested.

Previous seed collection has shown the extraction factor to be about 20% and the number of seeds per pound to be about 2,250,000. Seed extraction is difficult because the gummy material surrounding the seed makes washing a slow process. The germination of well ripened seed is high, with individual samples up to 80 percent.

Successful propagation resulted from treating the seedlings like eucalyptus. The seed bed is prepared with about equal parts of clay, sand, and filter press cake and is fumigated before sowing. Sowing is done under shade, which is maintained continuously until the seedlings shade the ground (See Fig. 1). After 10 weeks, when the seedlings are 4 to 6 inches tall, they are transplanted into the open at an 8 x 8 inch spacing. The transplant beds are heavily shaded for 2 weeks, after which the shade is gradually removed. Almost no mortality occurred in the transplanting. When the transplants are 10 to 24 inches tall (See Fig. 2) they are ready for lifting.

Fig. 1.—Yagrumo hembra seedlings 35 days after transplanting and 81 days from sowing.

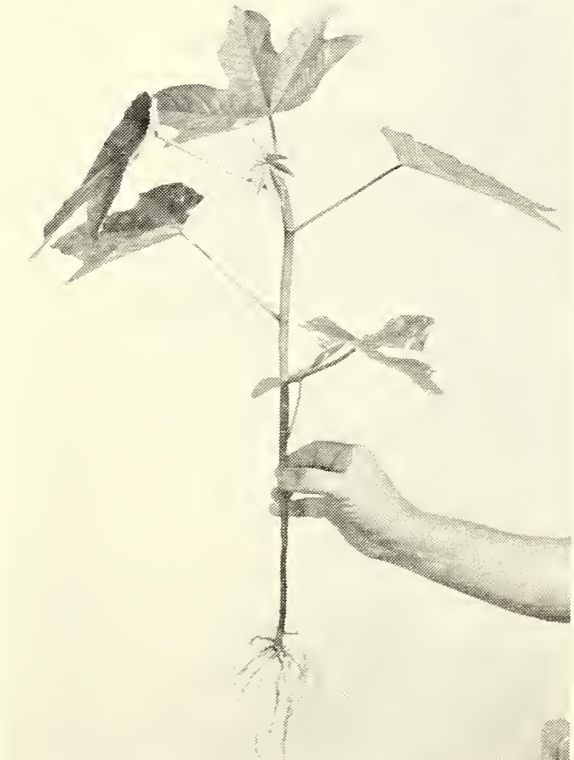


Fig. 2.—Seedling of Yagrumo Hembra 79 days after planted to an outside covered bed and 164 days from seed sowing.

Survival of bare-rooted seedlings in the field has not always been satisfactory, but 80 percent was obtained in six localities in 1958, equal to that of Casuarina. Most of the trees show little evidence of shock from transplanting, and in favorable locations the best specimens reached 6 feet in height in 7 months.

Teak Weeding on St. Croix

Severe grass competition has handicapped the development of plantations of teak (*Tectona grandis* L.) on St. Croix in the Virgin Islands. During the first two years it has been necessary to weed the plantations twice a year, an expensive practice involving hoeing. The most important competitor is guinea grass (*Panicum maximum* Jacq.). A test of the use of herbicides was made in 1958.

Treatments included (1) hoeing a 24-inch strip along the rows (2) hoeing the entire area (3) same as 2, above, with stubble sprayed with 100 gallons per acre of 2% aqueous emulsion of pentachlorophenol (4) same as 2, above, sprayed with 100 gallons per acre of 20% aqueous solution of CMU, and (5) same as 2, above, sprayed with sodium TCA at the rate of 20 pounds per acre in aqueous solution.

Treatments applied in January, at the beginning of the dry season were all effective 3 months later although regrowth of grass had begun in all of them. Retreatment in April was not effective until June, regardless of method. It was apparent that the reestablishment of the grass was taking place from new seed. Further tests are planned.

Complete weeding at the beginning of the dry season adversely affected trees. The 6-month height growth of the trees protected by grass strips 24 inches wide was 60 percent above that of the trees weeded completely. The poison spray was difficult to apply selectively, even though low power was used and a relatively windless period was selected. Teak mortality of 22% in the CMU plots, double that elsewhere, was apparently in part due to contact of the poison with the teak trees.

Advanced Mahogany Plantation Growth

Where adapted, broadleaf mahogany (*Swietenia macrophylla* King), is the most promising exotic plantation tree in Puerto Rico. In the protected sinkholes on the limestone region of the north coast and in the foothills below 1500 feet on clay soils which have not been degraded by farming this species is exceptional in growth rate and tree form.

Growth, development, and reproduction of mahogany plantations are under continuing observation because none of the plantations has yet reached maturity and the final harvest. The oldest plantations on record are two on the Luquillo Mountains, established in 1931. Regular reexaminations of both of these were made in 1958.

Both plantations are located on heavy clay soils in a rainfall belt of 90-120 inches annually. One is at about 800 feet elevation and the other at 1200 feet. One plantation has been dense and pure throughout its life, the other, because of heavy early mortality, consists of scattered mahogany trees surrounded by a volunteer stand.

The pure stand, now 27 years old, was unthinned until its 20th year, and has since been maintained at a basal area in excess of 100 square feet per acre. From 105 square feet in 1952 the stand grew to 153 feet in 1958. The average diameter of the dominant and codominant trees is now 14 inches, with the maximum, 18 inches. Current diameter growth of the dominant and codominant trees is about 4 inches per decade. A thinning made in 1958, reduced the basal area to 110 square feet per acre and yielded about 1000 board feet of timber per acre. Fruiting and natural regeneration appeared for the first time in the 23rd. year. First-year seedlings are now plentiful but only those in openings around the edges of the plantation have reached 6 feet in height.

The mixed stand, now 27 years old, shows clearly the effects of more open spacing in early years. The dominant and codominant trees average 18 inches, with a maximum of 24 inches. Tree form is as good as in the other plantation (20-to 30-foot merchantable heights) despite more open growth. The scattered occurrence of these trees has made precise basal area measurement impractical. Apparently it has always been below 100 sq. ft. per acre. Natural regeneration present as in the other stand, has been kept suppressed by the volunteer growth beneath the mahoganies.

The most striking feature of this second plantation is the sustained rapid diameter growth. Current diameter growth (1952-57) of the dominant and codominant trees is more than 6 inches per decade.

This growth rate is more than that of any other cabinet wood species under observation in Puerto Rico, and it approaches that of eucalyptus.

Tree Poisoning Techniques

Extensive stand improvement operations conducted as a part of the pilot management study have shown the need for more effective methods of eliminating undesirable trees. A shift from felling to girdling and then to poisoning has taken place in the past 3 years. The current standard method is treatment of frills with 5% 2,4,5-T in diesel oil. As described elsewhere in this report most trees can be killed within a year by this method. However, a more rapid and cheaper technique and a quicker kill are desired. This was the objective of an experiment begun early in 1958.

The test concerned trees of 5 common species in the diameter range of 5 to 11 inches, typical of that in the stands under treatment. The tests were made in January, deliberately selecting the time of year when results would be least rapid. Poisoning with ammonium sulfamate and 2,4,5-T (4 pounds acid equivalent per gallon) was compared with a chip girdle. A preliminary tabulation of the results after 12 months is shown in Table 1.

Table 1.—*The Results of Tree Poisoning Treatments*

Treatment	Percent Dead			Percent Unaffected		
	2 mo.	6 mo.	12 mo.	2 mo.	6 mo.	12 mo.
	%	%	%	%	%	%
Chip girdle	0	8	42	71	71	29
Frill with 19.3% Ammate	0	7	31	77	73	48
Frill with 2% 2,4,5-T in water	0	7	23	67	63	40
Basal incision with 10% 2,4,5-T in water	0	5	10	82	85	82
Basal spray with 5% 2,4,5-T in oil	2	50	73	40	35	20
Incised bark spray with 20% 2,4,5-T in water	16	44	62	56	40	17
Bark spray with 20% 2,4,5-T in water	0	8	28	85	72	36

The trees not accounted for in this table are in a stage of partial defoliation or loss of crown. Only two of these treatments appeared superior to the chip girdle. The most effective of the treatments, the basal spray with 5% 2,4,5-T in oil, proved to be no better than the current practice of frill girdling, and the transportation of the spray through the forest proved too cumbersome to be practical.

Additional treatments, begun later, applied sodium arsenite under similar conditions. Early result are shown in Table 2.

Pilot Management Study

The pilot management study, a 6,734-acre demonstration of the results of silvicultural treatment of secondary rain forest, continued into the third year of the first 5-year cutting cycle. About 3,480 acres have been subjected to their first improvement cutting. Details of the technique appeared in the last annual report. Frill-poisoning, using 2,4,5-T at 5 percent strength in diesel oil, continues to be superior to a number of other techniques and poisons tested. The average cost of the treatment for the year was 11.8 man-hours per acre. To the present about 480,000 board feet of timber have been sold from these operations.

Results of the poisoning, reported in preliminary fashion a year ago have now been summarized. An examination of 500 trees was made 9 months after treatment. Thirty-six species were included. Of the total, 345, or 69 percent were dead and 93 percent showed some effects in the crown and are expected to die. A particularly resistant species, pomarrosa (*Eugenia jambos* L) has not yet been defoliated by the poison but a few trees have broken off as a result of insect attack and decay in the bole at the point of treatment.

Detailed sampling of the stands before and after treatment has continued. Some 220 fifth-acre plots were measured in 2 compartments during the year, with about 100 more remaining. Data from 80 of the established plots have been summarized but no analyses have been completed.

Better utilization of the forest is in prospect. A small sawmill is to be set up near the forest in the near future, a facility which we hope will provide an outlet for many of the less-known timbers. The most important progress made in this direction during 1958 was the sale of all yagrumo hembra (*Cecropia peltata* L) in the cutting budget, as excelsior wood.

Table 2—*Preliminary Results of Poisoning Treatments*

Treatment	6-Month Results	
	% Unaffected	% Killed
Continuous frill with 50% sodium arsenite	25	45
Continuous frill with 25% sodium arsenite	25	55
Discontinuous frill with 50% sodium arsenite	20	60
Discontinuous frill with 25% sodium arsenite	60	27
50% sodium arsenite in cups (applied to palms only)	10	80
25% sodium arsenite in cups (applied to palms only)	50	40

FOREST UTILIZATION RESEARCH

Cooperation with private industry, the Commonwealth Division of Forests, and the Economic Development Administration was the keynote in the work of the Division of Forest Utilization Research in 1958. This cooperative work varied considerably depending on the nature of the request, the source, and the project. This work is described elsewhere in this report.

The preservation of fence posts was the main research project during 1958. A total of 4700 posts of 53 species, including one species of bamboo were collected, peeled, and piled for air seasoning. The green moisture content of all posts to be treated was determined from the average moisture content of samples taken adjacent to the top and bottom of each 6-foot post. The posts were weighed soon after peeling and the calculated ovendry weight determined. From this the moisture content of each post was calculated from the current weight at any given period of seasoning.

A manuscript on machining of Puerto Rican woods was reviewed, corrections made, and it is now awaiting publication.

A display of 40 Puerto Rican woods was prepared for the Sixth Session of the Latin American Forestry Commission Conference in Guatemala.

FOREST ADMINISTRATION

The Luquillo Experimental Forest, actually a part of the Caribbean National Forest, has continued to serve not only the research needs of the Center but also as a demonstration of the application of the principles of multiple forest land use in the tropics. As a National Forest this area is subject to the policies of the Forest Service in the United States and its management is dedicated to the principle of "the greatest good for the greatest number in the long run". The area serves as a locale for field experiments, a source of timber for commercial use, a spectacularly scenic resource for forest recreation, and on the peaks a unique area for radio communication. The protection, administration, and management of the 33,000-acre national forest continues to be an important part of the work of the Center.

Timber Sales

Sales of timber from the forest are made primarily as a part of the pilot management study described elsewhere in this report. During 1958 a total of 53 timber sales were made with receipts of $2,742. Sales of other products such as bamboo, moss, and fruits totalled $502. The main obstacle to timber sales is inaccessibility and the lack of facilities for milling lumber and preservative treatment of posts.

Special Uses

The proximity of the forest to a population center of over 300,000 is reflected in the number and types of special uses that are active on the forest today. At the present time there are 203 active permits, of which 140 are paid and 63 are free. In 1958 these permits earned a total of $6,535.67. Of the paid permits, 47 are for electronic installations on either El Yunque Peak or Toro Negro and 40 are for home sites in the La Mina Recreational Area. The others vary from camp sites to water lines.

The administration of the La Mina Recreational Area by the Commonwealth Public Parks and Rerceation Administration has been quite satisfactory. All facilities under their permit are being well maintained or improved; however, the whole area has reached its capacity in the number of people using the facilities. Over 156,000 people visited the area in 1958 and this was about a 20,000 increase over 1957 and a 50,000 increase over 1956. The number of visitors will undoubtedly continue to increase, and this on an area of only thirty-four acres. In recognition of the seriousness of the situation the Center submitted to the Commonwealth detailed plans for the expansion of facilities in the La Mina area and the development of an additional area on the south side of the forest.

A significant step taken during the year was the decision to eliminate the parcelero system, or agriculture permits, on the Luquillo Experimental Forest. This will end a complex and unsuccessful marriage of forest management versus crop production. Some twenty-two permittees still remain as holdovers from the 250 who formely lived in the forest. The goverment-owned residences have been sold to their occupants at a nominal price with the condition that they be removed by June 30, 1959. Those permittees who have their own homes are allowed to remain on a quarter-acre residence site for life tenure. All areas which have been farmed will be planted to trees as soon as possible.

There has been a continuous increase in demand for sites for radio communication on the forest with resulting problems of space and frequency interference. Two areas within the forest are especially suitable to this use at the present time because of their height, accessibility, and available power supply. These are El Yunque Peak (which has an area of about one-half acre) and Mount Maravilla and Mount Tres Dias at Toro Negro. Two radio advisory committees have been formed by the permittees to deal with frequency interference as well as road and site maintenance problems. These committees have operated to our mutual benefit.

Application has been made by the Department of the Navy for the construction of a radar site on East Peak in the Luquillo Unit, by the International Telephone and Telegraph Company for a radio relay site on El Toro in the Luquillo Unit, and Radiotelephone Communicators of Puerto Rico, Inc. for a radio relay site on Cerro Punta in the Toro Negro Unit. Completion of these projects would require about ten miles of new road construction and additional power lines to serve the sites.

Roads and Trails

The steepness of the slopes and the rainy climate within the national forest make the provision of transportation facilities a costly and continuing problem. During the past year a revised plan for development and maintenance of roads and trails was completed. About 6 miles of road are proposed for construction and some 35 miles of existing foot trails are being maintained. The present road system is maintained by the Commonwealth Goverment. The foot trails are maintained primarily to provide ready access for inspection of all of the compartments of the pilot management study. Mapping of these trails was begun during the year.

FORESTRY ASSISTANCE

Forestry assistance to Commonwealth and private agencies was offered by the Center in four general fields: propagation and distribution of forest tree planting stock, technical assistance to private landowners in forest management, assistance to the Commonwealth Division of Forests in public forest administration, and technical assistance in forest utilization.

The Forest Service shared with the Commonwealth the cost of the operation of a forest nursery and the distribution of nearly a million forest trees to farmers during the year. Also shared with the Commonwealth was the cost of a program of cooperative forest management in which farm foresters advise farmers directly on reforestation and woodlot management. This program, formerly concentrated within 5 critical municipalities on the eastern mountains, was expanded during the year to include 8 municipalities.

A joint integrating inspection was made with the Division of Forests of the Guavate Forest and a report was prepared to assist the Division to improve administration of this area. Similar inspections of other Commonwealth forests are scheduled for the future.

A 1-day field training session on stand improvement techniques was held for rangers of the Division of Forests.

One of the major problems in the use of wood for furniture and other manufactured products is the wood-moisture relations. The equilibrium moisture content, that is, the moisture content which wood will finally attain at a given combination of temperature and relative humidity, was calculated for the San Juan area. These data were furnished to local furniture manufacturers, the Ramey Air Force Base, and a local designer, and resulted partially in the awarding of contracts for furniture by the armed forces to local industry.

Information was furnished the Ramey Air Force Base on the cause of breakage in installing spliced antenna poles, and recommendations given on avoiding such breakage in the future. Help was given to a local manufacturer of knives on the possible source of local woods for handles, and methods that might be used to dye these handles a dark color. Assistance was given to a local manufacturer of a cement-wood fiber composition board on the procurement of raw material and methods of preserving the wood during seasoning.

In cooperation with the Economic Development Administration seven demonstrations on the use and maintenance of woods tools were given, with Mr. Frederick Simmons of the Northeastern Forest Experiment Station leading the instruction. About 50 people attended the sessions which were held at El Verde, Adjuntas, Guavate Forest, Toro Negro Forest, and Las Marias.

At the request of the Economic Development Adminisration, samples of local charcoal were sent to two, and wood samples to five, prospective manufacturers in the States.

FORESTRY TRAINING

The fifth tropical forestry short course was held in the spring of 1958. A total of 21 trainees from 12 countries attended the course. Details have been described fully in a previous issue of the Caribbean Forester (19:25-29, 1958).

VIRGIN ISLANDS PROGRAM

The Virgin Islands Forestry Program completed its fourth year as a cooperative venture between the Forest Service and the Virgin Islands Corporation. The program is financed through a $30,000 grant from the Corporation. The program has consisted of three main activities: Forest planting, forest improvement, and forest utilization. To date the program has been limited primarily to the island of St. Croix.

Forest Planting

Planting work centers around the introduction of Dominican mahogany (*Swietenia mahagoni* Jacq.) into natural forests and reforestation with teak (*Tectona grandis* L.). The mahogany stock is produced locally and the teak is imported from Puerto Rico. Seed handling and nursery practices have evolved gradually and are now as follows for Dominican mahogany: the seeds are collected in February and March and sown immediately in 5-inch plastic pots, using alluvial soil. Two seeds are sown per pot. They are propagated under light shade and are ready for planting by September.

Planting of mahogany is done in brushy areas in the more humid parts of the island (mean rainfall 40 to 60 inches in a normal year). Strip clearing is done at a spacing of 20 to 25 feet and the trees are planted 10 feet apart in the rows. About 15,000 trees were planted during the year, and early indications are that survival everywhere is very high.

Teak has been used for the reforestation of cleared lands. Most of the teak has been planted on lands of the Corporation but in the past year about 2000 trees were set out on private lands in different parts of St. Croix. Survival of teak to date has not generally been satisfactory, losses being due to stock delayed in shipment, stock below standard size, inexperienced planters, and unseasonable droughts. At its best, however, teak is sufficiently promising to suggest a continuing program to establish extensive plantations.

Forest Improvement

Improvement of natural forests on St. Croix has been limited to those already containing mahogany and has not yet progressed beyond the lands of the Corporation. During the past year about 15 acres were cleared of wolf trees to liberate young stands of mahogany. About 250 acres on the island still merit improvement.

Forest Utilization

The Program sawmill, used to provide a service to the community in cutting up numerous old trees of mahogany and other valuable species, was subjected to extensive repairs during the year. It has continued to operate on an occasional basis to cut logs removed from forest improvement operations and from private estates. Equipment is being acquired to set up a hot-and-cold-bath plant for the preservative treatment of fence posts.

The 1959 Tropical Forestry Training Course

F. BRUCE LAMB
Training Officer
Tropical Forest Research Center

INTRODUCTION

Technical assistance programs developing on a world wide scale draw increasing attention to the vital relationship between national welfare and national development of natural resources. In tropical regions the importance of managing the land for continuous long range production of valuable food and industrial raw material becomes more apparent every day with population growth and the desire for better standards of living.

A large proportion of the soils in the tropics are not suitable for continuous, clean cultivation, and the practice of forestry offers one of the most promising means of obtaining permanent yield of valuable products from such land. To achieve a higher level of production from tropical forest lands requires improved methods of utilizing the raw material available in the natural forests and a change in the forests composition to produce more valuable types of raw material.

Many countries that have extensive tropical forests lack the forestry technicians needed to organize the adequate utilization of their forest resources. For several years the Tropical Forest Research Center of the U.S. Forest Service has offered a tropical forestry training course at Río Piedras, Puerto Rico, in cooperation with the Food and Agriculture Organization of the United Nations and the International Cooperation Administration of the United States. This program provides tropical training for forestry technicians and helps to fill the need for tropical foresters. Since the first course in 1955, ninety trainees from thirty countries have taken advantage of the facilities offered.

The 1959 training program covered a period of 12 weeks from March 30 to June 19. The International Cooperation Administration recruited the trainees and financed travel and subsistence for all but two of the participants. ICA also paid the local costs of instructors, administration, and transportation.

The Food and Agriculture Organization of the United Nations provided many publications of special interest to tropical foresters and an instructor for the study of forest administration and policy.

The Tropical Forest Research Center was responsible for administration and conduct of the course. Assistance was provided by the Office of Technical Cooperation, Puerto Rico Department of State; Division of Forests, Fisheries, and Wildlife of the Department of Agriculture and Commerce of Puerto Rico; Agricultural Extension Service of the University of Puerto Rico; the Soil Conservation Service, and Agricultural Stabilization and Conservation Service both of the U.S. Department of Agriculture. Orientation, technical assistance, instruction, and training materials were provided within the fields of specialization of these organizations.

FACILITIES

Puerto Rico with its various land use and population problems combined with programs to solve them offers an excellent environment for the presentation of a tropical forestry program. The Tropical Forest Research Center in combination with other Federal and Commonwealth agencies has access to a wide range of land use programs. Tropical forestry administration has been in progress for 40 years. Forestry programs vary from reforestation projects begun 30 years ago to the development of management plans for natural forests. The wood utilization section has a well equipped installation for machining tests and preservative treatment of wood. Contact is also maintained with many private forestry and wood utilization projects. Library facilities cover tropical forestry and allied fields in several languages.

Equipment furnished by ICA made possible simultaneous translation from English to Spanish and vice versa. With this equipment the class material could be presented more rapidly than in previous years.

OBJECTIVES

The principal objective of the course was to explain and demonstrate to a picked group of practicing tropical foresters the methods, techniques and practices that promise success in the management of tropical forests and related natural resources. By means of personal interviews and a series of round table discussions the material of the course was adapted as far as possible to fit the problems of specific countries and individual trainees.

A long range objective of the program is to establish lasting personal contacts between foresters working in the tropics, and promote multilateral exchanges of ideas, points of view and problems.

Instruction

The personnel of the Tropical Forest Research Center did most of the teaching, covering a wide range of fields of individual specialization. The Commonwealth Division of Forests, Fisheries and Wildlife made a considerable contribution to the success of the course by assisting in the work of aerial photographic interpretation and field demonstration of regeneration, silviculture, and nursery practice on Commonwealth Forests.

Mr. Louis Huguet, Food and Agriculture Organization of the United Nations, presented material on forest legislation and policy and led the final round table discussion of individual country problems in this field. Mr. Huguet is stationed in Mexico and has had more than 10 years experience in Latin America.

TRAINEES

The program was open to men with forestry training and experience, preferably graduate engineer-agronomists or graduates of secondary or technical schools with at least 4 years of forestry experience. Trainees were expected to have an active professional interest in tropical forestry and a working knowledge of either Spanish or English. Candidates were recomended by their governments to the local ICA Mission which sponsored the training of qualified applicants.

Thirteen full time trainees from eight countries attended the course. The name, position and country of each is as follows:

Rémy Al Delphin Director of SHADA Mare Rouge Forestry Division	Haití
Apandi Mangoendikoro Director of Tarakan Forestry District	Indonesia
John Irving Reeves Forest Ranger Bureau of Forest Conservation	Liberia

Willie Wuelleh Cooper Forest Ranger Bureau of Forest Conservation	Liberia
Pablo Jaime Bellido Agricultural Instructor Ministry of Agriculture	Panamá
Carlos Aurelio López Ibañez Forestry Extension Agent Agriculture Extension Service	Colombia
Alvaro Villamizar Cardozo Forest Superintendent Municipality of Cali	Colombia
Rafael Cassannello Forester, Colombian-American Agricultural Technincal Service	Colombia
José Vicente Rodríguez M. Forest Superintendent Forest Experiment Station Piedras Blancas	Colombia
Alberto Loaisiga Cruz Forest Inspector Ministry of Agriculture and Livestock	Nicaragua
Julio César Moya A. Forest Inspector Ministry of Agriculture and Livestock	Nicaragua
Enrique del Valle Private Forester	Chile
Edwin Pacheco Smith Forester, Commonwealth Division of Forests, Fisheries and Wildlife	Puerto Rico

TRAINING PROGRAM

The training program included lectures, round table discussions, field trips, laboratory demonstrations, and training films.

Orientation 3 days

During the first three days the students were given general background information on Puerto Rico including history, economy and education. The history of forestry in Puerto Rico including the present status and the future were covered along with a preview of the course.

Round Table I 2 days

The trainees gave a general presentation of the geography and development of the

Fig. 1.—CELEBRATION OF THE SIXTH INTERNATIONAL COURSE OF FORESTRY.—Students attending the short course at the Tropical Forest Research Center Back row, left to right: E. Pacheco, Puerto Rico; R. Cassannello, Colombia; P. Bellido, Panamá; F. Bruce Lamb, Training Officer, TFRC; C. López, Colombia; A. Loáisiga, Nicaragua; R. Delphin, Haití; A. Mangoendikoro, Indonesia. Front row, left to right: J. Rodríguez, Colombia; J. Moya, Nicaragua; A. Villamizar, Colombia; W. Cooper, Liberia; E. del Valle, Chile; John Reeves, Liberia; A. Rivera, Puerto Rico.

countries represented which served as a background for the course and later discussions of individual forestry problems.

General Forestry 2 days

This review of the forestry field covered tree production, forest products, services of the forest, forest management and supporting fields, related fields, and world forestry.

Two days were taken up with field trips to give a general picture of forestry activities in Puerto Rico.

Dendrology 3 days

The material covered in this field included nomenclature, botanical classification, construction and use of botanical keys for tree identification, collection and preparation of botanical specimens.

Ecology 2 days

The use of environmental factors in the classification of tropical vegetation into Formations, Associations, and Types was presented. The importance of the proper evaluation of ecological factors in forest management and reforestation projects was emphasized. One day was spent in field demonstration.

Round Table II 2 days

A description of the tree species and forests of the countries represented was given by trainees along with questions and discussions.

Artificial Regeneration 2 days

Included in the discussion of this subject were purposes, problems, and methods of artificial regeneration. Seedling production, lifting, grading, storage and transportation were also covered along with tree planting principles and practices. One day was spent in the field observing forest nursery practices, and the training film "Soil Bank" was shown.

Silviculture 5 days

Silvics, silvicultural principles, tropical silviculture, and timber stand improvement were discussed. Field trips covering three days presented plantation treatment of mahogany and teak, timber stand improvement in mixed natural forest, mangrove forest cutting practices, and improvement of secondary forests.

Wood Utilization 9 days

The program of instruction on wood utilization covered forest products research in Puerto Rico, new uses of wood, wood structure, wood properties, milling practices, wood-moisture relationships, pulp and paper, wood laminates, seasoning and drying, wood preservation, finishes, joints, and fasteners.

The following films on utilization were shown: "A Piece of Wood", "The Small Sawmill", "Tree to Trade", and "Longer Life for Wood". Field trips were made to a local wood treating plant, a furniture factory, two paper plants, and a factory producing building material from a mixture of cement and excelsior.

Round Table III 2 days

The utilization problems of individual countries were discussed.

Forest Protection 1 day

This phase of the course included fire prevention and suppression, protection against insects and disease. Training films "Building a Fire Lane" and "Watershed Wildfire" were shown.

Public Forestry 3 days

Forest Service organization, U.S. National Forest resource policy, watershed management, forest engineering, safety programs, information and education methods were discussed. Training films "Rainbow Valley", "Mountain Water", "Water of Coweeta", and "Forest Service Engineer" were shown.

Forest Mensuration 9 days

Equipment use, map use, units of measurement, volume tables, basic statistics, aerial photo interpretation, type mapping, cruising techniques, types and designs of cruises, field cruise, and analysis of cruise data were considered.

Forest Management 2 days

Multiple use, timber production, management plans, and yield computation were discussed.

Forest Research 2 days

Research in regeneration, silviculture, and utilization were discussed along with research requirements, problems, and problem area.

Forest Policy and Legislation 2 days

Forest policy formulation, required legislation to implement policies and special problems in tropical America were covered in this presentation. The training film "The River" was shown.

Private Forestry 2 days

United States, State and private forestry programs were presented along with a panel discussion of local programs of assistance to private forestry. Representatives of the U.S. Agricultural Stabilization and Conservation Service, Commonwealth of Puerto Rico Division of Forests, and Agricultural Extension Service of the University of Puerto Rico assisted. The training film "Out of the Woods" was shown.

A one-day field trip demonstrated the type of work being done in Puerto Rico.

Round Table IV 3 days

A general discussion among the participants presented the special forestry problems, forest policy and legislative programs of each country. The course was terminated with a resume of the general forestry situation of the area represented by Mr. L. H. Huguet of FAO and presentation of diplomas by Dr. F. H. Wadsworth, Tropical Forest Research Center Leader.

Training Course 1960

The training course for 1960 will be similar to that offered in 1959 and will be held during the period September to December. The exact dates will be announced later. Persons desiring to attend the training course should apply through their Governments. Ordinarily, their application should be forwarded through their immediate superior to the Chief of their Forest Service or Ministry of Agriculture. If the individual or his Government wishes to pay his expenses, the Government will simply forward the application to Dr. Frank H. Wadsworth, Tropical Forest Research Center, U. S. Forest Service, Post Office Box 577, Río Piedras, Puerto Rico, giving such biographical data as age of applicant, education, past positions held, and present position.

If financial aid is desired, the proper Government official will ordinarily contact such agencies as the International Cooperation Administration of the United States of America, Food and Agriculture Organization of the United Nations, Rockefeller Foundation or Ford Foundation. The cultural attaché at the American Embassy in most countries is in a position to advise individuals and Government representatives regarding the availability of, and procedures for applying for, scholarships from these and other sources. Applications for funds should be forwarded to the central office of the financing agency not later than June 1, 1960. The principal point to remember is that the individual should apply through his Government and not directly to the Tropical Forest Research Center.

A Selected, Annotated Bibliography on Mahogany

F. BRUCE LAMB
Tropical Forest Research Center

The literature on mahogany goes back to the time of the conquest of the New World and is published in a variety of media and in several languages. Since the 17th century, mahogany lumber has been an important item in world hardwood lumber markets. Until recent years little interest has been shown in determining the position of mahogany in tropical forests as a permanent source of industrial raw material. The main effort has been spent in extracting the logs from the forest and promoting the sale of the products therefrom.

However, with the present drive of underdeveloped countries in the tropical regions of the world to improve their condition of life there has come an increased interest in natural resources. It has been well established that extensive tropical areas are for various reasons not suitable for permanent cultivation. Many of these lands are suitable only for forest growth. If these areas are to contribute to the permanent welfare of people that control them they must be managed to produce valuable woods or other forest products.

Mahogany, a product of the forest of tropical America, has been established for more than 200 years as a standard of quality for many uses of wood. Because of its position in the milieu of tropical vegetation and its universal acceptance as a wood, mahogany will no doubt receive increasing attention from tropical foresters.

This bibliography of the literature, which has been accumulated over a period of several years, is published in the hope that it may be of help to tropical foresters who are interested in mahogany.

It is not intended that this be considered a complete and exhaustive coverage of the field. Additional material was examined but omitted here because it did not contribute materially to the subject matter. Some publications of interest have undoubtedly been overlooked.

The material is grouped under ten of the major headings of the Oxford Decimal System of Classification for Forestry. Under the headings the citations are listed chronologically by years. Some of the publications covering a broad field are listed under several of the headings. An author index occurs at the end to facilitate location of the work of any particular author. The annotations are meant to give in as brief a manner as possible an idea of the content. Where the title of some citations is descriptive of the content no further remarks are made.

UNA BIBLIOGRAFIA SELECTA Y ANOTADA SOBRE CAOBA

La literatura sobre caoba se remonta a los tiempos de la conquista del Nuevo Mundo habiéndose publicado en varios idiomas y de diversos medios. Desde el siglo 17 la madera de caoba ha sido un artículo de importancia en los mercados mundiales de maderas duras. Hasta hace poco tiempo se habia demostrado poco interés en determinar las posibilidades de la caoba de los bosques tropicales como una fuente permanente de materia prima para las industrias. La mayor actividad y esfuerzo se ha empleado en extraer la madera bruta de los bosques y en la promoción de la venta de sus productos.

Sin embargo con el movimiento actual de los países tropicales subdesarrollados hacia el mejoramiento de sus condiciones de vida, ha despertado el interés en la contribución de los recursos naturales. Al mismo tiempo se ha reconocido que extensas zonas tropicales, por diversas razones, no son aptas para cultivarse permanentemente. Muchas de estas regiones se prestan solamente para la producción forestal. Naturalmente si dichas zonas han de contribuir al bienestar permanente de los pueblos que las controlan, deben manejarse para la producción de maderas valiosas o de otros productos forestales.

La caoba producida en los bosques de la América Tropical ha constituído durante más de 200 años un standard de calidad para muchos usos de la madera. Debido a la posición de la caoba en el ambiente de la vegetación tropical y a su universal aceptación como madera sin duda alguna atraerá cada vez mayor atención de los dasónomos del trópico.

Esta bibliografía de la literatura sobre caoba, acumulada durante un período de varios años, se ha publicado en la esperanza que pueda ser de ayuda a aquellos dasónomos interesados en esta materia.

No ha sido la intención que dicho trabajo se considere como un estudio completo y detallado. Se han examinado otras publicaciones, las que no se incluyeron por considerarse que no constituían una contribución importante a la materia. No hay duda de que algunas publicaciones de interés han pasado inadvertidas.

El material se agrupó bajo diez de los encabezamientos principales del Sistema Decimal Oxford de clasificación para literatura forestal. Bajo dichos encabezamientos las citas se enumeran cronológicamente por años. Algunas de las publicaciones que cubren un campo amplio estan incluídas bajo varios encabezamientos. Al final se incluyó un índice por autores para facilitar la selección de materias por sus autores. Ha sido la intención que las anotaciones den una idea del contenido de la manera más breve posible. En caso de que el título de algunas citas sea descriptivo de su contenido no se añaden otras notas.

17. SYSTEMATIC BOTANY

1. CATESBY, M.
1754. NATURAL HISTORY OF CAROLINA, FLORIDA AND THE BAHAMA ISLANDS. London. Printed for C. Marsh, T. Wilcox and B. Stichall.

Description and illustration of mahogany, type specimen for Jacquin's description of S. **mahagoni.** V.2, p.81.

2. LINNAEUS, C.
1758-59- SYSTEMA NATURAE. Ed. 10, 940 pp., Holmiae, L. Salvii.

First botanical description of mahogany as **Cedrela mahagoni** from Catesby's illustration.

3. JACQUIN, J. N.
1760. ENUMERATIO SYSTEMATICA PLANTARUM, QUAS IN INSULIS CARIBASIS. Haak, Lugduni Batavorum.

Description of genus **Swietenia** and species **mahagoni,** from Catesby's illustration.

4. DESROUSSEAUX
1789. MAHAGONI. In Lamarck's Dictionnaire encyclopedique de botanique (Paris) 3:678-679.

Botanical description of **Swietenia senegalensis** from Senegal, Africa (African mahogany).

5. JUSSIEU, M. A.
1830. LE GROUPE DES MELIACEAE. Memoires du Museum d'Histoire Naturelle, (Paris) 19:153-304.

S. senegalensis Desr. renamed **Khaya senegalensis,** Botanical description

6. ZUCCARINI, J. G.
1837-40. PLANTARUM NOVARUM VEL MINUS COGNITARUM, QUAE IN HORTO BOTANICO HERBARIOQUE REGIO MONACENSI SERVANTUR. IV fasiculi. Munchen Monschi, Franz. Abhandlungen Akademie.

Botanical description of **S. humilis.**

7. CANDOLLE, C. de
1873. MELIACEAE. In de Candolle, Monogr. Phan. 1:399-752.

Botanical description.

8. KING, G.
1886-87 **SWIETENIA MACROPHYLLA**, Hooker's Incones Plantarum. illus. London, Williams and Norgate.

Botanical description **S. macrophylla**, (Ser. 3, V. 6, Pl. 1950).

9. BUSCH, P.
1911. **DIE MAHOGANISORTEN DES HANDELS, GEORDNET NACH DEN EINZELNEN PRODUKTIONSGEBIETEN UND IHRER BOTANISCHEN ABSTAMMUNG.** Tropenpflanzer (Berlin) 15(9):479-493.

Types of mahogany, origin and botanical classification.

10. DIXON, H. H.
1918. **MAHOGANY, AND THE RECOGNITION OF SOME OF THE DIFFERENT KINDS BY THEIR MICROSCOPIC CHARACTERISTICS.** Royal Dublin Soc. Sci. Proc. (N.S.) 15(34):431-586.

Comparison of minute anatomy.

11. ROLFE, R. A.
1919. **THE TRUE MAHOGANIES.** Kew Bul. No. 3:201-206.

Source material on early history and synonymy, description of wood, range of **S. mahagoni, humilis, and macrophylla** from the literature.

12. BLAKE, S. F.
1920. **REVISION OF THE TRUE MAHOGANIES.** Jour Wash. Acad. Sci. 10(10):286-297.

History of botanical collections, descriptions and sources, detailed botanical description of genus **Swietenia** Jacq., **S. mahagoni, humilis, macrophylla, cirrhata, candollei**, type, locality, other localities and collectors, distribution given now incomplete.

13. PITTIER, H.
1920. **THE VENEZUELAN MAHOGANY, A HITHERTO UNDESCRIBED SPECIES OF THE GENUS SWIETENIA.** Jour. Wash. Acad. Sci. 10(1):32-34.

Botanical description of **S. candollei.**

14. STANDLEY, P. C.
1920. **CONTRIBUTIONS FROM THE U.S. NATIONAL HERBARIUM.** 23(3):559-561.

Botanical description, local use, common names, **S. humilis, S. cirrhata. S. macrophylla.**

15. PITTIER, H. and RECORD, S. J.
1921. **LA CAOBA VENEZOLANA.** 14 pp., Caracas, Tipografía Americana. Also Bol. Comercial e Industrial (Caracas) 18:582-593.

16. RECORD, S. J.
1921. **THE WOOD OF VENEZUELAN MAHOGANY (S.CANDOLLEI).** Yale Sch. of Forestry Contrib. 16:1-7. Also Bol. Comercial e Industrial (Caracas) 18:577-581.

Anatomy and comparison with **S. mahagoni**, commercial possibilities.

17. SARGENT, C. S.
1921. **MANUAL OF TREES OF NORTH AMERICA.** 910 pp., illus. New York, Houghton Mifflin.

Botanical description illus. distribution **(S. mahagoni).**

18. KOEHLER, A.
1922. **THE IDENTIFICATION OF TRUE MAHOGANY.** U.S. Dept. Agri. Bul. No. 1050, 18 pp., illus.

Distribution then known, physical properties, structure. Key for identification of true and mahogany-like woods.

19. HARMS, H.
1927. **SWIETENIA TESSMANNII HARMS.** Notizblat des Konigl. Bot. Gartens und Museums zu Berlin - Dahlem 10:180.

Botanical description.

20. MACBRIDE, J. F.
1928. **IDENTITY OF THE PERUVIAN MAHOGANY.** Trop. Woods 16:49-50.
S. tessmannii and **S. macrophylla.**

21. COLLARDET, J.
1930. **LES KHAYA, SON-ILS DES ACAJOUS?** Actes & Comptes Rendus. L'Association Colonies - Sciences (Paris) 6(6):197-209.

Name controversy, history, botany **Swietenia** and **Khaya**, comparison of wood properties, chemical, technological, physical, mechanical.

22. KRIBS, D. A.
1930. COMPARATIVE ANATOMY OF WOODS OF MELIACEAE. Amer. Jour. Bot. 17(8):724-738. 16 refs.

23. PANSHIN, A. J.
1933. COMPARATIVE ANATOMY OF THE WOODS OF MELIACEAE, SUB-FAMILY SWIETENIOIDEAE. Amer. Jour. Bot. 20: 638-688.

Botanical description of **Swietenia** species including wood description, general and minute. Range and distribution, now incomplete.

24. ANONYMOUS
1936. THE TRUE BOTANY OF MAHOGANY. Hardwood Record 73(10):9-10.

Botany of **Swietenia** and **Khaya,** name, wood comparison.

25. MELLVILLE, R. A.
1936. A LIST OF TRUE AND FALSE MAHOGANIES. Kew Roy. Bot. Gard., Misc. Inform. Bul. 3:193-210.

Mahogany trade, appearance of woods not Swietenia, list common and scientific names.

26. GLEASON, H. A. and PANSHIN, A. J.
1936. SWIETENIA KRUKOVII: A NEW SPECIES OF MAHOGANY FROM BRAZIL. Amer. Jour. Bot. 23(1):21-25.

Botanical description, status of species in genus, range habitat and occurrence, associates, logging, wood description, minute anatomy, (**S. macrophylla**).

27. ANONYMOUS
1937. TRUE AND FALSE MAHOGANIES. Kew Bul. Misc. Information p.274-276.

Discussion of application of name mahogany.

28. CHEVALIER, A.
1937. NOTES HISTORIQUES ET SOUVENIRS SUR LES ACAJOUS VRAIS. Rev. Bot. App. and d'Agric. Trop. 17(194):709-724.

Notes on early use, application of name to **Khaya** (African mahogany) development of name 'Acajou' French for mahogany.

29. HARMS, H.
1940. MELIACEAE. In Engler and Prantl, Die naturlichen Pflanzenfamilien, ed 2, Bd. 19b:1-172.

Botanical description.

30. LUNDELL, C. L.
1941. STUDIES OF AMERICAN SPERMATOPHYTES. - I. Contribution from Univ. of Mich. Herbarium No. 6., 37 pp. Ann Arbor.

Description of **S. belizensis** and occurrence in British Honduras.

31. RECORD, S. J.
1941. AMERICAN TIMBERS OF THE MAHOGANY FAMILY. Trop. Woods 66:7-33.

Lists American genera of family Meliaceae, describes **Swietenia** and species, variation in characteristics, early uses, various name spellings, sources of early shipment, distribution in upper Amazon, wood description, common names.

32. STANDLEY, P. C. and STEYERMARK, J. A.
1946. FLORA OF GUATEMALA. Fieldiana: Botany. Field Mus. Natl. Hist. 24(5):456-459.

Botanical description of 3 accepted species, **Swietenia mahagoni** (L.) Jacq., **S. humilis** Zucc., **S. macrophylla** King, giving limited information on range and distribution.

33. RECORD, S. J. and HESS, R. W.
1947. TIMBERS OF THE NEW WORLD. 640 pp., illus. New Haven, Yale Univ. Press.

Botanical description, discussion of species differences, wood variation, history of use, distribution, reforestation activities, wood description.

34. HESS, R. W.
1950. IDENTIFICATION OF SWIETENIA AND CARAPA. Trop. Woods No. 96:47-50

35. STEHLE, H.
1956. LES MAHOGANYS DES ANTILLES FRANCAISES ET LE SWIETENIA AUBREVILLEANA. Soc. Bot. France Mem. 1956/57 41-51. 23 refs.

Botanical description. Origin, history of introduction of mahogany to French Antilles, occurrence of intermediate form between small leaf and broad leaf ma-

hogany in the reproduction, description of the three types, discussion of synonymy and distribution, botanical description of the intermediate type as **S. aubrevilleana** Stehlé & Cusin, spec. nov. - hybrid, mutation or undescribed species introduced with the broadleaf, **S. macrophylla,** use in reforestation.

18. PLANT ECOLOGY

36. GIFFORD, J. C
1909. THE MAHOGANY TREE AND ITS GROWTH AND NATURE. Woods-Craft (Cleveland) 11(6):159-162.

37. ____________
1911. THE EVERGLADES. 134 pp., Kansas City, Everglades Land and Sales Co.

Description of occurrence of **S. mahagoni** in Florida.

38. HUMMEL, C.
1920. NOTES ON THE DEVELOPMENT OF THE WILD MAHOGANY AND PINE FOREST IN BRITISH HONDURAS. Agric. News (Barbados) 20:134-135.

39. RECORD, S. J.
1925. DISTRIBUTION OF THE SPECIES OF SWIETENIA. Trop. Woods No. 1:2-4.

Distribution listed now outdated.

40 ____________
1926. MAHOGANY IN THE UPPER AMAZON. Trop. Woods 6:1-2.

Occurrency of mahogany in Peruvian Amazon (**S. macrophylla**).

41. STEVENSON, D.
1926. REPORT ON THE FRESHWATER CREEK CROWN LANDS, LOWRY'S BIGHT, BRITISH HONDURAS. 8 pp., illus. Belize.

Description of mahogany producing forest types (**S. macrophylla**).

42. OWER, L. H.
1927. FEATURES OF BRITISH HONDURAS. Geog. Jour., (London) 70:372-386.

Description of geology, soils and vegetation of mahogany producing area.

43. OLIPHANT, J. N.
1928. MAHOGANY IN BRITISH HONDURAS. Empire Forestry Jour. 7(1):9-10.

Description of occurrence of **S. macrophylla,** relation to past cultivation, plant succession and vegetation types.

44. STEVENSON, D.
1928. TYPES OF FOREST GROWTH IN BRITISH HONDURAS. Trop. Woods 14:20-25.

Description of forest types producing mahogany (**S. macrophylla**).

45. STANDLEY, P. C.
1930. FLORA OF YUCATAN. Pub. _279, Field Museum of Natl. History; Bot. Serv. 3(3):157-492. 186 refs.

Geology, climate, vernacular names, Maya names, plant descriptions, important mahogany area (**S. macrophylla**).

46. ____________
1930. NOTES ON MEXICAN TREES - THE MAHOGANIES. Trop. Woods 21:6-8.

Discussion of nomenclature, occurrence in Mexico of (**S. macrophylla** and **S. humilis**).

47. WILLIAMS, L.
1931. THE FORESTS OF NORTHEASTERN PERU. Trop. Woods 25:5-12.

Importance, distribution, stocking, location of cutting, time of high water for rafting logs, climate (**S. macrophylla**).

48. ____________
1932. PERUVIAN MAHOGANY. Trop. Woods 31:30-37.

Discovery, botanical classification, distribution, sites, stocking. supply, description of tree and wood, insect caused defects, volume of exports, location of cutting (**S. macrophylla**).

49. CIFERRI, R.
1933. STUDI SULL'ECOLOGIA DEL MOGANO (S. MAHAGONI JACQ.) EN SANTO DOMINGO. Atti. Istit. Bot. di Pavia. 4: ser. 4:87-166., illus.

Distribution, geographic and altimetric, ecology, habitat, associates, regeneration, insects and diseases, seed and fruit study, silvics.

50. LUNDELL, C. L.
1933. PRELIMINARY SKETCH OF THE PHYTOGEOGRAPHY OF THE YUCATAN PENINSULA. Carnegie Inst. Wash. Contrib. Amer. Archeol. 2(12):257-321.

Vegetation studies in mahogany producing forest.

51. DUCKE, A.
1934 & 1938. COLHEITA DE MATERIAL BOTANICO NA REGIAO AMAZONICA. Braz. Min. du Agr. Bul. 23(1-3):71-79 & (4-6):33-47. 27(406):23-58.

Occurrence and exploitation of mahogany in the Amazon with description of vegetation, and names of other timber species.

52. STEVENSON, R.
1934. THE RESOURCES OF BRITISH HONDURAS. Bul Imperial Inst. No. 32:356-410.

Description of plant associations containing mahogany.

53. BARTLETT, H. H.
1936. A METHOD OF PROCEDURE FOR FIELD WORK IN TROPICAL AMERICAN PHYTOGEOGRAPHY BASED UPON BOTANICAL RECONNAISSANCE IN PARTS OF BRITISH HONDURAS AND THE PETEN FOREST OF GUATEMALA. p. 1-25, illus. Botany of the Maya Area; Miscellaneous Papers I-XIII Washington, Carnegie Inst.

Ecological description of forest in important mahogany producing area of Yucatan peninsula, including plant associations, plant succession, soils.

54. HOLDRIDGE, L. R.
1936. CAOBA. Rev. de Agri. de Puerto Rico Suplemento No. 3:25-30. illus., 6 refs.

Adaptation of mahogany to conditions in Puerto Rico.

55. RICE, C. H.
1936. THE NORTHERN OUTPOST OF MAHOGANY. American Forests 42:266-267.

S. mahagoni in Florida, distribution, differences in wood, mainland and islands, use.

56. LUNDELL, C. L.
1937. THE VEGETATION OF PETEN. 244 pp., illus. 60 refs. No. 478. Washington, Carnegie Inst.

Ecological study of vegetation of Peten, Guatemala, mahogany producing area, including history, geology, soils, climate, vegetation analysis and classification.

57. CIFERRI, R.
1938. OSSERVAZIONI SUL GENERE SWIETENIA E POSSIBILITA DI ACCLIMATIZAZIONE DEL VERO MOGANO (S. MAHAGONI) NELLA REGIONE DEL GIUBA (a. o. i.). L'Alpe (Milan). 25(4):89-95.

Distribution, introduction, ecology, production in Santo Domingo.

58. STANDLEY, P. C. and RECORD, S. J.
1938. THE FOREST AND FLORA OF BRITISH HONDURAS. Field Mus. Nat. Hist., Bot. Ser. 12. 432 pp., illus.

Discussion of soil, climate, forest types and important timbers including mahogany.

59. WILLIAMS, L.
1938. FOREST TREES OF THE ISTHMUS OF TEHUANTEPEC, MEXICO. Trop. Woods 53:1-11.

Forest description, occurrence of mahogany, coastal and central zone (**S. macrophylla**).

60. STEVENSON, N. S.
1939. ANNUAL REPORT OF THE FOREST DEPARTMENT, BRITISH HONDURAS. 25 pp., illus. Belize.

Mahogany exports, control of cutting on public and private land, mapping vegetation types from aerial photos, relation of forest types to soils, rainfall distribution map (**S. macrophylla**).

61. CHARTER, C. F.
1940. THE SOILS OF BRITISH HONDURAS. 31 pp., illus., 16 refs. Port of Spain, Trinidad.

Description of forest vegetation containing mahogany in relation to soil, northern portion, semi-deciduous monsoon forest; Chiquibul region. transitional to semi-evergreen rain forest; semi-evergreen rain forest of well-drained river valleys.

62. LUNDELL, C. L.
1940. THE 1936 MICHIGAN-CARNEGIE BOTANICAL EXPEDITION TO BRITISH HONDURAS. No. 14:1-57. illus., 65 refs. Botany of the Maya area. Miscellaneous Papers. Pub. 522. Washington, Carniegie Inst.

Archaeology, mahogany exploitation, classification and description of the vegetation, transect studies of forest types.

63. EGLER, F. E.
1941. MAHOGANY: A POTENTIAL RESOURCE OF SOUTH FLORIDA. Jour. of For. 39(8):725-726.

S. mahagoni in Florida, sites, ecology in West Indies, growth, quality.

64. STEVENSON, N. S.
1942. ANNUAL REPORT OF THE FOREST DEPARTMENT OF BRITISH HONDURAS. 8 pp. Belize.

Hurricane effect on forest, mahogany wind resistant.

65. ————————
1942. FOREST ASSOCIATIONS OF BRITISH HONDURAS. Carib. For. 3(4):164-172.

Description of mahogany producing plant associations, structure, physiognomy, composition, and habitat.

66. DUCKE, A.
1943. THE MOST IMPORTANT WOODS OF THE AMAZON VALLEY. Trop. Woods 75: 1-15.

Aguano (**S. macrophylla**) discussion of species, distribution, lumber trade.

67. PLATT, R. S.
1943. LATIN AMERICA. 564 pp. New York, McGraw-Hill.

Description of occurrence in part of Panama (**S. macrophylla**).

68. FROES, R. de Lemos
1944. MAHOGANY DISCOVERED IN THE STATE OF PARA, BRAZIL. Trop. Woods No. 78:1-3.

Logging upper Amazon, discovery of mahogany on Río Tocantins and Río Xingú, lower Amazon (**S. macrophylla**).

69. GIFFORD, J. C.
1944. TREES OF SOUTH FLORIDA. Scientific Monthly. 59:101-107.

Occurrence of **S. mahagoni** in Florida.

70. LUNDELL, C. L.
1945. THE VEGETATION AND NATURAL RESOURCES OF BRITISH HONDURAS. Plants and plant science in Latin America. pp. 270-273. Chronica Botanica.

Description of forest association, mahogany industry, vegetation type map.

71. STEVENSON, N. S.
1945. FOREST ASSOCIATIONS OF BRITISH HONDURAS. Carib. For. 6(2&3):45-61 and 131-147.

Description of mahogany producing plant associations, structure, physiognomy, composition, and habitat.

72. LITTLE, E. L.
1947. DOES MAHOGANY (SWIETENIA) OCCUR IN ECUADOR? Trop. Woods 92:41-43.

No herbarium material recorded from Ecuador, literature confused.

73. IRMAY, H. de
1948. LA CAOBA EN BOLIVIA. Boletin Forestal No. 1:5-12. illus., 13 refs. Pub. Facultad de Ciencias Agronómicas. Cochabamba. Bolivia, Imprenta Univ. Also in Carib For. 10(1):43-52. 1949.

Distribution map, associates, occurrence, supply, quality (**S. macrophylla**).

74. HOLDRIDGE, L. R., LAMB, F. B., and MASON JR., B.
1950. LOS BOSQUES DE GUATEMALA. 175 pp., illus. 25 refs. Guatemala, Instituto de Fomento de la Producción.

Peten forests, Maya occupation, effects of chicle production, mahogany logging operations, aerial photo study, ground studies at Uaxactun, Paso Caballos, La Libertad, Poptun; ground interpretation of photos, forest types.

75. LAMB, F. B.
1954. **UTILIZATION, DISTRIBUTION AND MANAGEMENT OF TROPICAL AMERICAN MAHOGANY.** 441 pp., illus., 269 refs. Ann Arbor Mich. Univ. Microfilms No. 7679.

Occurrence **S. mahagoni, S. macrophylla, S. humilis,** distribution maps and other details by country, ecological relationships in "Tropical Moist Forest" and "Tropical Dry Forest" in climax associations, primary and secondary successional stages, giving distribution, structure and composition, and habitat, profile diagrams. p. 123-197.

20. SILVICULTURE

76. VINCENT, F.
1884. **MAHOGANY IN CEYLON.** Indian For. 10:156-157.

List of mahogany trees planted at Jaffna 1840-45 measured in 1882. Av.7 feet circumference and 60 feet high. Wood appears equal in color and grain to wood form Central America.

77. TROUP, R. S.
1921. **THE SILVICULTURE OF INDIAN TREES.** V. 1, p. 205-208. illus. Oxford.

Swietenia mahagoni introduced to India 1795. Success in plantations variable, requires well drained soil, fruits well, seed at 20 years of age, flowers April and May, fruit ripen October to December, not tolerant to shade, insect damage severe, growth rapid on favorable sites, mean annual girth increment 2.2 inches. **S. macrophylla** introduced to India 1872, flowered and fruited in 12th and 13th year, this material type specimen for King's botanical description, grown in plantations, intolerant to shade, growth more rapid than **S. mahagoni.**

78. MELL, C. D.
1923. **PLANTING MAHOGANY IN VENEZUELA.** Pan Amer. Union Bul. 57:599-601. illus.
Comparison of **S. candollei** with other mahoganies.

79. NOLTEE, A. C.
1925. **SWIETENIA MAHAGONI JACQ. EN SWIETENIA MACROPHYLLA KING.** Med. van het Proetstation voor het Boshwezen, 125 pp., Java, Buitenzorg.

In Dutch, English summary, general account, history, distribution, names, exploitation, experience in Dutch E. Indies. **S. macrophylla, S. mahagoni** compared, insect attack, woods of two species in Java show only small differences.

80. OLIPHANT, J. N.
1925. **ANNUAL REPORT OF THE FOREST TRUST OF BRITISH HONDURAS.** 25 pp., Belize.

Short discussion of forest improvement, cost, insect attack, forest production of mahogany (**S. macrophylla**).

81. ------------
1926. **ANNUAL REPORT OF THE FOREST TRUST OF BRITISH HONDURAS.** 24 pp., Belize.

Discussion of stand improvement, light requirements, insect attack, cost of producing mahogany (**S.macrophylla**) in planted stands.

82. STEVENSON, D
1927. **ANNUAL REPORT OF THE FOREST TRUST OF BRITISH HONDURAS.**

Silviculture, insect attack, natural regeneration, forest improvement cost for mahogany (**S. macrophylla**).

83. ------------
1927. **FOREST RESEARCH IN BRITISH HONDURAS.** Bui. Imp. Inst., (London) 25 (3):313-320.

Regeneration, growth, seedling care in forest vegetation (**S. macrophylla**).

84. STEVENSON, N. S.
1927. **SILVICULTURAL TREATMENT OF MOHOGANY FORESTS IN BRITISH HONDURAS.** Empire For. Jour. 6(2):219-227. illus.

Description of forest types as related to mahogany regeneration, systems of propagation, forest improvement work, silvicultural treatment (**S.macrophylla**).

85. OLIPHANT, J. N.
1928. **MAHOGANY IN BRITISH HONDURAS.** Empire For. Jour. 7(1):9-10.

Description of occurrence of **S. macrophylla**, relation to past cultivation, plant succession and vegetation types.

86. ____________
1928. **ANNUAL REPORT OF FOREST TRUST OF BRITISH HONDURAS.** 17 pp., Belize.

Short discussion of silviculture, production, future supply of mahogany **S. macrophylla**).

87. ____________
1928. **THE CULTIVATION OF MAHOGANY IN BRITISH HONDURAS.** Papers, Third Brit. Emp. For. Conf. pp. 517-524.

Mahogany regeneration methods in natural, cut over, and cleared forests, insect attack, silviculture (**S. macrophylla**).

88. MARSHALL, R. C.
1930. **NOTES ON THE SILVICULTURE OF THE MORE IMPORTANT TIMBER TREES OF TRINIDAD AND TOBAGO.** 50 pp., illus. Port of Spain.

Plantations, soils, time of flower and fruit, seed germination, growth, insect and fungus attack, (**S. macrophylla**); (**S. mahagoni**) slower growth, less planted.

89. RECORD, S. J.
1930. **FORESTRY IN BRITISH HONDURAS.** Trop Woods 24:2-15.

Methods of regeneration, effect of competition, application of "Taungya" system (**S. macrophylla**).

90. TROUP, R. S.
1932. **EXOTIC FOREST TREES IN THE BRITISH EMPIRE.** 259 pp., 152 refs. Oxford.

Introduction into India 1872, sites, growth (**S. macrophylla** and **mahagoni**). World rainfall maps.

91. KINLOCH, J. B.
1933. **ANNUAL REPORT OF FOREST TRUST OF BRITISH HONDURAS.** 22 pp., Belize.

Short discussion of **S. macrophylla**, planting methods, growth, fire effects.

92. PONCE, S. E.
1933. **MAHOGANY AS A REFORESTATION CROP.** Makiling Echo 12(1):13-33

Introduction to Philippines (**S. mahagoni**) seed, from Cuba survival poor, growth 14 years 20 centimeters diameter, **S. macrophylla** seed from Calcutta better adapted to local conditions, good growth, climate, soils, silvical characteristics, root, stem, crown, reproduction, wind resistance, insects, important environmental factors.

93. CHAMPION, H. G.
1934. **TOUR JOTTINGS FROM SOUTH BENGAL.** Indian Forester 60(7):460-466. illus.

Small plantation estab. 1891 near Kaptai, after 38 years height 85 ft., diametes up to 22 inches. Natural regeneration profuse.

94. KINLOCH, J. B.
1937. **REPORT OF THE FOREST DEPARTMENT OF BRITISH HONDURAS.** 5 pp., Belize.

Silviculture, regeneration, stocking, forest successions.

95. STEVENSON, N. S.
1938. **ANNUAL REPORT OF THE FOREST DEPARTMENT OF BRITISH HONDURAS.** 25 pp., Belize.

Natural regeneration study, forest type map of country.

96. MARSHALL R. C.
1939. **SILVICULTURE OF THE TREES OF TRINIDAD AND TOBAGO.** 247 pp., illus. Oxford, Univ. Press.

S. macrophylla, distribution, habitat, botanical classification, seedling growth, silviculture, regeneration, plantation growth. **S. mahagoni**, distribution, habitat, silviculture.

97. DUQUE-JARAMILLO, J. M.
1940. **MELIACEAS COLOMBIANAS.** Tierras y Aguas 3(2):27-32; (22):3-11.

Botanical description and planting possibilities of **Swietenia.**

98. HOLDRIDGE, L. R. and MARRERO, J.
1940. **PRELIMINARY NOTES ON THE SILVICULTURE OF THE BIG-LEAF MAHOGANY.** Carib. For. 2(1):20-23.

Classification of species, differences S. **macrophylla S. candollei** noted, seed storage, germination, nursery, transplanting, seedling growth, insect attack.

99. STEVENSON, N. S.
1941. REPORT OF THE FOREST DEPARTMENT OF BRITISH HONDURAS. 4 pp., Belize.

Hurricane effect, silviculture S. **macrophylla**).

100. SWABEY, C.
1941. AN ISLANDER LOOKS AT THE MAINLAND. Carib. For. 3(1):39-40.

Mahogany regeneration and improvement, control of shoot borer, **Hysipyla grandella, (S. macrophylla).**

101. MARRERO, J.
1942. STUDY OF GRADES OF BROAD LEAVED MAHOGANY PLANTING STOCK Carib. For 3(2):79-87.

S. macrophylla, seed from Venezuela and Panamá, site requirements, insect attack, use of overgrown planting stock, pruning.

102. SMITH, J. H. N.
1942. THE FORMATION AND MANAGEMENT OF MAHOGANY PLANTATIONS AT SILK GRASS FOREST RESERVE. Carib. For. 3(2):75-77.

Site description, method of planting, importance of associate vegetation, insect attack.

103. MARRERO, J.
1943. A SEED STORAGE STUDY OF SOME TROPICAL HARDWOODS. Carib. For. 4(3):99-105.

S. macrophylla seed storage under various conditions, and germination tests, cold storage effective, prolongs life to one year.

104. STEVENSON, N. S.
1943. ANNUAL REPORT OF THE FOREST DEPARTMENT OF BRITISH HONDURAS. 8 pp., Belize.

Hurricane effect, mahogany regeneration, treatment of plantations.

105. LAMB, A. F. A.
1944. ANNUAL REPORT OF THE FOREST DEPARTMENT OF BRITISH HONDURAS. 13 pp., Belize.

Growth of forest trees and trees in open, cost of establishment by "Taungya", mahogany cutting in Guatemala, sample plot where past cultivation resulted in high stocking of mahogany, hurricane effect on mahogany producing forest.

106. RECORD, S. J.
1944. NOTES ON TROPICAL TIMBERS. Trop. Woods No. 80, p. 5.

Age by annual growth rings in India **(S. macrophylla).**

107. WADSWORTH, F. H.
1944. THE FIRST YEAR IN THE CAMBALACHE EXPERIMENTAL FOREST. Carib. For. 6(1):34-44.

P. 37 **S. mahagoni** transplant survival, direct seeding results.

108. LAMB, A. F. A.
1945. ANNUAL REPORT OF THE FOREST DEPARTMENT OF BRITISH HONDURAS. 18 pp., Belize.

Management of mahogany on private land under new law, drought and fire, hurricane in Toledo district, thinning costs, growth from sample plot data.

109. ————————
1946. ANNUAL REPORT OF THE FOREST DEPARTMENT OF BRITISH HONDURAS. 10 pp., Belize.

Hurricane damage, mahogany stumpage, mahogany planting costs, growth.

110. KINLOCH, J. B. .
1947. PLANTACION DE ARBOLES TROPICALES EN GUATEMALA. La Hacienda 42 (10):44, 62.

Development of plantations in Guatemala **(S. macrophylla).**

111. LAMB, A. F. A.
1947. ANNUAL REPORT OF THE FOREST DEPARTMENT OF BRITISH HONDURAS. 28 pp., Belize.

Mahogany planting costs, silviculture, treatment.

112. WADSWORTH, F. H.
1947. **THE SECOND YEAR IN THE CAMBALACHE EXPERIMENTAL FOREST.** Carib. For. 8(1):65-70.

S. mahagoni establishment, transplant, direct seeding, site requirements.

113. ____________
1947. **THE DEVELOPMENT OF SWIETENIA MAHAGONI JACQ. ON ST. CROIX.** Carib. For. 8(2):161-162, in Spanish 162-164.

Description of stands **S. mahagoni,** natural reproduction, sites, stocking, growth, one of best species for dry regions of Caribbean, easy to establish, wood unsurpassed value.

114. ____________
1947. **THE THIRD YEAR IN THE CAMBALACHE EXPERIMENTAL FOREST.** Carib. For. 8(3):203-207.

S. mahagoni growth, direct seeding, shade requirement.

115. LAMB, A. F. A.
1948. **ANNUAL REPORT OF THE FOREST DEPARTMENT OF BRITISH HONDURAS.** 28 pp., Belize.

Mahogany planting costs.

116. MARRERO, J.
1948. **FOREST PLANTING IN THE CARIBBEAN NATIONAL FOREST.** Carib. For. 9 (2):85-148., illus., 14 refs. English & Spanish.

S. macrophylla, candollei, mahagoni, planting and weeding costs, site requirements, light requirements, growth, insect attack, wind throw, recommends against pure stands.

117. VOOGD, C.N.A. de
1948. **DE BOSCULTUREN VAN JAMLAPPA.** Tectona 38(2):63-76.

In Dutch, **S. macrophylla** good results in plantations in Indonesia.

118. WADSWORTH, F. H.
1948. **FIVE YEARS OF FOREST RESEARCH ON THE NORTH COAST OF PUERTO RICO.** Carib. For. 9(4):373-376.

S. mahagoni, site climate, shade for establishment.

119. MARIE, E.
1949. **NOTES ON REFORESTATION WITH S. MACROPHYLLA IN MARTINIQUE.** Carib. For. 10:211-222. Also in French and Spanish.

Introduced 1900, first plantation 1905, nursery practice, transplanting, field planting, growth, pests, rotation, plantation care, cost and yield.

120. MARRERO, J.
1949. **TREE SEED DATA FROM PUERTO RICO.** Carib. For. 10(1):11-30.

S. macrophylla, S. mahagoni seed germination studies.

121. ANONYMOUS
1950. **TENTH ANNUAL REPORT TROPICAL FOREST EXPERIMENT STATION.** Carib. For. 11(2):59-80.

West Indian mahogany (**S. mahagoni**) growth, (**S. macrophylla**) thinning.

122. HOLDRIDGE, L. R., LAMB, F. B. and MASON JR., B.
1950. **LOS BOSQUES DE GUATEMALA.** 175 pp., illus., 25 refs. Guatemala, Instituto de Fomento de la Producción.

Nursery practice, field planting, plantation care, yield.

123. MRRERO, J.
1950. **RESULTS OF FOREST PLANTING IN THE INSULAR FORESTS OF PUERTO RICO.** Carib. For. 11(3):107-147. illus. In Spanish also.

S. macrophylla site requirements, growth.
S. mahagoni site requirements, growth.

124. MARRERO, J.
1950. **REFORESTATION OF DEGRADED LANDS IN PUERTO RICO.** Carib For. 11(1): 3-15. illus., 32 refs. Also in Spanish.

S. mahagoni, adaptability, establishment, nursery, transplant, direct seeding.

125. GUTIERREZ, J.T. and MARTINEZ, G.J.
1951. **NOTAS SOBRE TRABAJOS DE REPOBLACION ARTIFICIAL DE CAOBA Y CEDRO EN EL ESTADO DE CAMPECHE.** Chihuahua, Boletin Forestal 3(35):30-31,35.

Direct sowing preferred, germination 80%, requires rainfall exceeding 1600 mm. in Mexico.

126. HUGUET, L. and MARIE, E.
1951. LES PLANTATIONS D'ACAJOU D' AMERIQUE DANS LES ANTILLES FRANCAISES. Bois et Forests des Tropiques. 17(1):12-25.

Relationship **Swietenia and Khaya, S. macrophylla** 350 hectares pure plantations ages 0 to 40 years in Martinique, seed production, sale, germination, nursery, plantation method, high forest 'taungya', secondary forest cleared lines, light requirements, table of increments, 15 cubic meters per hectare per year growth, 200 trees per hectare, merchantable in 30 to 40 years, abundant natural regeneration in older plantations, suggests 'coupes d'éclaircies' group selection method of cutting to obtain adequate regeneration.

127. KERMANI, W. A.
1951. EXOTIC FOREST TREES IN EAST PAKISTAN. Pakistan Jour. For. 1(3):273-9.

S. macrophylla established in plantation 1891 at Kapati in 1950 average height 92 feet girth 4 feet 9 inches, some natural regeneration, seed collected for further planting.

128. CHINTE, F. O.
1952. TRIAL PLANTINGS OF LARGE LEAF MAHOGANY IN THE PHILIPPINE ISLANDS. Carib. For. 13(2):75-84. 33 refs. Also in Philipp. For Jour 6(4):313-325. 1949 illus.

History of planting in Philippines, climate and soil, silviculture, seed storage and sowing, nursery, field planting, treatment, growth, and yield, disease and pests.

129. BARNARD, R. C.
1953. EXPERIENCE WITH EXOTIC TREE SPECIES IN MALAYA. Malay. For. 16(1): 29-40.

S. macrophylla. 1903 to 1936 one tree 82 feet total ht. 67 inch circumference b.h. natural regeneration under trees. Plantations established since 1928, nursery practice, planting practice, early growth rapid.

130. BURGOS, J. A.
1954. UN ESTUDIO DE LA SILVICULTURA DE ALGUNAS ESPECIES FORESTALES EN TINGO MARIA, PERU. Carib. For. 15(1 &2) 14-53. illus., refs 31.

S. macrophylla, tree distribution, seed, wood, propagation, nursery, cuttings, comparison with other species in plantations at age of 6 years.

131. CREE, C. S.
1954. ANNUAL REPORT OF THE FOREST DEPARTAMENT OF BRITISH HONDURAS. 26 pp., Belize.

Pruning, natural regeneration, growth in sample plots, exports of logs and lumber, map of land ownership.

132. LAMB, F. B.
1954. UTILIZATION, DISTRIBUTION AND MANAGEMENT OF TROPICAL AMERICAN MAHOGANY. 441 pp., illus., 269 refs. Ann Arbor, Mich. Univ. Microfilms No. 7679.

Silvical and silvicultural characteristics of mahogany, reproductive habits, seed, growth habits, tolerance, soil requirements, moisture requirements, insects and diseases, fire, natural regeneration, artificial regeneration, nursery practice, seed storage, planting, silvicultural practices. p. 215-279.

133. CHAPUIS, J.
1955. LE MAHOGANY ET L'AMELIORATION DE LA FORET MARTINIQUAISE. Rev. For. Franc. 7(2):85-94.

S. macrophylla. 465 hectares planted in Martinique, various ages to 30 years, height growth 0.8 m. (mean annual increment), circumference growth 5 cm. (m.a.i.) 2400 trees per hectare planting.

134. CREE, C. S.
1955. ANNUAL REPORT OF THE FOREST DEPARTMENT OF BRITISH HONDURAS. 29 pp.. Belize.

Planting program, natural regeneration study.

135. PERERA S. P.
1955. SWIETENIA MACROPHYLLA AND ITS PROPAGATION BY STRIPLINGS. Ceylon For. n. s. 2(2):75-79.

Introduced to Ceylon 1890, natural regeneration, abundant striplings used to rehabilitate degraded forests with good results.

136. ANONYMOUS

1957. SEVENTEENTH ANNUAL REPORT, TROPICAL FOREST RESEARCH CENTER. Carib. For. 18(1 & 2):1-11.

S. mahagoni and **S. macrophylla,** test plantings established, plantation management results.

137. BASCOPE, F. et al.

1957. DESCRIPCIONES DE ARBOLES FORESTALES NO. 1 SWIETENIA MACROPHYLLA. 18 pp., illus., 16 refs. Mérida, Venezuela. Instituto Forestal Latino Americano.

Botany, silviculture, wood description.

138. FRITH, A. C.

1957. ANNUAL REPORT OF THE FOREST DEPARTMENT OF BRITISH HONDURAS. 24 pp., Belize.

Natural regeneration, direct seeding, growth.

139. LAMPRECHT, H. and HUECK, K.

1959. ESTUDIOS MORFOLOGICOS Y ECOLOGICOS SOBRE LA GERMINACION Y EL DESARROLLO EN LA PRIMERA JUVENTUD DE UNAS ESPECIES FORESTALES EN VENEZUELA. 37 pp., illus. Mérida, Venezuela. Inst. For. Lat. Amer.

Swietenia macrophylla. Description of fruit, seed, seedling development at 6 stages 33, 37, 50, 54, 57, 65 days old. Drawing.

30. HARVESTING, LOGGING, TRANSPORT

140. GIBBS. A. R.

1883. BRITISH HONDURAS. 198 pp. London, Sampson, Low, Marston, Searle, and Rivington.

Description of early logging operations.

141. BROWN, F. E.

1916. LOGGING MAHOGANY IN GUATEMALA. Timberman 17(10):34-35

Labor recruiting, squaring logs, grading logs, dye from bark and sawdust.

142. SAUNDERS, L. F.

1921. MAHOGANY PRODUCTION IN GUATEMALA. Timberman 22(5):48,48B.

Volume and sources.

143. ANONYMOUS

1925. MAHOGANY LOGGING IN MEXICO AND BRITISH HONDURAS. South Lumberman 119(1552):44.

144. BONNET, E. A.

1925. MAHOGANY CHIEF PRODUCT OF BRITISH HONDURAS. Bur For. & Dom. Com. Repts No. 31:271-272.

Colony based on mahogany trade, exported 200 years, logging risks, contract logging, advances against log production.

145. HAMLIN, M. J.

1926. MAHOGANY PRODUCTION. Timberman 27(6):76.

146. MAY, E. S.

1926. CENTRAL AMERICAN MAHOGANY. Timber Trades Jour. (London 99:551-554.

Recruiting labor, log grading and measurement, organization of logging, quality by countries of origin (**S. macrophylla**).

147. PAYSON, W. F. (ed.)

1926. MAHOGANY—ANTIQUE AND MODERN. A STUDY OF ITS HISTORY AND USE IN THE ARTS. 154 pp., illus. New York, Dutton.

Description of logging, sources and characteristiscs.

148. GILL, T.

1931. TROPICAL FORESTS OF THE CARIBBEAN. 317 pp., illus. Washington, Tropical Plant Research Foundation.

Description of early logging operations.

149. MILLER, W. A.

1941. MAHOGANY LOGGING IN BRITISH HONDURAS. Carib. For. 2(2):67-72.

Past cutting, density of stocking in forest, logging conditions, cruising, felling, trucking (**S. macrophylla**).

150. VON HAGEN, V. W.

1942. MAHOGANY GOLD. Amer. Forests. 48:539-542, 575. illus.

Mahogany logging operations in Honduras, and history.

151. MARKHAM, W. A.
1945. **MAHOGANY LOGGING IN BRITISH HONDURAS.** Timberman 46(12):52-54. illus.

Logging methods, log size, log defects, loss of logs in streams (**S. macrophylla**).

152. LAMB, G. N.
1946. **THE ROMANCE OF MAHOGANY.** The Chicago Naturalist 9(1):2-9. illus.

Botanical discussion without sources, distribution, locating trees, pests, logging (**Swietenia & Khaya**).

153. ------------
1947. **THE HUNT FOR MAHOGANY.** Natl. Hardwood Mag. 21(11):88-89, 131.

Brief sketch of mahogany exploitation in Latin America, discussion of supply and requirements of American market.

154. LAMB, F. B.
1948. **STATUS OF FORESTRY IN TROPICAL AMERICA.** Jour. of For. 46(10):721-726.

Mahogany trade, logging, export restrictions, planting.

155. DUBEAU, N. P.
1949. **PELIGROSO Y GRANDE; MAHOGANY HUNTING IN COLOMBIAN CHOCO.** Monsanto Mag. 28:18-22.

Logging experiences, forest description.

156. HARRISON, D. B.
1949. **MAHOGANY LOGGING IN CENTRAL AMERICA.** Alumni News N.Y. State Ranger School. 49:32-33, 37.

Account of truck and tractor logging.

157. ANONYMOUS
1950. **REPORT OF FAO MISSION TO NICARAGUA.** 200 pp., illus. FAO, UN Rome.

P. 52 Logging, occurrence, air reconnaissance locating mahogany.

158. SAKS, E. V.
1953. **TROPICAL MAHOGANY PRODUCTION.** South Lumberman 187(2345):127-130. illus.

Logging operations in Central America.

159. LAMB, F. B.
1954. **UTILIZATION, DISTRIBUTION AND MANAGEMENT OF TROPICAL AMERICAN MAHOGANY.** 441 pp., illus. 269 refs. Ann Arbor Mich. Univ. Microfilms No. 7679.

Logging, history, log export import figures, contract logging, tree location, defects in timber, felling and bucking, ox logging, machine logging, planning machine logging, aerial photo surveys, driving and rafting, log scaling and grading, shipping. P. 23-65.

40. INJURIES AND PROTECTION

160. KALSHOVEN, L. G. E.
1926. **BESCHADIGINGEN, ZIEKTEN EN PLAGEN VAN MAHONIE (S. MAHAGONI EN S. MACROPHYLLA), AANGEPLANT OP JAVA.** Mededell. Inst. Plantenziekten, (Java) No. 69:126.

In Dutch, English summary. Mahogany disease and pests in Java, fungi, insects, life cycle of shootborer, natural checks, recommends against pure plantations.

161. FRAVIE, M.
1930. **PLAGAS DE LA MADERA DEL CAOBA.** Mexico Forestal 8(8):182-186.

Defects in mahogany logs and lumber.

162. SCHEDL, K. E.
1937. **NEW SCOLYTIDAE AND PLATYPODIDAE (COLEOPTERA).** Proc. Roy. Ent. Soc. London Ser. B. Tax, 6(1):13-15.

Erineophilus guyanaensis Brit. attacks mahogany British Guiana.

163. GARCIA, L. A.
1939. **A MAHOGANY SEEDLING BLIGHT IN PUERTO RICO.** Carib. For. 1(1):25-26.

164. MARTORELL, L. F.
1939. **SOME NOTES ON FOREST ENTOMOLOGY.** Carib .For. 1(1):25-26

Apate francisca attacks **S. mahagoni**, Puerto Rico.

165. ------------
1940. **SOME NOTES ON FOREST ENTOMOLOGY.** Carib. For. 1(3):23-24.

Ichnaspis longirostris Signoret attacks **S. macrophylla, Puerto Rico.**

166. WOLCOTT, G. N.
1940. THE ENTOMOLOGIST LOOKS AT MAGA. Carib. For. 1(2):29-30.

S. mahagoni and termite resistance.

167. MOSES, C. S.
1955. LABORATORY DECAY TEST OF SOME COMMERCIAL SPECIES OF MAHOGANY. For Prod. Jour. 5(2):149-152.

Tested **S. mahagoni** and **macrophylla, Khaya** spp., **Shorea spp., Parashorea** spp., **Diptrocarpus** spp., **Swietenia** was highest in general level of decay resistance.

168. **ANONIMOUS**
1958. SHOOTBORERS OF THE MELIACEAE. Unasylva 12(1):30-31.

Trees attacked, type of damage, life cycle, control difficult, young plants protectived by leaving brush.

50. MENSURATION

169.GILL, T.
1925. ON THE TRAIL OF MAHOGANY. Yale Forestry School News 13(2):20-22.

Mahogany cruising.

170. STERLING, E. A.
1943. THE PETEN SURVEYS TO DETERMINE THE REMAINING CHICLE RESERVES. 42 pp. Unpubl. Report. New Orleans, James D. Lacey.

Cruise figures for mahogany northern Peten, Guatemala.

171. LAMB, F. .B.
1954. UTILIZATION, DISTRIBUTION AND MANAGEMENT OF TROPICAL AMERICAN MAHOGANY. 441 pp., illus. 269 refs. Ann Arbor, Mich. Univ. Microfilms No. 7679.

Aerial photo surveys, remaining sources of mahogany p. 203-214.

172. CREE, C. S.
1955. ANNUAL REPORT OF THE FOREST DEPARTMENT OF BRITISH HONDURAS. 29 pp., Belize.

Aerial photo study of mahogany forest, and inventory.

173. ORDEN, T.
1956. PREPARATION OF LOCAL VOLUME TABLE FOR LARGELEAF MAHOGANY AND ITS APPLICATION. Philippines Jour. For. 12(3-4):117-132.

Based on plantation trees in Philippines, information developed for 4 areas includes: estimated stand per hectare up to 400 trees, volume per tree 0.62 cubic meters at 24 years, estimated stock per hectare 141.36 cubic meters at 24 years, mean annual growth 5.88 cubic meters per hectare, growth percent 3.23 at 24 years.

60. MANAGEMENT

174. HOLDRIDGE, L.R., LAMB, F.B., and MASON JR., B.
1950. LOS BOSQUES DE GUATEMALA. 175 pp., illus., 25 refs. Guatemala, Instituto de Fomento de la Producción.

Forest management blocks, management of Poptun area.

175. LAMB, F. B.
1954. UTILIZATION, DISTRIBUTION AND MANAGEMENT OF TROPICAL AMERICAN MAHOGANY. 441 pp., illus., 269 refs. Ann Arbor, Mich. Univ. Microfilms No. 7679.

Mohogany forest management, **S. macrophylla,** 'Tropical Dry Forest', growing stock growth, intensive management extensive management, 'Tropical Moist Forest'. **S. mahagoni,** natural stands, planted stands, stocking, growth, yields, sustained yield management, financial returns. p. 280-350.

176. ARDIKOESOEMA, R.I. and DILMY, A.
1956. TENANG DJENIS KAJU JANG DISEBUT "MAHONI "ATAU "MAHAGONI" TERISTIMEWA KELUARGA "KHAYA". (notes on mahogany especially about the genus **khaya.**) Rimba Jour. For. (Indonesia) 5(5-6): 266-328. illus., 31 refs. In Indonesian, English summary.

Swietenia planted on soils not adapted to teak, shootborer attack both species, **S. mahagoni** attacked by miseltoe **Loranthus** sp., yield table and silvicultural data.

70. MARKETING

177. CHALONER, E
1850. THE MAHOGANY TREE. 117 pp., Liverpool, Rocklift.

General, sources, history of use. Discussion of trade to 1850.

178. MELL, C. D.
1917. TRUE MAHOGANY. U. S. Dept. Agri. Bul. No. 474, 24 pp.

Names by place of origin, distribution then known, wood characteristics, character by regions, market values, uses and supply, imports to New York 1892-1910, logging, minute anatomy of wood.

179. ANONYMOUS
1928. U.S. COURT AFFIRMS FEDERAL TRADE COMMISSION RULING ON "PHILIPPINE MAHOGANY". Trop. Woods 15:27 31.

Mahogany name controversy, use of name Philippine mahogany prohibited.

180. MELL, C. D.
1930. BIOGRAPHY OF THE WORD MOHOGANY. Timberman 31:146-152; 32:180-184; 33:113-115.

Discussion of use, name controversy, and development of mahogany trade.

181. BURDON, J.
1932. FORESTS OF BRITISH HONDURAS. Timber Trades Jour., (London) 122:350.

Importance of mahogany exports, remaining sources **(S. macrophylla).**

182. STOBART, T. A.
1932. EMPIRE MAHOGANY IN THE UNITED KINDOM. Crown Colonist.

Describes British trade, sales methods, p. 15

183. STEVENSON, R.
1934. THE RESOURCES OF BRITISH HONDURAS. Bul Imperial Inst. No. 32:356-410.

Mahogany export figures 1802-1932. History of logging industry in the country.

184. ANONYMOUS
1946. LICITACION PUBLICA DE CAOBAS NACIONALES. Rev. Agri. (Guatemala) Ser. (2) 2:359.

Public mahogany timber auctions.

185. BONFIN, S.
1950. ECONOMIA MADEIREIRA AVINCULACAO DO AGUANO. Assoc. Com. do Amazonas Bul. 9(106):3-8.

Amazon timber trade, especially mohogany.

186. LATHAM, B.
1951. A HISTORICAL SURVEY OF THE TIMBER TRADE. Wood (London) 16(2):61-63; 16(3):101-103. illus.

Account of British lumber markets handling of mahogany.

187. ————————
1954. MAHOGANY. Wood (London) 19(1-3): 15-17; 87-89; 125-127. illus.

History of introduction to Europe and early trade.

188. GALLANT, M. N.
1959. REPORT TO THE CARIBBEAN COMMISSION ON FORESTRY AND TIMBER TRADE IN THE CARIBBEAN AREA. Rome. FAO Report 1060. Part I, 40 pp., Part II, 104 pp.

Future mahogany market assured for prime quality, experience and information from plantations. French Antilles enriching forests with mahogany (S. **macrophylla**) by planting, excellent results, by 1957 a total of 1,703 hectares mahogany plantations established, growth data, quality forest exports from oldest plantations favorably reported—18 tons 1956, 45 tons 1957. Lumber produced locally good texture and figure.

3,500 hectares of additional plantations contemplated rate of 200 hectares per year. Natural regeneration profuse in openings made by fellings. Economic soundness of mahogany planting seems assured.

80. FOREST PRODUCTS AND THEIR UTILIZATION

189. CHALONER, E.
1850. THE MAHOGANY TREE. 117 pp., Liverpool, Rocklift.

General, sources, history of use.

190. CHAMBERS, R. & W.
1851. MAHOGANY. Chamber's Edinburg Jour. (London) 15:181-183.

Source and use, ship construction.

191. ANONYMOUS
1914. TROPICAL AMERICA'S MAHOGANY. American Lumberman (Chicago) 2049:41.

Characteristics and uses.

192. ANONYMOUS
1924. HISTORIC MAHOGANY. New York, Mahogany Association. 16 pp.

History of use.

193. RECORD, S. J. and MELL, C. D.
1924. TIMBERS OF TROPICAL AMERICA 810 pp., illus. New Haven. Yale Univ. Press.

Mahogany history, use of name, sources of supply, wood description, 5 species.

194. PAYSON, W. F. (ed.)
1926. MAHOGANY—ANTIQUE AND MODERN. A study of its history and use in the decorative arts. 154 pp., illus. New York, Dutton.

History of use in boat building and furniture.

195. STEVENSON, N. S.
1933. BRITISH HONDURAS MAHOGANY. Timber Trades Jour., (London) 127:813-814.

Milling practice.

196. HOWARD, A. L.
1934. TIMBERS OF THE WORLD. 672 pp., illus., 35 refs, London, MacMillan.

Vernacular names, characteristics of wood, use of name.

197. NIERENSTEIN, N.
1934. NATURAL ORGANIC TANNINS. 319 pp., London, Churchill.

Tannins in mahogany bark and wood.

198. SYMONDS, R. W.
1934. EARLY IMPORTS OF MAHOGANY FOR FURNITURE. Connoisseur (London) pp. 213-220; 375-381., illus.

199. LAMB, G. N.
1935-1951. THE MAHOGANY BOOK. eds 1 to 8. Chicago, Mahogany Assoc. Inc. illus.

History, sources, identification, uses.

200. RENDLE, J.
1938. COMMERCIAL MAHOGANIES AND ALLIED TIMBERS. For Prod. Res. Bul No. 81. 46 pp.

201. ANONYMOUS
1940. TIMBER LEAFLET. Timber Development Association. London 1(30):1-3.

Mahogany, Central American and Cuban names, distribution, tree, timber, seasoning, strength, durability, working qualities, uses and supplies.

202. BUSH, W. D.
1941. MAHOGANY (SWIETENIA SP.) FOREIGN WOODS, LEAFLET. 20 pp., illus. 39 refs. Washington, U. S. Forest Service.

Sources, nomenclature, distribution including map, supply by countries, reforestation not carried out, mahogany planted experimentally in many parts of world. Production volume of timber trade by years, wood properties, uses, other woods called mahogany in lumber trade, African mahogany, Philippine mahogany, etc.

203. LAMB, G. N.
1942. MAHOGANY GOES TO WAR. Wood Products 47(6):19-20 illus.

Wood qualities for uses, exacting specifications.

204. ANONYMOUS
1943. THE PROCUREMENT OF AMERICAN MAHOGANY. 68 pp., illus. Washington, Office of Economic Welfare. SR-31-325.

Species of mahogany, variation in leaves, flowers, fruits, and wood structure, detailed discussion of distribution, production, and characteristics by countries from Mexico to Brazil and Bolivia, U. S. import statistics, physical properties, log defects in detail, log measurement.

205. MARKHAM, W. A.
1945. MAHOGANY LOGGING IN BRITISH HONDURAS. Timberman 46(12):52-54 illus.

Saw milling.

206. PISHAWIKAR, D. G. and SHAH, S. V.
1946. A STUDY OF THE OIL FROM SEEDS OF SWIETENIA MAHAGONI. Jour. Univ. of Bombay 15A:Pt. 3, No. 20:17-20.

Content of insoluble fatty acids, separation of fatty acids, unsaturated acids, unsaponifiable matter, solid cake.

207. ANONYMOUS
1947. MAHOGANY. Industrial Ref. Serv., Commodity ref. Serv. U.S.D.C. 5:12:2:1-3. illus.

Production, U.S. imports, sources, characteristics, uses **(Swietenia, Khaya).**

208. DESCH, H E.
1947. THE MAHOGANIES. Wood, (London) 12(10):288-290. illus.

Distribution, characteristics, anatomical features, uses, also describes other woods sold as mahogany.

209. JANE, F. W.
1947. THE STRUCTURE OF WOOD, II MAHOGANY. Timber News (London) 55(2092): 52-54. illus.

Swietenia compared with several similar woods, **Shorea Entandrophragma** and **Aucounea.**

210. LAMB, G. N.
1947. MAHOGANY - FROM TREE TO TRIM. Cosgrove's Magazine 19(6):20-25. illus.

Characteristics of wood, early use, distribution, logging, milling ,finishing, uses.

211. RECORD, S. J. and HESS, R. W.
1947. TIMBER OF THE NEW WORLD. 640 pp., illus. New Haven, Yale Univ. Press.

Discussion of species differences, wood variation, history of use, distribution, wood description.

212. DICKINSON, F. E., HESS, R. W. and WANGAARD, F. F.
1949. PROPERTIES AND USES OF TROPICAL WOODS. Trop. Woods 95:1-145. illus., 11 refs.

Study of **S. macrophylla** plantation grown material, description of wood, drying, strength, decay resistance, test data. Other woods included.

213. LAMB, G. N.
1950. BURL AND SWIRL AND THE STRANGLER FIG. Veneer and Plywood 64 (2):61-63. illus.

Figure in mahogany and causes.

214. ANONYMOUS
1952. MAHONIE (MAHOGANY). Meded. Inst. Trop. Amst. No. 98 (Afd.) Trop. Prod. No. 38:18-20, 65.

Wood of **Swietenia, Khaya,** and **Entandrophragma** spp. described, common names and place of origin. In Dutch.

215. WANGAARD, F. F. and MUSCHLER, A. F.
1952. PROPERTIES AND USES OF TROPICAL WOODS. Trop. Woods 98:1-190., illus.

S. maerophylla (P. 101) test material young plantation grown trees, compared with forest grown. Mahogany, test data. Other woods included.

216. SAKS, E. V.
1953. TROPICAL MAHOGANY PRODUCTION. South. Lumberman 187(2345):127-130. illus.

Veneer cutting methods to produce figures material.

217. HALE, W. H.
1954. SOME TIMBERS USED IN PATTERN MAKING. Timber Technology 62(2178):177-179.

S. macrophylla withstands high moisture content of foundry sand, rough usage, repairs, storage.

218. LAMB, F. B.
1954. UTILIZATION, DISTRIBUTION AND MANAGEMENT OF TROPICAL AMERICAN MAHOGANY. 441 pp., illus., 269 refs. Ann Arbor, Mich. Univ. Microfilms No. 7679.

Mahogany utilization, physical characteristics, decay, insect attack, defects, milling, uses of mahogany, history furniture, architecture, boat construction, aircraft construction, models and patterns, miscellaneous uses, production statistics p. 10-22 and 74-122.

219. LAMB, G. N.
1954. MAHOGANY FOR FOUNDRY PATTERNS. Modern Patternmaking.

Name substitution, sources of true mahogany, characteristics for pattern making, grading rules, uses.

220. SAKS, E. V.
1954. TROPICAL HARDWOOD FOR VENEER PRODUCTION IN MEXICO. Carib. For. 15 (3&4):112-119. illus.

S. macrophylla log export ban, description of veneer, figures log characteristics.

221. WANGAARD, F. F., KOEHLER, A., and MUSCHLER, A. F.
1954. PROPERTIES AND USES OF TROPICAL WOODS. Trop. Woods 99:1-187. illus. 9 refs.

S. macrophylla (P. 149) range and wood variation, physical and mechanical test data, sources of material, durability to rot, conclusion that wood of this species is not affected by wide differences in geographical origin, test data. Other woods tested.

222. LAMB, G. N. and ALBINI, A.
1956. FIGURE TYPES IN MAHOGANY. Chicago, Mahogany Association. 32 pp., illus.

223. ANONYMOUS
1958. RULES FOR MEASUREMENT AND INSPECTION OF HARDWOOD LUMBER,—. 102 pp. Chicago, National Hardwood Lumber Association.

Rules for the measurement and grading of mahogany lumber and veneer.

224. CHAKRABARTY, M. M. and CHOWDHUR. D. K.
1958. THE FATTY ACID COMPOSITION OF THE SEED FAT FROM SWIETENIA MACROPHYLLA. Amer. Oil Chem. Soc. Jour. 34(10):489-490.

225. NORMAND D. and SALLENAVE, P.
1958. CHARACTERISTIC ET PROPRIETES DE ACAJOUS (SWIETENIA ET KHAYA). Bois et Forests des Trop. 59:43-52. illus.

Comparison of woods of American and African mahogany. English summary Test confirms American (**Swietenia**) and African (**Khaya**) mahoganies form a homogeneous group.

90. FOREST & FORESTRY FROM A NATIONAL POINT OF VIEW

226. NEVILLE, H. D.
1919. HARDWOODS IN CUBA. Cuba Review 18(1):13-25.

Cuban mahogany wood characteristics difference in relation to site, uses as fuel wood, poles, ties (**S. mahagoni**).

227. HUMMEL, C.
1925. FORESTS OF BRITISH HONDURAS. 122 pp. London, Crown Agents for the Colonies.

Discussion of mahogany producing forests and their management.

228. MATTHEWS, D. M.
1928. THE CUBAN FOREST PROBLEM. Mich. Acad. Sci. and Letters, Papers 9:525, 530.

Mahogany production volumes and forest destruction (**S. mahagoni**).

229. STEVENSON, N. S.
1935. FORESTRY IN BRITISH HONDURAS. 21 pp., British Empire Forestry Conference, South Africa. Belize, Govt. Print. Off. Also in Carib. For. 1(1):1-3. 1939.

Area, population, topography, geology, soils, climate forest types, mahogany variation with soil type, future supplies 25 million cubic feet cedar and mahogany.

230. SWABEY, C.
1939. FORESTRY IN JAMAICA. Carib For. 1(1):5-6.

S. mahagoni exported after 1665, little left now.

231. BEVAN, A.
1940. POSSIBILITIES FOR FORESTRY IN THE VIRGIN ISLANDS; ST. THOMAS, ST. JOHN, AND ST. CROIX. Carib. For. 2(1): 8-12.

Possibility of mahogany plantations, S. **mahagoni**).

232. HAGLEY, W. H.
1940. FORESTRY IN GRENADA. Carib. For. 1(2):5-6.

S. mahagoni and **S. macrophylla** established in wood lots on Grenada, small export to Trinidad.

233. GOMEZ-MENOR, J.
1943. LA CAOBA (SWIETENIA MAHAGONI (L.) JACQ. Rev. Agri. (Dom. Rep.) 34(147): 388-390.

Botanical background and relationships distribution and occurrence in Santo Domingo.

234. HOY, H. E.
1946. MAHOGANY INDUSTRY OF PERU. Economic Geography 22(1):1-13.

Discovery, logging, climate, site and wood quality, stocking, location of log production, cutting periods, size and growth, regulation of cutting, quality of lumber, plantation growth, indicates 40 yr. rotation **(S. macrophylla).**

235. STOVALL, R. P.
1947. MAHOGANY OF SANTO DOMINGO. Agric. Americas (Wash.) 7(8&9):107-108. illus.

S. mahagoni. 500,000 board feet cut annually, price, use. Cross in Cathedral bears date 1514.

236. SWABEY, C.
1949. GLIMPSES OF JAMAICA NATURAL HISTORY. Nat. Hist. Soc. of Jamaica 1(2): 73-75.

Mahogany, history, once abundant found in few locations now in Jamaica.

237. LAMB, F. B.
1953. THE FOREST OF DARIEN, PANAMA. Carib. For. 14(3&4):128-135. illus.

Remaining mahogany volume, logging, future supplies, plantation cost and return, distribution map **(S. macrophylla).**

238. PEET, C.
1954. MAHOGANY. American forests 60 (8):12-16.

General account of production in British Honduras.

239. LAMB, F. B.
1955. A STUDY OF MAHOGANY. The Asa Gray Bulletin N. S. 3(1):33-48. illus.

Description of area covered for dissertation, "Utilization, Distribution and Management of Tropical American Mahogany."

240 ____________
1959. PROSPECTS FOR FOREST LAND MANAGEMENT IN PANAMA. Trop. Woods 110:16-28.

Mahogany and other tree crops for permanent land use, mahogany production, need for management program.

AUTHOR INDEX

(By Item Number)

Effects of the 1956 Hurricane on Forests in Puerto Rico

FRANK H. WADSWORTH &
GEORGE H. ENGLERTH
Tropical Forest Research Center
Río Piedras, Puerto Rico

Tropical hurricanes, or cylonic storms revolving about a central "eye" and characterized by winds of 75 miles per hour or more and by heavy rainfall, frequently pass through the West Indies and occasionally strike Puerto Rico. These hurricanes normally originate either near the Cape Verde Islands or in the doldrums south of 10°N. latitude and between 40° and 55°W longitude[1]. They usually move westward into the Caribbean, then northwestward, becoming expended in the zone of the westerly winds north of the Tropic of Cancer. About 50 hurricanes have passed directly over Puerto Rico during the 450 years of recorded history[2].

Hurricane damage to exposed trees is generally spectacular. Breakage of branches and uprooting are important causes of failures in communications and electrical service and interruption of vehicular traffic. Damage of this character is deemed so serious by some that large and attractive trees along roadsides and near buildings sometimes are sacrificed to eliminate the hazard.

The effects of hurricanes on forests, many of which are in remote areas, are not well understood. Damage to forests, though less apparent to the layman, is nevertheless real, since the trees in the forest constitute a valuable crop which attains the proper size for harvesting only after years of exposure to hurricanes.

The prediction and prevention of hurricane damage are matters of interests to the entire population. In the forest, however, there is little evidence from past studies to determine whether or how hurricane damage might be minimized. The only attempt at a written description of the effects of hurricanes on trees in Puerto Rico concerns the hurricane of 1928[3]. It was observed that more trees were broken off than uprooted and that some trees escaped serious damage through loss of their leaves early in the storm. Some trees died without any apparent cause except defoliation. Dieback of limbs was caused by sun-scald on exposed branches. Dense forest was less damaged than open forest. This last observation appears to be corroborated by observers in Mauritius[4],[5] who found indigenous forest relatively resistant to hurricane damage.

Forestry in Puerto Rico has made its most important advances during a period in which no hurricanes passed over the island, from 1932 to 1956. The land area under forest management doubled, and forests were established or improved on thousands of acres. Lands of all types and in all parts of the island were included. Measured plots have been established in areas representative of many of these conditions. This growing investment in forests and forestry makes it imperative that more be known about the nature of hurricane damage and any circumstances which tend to minimize it. Accordingly, a field survey of hurricane damage was made by the Tropical Forest Research Center with the cooperation of the Division of Forests, Fisheries and Wildlife of the Commonwealth

---

1/ Tannehill, I. R. 1943. Hurricanes. Princeton University Press. pp. 265

2/ Fassig, O. L. 1929. On the frequency of hurricanes in the vicinity of Porto Rico. Porto Rico Jour. Pub. Health & Trp. Med. 5:106-113.

3/ Bates, Charles Z. 1929. Efectos del huracán del 13 de septiembre de 1928 en distintos árboles. Rev. de Agr. (Puerto Rico) 23:113-117.

4/ Vaukan, R. E. & Wiehe, P. O. 1937. Studies on the vegetation of Mauritius, Pt. 1. A preliminary survey of the plant communities.

5/ King, H. C. 1945. Notes on the three cyclones in Mauritius in 1945: their effect on exotic plantations, indigenous forest and on some timber buildings. Empire Forestry Rev. 24:192-195.

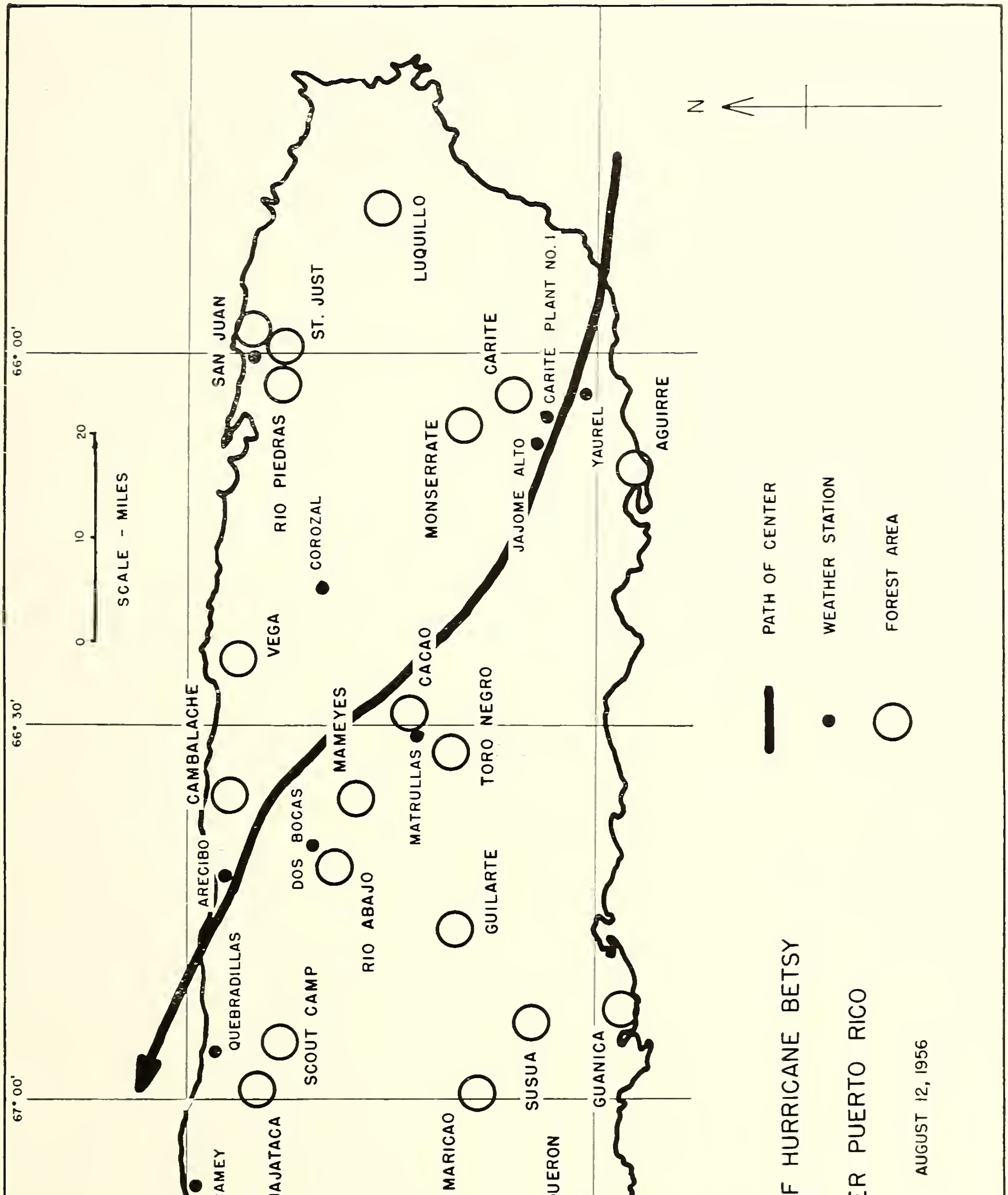

PATH OF HURRICANE BETSY
OVER PUERTO RICO
AUGUST 12, 1956
PATH OF CENTER
WEATHER STATION
FOREST AREA
SCALE - MILES
0
10
20
N
18° 30'
18° 00'
67° 00'
66° 30'
66° 00'
SAN JUAN
ST. JUST
RIO PIEDRAS
LUQUILLO
CAROZAL
VEGA
MONSERRATE
CARITE
CARITE PLANT NO. 1
JAJOME ALTO
YAUREL
AGUIRRE
CACAO
TORO NEGRO
MATRULLAS
MAMEYES
CAMBALACHE
ARECIBO
DOS BOCAS
RIO ABAJO
GUILARTE
QUEBRADILLAS
SCOUT CAMP
GUAJATACA
RAMEY
MARICAO
SUSUA
GUANICA
BOQUERON

Figure 1

Department of Agriculture and Commerce during the three months immediately following the hurricane of 1956.

THE 1956 HURRICANE

The 1956 hurricane, designated "Betsy" by the U. S. Weather Bureau, and locally called "Santa Clara", developed from an easterly barometric wave found in longitude 33°W. on August 6, reached hurricane intensity on August 10, and was centered over Puerto Rico from about noon to 3:15 p.m. on August 12[6]. The storm first hit Puerto Rico near Maunabo and left near Camuy. Its path, as plotted by radar, is shown in Fig. 1.

Recorded maximum wind velocities accompanying the hurricane were 92 miles per hour at San Juan, about 30 miles north of the path of the center, and 115 miles per hour at Ramey Air Force Base, 13 miles southwest of the path[6]. Unfortunately wind records were insufficient to show the pattern of extreme velocities over the island. However, all of Puerto Rico, according to the Weather Bureau,[6] received wind velocities of at least 50 miles per hour.

6/ U. S. Weather Bureau. 1956. Climatological Data, Puerto Rico and Virgin Islands. II, No. 8, GPO. Washington, D. C.

The maximum rainfall measured in Puerto Rico on August 12 was 8.7 inches at El Verde in the eastern mountains. The pattern of rainfall is shown for selected stations in Table 1. There it is seen that the tendency for rainfall to increase with proximity to the storm center, while generally apparent, is marred by a number of exceptions such as the heavy rainfall at Luquillo and the light rainfall at Aguirre. High rainfall appeared to extend farther in a northerly direction than to the south. A rather clear relationship with elevation is also apparent in Table 1. All but one of the stations receiving more than 5 inches of rainfall were above 1500 feet elevation. Moreover the least rainfall recorded at high elevation, 28 miles from the center, was equal to the rainfall much nearer the center at low elevations.

The rainfall immediately prior to Betsy might, by having already loosened the soil, contribute to the damage on the forest. However, an analysis of the August 9 to 11 rainfall on Puerto Rico indicates that it exceeded one inch for that period at only four of the selected stations. Such prior rain is believed to be too light to have contributed materially to the damage.

Table 1.—The relationship between location, elevation, and rainfall

Distance and Direction from storm center	Approximate Rainfall August 12[1]	Place of Observation
Miles	Inches	
	Elevation 0-1500 ft.	
37S	0.5	Guánica
33S	0.8	Boquerón
31N	3.2	San Juan
29S	1.2	Susúa
27N	2.7	St. Just
24N	2.3	Río Piedras
15S	4.6	Guajataca
13S	4.6	Scout camp
9S	4.1	Quebradillas
9NE	3.7	Vega
9N	2.4	Monserrate
7S	4.1	Río Abajo
6S	4.1	Dos Bocas
5S	1.6	Aguirre
4NE	6.2	Corozal
3N	2.4	Cambalache
3N	4.9	Carite Plant No. 1
1S	3.2	Yaurel
0	3.2	Arecibo
	Elevation 1500-3000 ft.	
28S	3.2	Maricao
25N	8.0	Luquillo
20SW	4.1	Guilarte
10SW	5.6	Toro Negro
7SW	8.6	Matrullas Dam
6N	4.2	Carite
4SW	6.3	Mameyes
3N	5.0	Jajome Alto
2SW	8.5	Cacao

1/ Based in some areas on interpolation from nearby station.

Hurricane Betsy was not as severe as many previous hurricanes. The storm was comparatively small in diameter (apparently little more than 100 miles), it progressed more rapidly across the island (about 20 miles per hour) than is usual, and the winds and rainfall which accompanied it both were considerably less than has been experienced in the past. Extremes for other hurricanes recorded in Puerto Rico are diameters in excess of 300 miles, forward velocity of less than 10 miles per hour, winds of 160 miles per hour, and rainfall up to 29 inches in 48 hours[1].

THE NATURE OF THE DAMAGE

Observations of the effects of the hurricane were made in 20 areas which contain natural or planted forests in Puerto Rico, the area surveyed totalling some 17,000 acres (See Fig. 1). These observations were based upon reconnaissance from the air and by counts on the ground within established plots or along transects[7]. In the selection of areas to be studied an effort was made to include a maximum range in the following factors: distance from the path of the center of the hurricane, elevation, topography, soil types, and stand structure and composition.

The most general type of damage to the forests was defoliation. In many areas the leaves of the exposed parts of tree crowns turned brown and dropped a few days after the storm passed. Elsewhere defoliation was immediate, apparently a direct result of the physical force of the wind.

Loosening and shredding of the bark of trees due to the whipping action of the winds was another form of damage. This effect was evident mostly in trees which had not been completely defoliated.

Breakage was another common effect of the hurricane on trees. At its least this form of damage affected only small limbs. At the other extreme trees were snapped off near the base. Such serious breakage resulted in damage to adjacent trees.

Uprooting was the usual effect of strong winds upon trees which were more resistant above than within the soil (See Fig. 2). At a minimum such trees were tipped and torn partially loose at the roots. However, uprooted trees were commonly blown to the ground, their root systems being pulled out of the soil, and neighboring trees often going down with them. In extreme conditions considerable areas of raw soil or rock were exposed beneath the upturned root systems.

Indirect effects of the hurricane on the forest are less spectacular but apparently serious. Defoliation apparently was followed by sun-scalding on the limbs and their subsequent death. Loosened bark, even where the tree is not killed, can adversely affect the quality of the tree. Insects and decay can enter where breakage has occurred. Trees which lean as a result of the wind tend thereafter to produce compression and tension wood which is of little value. Forest openings created by breakage and blowdown foster the development of vines which interfere with the re-establishment of the forest.

It was necessary for this study to define what constitutes the "loss" of a tree. Many of the trees damaged are neither dead nor will they die soon. Thus "loss" refers chiefly to the removal of a tree from the productive potential of the stand. Trees which suffered only defoliation and top breakage were not considered "lost". However, those with trunks snapped off, even where part of the tree could be salvaged, were considered "lost". Also trees with sufficient lean (15%+) to adversely affect future wood production, whatever their present salvage value, were considered "lost".

1/ Op. cit.

7/ Assistance is acknowledged for part of the field work by Benjamín Seda, Jorge Rivera, and forest ranger and guards of the Commonwealth Division of Forests, Fishieries & Wildlife; and by B. J. Huckenpahler, José Marrero, Raúl Ybarra Coronado, Ramiro Agosto Ruiz, and José Reyes Mateo of the Research Center.

THE RELATIONSHIP BETWEEN DAMAGE AND SITE

Observations made on the field were grouped on the basis of five factors of the physical environment: proximity to the path of the storm center, elevation, topographic exposure, aspect, and character of the soil. Site is not subject to much practical modification by man, but relationship to damage may show limitations on potential forest yields which need to be understood.

Fig. 2.—Damage to 26-year old white mangrove stand at Aguirre by Hurricane Betsy. Fifty-nine of the trees were broken or uprooted by the storm as determined by a sample plot of 621 trees.

Proximity to the Path of the Center of the Hurricane

Hurricanes normally are most active near the center and are progressively weaker toward the periphery. Thus it might be expected that forests would be damaged by hurricanes roughly in proportion to their distance from the center.

Table 2 compares damage to proximity to the path of the storm center. It is seen that no appreciable damage was recorded beyond 15 miles to the south or 27 miles to the north of the storm center. Within this range the damage shows a general tendency to increase as the path of the center is approached.

Table 2 shows certain inconsistencies in this relationship between distance and damage. At Toro Negro, for example, the damage was less than at Guajataca, yet the distance from the storm path was only two-thirds as great. In addition to general variation there was evident in the field extreme local variation, making difficult the classification of damage as shown in Table 2. At Guajataca, Río Abajo, and Cambalache severe damage was mostly in small areas or strips, suggesting both a large local variation in the susceptibility of different forest areas and the probability that there were numerous small squalls of exceptionally high velocity.

Table 2.—The relationship between location and hurricane damage

Distance and Direction From Storm Center	Degree of Damage: Negligible	Degree of Damage: Local or Slight	Degree of Damage: Extreme or Severe	Place of Observation
Miles				
37 to 20 S	x			Guánica, Boquerón, Susúa, Maricao and Guilarte
15 to 13 S		x		Guajataca and Scout camp
10 S	x			Toro Negro
7 SW		x		Río Abajo
5 S to 6 N			x	Aguirre, Mameyes, Cacao, Cambalache and Carite
9 to 27 N		x		Vega, Monserrate, Río Piedras, Luquillo, and St. Just
31 N	x			San Juan

The relationship between damage and distance from the center of Betsy would not necessarily be applicable to other hurricanes. The radius of the damaged area could vary greatly with the severity of the hurricane.

Elevation

Forest damage might be expected to show a relationship to elevation, yet the data do not bear this out. Although several areas at high elevation were severely damaged, such as Mameyes (1,600 ft.), Cacao (2,000 ft.), and Carite (1,800 ft.), others near sea level and no closer to the storm center, such as Aguirre (sea level) and Cambalache (100 ft.), were equally damaged. On each side of the path the most distant areas with reportable damage, Guajataca and St. Just, are both below 500 feet elevation. Within the Luquillo forest, where elevation ranges from 400 to 3,500 feet, damage did not increase with elevation.

Topographic Exposure

Most of the areas studied are rough in topography and afford within short distances an opportunity to compare the damage under different degrees of exposure and aspects.

On the limestone hills of the north coast damage was found both on the exposed hilltops and in the protected areas between the hills. A count of trees broken off or windthrown at Cambalache showed that of 834 trees on a hilltop 26 percent were lost, whereas of 1,445 trees on the adjacent slopes 21 percent were lost. Browned leaves and defoliation were chiefly confined to hilltops and exposed upper slopes, suggesting that the surviving trees there withstood more wind than those remaining in more protected areas. Nevertheless, on a few exposed slopes at Guajataca all vegetation was removed.

Evidence from other parts of the island supports the observation that trees on exposed hills and ridges withstood the winds at least as well as on slopes and in valleys. In the northern part of the Luquillo forest damage on the ridges was limited to defoliation, yet near the bottom of the deep Mameyes Valley windthrow was locally severe. At Mameyes, in the central mountains, damage was most severe on concave slopes protected from normal winds. At Cacao the most extensive damage seen in the mountains, about 300 acres with nearly every tree windthrown, was located in a deep valley.

Whereas the susceptibility of the forest to wind damage may not have been proven greater in the valleys than on the ridges, there can be no question but that the economic loss in the valleys is by far the most important. Lower slopes and valleys usually bear better stands than upper slopes and ridges, both as to quality of species, and tree form and height. The loss of these better trees may be in terms of sawtimber, either actual or potential, whereas on the ridges the trees generally contain only posts, poles, or short logs. This relationship is particularly sharp at Luquillo, St. Just, and Río Abajo, where potentially valuable plantations in the valleys suffered yet natural forests on the upper slopes, where little investment had been made, were much less affected.

Aspect

West Indian hurricanes are described as areas in which the general wind direction, as visualized on a map, forms a counterclockwise spiral about the center. Thus any area in the hurricane zone can be expected to experience, sooner or later, winds of hurricane force from all directions. An area directly in the path of the center should receive winds in one direction which gradually strenghten in violence and then a complete reversal of direction and gradual reduction in force. Areas affected but not in the path of the center experience winds which may gradually shift 90 degrees or more. Considering the direction of the drift of Betsy across the island, areas directly in the path of its center might be expected to receive north and south winds; areas to the north of the path, southeast to northeast winds, and areas to the south of the path northwest to southwest winds.

Observations in the field, which included the prevailing direction of windfallen trees, generally bear out this description. Areas lying in the path of the center were affected mostly by those winds which preceded the eye of the storm. Other areas were affected chiefly by winds from the direction to be expected when the storm center was closest. The significance of wind direction to damage was especially apparent on opposing slopes.

To the north of the path the damage was due mostly to easterly winds. At Luquillo defoliation was chiefly on east-facing slopes in watersheds draining north and east, with only the west-facing slopes entirely unaffected. At Vega defoliation was also apparent only on the east-facing upper slopes. At Carite damaging winds ranged from east to northwest. Defoliation at Cambalache was chiefly in areas exposed to the east and north, yet in number of trees destroyed the west slope suffered more heavily (30%) than the east (11%). From Cambalache to Arecibo the north-facing slopes showed most defoliation.

To the south of the path the damaging winds were mostly westerly. At Guajataca northwest winds damaged the north- and west-facing slopes, whereas those facing south were intact. At Toro Negro blowdown was caused by northwest winds also. At Aguirre windthrow was chiefly toward the east, indicating that the damaging winds were from the west. At Cacao, only 2 miles from the center, trees were blown down regardless of aspect, indicating destructive winds from several directions.

Soil

The forests in which hurricane damage was studied cover a wide range of soil conditions, some of which might well be significant to the resistance of trees to windthrow. In areas where windthrow was serious it is clear that anchorage of the trees in the soil was deficient. Where damage is due to breakage rather than windfall, anchorage might be considered adequate.

The soil characteristic most significant to damage might be expected to be soil depth, since trees with shallow roots could be expected to have less anchorage than those deeply rooted. However, the observations do not bear this out. At St. Just the forest on the shallow soils of the slopes was undamaged, yet serious uprooting took place in a comparable stand on the deep soils of the bottomland. In the Luquillo Forest damage on shallow soils was nearly all breakage. On the shallow soils on the limestone hills at Guajataca, Vega, Río Abajo, Cambalache, and the Scout Camp breakage was far more serious than uprooting, and in many places neither was important. Adjacent to these hills at Guajataca and Río Abajo the forests of deep soils suffered serious damage, chiefly due to uprooting. An exception was found at Cambalache where breakage was also most important on the deep soils of the bottomland. The factor responsible for this resistance to windthrow on shallow soils may well be anchorage of the roots in cracks and other openings in the upper layer of the parent rock.

Normal available moisture in the soil, unlike soil depth, appears to be very significant to tree anchorage. The most serious damage due to uprooting was on deep soils where moisture is normally abundant, and particularly where protection from the normal trade winds further favors moist conditions. Outstanding losses under these conditions, not shared by adjacent forests in less moist or protected locations were found at Luquillo, Carite, St. Just, Mameyes, Cacao, Guajataca, Río Abajo, Cambalache, and Aguirre.. The Luquillo forest, normally 50 percent more rainy than all other forests studied, suffered more damage than some other forests much closer to the path of the storm center. The relationship described here is further supported by the small root systems of the trees blown over. It would appear that under conditions of abundant moisture and protection from prevailing winds the top-root ratio of the trees increases to a point which reduces capacity to withstand exceptional winds.

THE RELATIONSHIP BETWEEN DAMAGE AND THE CONDITION OF THE FOREST

Observations on damaged forests were directed toward relationships with the structure and composition of the stands. Structure concerns the proportionate representation of different tree sizes and the density of the stand. Composition is concerned with the number and the identify of the species present. These conditions, unlike those of site, are subject to control and might be materially modified if suggested by differences in the susceptibility of different types of stands. The stands observed varied from those with all trees of the same young age and of only one or a few species to the very old uneven-aged forests with 30 or more species per acre such as originally covered most of Puerto Rico.

Structure and composition in Puerto Rican forests vary together to such a degree that it was not possible to isolate entirely either of them in order to relate damage to it. Stands which are even-aged in structure are almost everywhere pure in composition and stands which are all-aged are generally mixed. Thus comparisons could be made only among even-aged pure and all-aged mixed forests. Within these two conditions it was possible to make a few comparisons in young and old and in dense and open stands and to different individual tree species.

All-aged Mixed vs. Even-aged Pure Stands

There was a general difference in the character of the damage in all-aged mixed stands as compared with even-aged pure stands. In all-aged stands there was a range of susceptibility of individual trees within the stand, due apparently to inequalities in the degree of exposure of each tree and also, to a lesser degree, to species characteristics. Thus dominant, exposed trees generally suffered more than those subordinate in the canopy. This relationship was observed at Guajataca, Cambalache, Río Piedras, Luquillo, and St. Just.

In even-aged pure forests damage was far less selective than in all-aged mixed stands. Forests of this character, if damaged at all, generally suffered severely, apparently because all trees were so similar as to be about equally susceptible. Extensive damage of this type was suffered by even-aged pure forests at Guajataca, the Scout Camp, Río Abajo, Toro Negro, Aguirre, Mameyes, Cacao, Cambalache, Carite and Luquillo.

The extreme character of such damage to even-aged forests is apparent in a number of areas where data were taken. The most extensive devastation seen in even-aged pure stands was in coffee shade at Cacao. There in an area of 300 acres almost every tree was windthrown. At Aguirre a sample of 621 trees in an area of several hundred acres of 26-year-old (4 to 12 inches d.b.h.) natural forest showed 59 percent of the trees lost.

Pure forest plantations also suffered heavy losses in several areas. In the Luquillo forest one 19-year-old plantation (5 to 10 inches d.b.h.) was reduced from 600 to 12 trees per acre; another from 960 to 128. At Carite a 15 year-old plantation (6 to 15 inches d.b.h.) was reduced from 380 to 20 trees per acre, and an 18-year-old plantation (6 to12 inches d.b.h.) from 202 to 2 trees per acre. At Río Abajo an 18-year-old plantation (6 to 11 inches d.b.h.) was reduced from 293 to 30 trees per acre.

In a few areas it was possible to compare within close range the degree of damage suffered by all-aged and even-aged forests. Although it was frequently difficult to classify the severity of the damage, an attempt was made in Table 3. There it is seen that among the stands studied even-aged stands everywhere suffered as heavily as all-aged stands, and generally more so.

Age of Trees and Stands

Few direct comparisions were possible between old and young trees subject to similar exposure. It has already been pointed out that the larger (and presumably older) tress in all-aged forest are generally more affected than the subordinate trees. However, this appears to be due chiefly to greater exposure, rather than age. That advanced age is not alone an important factor in susceptibility is apparent in the many old trees on exposed ridges and slopes on the mountains, some of which must have survived dozens of hurricanes.

Table 3.—Comparative Damage in All-Aged and Even-aged Forests.

	Degree of Damage[1]		
	Negligible	Local or Slight	Extensive or Severe
Toro Negro	A	E	
Guajataca		A	E
Río Abajo		A	E
Carite		A	E
Cambalache			AE

1/ A - all-aged mixed stands; E - even-aged pure stands.

A contrast between damage to young and old forests was apparent at Aguirre. There, as has already been described, a 26 year-old even-aged forest suffered extensively, more than half of the trees being eliminated. In the midst of this area a 3-year-old stand of trees 12 feet tall was unharmed.

At Luquillo the greater resistance of young trees was also apparent in plantations of eucalyptus (*Eucaliptus* spp.) There 12 year-old plantations (4 to 10 inches d.b.h.) lost 15 to 40 percent of their trees, whereas 5-year-old plantations (1 to 3 inches d.b.h.) remained undamaged.

Stand Density

No observations were made in natural stands which were alike except for density. However, the effect of the hurricane in adjacent thinned and unthinned stands could be compared at Cambalache and at the Scout Camp. At Cambalache a 6-year-old plantation of teak (*Tectona grandis* L.) 3 to 4 inches d.b.h. had been thinned about 6 months before the hurricane. The results are shown in Table 4.

The greater hazard created by heavy thinning is apparent in Table 4. Of the trees lost, about 35 percent were broken off, 5 percent were uprooted, and 60 percent were tipped or bent permanently. Those left standing were not only defoliated but had been so whipped by the wind that much of their bark was stripped off or hanging in loose shreds. All tree areas have made a remarkable recovery. After cutting off the trees considered lost, the stumps have produced sprouts which in the larger openings provide a satisfactory replacement stand. Bark stripping on the trees left proved to be less serious than anticipated as new bark was formed over all wounds.

Another similar result from thinning was observed at the Scout Camp in an even-aged pure stand of guaraguao (*Guarea trichilioides* L.) averaging 6 to 10 inches d.b.h. A portion of this stand thinned from 100 to 80 square feet of basal area per acre 9 months earlier suffered crown breakage in more than 50 percent of the trees whereas nearby unthinned stands suffered only slightly.

The most seriously damaged plantation at Río Abajo had been heavily thinned only months before the hurricane. This plantation, 18 years of age and ranging from 6 to 11 inches in diameter, had been thinned from about 100 to 40 square feet of basal area.

Table 4.–Teak Losses at Cambalache

Basis of measurement	Number per acre by degree of thinning		
	Heavy	Light	None
Before Hurricane			
All trees	380	620	785
Crop trees	100	100	100
Basal area, sq. ft.	28	42	53
Losses			
All trees	180	65	45
Crop trees	60	35	25

The hurricane reduced it from 293 to 30 trees per acre. Damage in comparable adjacent plantations, while substantial, was less severe.

Tree Species

Observations already described have indicated variation in the susceptibility of forests to damage related to site and general stand conditions. Most of these observations are confounded in some degree with differences in the tree species present. Now, looking at it the other way, which tree species, other things being equal, showed the greatest susceptibility or resistance to the hurricane?

Variations in sites and stand conditions from place to place make difficult true comparisions of the susceptibility of different tree species to hurricane damage. However, it is apparent in Table 5, which presents data from a single location, that real differences do exist.

Indications of relative susceptibility were evident in other forests where individual species suffered either much more or much less than the general run of the forest. Where this relationship was observed under more than one condition the indication is especially strong. The results of these observations are summarized in Table 6. In this tabulation susceptible species are classified as subject primarily to windthrow (anchorage weaker than the stem) or to breakage (stem weaker than anchorage). Resistant species apparently have neither deficiency.

Table 5.—Damage to Different Tree Species on a West Slope at Cambalache

Trees Species	Percent Lost	Trees Examined
	%	No.
Sanguinaria (*Dipholis salicifolia* [L.] A.D.C.)	5	22
Uvilla (*Coccoloba diversifolia* Jacq.)	8	37
Almácigo (*Bursera simaruba* [L.] Sarg.)	18	17
San José (*Sabinea florida* [Vahl.] D.C.)	22	55
Verde seco (*Tetrazygia eleagnoides* [Sw.] D C.)	47	106
Mameyuelo (*Ardisia obovata* Desv.)	54	85
Laurel avispillo (*Nectandra coriacea* [Sw.] Griseb)	55	58

Table 6.—Especially Susceptible or Resistant Tree Species.

Species	Where Observed
Susceptible to Windthrow	
Caoba hondureña (*Swietenia macrophylla* King)	Luquillo, Carite, Río Abajo, St. Just
Ciprés (*Cupressus lusitanica* Miller)	Luquillo, Toro Negro
Cupey (*Clusia rosea* Jacq.)	Guajataca, Cambalache
Eucalyptus (*E. robusta* J. E. Smith & *alba* Reinw.)	St. Just
Jácana (*Pouteria multiflora* [A.DC] Eyma)	Guajataca
Laurel (*Nectandra* spp.)	Río Piedras, Cambalache, Río Abajo
Mangle blanco (*Laguncularia racemosa* [L.] Gaertn.)	Aguirre
Teca (*Tectona grandis* L.)	Luquillo, Carite
Susceptible to Breakage	
Algarrobo (*Hymenaea courbaril* L.)	Luquillo
Avelluelo (*Colubrina arborescens* [Mill.] Sarg.)	Río Abajo
Bucayo (*Erythrina poeppigiana* [Walp.] O.F. Cock)	Río Abajo
Casuarina (*Casuarina* spp.)	Luquillo, Cambalache, Scout Camp
Cedro Macho (*Hyeronima clusioides* [Tul.] Muell.)	Río Abajo
Eucalipto (*Eucaliptus* spp.)	Luquillo, Carite, St. Just, Cambalache
Guaba (*Inga vera* Willd.)	Luquillo, Carite, Mameyes, Cacao Guajataca
Guano (*Ochroma pyramidale* [Cav.] Urban)	Guajataca
Guaraguao (*Guarea trichilioides* L.)	Scout Camp
Mangle blanco	Aguirre
Mahoe (*Hibiscus elatus* Sw.)	Río Abajo
Teca	Carite, Cambalache

Wind Resistant

Almácigo (*Bursera simaruba* [L.] Sarg.)	Vega
Aquilón (*Laugeria racemosa* Vahl)	Guajataca
Ausubo (*Manilkara bidentata* [A. DC] Che.)	Monserrate
Caoba dominicana (*Swietenia mahagoni* Jacq.)	Guajataca, Río Abajo
Capá blanco (*Petitia domingensis* Jacq.)	Luquillo, Guajataca, Scout Camp, Río Abajo
Capá prieto (*Cordia alliodora* [R&p.] Cham.)	Guajataca, Monserrate
Hoja menuda (*Eugenia* sp.)	Cambalache
Maga (*Montezuma speciosissima* [Sesse & Moc.] Dubard)	Río Abajo
Mangle colorado (*Rhizophora mangle* L.)	Aguirre
María (*Calophyllum braziliense* Camb.)	Luquillo, Carite, Guajataca, Scout Camp, Río Abajo, St. Just
Moca (*Andira inermis* [W. Wright] H.B.K.)	Guajataca
Roble (*Tabebuia heterophylla* [DC] Britton)	Guajataca, Río Abajo, Luquillo, Carite

Table 6, in presenting exceptional species, undoubtedly includes only a few of those which might, with more observations or hurricane force, be so classified. Species found only near the path of the storm, located only on susceptible sites or in even-aged plantations probably showed failings which may be equally characteristic of but less evident in species not so located. Thus, although all-aged forests are much more extensive than even-aged, some 60 percent of the ratings were based upon even-aged forests.

Considering the proportion of native and exotic tree species exposed to the hurricane the number of susceptible exotics was high. Of those species susceptible to windthrow only cupey, laurel, and mangle blanco are native species in natural forests. Those susceptible to breakage include the following natives in natural environment: algarrobo, avelluelo, cedro macho, and guano. Nevertheless a few planted species, such as caoba dominicana, maría, and roble proved resistant.

CONCLUSIONS

1. Serious forest damage in Puerto Rico due to Hurricane Betsy was confined to an area within about 6 miles of the path of the center. Damage was negligible beyond 15 miles southwest and 27 miles northeast of the path.

2. Damage was as serious on sites protected from normal winds as on those exposed.
3. Forests on slopes are subject to the hazard of hurricane damage regardless of aspect.

4. Forests on shallow soils have not proven to be less windfirm than those on deep soils.
5. Uprooting of trees, indicating poor anchorage, is a common form of hurricane damage on soils which normally are very moist or wet.

6. All-aged mixed forest frequently suffer from slight and selective hurricane damage; even-aged pure forests generally suffer either no damage or very serious damage.
7. Heavy thinning of forests is conducive to susceptibility to wind damage.
8. Different tree species vary to a significant degree in their susceptibility to windthrow and breakage from hurricanes.

Ranura y Cuenca de Pino Radiata

Por Dr. Ervin Ijjász
Universidad Austral de Chile

Las anomalías de la madera pueden producirse por varias causas, que pueden ser de origen interno o externo. Las internas son las causadas por las propiedades hereditarias de las especies. Las externas pueden tener origen en los fenómenos naturales, como son los rayos, vientos, granizos, o ser de origen animal o vegetal como insectos, hongos o parásitos. Finalmente pueden ser de origen humano, como incendios u otros daños ocasionados por actividad humana. A este grupo pertenecen aquellas anomalías que son producidas por el tratamiento inadecuado de las maderas, como rajaduras o alabeos.

La producción de anomalías puede ser en árbol vivo o volteado, ya sea en los rollizos o bases (vigas) pero también en maderas elaboradas, como tablas, tirantes o durmientes.

La ciencia maderera divide las anomalías en los siguientes tres grupos: (a) defectos, (b) alteraciones y (c) deformaciones.

Los defectos son anomalías estructurales de la madera como la acebolladura, rajaduras, nudos o excentricidad. Estos afectan solamente las propiedades físicas y mecánicas de la madera.

Las alteraciones influyen hasta en la composición química de la madera, como por ejemplo las manchas, podredumbre y tumores.

Las deformaciones son anomalías que afectan la forma y la disposición de los tejidos, como el alabeo y revirado.

RANURA

La ranura y la cuenca de *Pinus radiata* D. Don pertenecen al primer grupo - los defectos. Afectan las propiedades físicas y mecánicas de la madera y dan en algunos casos un aspecto muy característico a estos pinos. A continuación describiremos estos defectos muy particulares de los *Pinus radiata* chilenos por cuanto no se tiene conocimiento de ellos en otros países ni figuran en la literatura.

La ranura (Fig. 1) es una depresión superficial alrededor de los haces foliares del tronco e influye principalmente sobre las características estéticas. Cuando es muy pronunciada su presencia en el fuste es muy notorio y da tal característica a su madera que facilita su exacta determinación. Su distribución sigue las leyes del orden de las agujas. Estas ranuras son de muy diversos tamaños según la edad del árbol, su vigorosidad, su situación dentro de la masa boscosa, las características del sitio, exposición y otros factores. Generalmente son de 5 a 40 mm. de longitud, 1 a 8 mm. de ancho, y 5 a 20 mm. de profundidad. Muchas veces las ranuras están dentro de un surco longitudinal que proporciona un extraño aspecto característico al tronco. Estos surcos a veces corren en espiral a lo largo del tronco. Las ranuras son muy notorias en los troncos descortezados. Bajo la corteza solamente se les aprecia con experiencia.

Las ranuras de un mismo tronco varían mucho en sus tamaños. Muchas veces ranuras de diferentes tamaños se acercan tanto que forman una línea en zig-zag. La mayoría de las ranuras poseen una forma de carrete con extremidades agudas y ensanchadas en el medio. Si la ranura es corta y ancha, su forma se acerca a la elíptica. Las de tamaño más chico se acercan a la forma redonda.

Como hemos dicho, las ranuras son depresiones en el tejido del tronco alrededor de los haces de agujas. Todas las ranuras se continuan en el tronco con los rayos modu-

Fig. 1.—Tronco ranurado de Pinus radiata D.

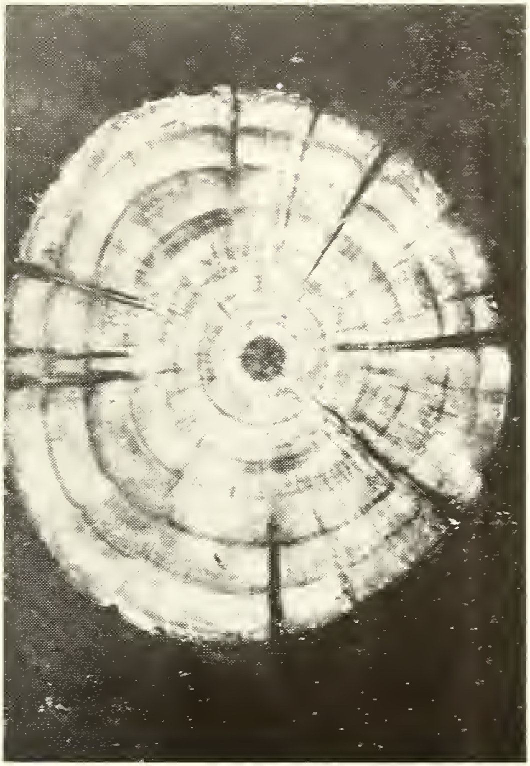


Fig. 2.—Ondulación de los anillos de crecimiento en tronco ranurado.

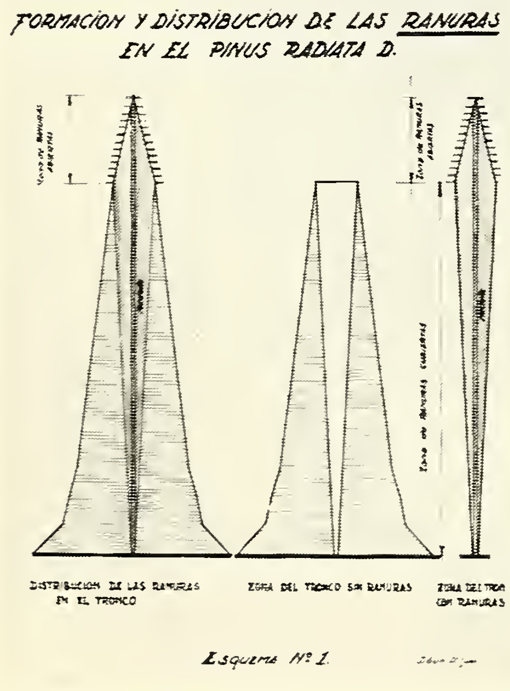


Fig. 3.—Esquema No. 1.

Fig. 4.—Tabla ranurada de Pinus radiata D.

Fig. 5.—Tabla ranurada mixta de Pinus radiata D (Parte derecha ranurada, parte izquierda sin ranuras).

Fig. 6.—Cuenca de Pinus radiata D. (en la terminación de los nudos (pedúnculo) puede observarse las depresiones causadas por los conos.

Fig. 7.—Tronco deformado por las cuencas de Pinus radiata D. .La deformación fué causada por 4 conos.

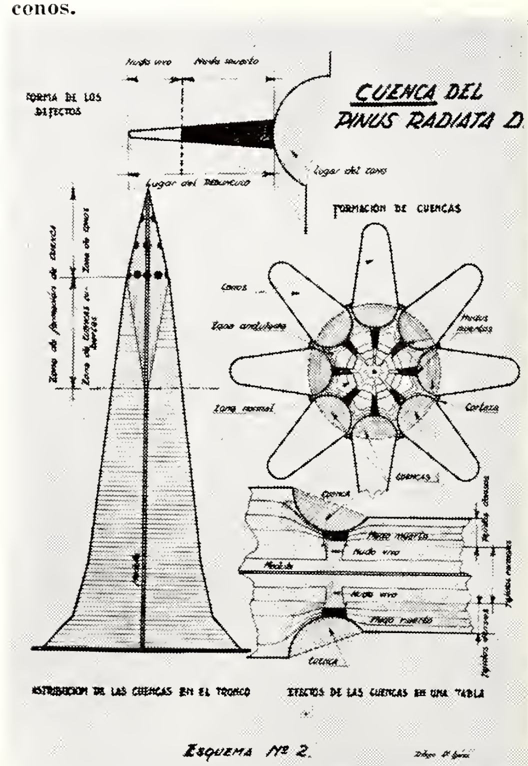


Fig. 8.—Esquema No. 2.

lares, que son de gran tamaño. En los árboles solitarios las ranuras son más grandes y su distribución es desigual. En algunos árboles aparecen en manchas o grupos sobre el tronco debido a la presencia de agujas según las proyecciones de los rayos solares sobre el fuste. En otros árboles se desarrollan más en un lado que en otro, según su exposición; por lo general en el lado sur y oeste son más débiles que en norte y este.

Origen

Buscando el origen de la formación de las ranuras encontramos tres posibilidades que son: (a) propiedades heredadas, (b) propiedades adquiridas y (c) efectos de ambas.

Nuestros estudios nos condujeron a la convicción de que la ranura es el efecto de la característica heredada del árbol desarrollado excesivamente por las condiciones óptimas de los factores de crecimiento.

Afirmamos nuestra opinión en el hecho de que si las ranuras fueran propiedades heredadas de la especie, entonces deberían presentarse en todos los árboles sin excepción, en cualquier sitio. Nuestras observaciones sin embargo, nos muestran que este defecto solo se produce en pequeñas cantidades, así por ejemplo en los bosques estudiados solo llegaba a 1 ó 2 por ciento.

Por el contrario, si las ranuras fueran propiedades adquiridas causadas por factores de crecimiento, entonces todos los ejemplares de un mismo sitio deberían tenerlas. Sin embargo, según observamos en un mismo sitio solo aparece esta anomalía en algunos ejemplares sin ningún orden o regla. Por lo tanto, ésto tampoco es real.

Nuestras experiencias demuestran que las ranuras aparecen siempre en los ejemplares que son más fuertes y desarrollados del promedio o sea en los que su vitalidad supera a los demás. Así se nos presentó la idea de que el defecto de ranura es el resultado de la extraordinaria vitalidad del árbol causado por las óptimas condiciones de crecimiento.

Ocurrencia

En condiciones normales de crecimiento, a pesar de que la parte superior del fuste del pino radiata está siempre cubierta con haces, no se forman ranuras, pues el árbol se desprende de sus agujas a tiempo y el crecimiento longitudinal de los rayos medulares está sincronizado con el crecimiento en espesor del árbol. Cuando no existe esta normal armonía de crecimiento por los efectos de los factores del sitio, las agujas son más fuertes y vigorosas y no se desprenden a tiempo; el crecimiento de espesor del tronco es tan grande (1 - 3 cm.) que envuelve la base de los haces foliares dando depresiones que nosotros denominamos ranuras. Este hecho proporciona a los anillos de crecimiento una forma ondulada (Fig. 2) muy parecida al defecto llamado "Haselholz" que se encuentra en la *Picea excelsa* (H. Knuchel. Holzfehler, 1947, Pág. 25). Este defecto se caracteriza por la depresión en forma de "v" que presentan los anillos de crecimiento en los rayos medulares, lo que confiere al tronco una sección ondulada y proporciona una madera llamada "Hagel-Ton" o "Mandli-Holz" (Greyerz "Das Hagel, Ton oder Mandli-Holz". Schweizerische Zeitschrift fur Forstwirtschaft, 1919, Pág. 125) apreciada por su estética. La característica de las maderas que sufren este defecto, según Greyerz, es que se parten fácilmente en sentido radial y muy difícilmente en sentido tangencial. Las maderas ranuradas tienen las mismas características. Se parten tan fácilmente en sentido radial, que hasta en el secamiento se rajan en la dirección de los rayos medulares. En la dirección tangencial estos rayos medulares actúan como clavos evitando su rajadura. La madera "Ton-Holz" es muy apreciada en Europa como madera resonante. Posiblemente la madera ranurada encontrará la misma utilización, además de su valor decorativo.

La formación de ranuras solo dura hasta la caída de las agujas. Después de ésto, la madera cubre las depresiones y ondulaciones de los anillos de crecimiento, tapándolos completamente. Así las ranuras en un árbol adulto se originan en la punta y van desapareciendo hacia abajo. En consecuencia, se distinguen dos tipos de ranuras: abiertas y cubiertas. Mientras la primera es un defecto superficial del tronco, la segunda es ya un defecto interno de los tejidos del árbol, que solo se aprecia después del aserrado. La madera de los árboles ranurados puede ser dividida en partes ranuradas y en partes lisas. La parte lisa recubre como una capa a las partes ranuradas en forma de cono truncado. La parte ranurada constituye un bicono cuyo diámetro medio es el diámetro menor del cono (Fig. 3.)

De lo expuesto se concluye que en el aserrado de un tronco ranurado obtenemos maderas de tres tipos, según la parte del tronco de donde procedan; (a) ranuras (Fig. 4), (b) sin ranuras o (c) mezcla de ambas Fig. 5). Un aserradero radial proporciona en la parte inferior del tronco madera mixta con o sin ranuras y en la parte superior tablas ranuradas. En la desbobinación solo se llega a las partes ranuradas después del corte de la capa exterior.

Importancia

La ranuración en las maderas solo se considera como defecto por el hecho que es una anomalía de los tejidos, que en cierto modo cambia sus propiedades físicas y mecánicas, pero desde el punto de vista comercial, para fines decorativos es ventajoso y cuando ésto sea descubierto por la industria de la foliación y terciado, seguramente será muy apreciado, lo mismo que el "Vogelauge" del arce y la "madera ondulada" (Welliger Faserverlauf) (J. Durst "Taschenbuch der Fehler und Schaden des Holzes. 1955, pág. 31) y otras irregularidades de tejidos buscados por la ebanistería.

CUENCA

Descripción

Este defecto que nosotros denominamos cuenca es una depresión en el tronco de *Pinus radiata* causada por la base de los conos o estróbilos. (Fig. 6).

Generalmente los conos de *Pinus radiata* crecen sobre los troncos y ramas en grupos horizontales de 3 a 5 pero su número puede subir hasta 11 piñas en casos excepcionales. (Echevarría-Simón, Crecimiento y producción en el norte de España y aplicación a la elaboración de la pasta de celulosa, Tercera edición, 1956, pág. 12).

Estos conos, lo mismo que las ramas, están adheridos a los tejidos y sólo se les puede considerar como partes biológicas del árbol hasta su maduración (2 a 3 años). Después de cumplir su función biológica no se desprenden enseguida, sino que, al igual que las ramas secas, permanecen aun en sus lugares. De estos conos inútiles el árbol debería desprenderse por fuerzas mecánicas, presión de sus tejidos o por vía biológica pudriendo su pedúnculo. La presión mecánica no es suficiente para desprender el cono y por el gran contenido de resina de pino radiata el proceso biológico es muy lento durando varios decenarios según las circunstancias locales. En consecuencia los estróbilos permanecen varios años sobre el tronco. Como los conos se forman adheridos inmediatamente sobre los troncos o ramas, los tejidos, en el rápido crecimiento de espesor, rodean su base formando así la cuenca. La profundidad de esta depresión varía según la vitalidad del árbol. Según V. Pastor (Cartilla Forestal, El *Pinus insignis*[1/], 1936) el crecimiento en diámetro es mayor de 2 cm. anuales, llegando en condiciones especiales a sobrepasar los 3 cm.

Origen

A pesar de que los conos aparecen en todos los árboles en el tronco y en las ramas, la cuenca es un defecto resultante de las propiedades heredadas y la influencia de los factores de crecimiento. Pues las depresiones son muy profundas solamente en aquellos individuos que se desarrollan en un medio muy favorable, es decir, su vitalidad

1/ Sinónimo para P. radiata.

es más alta que los otros. En estas plantas, cuando en un lugar existen muchos conos, éstos están tan profundamente introducidos en el tejido del árbol que en algunos casos la parte superior queda raquítica, siendo además el punto preferido por donde se rompen los troncos, pues está completamente deformado. Esto puede observarse muy frecuentemente (Fig. 7).

Aumentando los efectos de las cuencas bajo condiciones favorables en Chile (V. Pastor, El Pinus insignis, 1936) el pino radiata tiene una vegetación de invierno tan intensa como la de verano; es decir, no interrumpe su vida vegetativa. Aunque esta afirmación de Pastor es exagerada, es indiscutible que la vida vegetativa continúa durante todo el año variando sólo su ritmo.

Toda cuenca termina en un nudo muerto por el pedúnculo del cono, que penetra en los tejidos del tronco por lo menos a una profundidad de 2 a 3 anillos, según el tiempo que permanezca el cono sobre el tronco.

Importancia

Según lo expuesto, los efectos de las cuencas pueden agruparse en los siguientes tres grupos: (a) deformaciones de los tejidos por las depresiones, causadas por los conos; (b) el defecto producido por el pedúnculo del cono (nudo muerto y nudo vivo) y (c) las irregularidades causadas por la opresión de los conos (Fig. 8). Mientras que los dos primeros son efectos inmediatos, este último efecto no lo es.

Todas estas irregularidades de los tejidos causadas por la cuenca influyen también en las propiedades físicas y mecánicas de la madera.

Después de la caída de los conos el árbol cicatriza estas cuencas. Las partes cicatrizadas pueden encontrarse en el tronco de los árboles, desde la edad de fructificación hacia arriba (aproximadamente desde los 10 años). Del mismo modo cubre también los densos tejidos causados por la opresión de los conos. Por consecuencia en la misma parte del tronco, hay una parte inferior de tejido denso y sobre ésta una parte exterior de tejido normal. Esta variación de los tejidos, similar a la diferencia de los tejidos de los anillos de crecimiento (primavera y otoño), altera totalmente las propiedades físicas y mecánicas de estas partes, disminuyendo naturalmente el valor comercial de todo el tronco.

Las anomalías causadas por los pedúnculos de los conos, son semejantes a los defectos biológicos de los tejidos denominados "nudos muertos" que, como es sabido, son uno de los defectos más desagradables, pues el pedúnculo como nudo muerto, queda siendo un cuerpo extraño en los tejidos, que no está adherido a las fibras que lo circundan. Estos clavos contribuyen fuertemente a la desvalorización de la madera. Aumenta su efecto perjudicial el hecho de que están situados a un mismo nivel en dirección radial, lo que, como ya hemos dicho, debilita enormemente este sector del tronco.

RESUMEN

Los defectos de ranura y cuenca tratados en este artículo, como se ve, tienen efectos considerantes en la utilización del *Pinus radiata*. Como el defecto de ranura es más ventajoso que perjudicial, su eliminación no es un problema silvícola. Por el contrario, los efectos perjudiciales de las cuencas nos obligan a tratarlas con igual importancia que los nudos, debiendo por lo tanto, evitarse mediante una poda artificial, oportuna y correcta.

Tropical Silviculture

The Forestry and Forest Products Division of FAO has published a series of Forestry and Forest Products Studies. *Tropical Silvicurture* is Number 13 of this series. It is a three volume work prepare by I. T. Haig, M. A. Huberman, U. Aung Din, et al.

This publication undertakes the summation and evaluation of silvicultural experience in the tropical forests of the World. Volume I is a review and summary of the literature on the subject by the above named authors. Volme II and III are made up to the papers presented in this field at the Fourth World Forestry Congress of 1954.

This work is the only comprehensive reference now available in the field of tropical silviculture and will be of interest to those tropical foresters who have not seen it. Vol. I, 190 pp., $2.00; Vol. II, 415 pp., $4.00; Vol. III, 101 pp., $1.00. FAO, United Nations, Rome, Italy.

double-spaced typewritten pages, although an occasional longer article of special interest may be acceptable. Articles should be submitted in the author's native tongue, and should include title or position of the author as well as a brief summary of the material. Manuscripts should be typewritten, double spaced, on one side of the page only, on 8½ x 11 inch white bond paper.

Tables should be numbered consecutively, each on a separate sheet with a title. Footnotes used in tables should be typewritten as part of the table and designated by numerals.

Illustrations should be designated as figures and numbered consecutively. Captions for each illustration should be submitted on a separate sheet. Photographs submitted for illustrations should be clear, sharp, and on glossy paper, preferably 5 x 7 or 8 x 10 inches in size.

Footnotes should be numbered consecutively, with a superior figure placed after the word in the text to which the footnote refers. The footnote should appear in the text in the line following the reference number, separated from the text by a short line running inward from the left margin of the text. Footnotes are used to give credit to unpublished material and communications. If only a few references to literature are made, literature citations may be placed in footnotes. Literature citations should include the author, year published, title of the work cited, name of publication, and pages.

Manuscripts should be sent to the Leader, Tropical Forest Research Center, Río Piedras, Puerto Rico.

Opinions expressed in this journal are not necessarily those of the Forest Service. Articles published in the Caribbean Forester may be reproduced, provided reference is made to the original source.

●

Le "Caribbean Forester" est une revue semiannuelle qui a été publiée depuis l'année 1938 en Puerto Rico por le Centre Tropique de Recherche Forestier, Service Forestier du Départment de l'Agriculture des Etats-Unis. Cette revue est dediée a l'aménagement et a l'utilisation des forests surtout dans la region caraibe.

Par les pages de cette revue les personnes qui travaillent aux tropiques peuvent etre informées sur les problemes specifiques des forets tropicales et sur les travaux effectués pour realiser une ameilloration technique par l'aménagement et l'usage des resources forestiéres. Cette revue pourvoit aussi un moyen de destribuer l'information et les resultats obtenus par le programme experemental du Centre Tropique de Recherche Forestier de Puerto Rico; en plus cette revue offre ses pages a les autres travailleurs forestiers des pays tropicaux pour qu'ils purssent publier les resultats de leur travaux.

Cette revue accepte volontiers des contributions ne depassant pas 20 pages dactilografiées a double espace, cependant que certains travaux du intéret spécial plus long purvent etre acceptés. Les contributions doivent etre ecrites dans la langue maternelle de l'auteur et doivent bien preciser son titre et sa position professionnelle, l'appert doct etre accompagné d'un résumé de l'étude. Les manuscripts doivent etre dactilografiées en double espace su du paper 8½ por 11 pouces.

Les tables du travail doivent etre numerotées en ordre sur page separée et les notes au pied de ces tables doivent etre dactilografiées, comme une partie du table.

Les illustrations doivent etre designées avec des numeros consecutifs. Les titres de chaque illustration doivent etre sumis sur une page separée Les photographies comme les illustrations doivent etre bien claires, bien definies et sur papier glacé preferablement 5 x 7 pouces au 8 por 10.

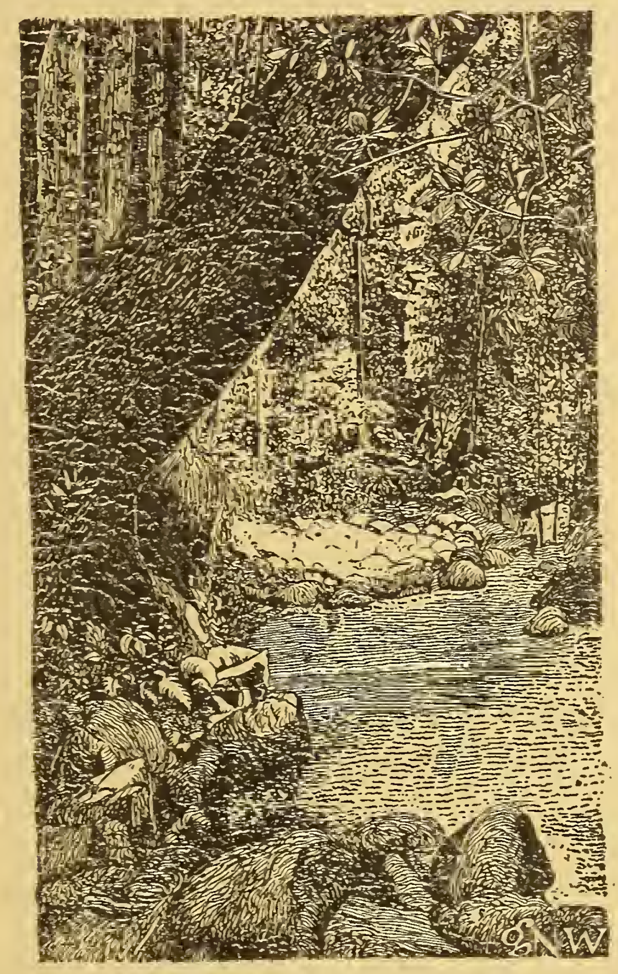
Les notes au bas de la page doivent etre numerotées apíes le mot qui fait reference a la note. La note au pied devra aparaitre dans le texte sous la ligne qui suit le numero de reference, separée de texte par une ligne courte couront de gauche a driole de la marge du papier. Les notes au pied sont usées pour faire honneur aux travaux qué nónt pas été publiés. Si on fait seulement quelques-unes reference quá la litterature pauvent designée les comme notes au pied. Citation au litterature publiée doivent comprendu, l'auteur, l'année publiée, le titre du travail, le nom de la revue et les pages de cette revue.

Les manuscripts doivent etre evnooyés a: "Leader, Tropical Forest Research Center, Río Piedras, Puerto Rico."

Nous voulons rappeller a nos lecteurs que les opinions expumées dans cette revue ne sont pas necessairement les opinions du Forest Service et que les articles publiés dans la revue le "Caribbean Forester" peuvent etre reproduits mais doivent jaire reference a cette revue.


UNITED STATES
ATLANTIC
OCEAN
GULF OF
MEXICO
MEXICO
BAHAMA
ISLANDS
CUBA
PUERTO
RICO
JAMAICA
HAITI
DOMINICAN
REPUBLIC
GUADELOUPE
DOMINICA
MARTINIQUE
STA. LUCIA
BRITISH
HONDURAS
CARIBBEAN SEA
HONDURAS
TRINIDAD
GUATEMALA
SALVADOR
NICARAGUA
PACIFIC
OCEAN
COSTA
RICA
PANAMA
VENEZUELA
BR.
GUIANA
COLOMBIA

Caribbean Forester



U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

TROPICAL FOREST RESEARCH CENTER
RIO PIEDRAS, PUERTO RICO

VOLUME 20 NOS. 3 AND 4
INDEX VOL. 11 TO 20

JULY - DECEMBER, 1959

Caribbean Forester

El Caribbean Forester es una revista semestral gratuita publicada en Puerto Rico desde el año 1938 por el Centro Tropical de Investigaciones Forestales del Servicio Forestal del Departamento de Agricultura de los Estados Unidos. Esta publicación está dedicada a promover la mejor ordenación y utilización de los recursos forestales del trópico con especial énfasis a la región del Caribe.

Provee información a los que laboran en la dasonomía y ciencias afines sobre los problemas específicos que confrontan, las políticas forestales vigentes y el progreso del trabajo que se lleva a cabo para mejorar la ordenación y utilización de los recursos forestales tropicales. También sirve como medio informativo sobre los resultados y el progreso de los programas experimentales, en ordenación forestal tropical y utilización, que se llevan a cabo en el Centro de Investigaciones en Puerto Rico. También le brinda una oportunidad a otras personas interesadas en la dasonomía tropical para presentar el resultado de sus trabajos.

Se solicitan aportaciones de otras fuentes en el campo de la dasonomía tropical siempre que no estén considerándose para publicación en otras revistas. El manuscrito generalmente no debe exceder 20 páginas escritas a máquina a doble espacio, aunque ocasionalmente podría aceptarse un artículo más largo cuando tuviera un interés especial.

Los artículos deben someterse en la lengua vernácula del autor, deben incluir su título o posición que ocupa y un resumen corto. Deben estar escritos a máquina a doble espacio, solamente en un lado de la página, en papel blanco primera, tamaño 8½ por 11 pulgadas.

Las tablas deben numerarse consecutivamente, cada una en una hoja separada con su título. Las notas al pie usadas en las tablas deben escribirse a máquina como parte de la tabla y designarse por medio de números.

Las ilustraciones deben designarse con números y numerarse consecutivamente. Los títulos para cada ilustración deberán someterse en una página separada. Las fotografías sometidas como ilustraciones deben ser claras, bien definidas y en papel glaseado, preferiblemente 5 por 7 u 8 por 10 pulgadas en tamaño.

Las notas al pie deben numerarse consecutivamente con un número de llamada siguiendo la palabra en el texto a la cual hace referencia la nota al pie. La nota al pie debe aparecer en el texto en la línea siguiendo el número de referencia y separada del texto por medio de una línea corta hacia dentro desde el margen izquierdo del texto. Las notas al pie se usan para dar crédito a material no publicado y a comunicaciones. Si se hacen solamente unas pocas referencias a la literatura entonces dichas citas pueden aparecer como notas al pie. Las citas incluirán el nombre del autor, el año de publicación, el título del trabajo, y el nombre y páginas de la publicación.

Los manuscritos deben enviarse al Líder del Centro Tropical de Investigaciones Forestales, Río Piedras, Puerto Rico.

Las opiniones expresadas en esta revista no coinciden necesariamente con las del Servicio Forestal. Los artículos publicados en el Caribbean Forester pueden reproducirse siempre que se haga referencia a la fuente original.

The Caribbean Forester is a free semi-annual technical journal published since 1938 in Puerto Rico by the Tropical Forest Research Center, Forest Service, U. S. Department of Agriculture. This publication is devoted to the development of improved management and utilization of tropical forest resources, with special interest in the Caribbean region.

Through the pages of the journal tropical foresters and workers in allied scientific fields are informed of specific problems of tropical forestry, policies in effect in various countries, and progress of work being carried out for the improvement of the management and utilization of forest resources. It furnishes a means of distribution of information on the progress and results of the experimental programs of the Tropical Research Center in Puerto Rico. In addition, it affords an opportunity for other workers in the field of tropical forestry to make available the results of their work.

Contributions for the journal are solicited. However, material submitted should not be under consideration for publication elsewhere. Manuscripts should not ordinarily exceed 20

(Continúa en la portada #3)

The printing of this publication has been approved by Director of the Bureau of the Budget (June 26, 1958)
The Tropical Forest Research Center is operated in cooperation with the University of Puerto Rico.

VOL. 20 NOS. 3 AND 4 JULY - DECEMBER, 1959

Caribbean Forester

Contents

Sumario

FIFTH WORLD FORESTRY CONGRESS

The Fifth World Forestry Congress to be held in Seattle, Wasington, U.S.A. August 29 to September 10, 1960 is the first such Congress to be held in the Western Hemisphere. Previous World Forestry Congresses have been in Rome, Italy, 1926; Budapest, Hungary, 1936; Helsinki, Finland, 1949; and Dehra Dun, India, 1954.

The program of the Fifth Congress is divided into 10 sections. The 10th section on Tropical Forestry will be of special interest to readers of the Caribbean Forester. The provisional program indicates that world recognized authorities on tropical forestry will present papers on various aspects of the following topics:

The Regeneration and Establishment of Tropical Forests
Obstacles to Tropical Forestry
Intensive vs. Extensive Management of Tropical Forests
Shifting Agriculture

Copies of the Proceedings of the Congress will be made available for purchase and the individual papers will no doubt be available in the form of reprints.

Inquires concerning the Congress and the Proceedings should be addressed to:

I. T. Haig, Executive Secretary
Fifth World Forestry Congress
c/o Office of International Conference
U. S. A.
Department of State, Washington 25.
D. C.

Growth and Regeneration of White Mangrove in Puerto Rico

By Frank H. Wadsworth

Tropical Forest Research Center

Puerto Rico

Mangrove is one of the most important forests of the tropics as a source of timber, fuel, posts, poles, tanning, and other minor products. Along protected shorelines, estuaries and lagoons at levels from just below low tide to just above high tide (6) from latitude 32° North to slightly farther south of the equator mangrove covers millions of acres. Throughout the world mangrove is similar in physiognomy, although the four major tree species which make up the mangroves of tropical America (some also in West Africa) are distinct from those in the East.

Puerto Rico's coasts once supported some 30,000 acres of mangrove, if we are to judge by the extent of the organic soils they produce (7). Early descriptions of the mangroves of Puerto Rico are not detailed, but little-disturbed mangroves elsewhere suggest that it must have been dense and composed of large trees. The woods of the mangrove were prized for boat building, construction, and posts.

Some 18,000 acres of mangrove remain in Puerto Rico. The decrease in mangrove area, while substantial, is less remarkable than the fact that this forest has resisted encroachment so well. Accessible to the earliest coastal settlements along harbors and protected estuaries, the entire mangrove has been cut over, most of it many times. Decades of the extraction of charcoalwood resulted in repeated clearcutting of stands as soon as the trees reached two or three inches in diameter. Much of the mangrove that remains is immediately adjacent to highly developed urban or agricultural lands. Locally no other type of forest has survived such heavy and repeated cutting nor such close proximity to densely populated areas.

Mangrove probably will not, in the foreseeable future, cease to exist in Puerto Rico as a possible source of forest products, even though encroachment can be expected to continue, especially near San Juan. The persistence of the mangroves of Puerto Rico is due primarily to the inhospitable nature of the site for other uses. Conversion to cropland, although this has taken place on extensive areas, involves costly drainage, a process which in one area requires perpetual pumping. The soil, more than 30 percent organic, is an unstable base for urban construction, even when raised by superficial filling, as is regrettably apparent in the surface of Isla Grande Airport. A current project to extend Isla Verde Airport into the mangrove involves the removal hydraulicly of the muck to a depth of 35 feet and the substitution of sand. About 8,500 acres of mangrove lie within Commonwealth forests and are thus by public policy reserved from other uses and protected and managed for timber production.

White mangrove *(Laguncularia racemosa* [L.] Gaertn.) is the most abundant of the four local species of mangrove, the others being red mangrove *(Rhizophora mangle* L.); black mangrove *(Avicennia germinans* [L.] Stearn or *A. nitida* Jacq.); and buttonwood *(Conocarpus erecta L.)*. The occurence of these species is markedly zoned by environmental differences which are both natural and man-made. It has been suggested that there have been substantial changes in the composition of these forests during the period that they have been subject to exploitation (3). Whatever the full importance of different factors upon these stands, it may be said that red mangrove now is limited largely to a seaward fringe of this forest, frequently no more than 25 feet in width, and to small patches or strips behind this fringe. Buttonwood, whatever may have been the extent of its original occurrence, is not now available in commercial quantities, occuring only as scattered, malformed individuals along the landward edge of the swamps. The rest of the area, and this includes the central part of all extensive forests, is composed almost entirely of white and black mangroves, with the former generally dominant.

White mangrove can be expected to continue to dominate most of the mangroves of Puerto Rico. Its abundance today is testimony to its capacity to withstand frequent cuttings. Its sprouting vigor after cutting or windthrow does not characterize red mangrove, and is unequalled by black mangrove. If, as is reported from Florida (2), white mangrove constitutes a more advanced successional sere than black, the latter can be expected to disappear with the gradual natural rise in the soil surface. Nevertheless, a natural rise in soil level to a point where white mangrove will be invaded by upland forest species appears to be a very distant prospect in most areas.

Timber production from white mangrove forests apparently will always have roundwood products as its objective. Neither white nor black mangroves commonly grow to sawtimber dimensions, yet the good form of both makes them generally suitable for posts and poles. Although the service life of untreated fence posts of these species is only 18 to 30 months, they treat well by nonpressure preservative methods (hot-and-cold bath) which should extend their service life to more than 10 years.

THE PROBLEM

The greater accessibility of the mangrove than other local forests, the high present and potential demand for mangrove products (more than 10,000,000 fence posts alone consumed annually in Puerto Rico), and the simplicity of these nearly pure forests in contrast to the complex mixtures of the uplands have all created a need to know how to produce high sustained yields from mangrove. Basic to such production is information as to the growth rate and regeneration of white mangrove.

SILVICULTURAL EXPERIENCE

With the exception of an excellent ecological study of mangroves in Florida (2) and a review of silvical data (1) the literature bears little evidence of research or forestry experience in the mangroves of this hemisphere which is of significance to their silviculture. It appears that the mangroves, extensive and accessible as they are, have been almost completely neglected by foresters in tropical America.

The most extensively reported silvicultural experience in mangroves appears to be that of Malaya (4, 5, 9, 10). There the initial approach was, as in upland forests, by cutting to a girth limit. Some good crops of regeneration were produced in this manner. However, results were considered generally unreliable and the method was abandoned in favor of heavier cutting, leaving only scattered seed trees. This technique was in turn abandoned because the seed trees were soon windthrown and the regeneration was less complete, making necessary extensive planting. The shelterwood system was tested and concluded to be no more satisfactory from the standpoint of regeneration, and involved heavy wind damage to the overstory. Although completion of the final cut within 4 years after the regeneration thinning minimized damage to the young trees, which were then less than 3 feet tall, numerous unregenerated areas still required planting.

Clearfelling after a number of intermediate cuts has been the regeneration practice in Malayan mangroves since 1931. Considered normally as successful in regeneration as the seed-tree method (about 20 percent of the area requiring planting) this practice produces a greater harvest yield. The success of this technique is believed to be due largely to the presence of regeneration on the ground before felling. Failures are common in the areas subject to deep flooding.

Mangrove regeneration in Malaya has generally required planting of failed spots, a feature which is now under close scrutiny because of rising labor costs. Efforts are now directed toward complete regeneration by natural means. It has been suggested (4) that the minimum girth and seed tree methods should be retested under present circumstances since experimental proof of their failure is lacking. Another suggestion has been to regenerate the forest in strips so that no unregenerated area will be distant from a seed source.

In Puerto Rico early observations and experience were recorded by Holdridge in 1940 (3). The rapid regeneration of many clearcut areas led to the conclusion that mangrove is capable of fast growth, at least initially. Past cuttings were thought to have favored white mangrove at the expense of red and black mangrove, in part because the red mangrove does not sprout. Regeneration failures were laid to adverse water levels, the fern *Acrostichum aureum* L., and excessive salinity. Direct seeding of red mangrove produced survivals of more than 90 percent. Lifting and planting of two-foot wildings or white mangrove gave excellent survival and height growth of 3 feet in 10 months. Use of wildings of black mangrove was unsuccessful. It was also apparent to the author shortly after Holdridge's paper apeared that traditional permits issued by the government for cutting of mangrove posts from public lands were creating residual stands of malformed sprouts of little or no present or prospective value.

PROCEDURE

Studies were undertaken in typical stands of white mangrove in the two most extensive areas of mangrove in Puerto Rico: (1) at Piñones, east of San Juan on the Atlantic coast, and (2) at Las Mareas, east of Jobos Bay on the Caribbean coast. Both areas are within Commonwealth Forests and are protected and managed by the Division of Forests, Fisheries and Wildlife of the Puerto Rican Department of Agriculture and Commerce. Assistance by many of the personnel of the Division in the field work is gratefully acknowledged.

The first study undertaken concerned thinning in a small sapling stand of unknown age (1 inch average d.b.h. and 20 feet in height) at Piñones. In 1938 five quarter-acre plots were established in this stand, four of which were thinned to different degrees. All remaining trees of 4.5+ feet in height were tallied by diameter, and 100 trees in each plot were tagged for remeasurement. The stands within these plots and the tagged trees were remeasured in 1942, 1945, and 1949.

Numbers of trees per acre, basal areas, and growth of tagged trees were determined.

The effects of the 1938 thinning had largely disappeared by 1949, and since diameter growth proved unexpectedly slow, three of the plots were then subjected to a second thining experiment. At that time the average d.b.h. was 1.7 inches and the height was about 30 feet. One plot was thinned to 79 square feet of basal area per acre and another to 61 square feet. The stand and the tagged trees were measured before and after treatment and in 1951, 1953, and 1955.

A third study was begun in 1949 at Las Mareas to determine the effect of thinning on tree growth and natural regeneration in a larger, 19-year-old pole stand (See Figure 1). This stand averages 4.3 inches d.b.h. and the canopy was 65 feet in height. Four quarter-acre plots were established, and all trees within them were tagged and classified by crown position. These were all left unmodified until remeasurement in 1952, at which time one plot was thinned to 77 square feet of basal area per acre and another to 63 square feet, the remaining two being left unthinned. A final remeasurement was made in 1955.

The lack of regeneration in the thinned plots at Las Mareas led in 1951 to a study of regeneration after clearcutting nearby. A strip 66 feet wide by 660 feet in length, with the long axis north-south, perpendicular to the wind direction, was cut in the pole stand. Adjacent strips, of equal dimensions and toward the windward, were cut in 1953 and 1955. Observations and measurements in the regeneration have been made annually since that time.

A cubic-foot volume table, based upon diameter at breast height (d.b.h.) and total height and including all volume to a 1-inch bole diameter limit, was constructed from measurements of 130 trees of white mangrove felled in the 1951 clearcutting at Las Mareas.

Figure 1. - Unthinned 19-year old pole stand of white mangrove

The table, developed from a logarithmic formula derived by the least squares method and simplified for average heights, has been used to appraise stand increment in the plots under measurement.

Some of the comparisons originally intended in these studies could not be made. One reason was an unexpected degree of initial variability among the few plots studied, some of which were found to differ too much to be comparable. Another was wind damage, which seriously modified the relative densities resulting from the treatments intended for comparison. Except where specifically qualified the results presented include only those free of serious interference from these sources.

RESULTS

The chief results of these studies concern tree growth in unthinned mangrove, tree growth in thinned mangrove, and natural regeneration. The results from the different studies are combined in the descriptions under each heading.

Tree Growth in Unthinned Mangrove

The growth of trees in plots in three unmodified white mangrove stands is summarized in Table 1. These stands represent the range in diameter up to that of commonly used posts. Trees of larger size have been used in the past only for charcoal, a lower value product. Tree growth was measured in the plot in the small sapling stand from 1938-1942, in the large sapling stand from 1951-1955, and in the pole stand the period was 1952-1955.

Table 1. — Growth of Unthinned White Mangrove

Index	Small Sapling Plot	Large Sapling Plot	Pole Plot
Stand conditions[1]			
Average d.b.h., inches	1.0	1.7	5.0
Trees per acre	13,640	9,040	940
Basal area, sq. ft. per acre	71	148	126
Volume, cu. ft. per acre	550	1,580	2,680
Subsequent diameter growth			
Basis of measurement			
Number of trees	93	61	201
Period, years	4	4	3
Annual growth, inches			
Mean, all trees	0.041	0.102	0.107
Dominants	0.100	0.324	0.183
Codominants	0.120	0.192	0.157
Intermediates	0.060	0.126	0.093
Suppressed	0.010	0.062	0.067

1/ Based upon 1/4-acre sample of each stand.

The great density in the small sapling plot is manifested in a number of ways. The number of trees and basal area at this early stage are unequalled in the uplands of Puerto Rico except by coppice stands of pomarrosa, *Eugenia jambos* L. (8). Mean diameter growth is very slow and corresponds to that of trees inferior to intermediate in crown position, showing the large preponderance of suppressed trees. Although basal area increment was 5 square feet per acre per year for the 4-year period measured, the annual mortality was 780 trees per acre, about 6 percent. Slow tree growth is evident in the record of this plot for the longer period of 11 years from 1938 to 1949. During that time basal area rose to a phenomenal 148 square feet per acre (8 square feet per year) in spite of the death of 4,600 trees per acre (3 percent par year), yet the average d.b.h. rose only 0.7 inch. Many of the dead trees had been attacked by the stem borer, *Psychonoctua personalis* Grote.

Diameter growth in the plot in the large sapling stand averaged more than twice as rapid as in the small sapling plot (the same plot 13 years earlier). Nevertheless, as in that stand, the mean d.b.h. growth of the large saplings is seen in Table 1 to rank between that of intermediate and suppressed trees, showing a continued preponderance in these categories.

The pole stand plot, although its basal area is less than that in the large sapling stand, showed slower d.b.h. growth by crown classes, suggesting an inferior site. Nevertheless, the mean growth rate, more rapid than the average for the intermediate trees, apparently because of the disappearance of many of those which were suppressed, was as high as in the large sapling stand. Basal area increment for the 3-year period of measurement was negligible, apparently due to the mortality of 44 trees per acre per year, or 5 percent. Mean annual net volume increment for the 22 years to the beginning of the period of measurement was 122 cubic feet per acre.

The presence of a few trees of black mangrove in these plots made it possible to compare the concurrent d.b.h. growth rates of the two species in the best represented crown classes. The results, shown in Table 2, show differences so slight that they proved to be of no statistical significance.

Tree Growth in Thinned Mangrove

The slow mean diameter growth in the mangrove and the high proportion of suppressed trees suggested thinning as a corrective measure. Thinnings were tested in each of the three stands described.

One half-acre in the small sapling stand, thinned to a density of 40 square feet of basal area per acre (compared to 71 in the adjacent unthinned stand) suffered no wind damage and in the four subsequent years grew an annual average of 0.068 inch in mean diameter,

Table 2. — Comparative d.b.h. Growth of White and Black Mangrove

Plot	Crown Class	Trees of Each Species	Period of Measurement	Mean Annual d.b.h. Growth White Mangrove	Mean Annual d.b.h. Growth Black Mangrove
		No.	Years	Inches	Inches
Large sapling	Codominant	42	4	0.242	0.289
Pole	Suppressed	43	6	0.156	0.153

compared to 0.041 inch in the unthinned plot, a difference of 65 percent. However, the thinning required about 20 mandays of labor per acre and yielded only small stakes of little value, so there appeared to be little prospect of practical thinnings in such small stands. Moreover, during the subsequent 11 years natural mortality in the unthinned stand reduced its density to that of the thinned stand, and the dominant trees in the former were equal in quality to those in the thinned stand.

The thinnings in the large sapling and pole stands are described and their results compared with the same plots before thinning and the adjacent unthinned plots are summarized in Table 3. The thinned plots are adjacent to and initially were essentially similar to the plots in the respective unthinned stands described in Table 1. Directed toward a residual basal area of 60 square feet per acre, the thinnings were considered heavy, removing 72 percent of the trees in the large sapling plot (see Figure 2) and 46 percent of those in the pole plot. However, because the thinning was from below, the reduction in basal area and volume was less than proportional to that in number of trees. This type of thinning had and immediate effect in raising the average d.b.h. In no instance did the thinning precipitate significant windfall losses.

Figure 2. - Large sapling stand of white mangrove after thinning.

The effects of thinning upon diameter growth in the large sapling plot are evident in Table 3. The mean diameter growth in the thinned plot during the first 4 years after treatment was about 3 times that in the unthinned plot. Whereas the mean growth rate in the unthinned plot was 19 percent below that of the average intermediate tree, in the thinned plot it was 11 percent above the average intermediate, showing a reduction in the representation of suppressed trees due to thinning. The average diameter growth rate for trees in each crown class was higher in the thinned than in the unthinned plot and most marked in the subordinate trees. In the important codominant and intermediate classes these differences proved highly significant. This means that those trees in each class before treatment grew more slowly than those in the same class (not necessarily the same trees) after treatment.

In the pole stand the unthinned plot and the plot selected for thinning were initially similar. The difference between the average d.b.h. of the two plots was not statistically significant. The mean annual net increment, at age 22, in the unthinned plot was 122 cubic feet per acre, compared with 108 cubic feet in the plot selected for thinning. Mean diameter growth during the three years prior to treatment differed only 0.013 between the two plots, an amount of no statistical significance.

In the thinned pole plot the three-year mean diameter growth increase was highly significant, whereas the increase in the unthinned plot, only 5 percent, was not. The concurrent difference in mean diameter growth between the two plots after thinning, 0.116 inches, proved also highly significant. The increase in average d.b.h. growth by crown classes, as in the large sapling stand, was most marked in the subordinate classes. The average growth rates for the codominant and intermediate crown classes both increased by highly significant amounts. An analysis of d.b.h. growth of 197 individual trees in the unthinned plot showed them to be growing only 2 percent more in the second three years than they had in the first. The corresponding difference for 82 trees in the thinned plot was 80 percent; the former increase not statistically significant and the latter highly significant.

Differences in overall stand development in these two pole plots were found. In the unthinned plot the basal area increment declined slightly one square foot per acre per year for the first three years to none in the last three years. In the thinned plot basal area increment jumped from -7 to +5 square feet. Both plots lost the same number of trees per acre in the three years before treatment, yet after treatment the losses in the thinned plot were only one third as great in number of trees as in the unthinned plots. Even on a percentage basis tree mortality was less in the thinned plots (3 vs. 5 percent per year). In volume increment the unthinned plot declined from 2 percent to 1 percent per

Table 3. — Growth in Thinned White Mangrove

	Large Sapling Plot		Pole Plot		
	Thinned	Difference from Unthinned Plot	Thinned	Difference From Before Thinning	Difference From Unthinned
		Percent		Percent	Percent
Stand Conditions[1]					
Average d.b.h., inches	1.9	+12	5.5	+4	+10
Trees per acre	3,020	-67	380	-46	-60
Basal area, sq. ft. per acre	61	-59	63	-42	-50
Volume, cu. ft. per acre	770	-51	1,380	-42	-49
Subsequent diameter growth					
Basis of measurement					
Number of trees	57		84		
Period, years	4		3		
Annual growth, inches					
Mean, all trees	0.307	+201	0.223	+108	+108
Dominants	0.340	+20	0.307	-	+68
Codominants	0.310	+61	0.253	+15	+61
Intermediates	0.278	+121	0.220	+77	+137
Suppressed	-	-	0.170	+166	+154

1/ Based upon one 1/4-acre sample of each stand.

year while the thinned plot jumped from -5 to +6 percent.

Natural Regeneration

Natural regeneration, although an objective of treatment only in the pole stand, was a subject of observations in all studies. None of the thinnings in the sapling stands produced efective natural regeneration. Even in the pole stand the thinning did not serve as an adequate preparatory cut for regeneration. A few seedlings of red and black mangrove appeared, but none of white, presumably because of its relative intolerance.

The failure of white mangrove regeneration to appear under the thinned pole stand led to a test of clearcutting in narrow strips (See Figure 3). The stand selected was similar to that in the unthinned plot, and results were obtained concurrently. At the end of the first year the strip was not completely regenerated, although there were sprouts to 8 feet in height. The windward half of the strip had a fair crop of 4 inch seedlings of white mangrove, and a good crop was seen under the adjacent remaining forest. No wind damage to the standing trees along the edge of the strip occurred. A few areas throughout the strip showed seedlings which apparently had floated in and germinated along the edge of inundated areas. Only a few seedlings of black and red mangrove were found.

At the end of the second year the strip was regenerated completely. Sprouts had grown to 12 to 15 feet in height and abundant seedlings were up to 4 feet tall. There was no windthrow along the edges. A second strip, adjacent and to the windward (east), was then cut (See Figure 4) with equally successful results. The process was repeated at the end of the fourth year.

The young growth arising from these cuttings (See Figure 5) was the only stand to escape serious damage in the hurricane which

Figure 3. - Clearcutting in pole stand of white mangrove.

destroyed 59 percent of the trees in 2000 acres of mangrove in 1956. At age 9, the original strip contains 3,100 trees per acre with a mean d.b.h. of 2.6 inches and a maximum of 5 inches, a canopy height of 35 feet, and a basal area of 115 square feet per acre. About 70 percent of the trees are white mangrove, the rest is black.

As the new stand developed concern was felt that it would be primarily coppice and of poor form (See Figure 6). The rapid early growth of sprouts was evident generally, and in the 9-year-old stand 43 percent of all trees (60 percent of all of white mangrove) are of sprout origin. However, measurements of a few trees, beginning at age 3, indicate that the sprouts no longer are outgrowing in diameter the straighter seedlings (See Figure 7). In the period 1954-57 the seedlings outgrew the sprouts by about 30%. Since then the relationship is apparently even more favorable to the seedlings. However, the data collected have not been adequate to determine whether this difference is statistically significant.

CONCLUSIONS

The scope of these studies was such that they lead to definite conclusions regarding the behavior only of individual trees of white mangrove. A number of indications are also apparent concerning stand behavior, but replication was inadequate to establish these conclusively. The findings are assumed to be limited in applicability by environmental and stand conditions which are not fully understood. Although the sites selected for study appeared to be typical of large local areas of white mangrove forest, it is possible that rates of sedimentation, water levels, and salinity at these sites may prove to be less representative than they appear. Both the conclusions reached and indications apparent in these studies are described, the latter being qualified.

Figure 4. - Second clearcutting of pole stand. Newly cleared strip to the right and 2-year old regeneration on adjacent strip to left.

1. Undisturbed small sapling stands of white mangrove, developing after clearcutting, while the average d.b.h. is still only 1.0 inch, may contain 13,600 trees, 70 square feet of basal area, and 550 cubic feet of wood per acre.

2. Tree mortality in the small sapling stand studied was 6 percent annually, or 780 trees per acre over a period of 4 years.

3. Diameter growth of trees in a plot in the small sapling stand averaged only 0.04 inch annually. For codominant trees the average was 0.12 inch.

4. Undisturbed large sapling stands of white mangrove may, when an average d.b.h. of 1.7 inches is reached, contain 9000 trees, 148 square feet of basal area, and 1580 cubic feet of wood per acre.

5. Diameter growth of trees in a plot in the large sapling stand averaged 0.10 inch annually. For codominant trees the average was 0.19 inch.

6. Undisturbed stands of white mangrove 22 years old may attain pole size, an average d.b.h. of 5.0 inches, 940 trees, and 2680 cubic feet of wood per acre, a mean annual net volume increment of 122 cubic feet per acre.

7. Tree mortality in the pole stand studied was 5 percent annually, or 44 trees per acre over a period of 3 years.

8. Diameter growth of trees in a plot in the pole stand averaged 0.11 inch annually. For codominant trees the average was 0.16 inch.

9. There was no significant difference in d.b.h. growth rates of white and black mangroves in the plots studied.

Figure 5. - -Natural regeneration of white and black mangrove 3 years after clearcutting.

Figure 6. - Sprouts of white mangrove 5 years old, showing typical leaning of lower stems.

10. Thinning a plot in the large sapling stand to a residual basal area of 60 square feet per acre tripled mean d.b.h. growth during the subsequent 4 years. In a plot in the pole stand a similar thinning doubled mean d.b.h. growth during the following 3 years. These increases arose from two sources: (a) the elimination of slow-growing trees and (b) the acceleration of the growth rate of those remaining. This acceleration was produced in part by an upward shift in the position of the remaining tree crowns in the canopy, but was also significant in trees where no marked change in crown position took place.

11. No serious windthrow losses were suffered as a result of the thinnings made.

12. The thinings made did not induce effective natural regeneration of any species.

13. Adequate natural regeneration of white mangrove appeared within 2 years on strips 66 feet wide clearcut perpendicular to the wind in the pole stand.

14. Wind damage along the edge of the clearcut strips was no greater than elsewhere in the pole stand.

15. A 5-year-old sapling stand on the area regenerated after clearcutting suffered negligible damage in a hurricane which destroyed 59 percent of the trees in the adjacent pole stand.

16. Evidence of water-borne seed of white mangrove in the clearcut strips indicates that regeneration might be equally prompt on larger clearcut areas.

17. Naturally regenerated white mangrove 9 years after clearcutting in strips attained an average d.b.h. of 2.5 inches (maximum 5.0 inches), a canopy height

of 35 feet, and a basal area of 115 square feet per acre.

18. The white mangrove trees regenerated after clearcutting at age 9 were 60 percent of sprout origin, but the seedling trees are currently at least holding their own in d.b.h. growth as compared with the sprouts.

LITERATURE CITED

1. Bascope, Federico; Bernardi, A. Luciano; Jorgensen, Richard N.; Hueck, Kurt; and Lamprecht, Hans.

1959. LOS MANGLARES EN AMERICA. Descripción de Arboles Forestales No. 5. Inst. Forestal Latinoamericano, Mérida Venezuela. 52 p., illus.

Figure 7. - Seedling of white mangrove 5 years old, showing characteristic enlarged butt and erect growth.

2. Davis, John H., Jr.

1940. THE ECOLOGY AND GEOLOGIC ROLE OF MANGROVES IN FLORIDA. Carnegie Inst. Wash. Pub. No. 517, Paper XVI. 412 p., illus.

.3 Holdridge, L. R.

1940. SOME NOTES ON THE MANGROVE SWAMPS OF PUERTO RICO. Carib. Forester 1 (4):19-29.

4. Noakes, D.S.P.

1951. NOTES ON THE SILVICULTURE OF THE MANGROVE FORESTS OF MATANG, PERAK. Malayan Forester 14:183-196.

5. ————

1957. MANGROVE. TROPICAL SILVICULTURE. Forestry & Forest Products Series No. 13. FAO Vol. II 309-318.

6. Richards, P.W.

1952. THE TROPICAL RAIN FOREST. Cambridge Press 450 p., illus.

7. Roberts, R.C.

1942. SOIL SURVEY OF PUERTO RICO. U.S. Dept. Agri. & Univ. Puerto Rico Agr. Expt. Sta. 495 p., illus.

8. Wadsworth, Frank H.

1943. POMARROSA, **JAMBOSA JAMBOS** (L.) MILLSP. AND ITS PLACE IN PUERTO RICO. Carib. Forester 4(4):183-194.

9. Walker, F.S.

1938. REGENERATION OF KLANG MANGROVES. Malayan Forester 7:71-76.

10. Watson, J.G.

1928. MANGROVE FORESTS OF THE MALAY PENINSULA. Malayan Forest Rec. No. 6, 260 p., illus.

Centennial of Forest Administration in India

India's forests occupy 278,083 sq. miles, forming 22% of the total land area (1,266,980 sq. miles). They yield annually nearly 500,000,000 cu. ft. of hard woods and 50,000,000 cu. ft. of coniferous softwoods. The annual gross revenue of all Forest Departments in India, for the year 1958-59 was Rs. 46,37,00,000. The total expenditure on staff and productive works was Rs. 19,45,00,000 leaving a net surplus of Rs. 26,92,00,000. The average net surplus per sq. mile works out to Rs. 968.

Systematic scientific management of India's forests commenced in the year 1861. The Government of India, with the cooperation of State Forest Departments, propose to celebrate the centenary of forest administration in India during 1961, in a fitting manner. At that time, two volumes of centenary publications will be issued, describing India's forests in all their aspects.

It is proposed that articles of general interest on forestry from eminent foresters in India and abroad, should form part of the centenary publications. The President, Forest Research Institute and Colleges, will gratefully acknowledge contributions for the above publications.

Early Results of Mycorrhizal Inoculation of Pine in Puerto Rico

By Charles B. Briscoe

Tropical Forest Research Center

Despite the presence of more than 500 native tree species in Puerto Rico, many efforts have been made to introduce pines. These attempts have been made because, compared to the native species, pine has a much wider accepted market and has the longer fiber necessary as a component of kraft papers. In addition pine produces higher yields on poor sites, and its silviculture and utilization are relatively simple. The latter two reasons alone would be sufficient on this island, where there is an abundance of degraded, abandoned agricultural land and a population almost completely lacking a woods-working background.

Although private introductions may have been attempted earlier, the first efforts of the U. S. Forest Service to introduce pine was in 1932. During the next two decades 93 studies were made, including 27 species listed, drawn from North America, Central America, the West Indies, Europe, and southeastern Asia. Trials were made on soil varying from heavy plastic clays to very light sandy loams. Elevations varied from less than 100 meters to more than 1000. Waterlogged, wet, moist, and dry soils were planted.

Seedlings were outplanted barerooted and in various types of containers. Planting was deep and shallow, and in deep shade to full sun. Plantations were left completely untended, cleaned completely, and cleaned in a circle around plants. Seedlings were fertilized in the nursery and in the field; fertilization was nitrogen only, minor elements, nitrogen-phosphorous-potassium, and complete.

Although various treatments and species led to better development in the nursery, greater survival and longer persistence in the field, the ultimate result of all studies was complete failure. The only really encouraging note was that seedlings of *Pinus elliottii* Engelm. and *P. caribaea* Morelet treated in the nursery in 1950 with an inoculum of mycorrhizal fungi yielded outstanding seedlings. These failed in the field, but failure appeared to be clearly attributable to field handling rather than to a lack in the seedlings themselves.

INTRODUCTION OF MYCORRHIZAL FUNGI

Therefore, encouraged by reports of the success of the Trinidad Department of Forestry following mycorrhizal inoculation of pine seedlings, attention was concentrated beginning in 1955 on the introduction of mycorrhizal fungi. This was done in three ways: inoculating seedlings already established in the field, importing inoculated seedlings, and treating nursery bed with imported inoculum.

Inoculation of established seedlings

Seedlings of slash pine (*P. elliottii elliottii* Engelm.) were treated two years after outplanting with inoculum collected under stands of loblolly (*P. taeda* L.) and shortleaf (*P. echinata* Mill.) pine in North Carolina, U. S. A. The material was also kept separately as collected from the F horizon

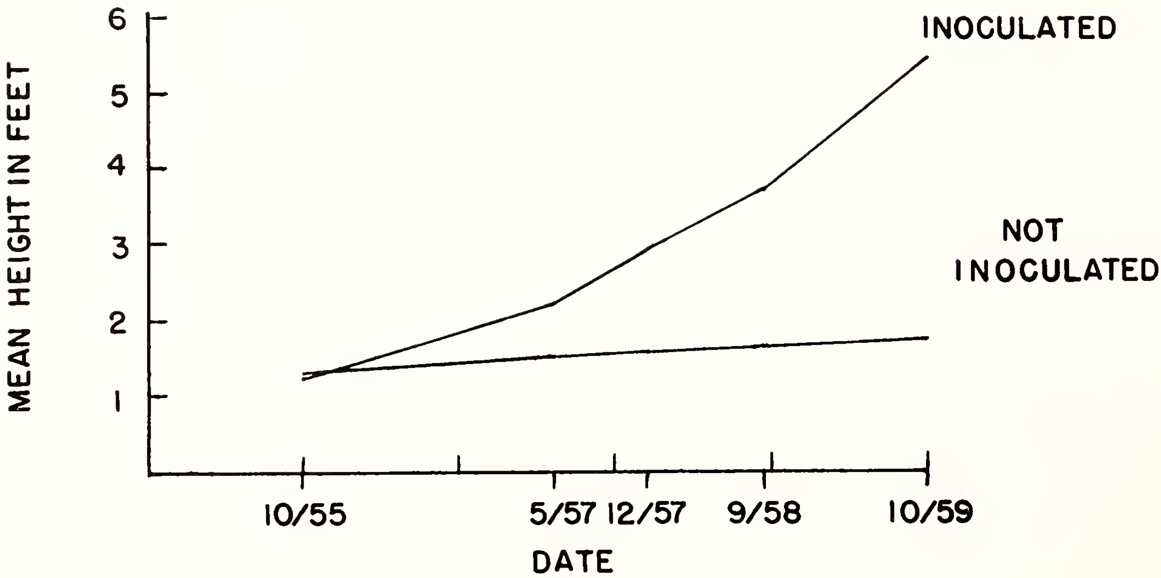


Figure 1. - Growth of established seedlings, 1955 - 1959. Basis: seedlings alive in 1959.

(fermented organic material) and the A_1 horizon (uppermost mineral soil including incorporated organic matter).

The soil in a circle with a 1-foot radius around each seedling to be treated was removed to a depth of four inches. A double-handful of inoculum was then thoroughly mixed with the soil and the mixture was replaced. From around half the checks the soil was removed and treated in the same way, except that no inoculum was added. The remaining check seedlings were left undisturbed.

Survival of the 20 inoculated seedlings was 85 percent; survival of the 22 seedlings not inoculated was only 36 percent. Of the surviving seedlings, those inoculated grew more than 13 times as much as those not inoculated (Figures 1 and 2).

That the improved growth was not due to the disturbance which accompanied the treatment is shown by the fact that for the disturbed controls the 1959 height was only 20 percent greater than the 1955 height, but the undisturbed controls grew 70 percent during the same period.

Differences correlated with overstory species and soil horizon of inoculum did not approach statistical significance.

Planting imported seedlings

In 1958 one-year-old seedlings of slash and loblolly pines were flown in from Mississippi, U.S.A., and outplanted at seven widely scattered locations.

Survival and growth have been satisfactory (Table 1 and Figure 3). Field inspection three months after planting showed mycorrhizae to be present on the roots of virtually all surviving seedlings.[1]

Inoculation in seedbed

In 1959 inoculum collected[1] under a Virginia pine *(P. virginiana* Mill.) overstory in Maryland, U.S.A., was applied to sowings of *P. caribaea* Morelet seed from British Honduras and from Cuba.

1/ Dr. Edward Hacskaylo, Plant Physiologist, Forest Physiology Laboratory, U. S. Forest Service, Beltsville, Maryland.

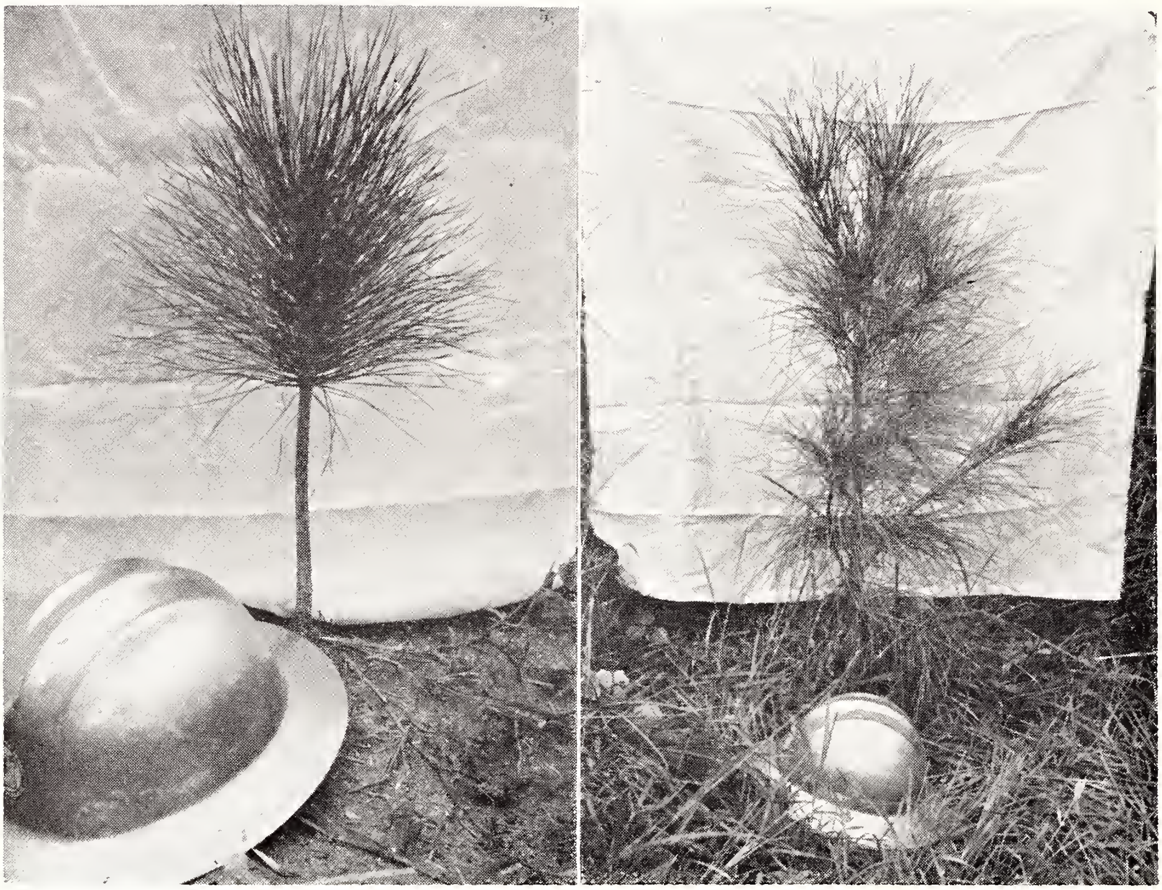
Excellent seedlings were produced (Figure 4) and early survival following outplanting of potted seedlings averaged almost 98 percent.

SUMMARY

Because of their established market, utility, productivity, and relatively simple care needed many efforts have been made to introduce the true pines to Puerto Rico, an island on which no pines are indigenous.

Ninety-three studies varying in species, site, and cultural methods were unsuccessful, but indicated that mycorrhizal fungi might be a critical factor. Three studies were made to determine a practicable way of bringing in the fungi: Importing inoculated seedlings, applying imported inoculum to established seedlings, and applying imported inoculum to the nursery seedbed. All were successful, and healthy, vigorous pine seedlings are now establish on twenty different sites.

A. B.
Figure 2. - Slash pine in October 1959. A. Not inoculated with mycorrhizae. B. Inoculated in October 1955.



A. Loblolly. B. Slash

Figure 3. - Imported pines one year after outplanting.

List of Species of Pines Planted in Puerto Rico, 1932-1951

- *Pinus ayacahuite*
- P. *attenuata*
- P. *canariensis*
- P. *caribaea*
- P. *densiflora*
- P. *elliottii densa*
- P. *elliottii elliottii*
- P. *glabra*
- P. *halepensis*
- P. *insularis*
- P. *longiflora*
- P. *merkusii*
- P. *muricata*
- P. *occidentalis*
- P. *oocarpa*
- P. *patula*
- P. *pinaster*
- P. *pinea*
- P. *radiata*
- P. *rigida*
- P. *serotina*
- P. *sylvestris*
- P. *taeda*
- P. *thunbergii*
- P. *torreyana*
- P. *tropicalis*
- P. *virginiana*

Table 1. — Survival of Imported Seedlings in Plantations Kept Weeded

Species	Survival percentage	
	Heavy soil	Light soil
	%	%
Slash	45	60
Loblolly	65	90

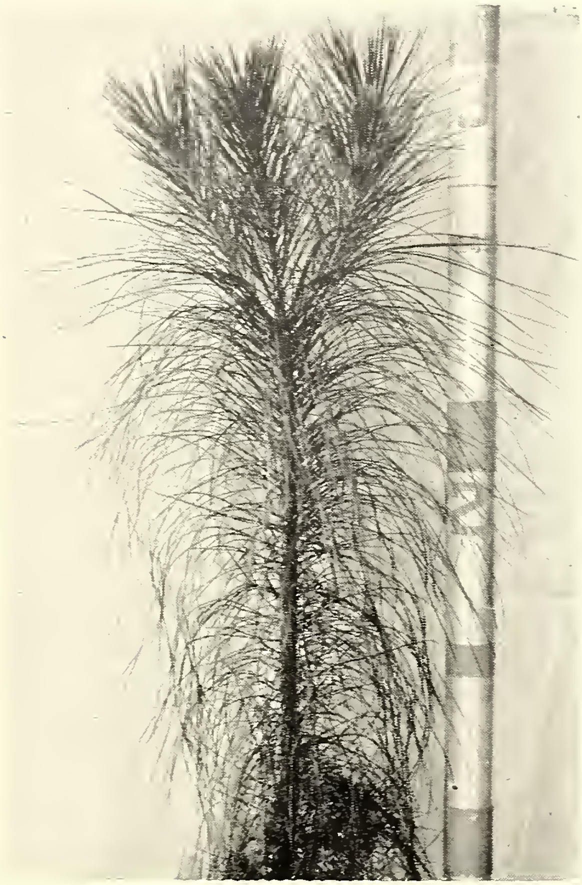


Figure 4. - Pinus caribaea inoculated with mycorrhizae in the seedbed. Seed source, British Honduras; age, 11 months.

Forestry and the Timber Trade in the Caribbean Area

By M. N. Gallant

FAO No. 1060 United Nations, Rome

Part I 40 pp. Part II 104 pp. 1959

Review

Mr. Gallant, a well known British tropical forester, has prepared an interesting and useful report on the forestry and timber trade situation in the Caribbean area. The report covers the countries served officially by the Caribbean Commission consisting of the islands in the arc from Jamaica through Trinidad to the Netherlands Antilles together with the three Guianas and British Honduras but excluding the Bahamas, Cuba, Haiti, Santo Domingo, as well as the Central and South American republics adjoining the Caribbean area.

Part I deals with the general aspects of the subject in this area. The discussion of the trade in forest products includes inter-Caribbean trade in timber, and the export trade in timber to countries outside the area with data on volume and value of imports and exports.

Forestry activities in the mainland area are discussed in relation to extensive forest resources and the need to increase the utilization of the raw material available. In the islands the need to increase the productivity of the forest land through planting is emphasized.

Steps needed to increase industrialization of forest products and to promote the timber trade in the Caribbean area are mentioned.

Part II gives more detailed information on the countries visited covering such subjects as internal timber consumption, exports, imports, extraction and sawmilling, lumber nomenclature and grading, and general forestry activities. In the sections on Martinique, Guadaloupe and St. Lucia interesting observations are made on the promising development of mahogany plantations. The possible financial returns are predicated, which appear to be rather optimistic based on experience in Puerto Rico.

The Coastal Swamp Forests of Nariño, Colombia

F. Bruce Lamb

Tropical Forest Research Center

The Pacific coast forest of southern Colombia, particularly the province of Nariño, show a clearly marked transition between tree associations from salt water through brackish and fresh water swamps to the mixed upland forest. In recent years these forests have attracted increasing attention from commercial firms interested in both the local and export lumber trade. If the lumber industry develops in this region an understanding of the ecological relationships of the forest associations will be important in developing forest management plans to maintain forest productivity.

The wood that is attracting most attention recently is 'cuangare' *(Iryanthera juruensis* Warb.).[1] This tree grows in abundance in the fresh water swamps of the region. Veneer logs have been shipped in quantity to Germany during the last 15 years, and a local sawmill and veneer industry has been established to supply local and export markets with this wood.

The interest in lumber of this region is centered around Tumaco in the province of Nariño. It was in this area that information for this paper was collected. Observations were limited to those areas visited carrying out a reconnaissance timber survey of the forests in the Tumaco area, and do not constitute a detailed ecological study of the vegetation.

Tumaco is located at Lat. 1°50' N., Long. 78°45'W., and the lowland forests discussed here are in the wet tropical zone designated ecologically as the tropical moist forest formation by Holdridge's classification (5). The average annual rainfall at Tumaco is 3075 mm (12). The precipitation is evenly distributed, with less than 50 mm/month occurring only in March and August. The mean temperature is 27°C. (9).

Geology and Soil

The coastal plains around the gulf of Tumaco are recent Quaternary alluvial deposits. Just behind the coastal plain are found low hills of dissected Pleistocene gravels and Tertiary sediments (12).

The soils of the coastal plain are sandy loam and fine clay, gray in color, over a layer of sandy loam at a depth of approximately one meter. These soils have developed over what appears to be a layer of volcanic sand deposited in a shallow sea (9). On the uplands humus-infiltrated lateritic soils develop. They are deep, heavy textured clay soils, varying from red to yellow in color, acid in reaction.

Swamp Forest Associations

The unusual tides of the area profoundly affect the drainage of the lowlands and have a controlling effect on much of the swamp vegetation. The maximum difference in water level from high to low tide is approximately 18 feet during spring tides, and the minimum difference probably not less than 10 feet during neap tides. This daily variation in the water level results in salt and bracksih water being forced far up the estuaries and streams at high tide, backing up or impounding fresh

1/ A. C. Smith, "New to Nariño; a record from the Pacific coast region of Dept. El Valle by A. C. Smith (Contrib. U. S. Nat. Herb. 29:324. 1950)". 1955 correspondence.

water and causing extensive flooding. Flooding reaches a maximum when periods of high rainfall coincide with spring tides or exceptionally high equinoctial tides.

Manglar

In the Gulf of Tumaco there are extensive, exposed mud flats at low tide. Red mangrove *(Rhizophora mangle* L.)[2] colonizes these mud flats at a considerable distance below the high tide level, forming dense stands of small trees with tiers of prop-roots that anchor the plants in the soft soil. These intertwined roots form an effective trap for all kinds of floating debris which, along with sediment, settles and builds up the soil level until a mature mangrove community develops. This is often an impressive forest of trees up to 30 inches in diameter and 90 feet tall, 30 to 40 feet to the first limbs. Volumes as high as 20,000 board feet to the acre are not uncommon. These are often almost pure forest of red mangrove, with a few bromilead aeroids in the crowns and a large coarse fern *(Acrostichum aureum* L.) called "ranconcha" locally in the understory.

In the coastal areas between the rivers or estuary outlets this plant association may extend to a considerable distance inland, depending on topography, soil, and soil moisture conditions. In a few places on the Gulf of Tumaco the mixed highland forest comes right down to the sea shore, leaving room for only a narrow belt of mangrove. Viewed from the air, on the inner side of some of the deeper zones of mangrove the vegetation merges into an area of low marsh-like vegetation made up apparently of coarse grasses, ferns and small palms called locally "ranconchal" Figure 1. Because of the difficulty in reaching these areas none were visited on the ground.

Along the inner edge of the mangrove swamp there appears a rather narrow zone of open, low forest dominated by black mangrove *(Avicennia nitida* Jacq.) with an abundance of pneumatophores on the ground. Also present in some places is the "Jeli" mangrove *(Conocarpus erectus* L.) which may vary from a prostrate trailing shrub to an erect small tree. There may also appear ferns, epiphytes, shrubs and grasses. From this zone of open vegetation the transition may be abrupt to a closed swamp forest of sajo *(Campnosperma panamensis* Standl.)[3] Figure 2.

Leaving the coast and proceeding up the estuaries and streams, the low red mangrove of the mud flats disappears, but the forest of large mature mangrove continues inland in a narrowing belt along the streams for several miles in some places. On the Río Colorado some of the best stands of large mangrove trees of the area can be observed. These extend more than four miles inland in a narrow belt averaging 300 feet in width on either side of the stream. Where these large trees are felled for the removal of bark for tannin a pure stand of ranconcha ferns develops. No evidence was observed to indicate what direction this deflected succession will take.

The limited observations made do not provide a basis for determining the successional relationships between the various mangrove communities found. However, the general trend seems to agree with observations made by Davis in similar vegetation in Florida (3). He indicates the main line of succession proceeds from the "pioneer *Rhizophora* family" to the 'mature *Rhizophora* consocies' through the '*Avicennia* - salt marsh associes' and the '*Conocarpus* transition associes' to 'hammock forest', the regional climatic climax.

2/ Called R. brevistyla by Cuatrecasas (2) and West (11, 12).

3/ Sajo is the local name used by Little (8) and Acosta-Solis (1) for Cespedesia spathulata (Ruiz & Pav.) Planch. apparently found in Ecuador in similar swamp forest situations. This tree is called pacora in the Tumaco area.

Figure 1. - Aerial view of the swamp forest. At extreme right the light area is water bordered by "manglar", followed by a low salt marsh or "ranconchal", with a narrow transition zone into "sajal" on the left, followed by "guandal" in the upper left.

The 'mature mangrove forest' is regarded by Davis as a stable subclimax type, not part of the main succession from open sea to inland forest and not tending to change into any other type of vegetation.

Cuatrecasas (2) referring to the mangrove associations on the Pacific coast of Colombia says that there are several mangrove communities. Each species appear in exclusive associations that are distributed from the sea inland in accordance with the solidity of the land, the salinity of the soil and the distance from the ocean.

The most frequent succession of communities as listed by Cuatrecasas are as follows:

Red mangrove *(Rhizophora brevistyla)* on the sea front.

Black mangrove *(Avicennia nitida)* on somewhat higher land.

White mangrove *(Laguncularia racemosa* Gaertn.) farther inland.

Jeli mangrove *(Conocarpus erectus)* on still more elevated land.

Because of the accumulation of deposits of alluvium in certain locations this succession may appear to the inverted. In some places where hard, rocky, shallow soil appears near the red mangrove the small tree piñuelo *(Pelliceria rhizophorae)* is found mixed with the red mangrove and is followed inland by the *Avicennia* and *Laguncularia* associations. Associated with the *Avicennia* and *Laguncularia* may found the small tree *Ardisia granatensis* and the shrub *Pavonia rhizophorae.*

Note photos 1, 2 & 3 by W. L. Bender. Servicio Técnico Colombiano Americano.

Natal

At the upper limit of the mangrove forest on the estuary and stream banks there occurs a rather abrupt transition to a forest of nato, called *(Mora megistosperma* [Pittier] Britton & Rose) by Little (8), Holdridge (6), Acosta-Solis (1) and West (11) but *(M. oleifera)* by Cuatrecasas (2). The natal is found on low inundated land that is affected daily by the in and out flow of river water backed up and released alternately by the tides. This transitional synusia has some resistance to salinity but is probably exposed to brackish water only during exceptionally high tides. Nato forms almost pure stands often larger than 3 feet in diameter and 100 feet or more in height. The forest is closed and dark in comparison to the mangrove forest. The tree is characterized by large plank buttresses and dark scaly bark. Occasional associates listed by Cuatrecasas (2) are: *Symphonia globulifera, Brossimum utile, Hirtella carbonaria, Pachira aquatica, Iryanthera ulei, Fagara hygrophila, Sterculia aerisperma, Cespedesia repanda,* and the palms *Euterpe cuatrecasana, Maurtiiella pacifica* and *Zamia chigua. Pterocarpus officinalis* Jacq. is sometimes found associated with nato and in pure stands in brackish water zone above the mangrove. The ground is usually bare and the understory open.

Sajal

Inland, behind both the mangrove and the nato forest there is usually found a transitional forest of sajo. The change from manglar or natal to sajal is rather abrupt in the locations observed. There is usually a narrow belt of low vegetation or almost bare ground 25 to 50 feet wide in this transition zone, with the profile of the vegetation on either side sloping rapidly into the open area (Figure 1).

It appears that the sajal association is not directly affected by flooding with either brackish or salt water, but perhaps there is some residual salinity in the soil from previous flooding by brackish water. The sajal is a swamp type with the forest floor apparently continuously flooded with fresh water. It is practically a pure forest of tall, spindly sajo trees, all about the same size, with a few epiphytes and vines, an occasional small palm and a sparse understory of shrubs and herbaceous plants. The trees form a single, rather open canopy at 50 to 60 feet above the ground. In the stands of pure sajo a tree over 20 inches in diameter is rare. The stands are quite variable in density, with up to 300 trees per acre 4 inches and larger in diameter. In one of the best stands observed there were 70 acres of sajal averaging 110 trees per acre, 12 to 20 inches in diameter with a gross volume of 2450 cubic feet of wood per acre to a 4 inch top. In another locality 300 trees to the acre 6 to 18 inches in diameter, containing 4000 cubic feet of wood to a 4 inch top were reported.[4] Figure 2.

Near the coast in the area between streams and behind the zone of mangrove, sajo may form stands several hundred acres in extent. However, upstream sajo generally forms only a narrow zone between the stands of mangrove and nato, along the river bank and the freshwater swamp forest further inland, see Figures 1, 2 and 5.

Guandal

The sajal generally merges gradually into the true freshwater swamp forest dominated by the tree cuangare, Figures 1 & 3. This type of forest occupies the low-lying land between the streams and estuaries behind the previously described plant associations,

4/ W. L. Bender, Timber Management Specialist, ICA, USOM, Colombia.

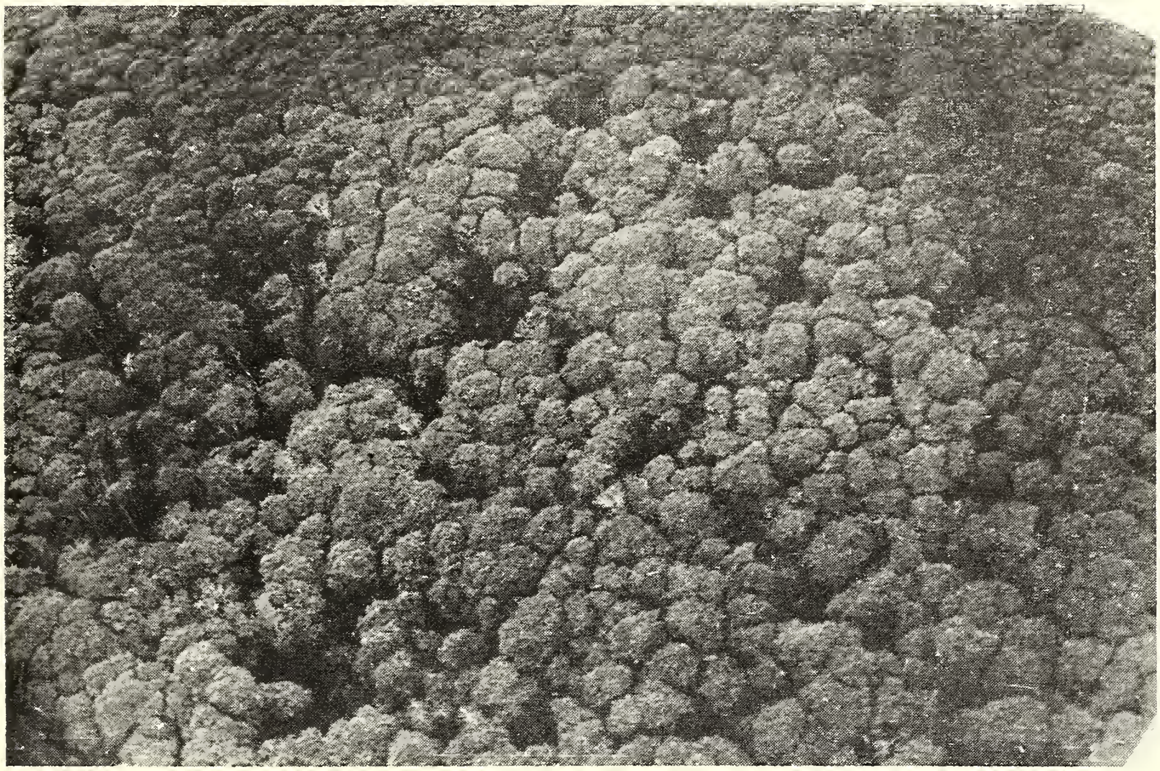


Figure 2. - Aerial view of "sajal".

out of reach of the tide waters. It is also found inland on low-lying stream banks flooded by fresh water, above the level reached by salt or brackish tide water. Areas as large as 1,000 acres or more in extent of this type of forest may develop in the deltas of the large rivers such as the Río Mira and Río Patia.

The guandal is made up almost entirely of cuangare with an occasional vine, a few small palms and woody plants in the understory. It is a closed, single-canopied forest 90 to 100 feet tall with trees ranging up to 50 inches in diameter, often with 50 feet of clear cylindrical bole. The stands are usually rather uniform in diameter and height with 100 or more stems per acre containing as much as 10,000 board feet. Maximum volumes may reach 25,000 board feet per acre.

In marginal areas of the guandal other species tolerating swamp conditions such as sajo, machare *(Symphonia globulifera* L.), chanul *(Humira procera* Little), tangare *(Carapa guianensis Aubl.)* and maria *(Calophyllum longifolium* Willd.) may be found scattered through the forest. Sajo grows larger in the guandal than in the sajal, reaching a diameter of 26 inches in comparison to a maximum of 20 inches in the sajal.

The forest floor is covered just above the mean high water level with a mass intertwined tree roots mixed with a thick layer of brownish peat composed of partially disintegrated plant remains. Travel in this type of forest is difficult because if one breaks through the layer of peat and roots he sinks into knee-deep water.

These guandal forests are probably similar to the oligotropic ombrogenous moors of the East Indies and other parts of tropical America discussed by Richards (10, P.291). Because of the difficulty of exploring them and their low value they have received little attention.

Little (8) and Acosta-Solis (1) report a tree called cuangare *(Dialyanthera gordoniaefolia* [A.D.C.] Warb.) as occurring on similar sites near Esmeraldas, Ecuador. Cuatrecasas (2) gives *Iryanthera ulei* and *D. gracilipes* (cuangare) as a component of the natal swamp forest and Dugand[5] states that cuangare is the name used in western Nariño for the myristicaceous tree, *Dialyanthera gordoniaefolia*. The distribution of these species in relation to *Iryanthera juruensis* Warb. collected in the Tumaco area and whether or not they occur together apparently has not been determined.

Mixed Upland Forest

Where the guandal adjoins the uplands or where silting conditions on the streams form natural stream bank levees, there is a transition to mixed tropical moist forest.

The trees found in this transition zone from swamp to upland forest are tangare *(Carapa guianensis)*, chalviandi *(Virola* sp.)[6] machare *(Symphonia globulifera)*, chanul *(Humira procera)*, laguna *(Vochysia* sp.)[7], cuangare de loma *(Iryanthera* or *Osteophloeum)*[8], and tagua palm *(Phytelephas* sp.). Although these transition species quickly give way to true upland forest where the swamp areas adjoin highland, they form the permanent association of trees along the natural stream levees except where the vegetation has been destroyed for agriculture.

The true upland forest is a variable, complex mixture of more than 100 tree species. In the limited areas examined, the commercial size trees in their approximate order of abundance are: sande *(Brosimum utile* H.B.K. Pittier), tulapuerta (sp?), tangare *(Carapa guianensis)*, caobano *(Platymiscium quinnatum* [Jac.] Dugand), chanul *(Humira procera)*, chalviandi *(Virola* sp.), pialde *(Trichilia* sp.), naguare (sp?), chimbuzo (sp?), machare *Symphonia globulifera)*, jigua *(Nectandra sp.)*, mascare *(Hieronyma* sp.), chimbuya *(Vochysia sp.)*, piaunde (sp?), chachajo (sp?), tainde (sp?), genene (sp?) and numerous palms.

This forest is made up of three strata of woody plants. The topmost or emergent stratum is a discontinuous canopy of large trees usually with umbrella shaped crowns reaching a height of 130 feet and spreading as much as 120 feet in diameter. Sande and tulapuerta are prominent trees in this category.

The middle stratum is a continuous and closed canopy of mixed composition between the 60- and 100-foot level. Crowns are usually irregular in shape. The lower stratum is irregular and discontinuous. Various types of palms are conspicuous in this stratum. The ground cover is sparse. Epiphytes and vines are common to abundant in the upper stratum. The botanical work required for an adequate description of this vegetation remains to be done.

From the standpoint of timber volumes, this is the best mixed tropical forest seen by the writer in tropical America. Volumes averaged 10,000 board feet per acre in the areas

5/ A. Dugand, Instituto de Ciencias Naturales, Univ. Nac. de Colombia.

6/ A. C. Smith "A new species, same as Little (8) 6300, 6315 (US) from Esmeraldas, Ecuador. Held hoping to receive adequate collections to permit description of the species. This specimen has good pistillate flowers, but waiting to see if a good staminate collection will be discovered." 1955 correspondence.

7/ A. C. Smith "Apparently no species in Stafleu's monograph. It may represent a new species." 1955 correspondence.

8/ A. Dugand Inst. de Cien. Nat., Univ. Nac. de Col. 1955 correspondence.

Figure 3. - Aerial view of "guandal". On the lower left is seen an abandoned rice plot being taken over by woody vegetation. Just above this clearing, felling has been started for a new rice plot, and beyond this is a natural forest of cuangare.

examined, and maximum volumes of 35,000 board feet per acre were observed.

Plant Association Relationships

The various mangrove associations, from the pioneer *Rhizophora* on the tidal flats through the mature *Rhizophora*, *Avicennia*, *Laguncularia*, and *Conocarpus* associations, appear to be transitional, especially in the deltas of the large rivers around the Gulf of Tumaco (Río Patia and Río Mira) where the land is encroaching on the sea. The mature *Rhizophora mangle* forest on the banks of the smaller streams where silting is not taking place is probably an edaphic climax association.

The natal association on stream banks not being built up by silt may also be an edaphic climax association. However, in various places in the delta of the Río Mira where estuary channels were observed to be changing course in guandal swamp, remains of both nato and mangrove could be seen at low water buried in the stream banks. Since neither nato nor mangrove wood float, this would indicate that as the delta area is built up by silt and an accumulation of humus sajo and cuangare take over areas previously supporting nato and mangrove.

Sajal is a transitional association between manglar or natal and fresh-water swamp forest of Cuangare. Bender[9] reports a surprising amount of cuangare reproduction in sajal.

Guandal, fresh-water swamp forest, is apparently an edaphic climax association.

The mixed upland tropical forest is climatic climax vegetation in the tropical moist forest formation. Distinct plant associations may develop in this formation, but they apparently have not been studied or described in this area. See map Figure 5.

The observations on which this article is based were confined to the Tumaco area. However, an examination of the literature cited in the bibliography and a rapid aerial view of the forest of the coastal region between Tumaco and Buenaventura suggests that the forest types described extend over a considerable area of the Pacific Coast of Colombia and Ecuador.

Economic Importance of Forest Lands

Vegetable ivory from the Tagua palm was an important product from these coastal forests during the first two decades of this century. More recently bark from red mangrove has been stripped in considerable volume and shipped to a tannin extraction plant at Buenaventura.

No use of commercial importance has been made of the mangrove wood in the Tumaco area even though it is suitable for a good grade of charcoal. Nato has been shipped to Perú and other South American countries as railroad ties. Trial shipments of sajo have been made to a paper plant in Cali to determine the possibilities of making paper of this wood. The results of this work are not known.

Cuangare because of its mode of occurrence and size is attracting considerable attention in the local and export lumber trade. It has been found suitable for plywood core stock, utility grade face veneers, shop and construction lumber. The wood is being promoted under the name Virola which has become established for a similar wood from the closely related genus *Virola.*

In the delta and lower drainage area of the Río Mira considerable areas of guandal on recent alluvial soils have been cleared for pasture and banana plantations. On some of the other streams farmers have cleared small patches for rice plantings. Agriculture in these areas, based on limited observations, seems to have been only moderately successful. One or two crops of rice are all that can be planted with present primitive methods because of apparent soil deterioration from the rapid loss of organic matter and the difficulty of controlling the mass of secondary vegetation that soon develops. In one area where a few trees of cuangare were left standing, reproduction of this tree was observed coming up in the mass of secondary herbaceous and woody vegetation. Due to the limited time spent in the region no detailed studies of cuangare reproduction were possible.

Where this forest is exploited for the timber, small barges equipped with double drum winches and cables are brought in. These are used to drag the logs from the forest, and numerous drainage canals running from the interior of the guandal to the stream bank result where the logs are dragged out.

Because of the uniform size of the trees in this forest, cutting results in almost complete removal of the forest cover. Figure 4. No observations have yet been made to determine what effect this opening up of the canopy coupled with improved drainage due to the logging operations will have on the vegetation that develops. Studies need to be

9/ W. L. Bender Op. Cit.

undertaken to determine how cuangare stands can be regenerated in areas logged, since this tree seems to offer the best permanent use of the site.

Comparing fresh-water swamp forest of the Tumaco area with similar forests in other sections of Colombia and Panamá, it appears that cuangare may make a better use of the site than do swamp species in other areas. Cativo *(Prioria copaifera)* for example, growing in the swamp forests of the Río Atrato, Colombia and in various river drainages of Darien, Panamá, reaches commercial size only on land just above the normal water level, such as the natural levees on the river banks (7). In the shallow lagoons behind these levees cativo trees are small and scattered.

Figure 4. - Double drum winch mounted on barge in the "guandal", used to drag cuangare logs from the guandal to stream banks.

Colombia has extensive areas of fresh-water swamp in the Río Atrato and Río Magdalena drainages that are now producing nothing of value, but might support forests of cuangare; experimentation on a small scale to determine the facts would be worth while.

The forest industries of the area are becoming interested in some of the upland trees, such as sande, tangare, chalviandi, and tulapuerta. If the forest industries prosper in this area forest management problems may receive some attention. Preoccupation is being expressed because of the areas of upland forest cleared by small farmers, especially in the drainage of the Río Chaguí, for plantain plantations to supply other areas along the coast. These plantings continue in production for 5 or 6 years and then are abandoned because of diminishing yields caused by soil deterioration. A new area of high forest is felled and the old one left to grow up to secondary vegetation.

Natural reproduction of cedar *(Cedrela* sp.) was noted in abandoned clearings on upland sites in several places, and several small cedar plantations were seen along the Ferrocarril de Nariño that appeared to be progressing satisfactorily. However, no information was available regarding date of establishment and treatment. Mahogany *(Swietenia macrophylla)* seed were obtained from Panamá during the time of this survey. These were started in bamboo pots and planted in 1954 in an experimental area on the Río Chaguí and are growing well according to a recent communication[10].

10/ W. L. Bender Op. Cit.

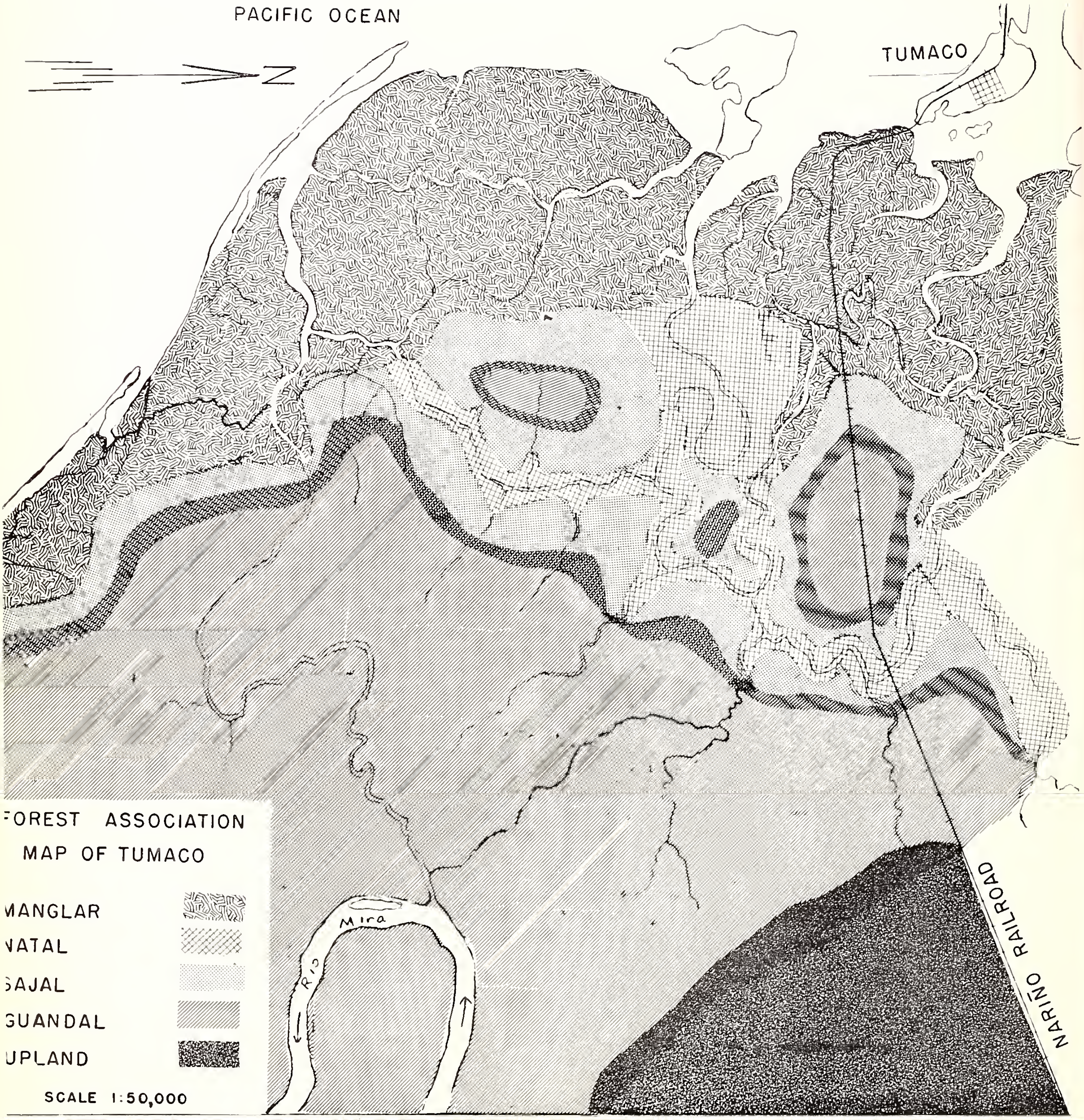


Figure 5. - Type Map.

Summary

The developing interest of the lumber industry in the forest of the Pacific coast of Colombia has brought about a need for better knowledge of the forests of this region. A reconnaissance timber survey in the Tumaco area made possible the observations recorded here.

Extensive swamp forests have developed in the coastal lowlands as a result of flooding by salt, brackish, and fresh water. The forests that develop under these conditions are relatively simple in composition and produce a considerable volume of wood that is drawing commercial interest.

Mature mangrove swamp forest may contain volumes of 20,000 board feet per acre composed of trees as large as 30 inches in diameter 30 to 40 feet to the first limb. Sajo forest may have up to 300 trees to the acre 6 to 18 inches in diameter with a gross volume of 2450 cubic feet per acre.

Cuangare forest produces as much as 25,000 board feet per acre in trees up to 50 inches in diameter with often 50 feet to clear cylindrical bole. The mixed upland tropical forest is a complex mixture of species with volumes as high as 35,000 per acre.

Planting of valuable timber species as well as the encouragement of natural reproduction will no doubt be part of any future forest management program in the forests of the Tumaco area. However, a great deal of work remains to be done in both wood utilization and forest management before the maximum yield can be obtained from the forest resources of this region on a permanent basis.

BIBLIOGRAPHY

1. Acosta-Solis, M.
1959. **LOS MANGLARES DEL ECUADOR.** Inst. Ecuatoriano de Ciencias Naturales. Contrib. No. 29. 82p.

2. Cuatrecasas, José
1958. **ASPECTOS DE LA VEGETACION NATURAL DE COLOMBIA.** Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales 10(40)221-264.

3. Davis, J. H.
1940. **THE ECOLOGY AND GEOLOGIC ROLE OF MANGROVES IN FLORIDA.** Tortugas Lab. Paper No. 22 Carnegie Inst. of Wash. Pub. 517, p. 303-412.

4. Holdridge, L. R. and Teesdale, L. V., Myer, J. E., Little, E. L. Jr., Horn, E. F., Marrero, J.
1947. **THE FORESTS OF WESTERN AND CENTRAL ECUADOR.** U. S. Forest Service. 134p.

5. Holdridge, L. R.
1953. **DETERMINATION OF WORLD PLANT FORMATIONS FROM SIMPLE CLIMATIC DATA.** Science. 195(2727): 367-368.

6. Holdridge, L. R. & Budowski, G.
1956. **REPORT OF AN ECOLOGICAL SURVEY OF PANAMA.** Carib. For. 17(3 & 4):92-110.

7. Lamb, F. B.
1953. **THE FORESTS OF DARIEN, PANAMA.** Carib. For. 14(3 & 4):128-135.

8. Little, Elbert L., Jr.
1948. **A COLLECTION OF TREE SPECIMENS FROM WESTERN ECUADOR.** Carib. For. 9:219-288.

9. McLaughlin, J. H. & Simmons, C. S.
1957. **EL CACAO EN COLOMBIA.** International Cooperation Administration.

10. Richards, P. W.
1952. **THE TROPICAL RAIN FOREST.** Cambridge Univ. Press 450 p.

11. West, R. C.
1956. **MANGROVE SWAMPS OF THE PACIFIC COAST OF COLOMBIA.** Assoc. American Geographers. 64(1):89-121.

12. West R. C.
1957. **THE PACIFIC LOWLANDS OF COLOMBIA.** Soc. Sci. Ser. No. 8, Lousiana State Univ. Press. Baton Rouge 278 p.

Subject Index to Volumes 11 to 20 of the Caribbean Forester
December 1949 – December 1959

Author Index to Volumes 11 to 20 of the Caribbean Forester

December 1949 – December 1959

double-spaced typewritten pages, although an occasional longer article of special interest may be acceptable. Articles should be submitted in the author's native tongue, and should include title or position of the author as well as a brief summary of the material. Manuscripts should be typewritten, double spaced, on one side of the page only, on 8½ x 11 inch white bond paper.

Tables should be numbered consecutively, each on a separate sheet with a title. Footnotes used in tables should be typewritten as part of the table and designated by numerals.

Illustrations should be designated as figures and numbered consecutively. Captions for each illustration should be submitted on a separate sheet. Photographs submitted for illustrations should be clear, sharp, and on glossy paper, preferably 5 x 7 or 8 x 10 inches in size.

Footnotes should be numbered consecutively, with a superior figure placed after the word in the text to which the footnote refers. The footnote should appear in the text in the line following the reference number, separated from the text by a short line running inward from the left margin of the text. Footnotes are used to give credit to unpublished material and communications. If only a few references to literature are made, literature citations may be placed in footnotes. Literature citations should include the author, year published, title of the work cited, name of publication, and pages.

Manuscripts should be sent to the Leader, Tropical Forest Research Center, Río Piedras, Puerto Rico.

Opinions expressed in this journal are not necessarily those of the Forest Service. Articles published in the Caribbean Forester may be reproduced, provided reference is made to the original source.

Le "Caribbean Forester" est une revue semi-annuelle qui a été publiée depuis l'année 1938 en Puerto Rico por le Centre Tropique de Recherche Forestier, Service Forestier du Départment de l'Agriculture des Etats-Unis. Cette revue est dediée a l'aménagement et a l'utilisation des forests surtout dans la region caraibe.

Par les pages de cette revue les personnes qui travaillent aux tropiques peuvent etre informées sur les problemes specifiques des forets tropicales et sur les travaux effectués pour realiser une ameilloration technique par l'aménagement et l'usage des resources forestiéres. Cette revue pourvoit aussi un moyen de destribuer l'information et les resultats obtenus par le programme experemental du Centre Tropique de Recherche Forestier de Puerto Rico; en plus cette revue offre ses pages a les autres travailleurs forestiers des pays tropicaux pour qu'ils purssent publier les resultats de leur travaux.

Cette revue accepte volontiers des contributions ne depassant pas 20 pages dactilografiées a double espace, cependant que certains travaux du intéret spécial plus long purvent etre acceptés. Les contributions doivent etre ecrites dans la langue maternelle de l'auteur et doivent bien preciser son titre et sa position professionnelle, l'appert doct etre accompagné d'un résumé de l'étude. Les manuscripts doivent etre dactilografiées en double espace su du paper 8½ por 11 pouces.

Les tables du travail doivent etre numerotées en ordre sur page separée et les notes au pied de ces tables doivent etre dactilografiées, comme une partie du table.

Les illustrations doivent etre designées avec des numeros consecutifs. Les titres de chaque illustration doivent etre sumis sur une page separée Les photographies comme les illustrations doivent etre bien claires, bien definies et sur papier glacé preferablement 5 x 7 pouces au 8 por 10.

Les notes au bas de la page doivent etre numerotées apíes le mot qui fait reference a la note. La note au pied devra aparaitre dans le texte sous la ligne qui suit le numero de reference, separée de texte par une ligne courte couront de gauche a driole de la marge du papier. Les notes au pied sont usées pour faire honneur aux travaux qué nónt pas été publiés. Si on fait seulement quelques-unes reference quá la litterature pauvent designée les comme notes au pied. Citation au litterature publiée doivent comprendu, l'auteur, l'année publiée, le titre du travail, le nom de la revue et les pages de cette revue.

Les manuscripts doivent etre evnooyés a: "Leader, Tropical Forest Research Center, Río Piedras, Puerto Rico."

Nous voulons rappeller a nos lecteurs que les opinions expumées dans cette revue ne sont pas necessairement les opinions du Forest Service et que les articles publiés dans la revue le "Caribbean Forester" peuvent etre reproduits mais doivent jaire reference a cette revue.


UNITED STATES
ATLANTIC OCEAN
GULF OF MEXICO
MEXICO
BAHAMA ISLANDS
CUBA
PUERTO RICO
JAMAICA
HAITI
DOMINICAN REPUBLIC
GUADELOUPE
DOMINICA
MARTINIQUE
STA. LUCIA
BRITISH HONDURAS
CARIBBEAN SEA
HONDURAS
TRINIDAD
GUATEMALA
SALVADOR
NICARAGUA
PACIFIC OCEAN
COSTA RICA
PANAMA
VENEZUELA
BR. GUIANA
COLOMBIA