Caribbean Forester

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Caribbean Forester

El Caribbean Forester es una revista técnica semestral gratuita publicada en Puerto Rico desde el año 1938 por el Instituto de Dasonomía Tropical del Servicio Forestal del Departamento de Agricultura de los Estados Unidos. Esta publicación está dedicada al progreso de la mejor ordenación y utilización de los recursos forestales del trópico, con especial enfoque en 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 conseguir la ordenación y utilización de los recursos forestales tropicales. También provee informativo sobre los resultados y el progreso de los programas experimentales e investigación forestal tropical que se llevan a cabo en el Instituto de Dasonomía Tropical en Puerto Rico. Además [illegible] una oportunidad a otras personas interesadas en la dasonomía tropical para publicar el resultado de su trabajo.

Se solicitan aportaciones de otras fuentes en el campo de la dasonomía tropical y ciencias afines que no estén consideradas para publicación en otras revistas. El manuscrito generalmente no debe exceder 20 páginas escritas a maquinilla a doble espacio, aunque ocasionalmente podría aceptarse un artículo más largo si éste 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 maquinilla 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 de las tablas deben escribirse inmediatamente debajo de la tabla y designarse por medio de números.

Las ilustraciones deben designarse como figuras y numerarse consecutivamente. Los títulos para cada ilustración deben escribirse en una página separada. [illegible] bien definidas en papel [illegible] preferiblemente de por 7 a 8 por 10 pulgadas [illegible].

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[illegible] al Director del Instituto de Dasonomía Tropical, Río Piedras, Puerto Rico.

Las opiniones expresadas en esta revista no [illegible] 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 Institute of Tropical Forestry, 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 [illegible] of information on the progress and results of the experimental programs [illegible] Institute of Tropical Forestry [illegible] and 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)

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On August 1, 1961 the title INSTITUTE OF TROPICAL FORESTRY replaced the older designation of Tropical Forest Research Center for the United States Forest Service unit in Río Piedras, Puerto Rico. The title of the officer in charge was changed at the same time from Center Leader to DIRECTOR.

These changes were made in order to reflect more accurately the type and scope of activities carried on at the Institute. In addition to research in Forest Management and Forest Utilization, programs are active in National Forest Administration, in State and Private Forestry, and in international cooperative work, including training participants from throughout the Tropics.

All future communications should be addressed to:

Director
Institute of Tropical Forestry
Box 577
Río Piedras, Puerto Rico

Except for the 1960 Annual Report, the articles in this issue of the CARIBBEAN FORESTER are papers presented at the Fifth World Forestry Congress. It is hoped that publication here will advance tropical forestry by presenting this information to many foresters who may be unable to obtain copies of the Congress Proceedings.

N O T A S

El 1 de agosto de 1961 se cambió el nombre del Centro Tropical de Investigaciones Forestales, unidad del Servicio Forestal de los Estados Unidos en Río Piedras, Puerto Rico a INSTITUTO DE DASONOMIA TROPICAL. Al mismo tiempo se substituyó el título del Líder del Centro por el de DIRECTOR.

Estos cambios se efectuaron con el fin de reflejar con más exactitud la clase y alcance de las actividades llevadas a cabo por el Instituto. Además de las investigaciones en Ordenación Forestal y Utilización Forestal hay programas activos en Administración de Bosques Nacionales, Dasonomía Estatal y Privada, y en trabajo cooperativo internacional incluyendo el adiestramiento de participantes de los Trópicos.

De ahora en adelante toda comunicación deberá dirigirse a:

Director
Instituto de Dasonomía Tropical
Apartado 577
Río Piedras, Puerto Rico

Todos los artículos, con excepción del Informe Anual del 1960, publicados en esta edición, fueron trabajos presentados en el Quinto Congreso Mundial de Dasonomía. Es nuestro deseo al publicarlos en esta revista promover la dasonomía tropical haciendo llegar esta información hasta muchos dasónomos que no podrán obtener copias de las Actas del Congreso.

1960 Annual Report

Tropical Forest Research Center

A thorough analysis by the Center of forestry needs in Puerto Rico, made at the request of the Governor late in 1959, set the stage for a complete review of the program of the Center relative to these objetives. Thus, in addition to continuation of project work, analyses of problems in three of the most important fields of forestry — timber production, timber utilization, and recreation — were undertaken.

The overall study showed the potentialities of forestry in Puerto Rico to be greater than has been generally recognized. About half of the value of Puerto Rico's forest products requirements estimated for the year 2000, some $62,000,000, could be produced locally on land unsuited to other crops. The employment value of this timber crop would be $20,000,000 annually. The chief potential products, hardwoods, lumber and veneer, pulpwood, piling and poles, and softwood lumber, will require the development of commercial primary processing, an activity almost nonexistent here today. Properly developed forest recreation would be worth at least $350,000 annually to the Commonwealth today, and the demand is rising rapidly.

In the field of timber production the crying need continues to be for the development, for extensive deforested areas, of timber crops which present a sufficiently attractive economic prospect to interest landowners in making the investments necessary for their establishment and production. This has been the main problem toward which the Center's efforts have been directed since its establishment.

Early studies showed a number of conditions that affect the prospects for timber production. Trees of some sort can be grown almost anywhere in Puerto Rico. High-quality timber species, including many exotics, are adapted to the local environment, but production of these appears possible on only the best of the lands unsuited for other crops. The need to make the growing of timber economically more attractive has led to concentration on the more rapid growing tree species. It now appears clear that short rotation, simplicity of establishment and management, and uniformity of product will be as important to the local success of timber production as will be the quality of the final product. Promising experiments are under way on several sites and with several crops and techniques. If successful they should show how to make the most of these advantages.

The fact that, in the face of the dense population and heavy demand for timber, at least 400,000 acres of land in Puerto Rico, are now covered by trees suggests a ready source of timber products which should be used to the utmost and developed on a basis of sustained yield. In terms of early timber yields these existing forests would appear to present a more attractive prospect than the deforested areas where trees must first be established.

These remaining forests are much less an immediate source of timber than their extent might suggest. Included are brushy stands on extremely adverse sites where it is doubtful if timber can ever be produced economically; remote, steep areas where extraction of timber is costly if not impractical; abandoned coffee plantations, where trees are chiefly of spreading form and not of select timber species; and stands which have been heavily culled and contain few large, well formed trees of high quality species. Thus in most

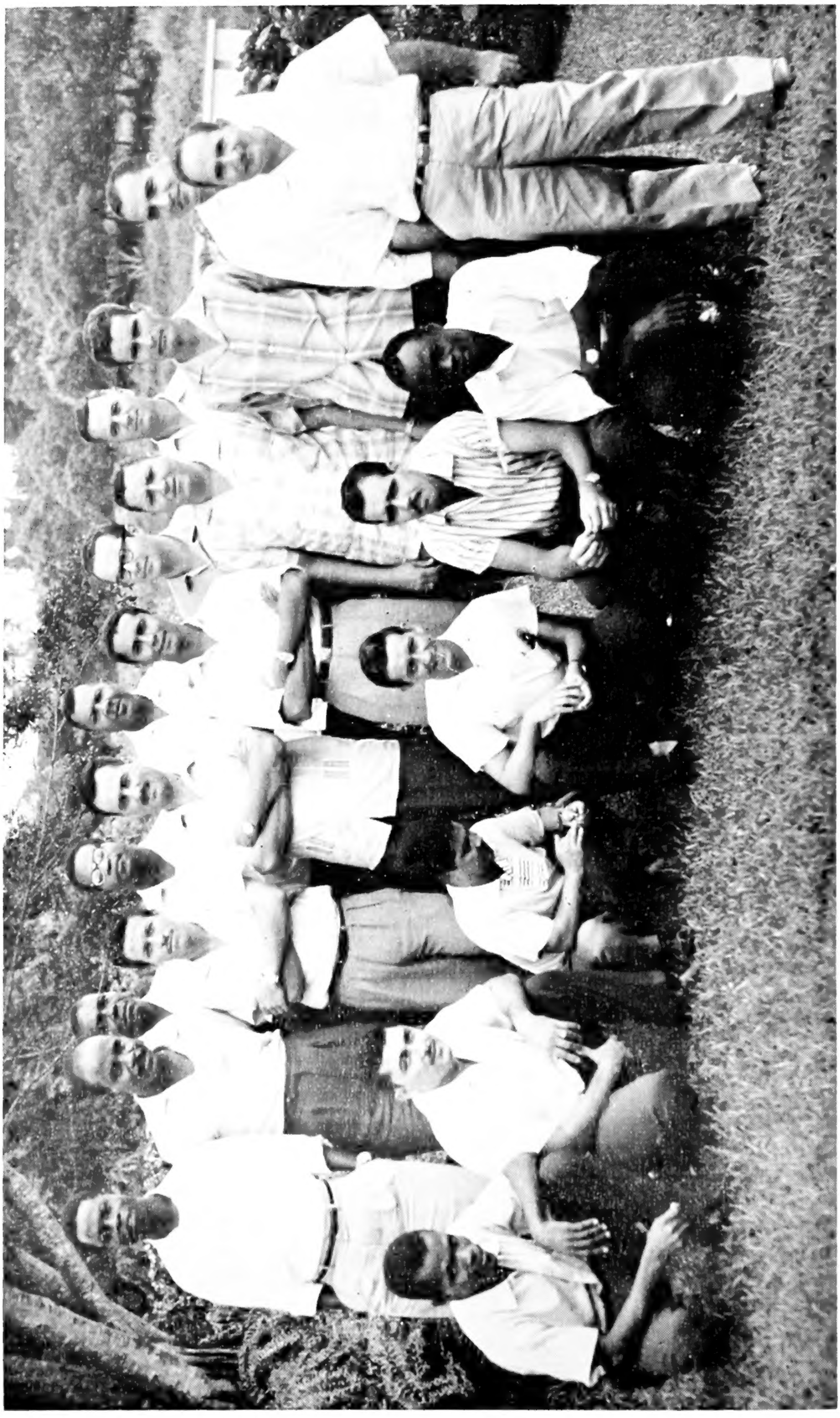

Figure 1. Participants in 1960 Tropical Forestry Short Course. Standing, left to right: T. W. Giple, M. Verdier, G. E. Israel, J. V. Larios, H. C. Flowers, A. A. Fontana, B. U. Leslie, M. T. Mozo, T. L. Venegas, C. Colón Bermúdez, Dr. F. H. Wadsworth, J. Díaz Nieves, A. E. Zambrano, and J. Anglero. Kneeling; A. B. Maduro, C. Pérez Vázquez, D. C. Ortiz, E. G. Neira, C. A. da Silva, and P. B. Toe. Not pictured: A. Duclos and J. K. Fletcher. Countries represented: Brazil, British Honduras, Chile, Colombia, Haiti, Jaamica, Liberia, Nicaragua, Panamá, Puerto Rico and the West Indies Federation.

forest areas the primary management objective, as on deforested lands, must be to bring on a much superior crop of trees while making the most of existing stands as a source of seed or protection for the new crop, and as a source of forest products to be harvested in a manner consistent with future productivity of the land.

Efforts to improve existing forests by elimination of the least promising trees and by introduction of superior species are under way. These practices are generally less spectacular in their effects than is reforestation, and their early rewards may be only slightly more attractive economically, since many of the trees which must be eliminated are of little or no commercial value. In fact, these forests, as an environment for regeneration of better stands, may prove to be little if any superior to that of deforested areas, where control of tree quality and spacing by artificial methods may prove more simple, and early productivity may prove correspondingly higher.

The great disparity between the condition of most existing forests and that which is needed for high timber productivity does not in any way detract from the desirability of making the most of the trees they now contain. With some 500 tree species native to these forests, but with current use of these trees almost entirely limited to posts and poles which are not even treated with preservative, a great potential in use development is apparent.

Investigations already completed at the Center have provided guides for the selection of species for reforestation or to be favored in existing stands. They have shown the machinability of 70 native woods, including all tree species which commonly grow to sawtimber dimensions. They have shown the suitability of an equal number of common post species for nonpressure preservative treatment. These investigations have had a clearly beneficial effect on tree planting policies and have resulted in the establishment of commercial building board and nonpressure preservative treatment plants.

The lag in the application of new information resulting from research has become more serious as research progress has accelerated in recent years. Tree planting on private lands is progressing at a rate so slow that it will take 160 years to cover the land now recognized as critically in need of reforestation. Less than 1 percent of the 11,000,000 fence posts used each year are subjected to preservative treatment, and the volume of lumber produced from existing forests averages about one board foot per acre per year. Lumber production is now probably at the lowest level it has been at any time in the past century, and this in the face of rapid expansion in other fields of industrial activity.

The need to encourage application of research results has involved the Center in an increasing number of activities directed toward this end. These include the following:

1. Financial assistance to the Commonwealth government for the production and free distribution of forest planting stock.

2. Financial assistance to the Commonwealth government for technical forestry assistance to landowners and primary processors of forest products.

3. Tehnical guidance in the use of incentive payments for forest planting or improvement as a part of the Agricultural Conservation Program.

4. Demonstration of multiple-use public forest administration in the 27,000 acre Luquillo Experimental Forest and sharing of findings with the Commonwealth Division of Forests.

5. Improvement of some 7,000 acres of secondary forest on a pilot scale in the Luquillo Forest.

6. Demonstration plantings of promising

tree species in various farm areas needing reforestation.

7. Demonstration of nonpressure preservative treatment, logging, sawmilling, and kiln drying in pilot plants established by the Center.

8. Technical assistance to primary and secondary processors of forest products concerning raw materials, seasoning, processing, and finishing.

9. Direction for the Virgin Islands Corporation of a program there including the production and distribution of tree planting stock and technical assistance in planting, plantation maintenance, forest improvement, harvesting, milling, and preservative treatment.

Future emphasis in the program of the Center is expected to be concentrated on the following activities:

1. Continued search for highly productive, short-rotation forest crops, including genetic improvement and fertilizing of the better species already found promising.

2. Development of less expensive and more effective techniques for forest improvement.

3. Collection of up-to-date information on prospective costs and returns to landowners from different forestry practices.

4. More complete demonstration of the advantages of using local woods, through development of simple logging techniques, proper seasoning, processing, and the preparation of samples of a number of marketable products, giving special emphasis to those woods most likely to be produced in future forests and plantations.

5. Accelerated development of the Luquillo Experimental Forest for its growing recreational values, consistent with research needs.

The highlights of the accomplishments of the Center during 1960 follow:

FOREST MANAGEMENT RESEARCH

At the beginning of the year 143 studies were active in this field. Three of these were closed during the year, two new studies were begun, and a number of old studies were combined, leaving the total number of active studies at the end of the year at 135.

Dendrology

The semi-popular book "Arboles Comunes de Puerto Rico e Islas Vírgenes", describing some 260 local tree species, is in press. Low-altitude aerial reconnaissance with the assistance of the U. S. Navy, using helicopters, was begun to locate, among some 220 areas of vegetation which appear on aerial photographs to be little disturbed, those which warrant an ecological survey on the ground.

Phenology

Weekly measurements of rainfall, temperature, and humidity, and the growth in circumference of ten trees nearby have been continued at four locations in the Luquillo Experimental Forest. The rainfall pattern during the 1960 dry season differed from that in 1959 and has tended to confirm the early impression that growth is correlated with rainfall, with the exception of deciduous species during their leafless period.

Variation and Selection

Results obtained from germinating seed of known parentage have indicated very strongly that intermediate-leaf seedlings from a bigleaf *(Swietenia macrophylla)* mahogany or small-leaf *(S. mahagoni)* parent are in fact interspecific hybrids. This intermediate form continues to show a number of attributes superior to the typical species.

Site Improvement

A study was begun to determine the effect of applying chemical fertilizers in established teak plantations. Eighteen different combinations of fertilization were tested on 16 plots at 8 different locations. Six months after the initial application, average diameter growth in all fertilized plots exceeded that of the controls, the greatest by about 60 percent.

Nursery Practice

The most successful innovation in nursery practice during the year was the use of sphagnum moss as a medium for potting pine seedlings in the nursery. Growth of seedlings potted in sphagnum moss exceeded the growth of those potted in clay, fertilized clay, or a mixture of sandy loam and vermiculite. In addition, because of compressibility of the sphagnum moss and its lighter weight as compared with soil, the cost of field labor for transporting the seedlings from the truck to the actual planting location was cut by more than one-half.

Species Adaptability

Previous reports have called attention to the need for highly productive tree species for the various extensive sites in Puerto Rico where forests are needed but have been eliminated. Efforts during th past year were concentrated on four of these sites.

Deep Sandy Loam Soils

In 1959 Honduras pine *(Pinus hondurensis* Loock) and Cuban pine *(Pinus caribaea* Morelet) were planted at eight locations in the sandy loams. Planted with them were some promising hardwoods: tulipán (*Spathodea campanulata* Beauv.), American sycamore *(Platanus occidentalis* L.), yagrumo hembra *(Cecropia peltata* L.), and eucalyptus *(Eucalyptus patentinervis* R. T. Baker). In 1960 additional plantings of Honduras pine were made at the same locations and Antilles pine *(Pinus occidentalis* Sw.), Masson pine *(P. massoniana* Lambert), casuarina *(C. equisetifolia* L.), African mahogany *(Khaya nyasica* [E. G. Baker] Stapf), Mexican cypress (*Cupressus lusitanica* Mill.), teak *(Tectona grandis* L.), guanacaste *(Enterolobium cyclocarpum* [Jacq.] Gris.), saman *(Pithecellobium saman* [Jacq.] Benth.), and mahoe *(Hibiscus elatus* Sw.) were added to the species under trial on this site.

Of the six species planted in 1959 the Honduras pine has proven clearly superior except on very moist sites, where the hardwoods, especially eucalyptus and tulipán, have outgrown the pine. Results are not yet evident from the 1960 plantings.

Shallow Clay Loam Soils

Of 10 tree species established experimentally on this site in 1958 and 1959, tulipán, with 70 percent, continues to have the highest survival percentage. Honduras pine also averages 70 percent survival but is one year younger. The fastest average growth is that of yagrumo hembra, but this is primarily a reflection of the growth at one exceptionally well-watered location where the trees at age 30 months averaged 21 feet in height. Mexican cypress is quite vigorous but is susceptible to windthrow at all locations. Neither casuarina nor eucalyptus have done as well as anticipated on these adverse sites.

During 1960 one additional location was planted with 13 additional species. Of these cadam *(Anthocephalus cadamba* Miq.) is by far the most promising. African mahogany and plumajillo *(Schizolobium parahybum* [Vell.] Blake) from Guatemala are also off to a good start.

Humid Limestone Soils

New plantings of mahoe, teak, cadam, paricá *(Schizolobium parahybum* from Brazil), African mahogany, guanacaste, Honduras pine, bigleaf mahogany *(Swietenia macrophylla* King), small-leaf mahogany *(S. mahagoni* Jacq.), Pacific mahogany *(S. humilis* Succh.), St. Croix roble (vigorous-appearing strain of *Tabebuia heterophylla* [D. C.] Britton), South Florida slash pine *(Pinus elliottii densa* Little and Dorman), and Cuban pine were established in the humid limestone regions. No results are apparent as yet.

Mountain Clay Soils

Three new plantings were established in 1960 on the deep clays of the mountains. Of 21 species planted, the most promising so far is cadam.

Growth of Trees and Stands

Growth records for approximately 4,000 trees were prepared for punch-card analysis. Preliminary computations were completed for approximately 22,000 trees but detailed analyses were held up pending the completion of punching and preliminary computations for all available growth measurements.

New growth plots were made in established plantations of cedro macho *(Hyeronima clusioides* [Tul.] Muell.), mahoe, guanacaste, and kauri *(Agathis australis* Salisb.)

Routine measurements were made of a number of studies. Capá prieto *(Cordia alliodora* [Ruiz and Pav.] Oken.), averaging 4.7 inches d. b. h. in the eastern mountains on deep clay at 600 feet elevation with 120 inches of rainfall, is currently growing in cross-sectional area at slightly more than 8 percent per year.

Roble averaging 5.1 inches d. b. h., planted nearby on a severely eroded pasture in 1948 is currently growing 8.5 percent in basal area per year.

Mahoe, averaging 5.7 inches d. b. h., grew 9.4 percent per year in basal area in the moist limestone areas near sea level with 60 inches of precipitations, and on a well watered site in the Central Mountains trees averaging 6.9 inches d. b. h. made basal area growth of 15.9 percent.

Primavera *(Cybistax donnell-smithii* [Rose] Seibert) showed a similar pattern. In the moist limestone hills trees averaging 3.1 inches d. b. h. made 12.1 percent per year basal area growth, yet in the humid eastern mountains trees averaging 11.9 inches d. b. h. made basal area growth of 16.1 percent.

Chemical Arboricides

Application of the soil sterilant Fenuron (3-phenyl-1, 1-dimethlurea) in the eastern mountains at the rate recommended by the manufacturer was completely unsuccessful in eliminating undesirable trees. This chemical has proven elsewhere to be less efficient in areas of high temperature and high rainfall, both of which apply to the test area. Future studies are planned with varying rates of application to see whether this disadvantage can be overcome.

Pomarrosa *(Eugenia jambos* L.), which has been very resistant to the standard appiication of 2 percent 2,4,5-T in frills, died promptly when treated with a 20 percent solution.

Pilot Management

The pilot management project in the Luquillo Experimental Forest, involving the improvement of 6,734 acres of secondary rain forest, continued in 1960, the fifth year of the first cutting cycle. By the beginning of the year 5,079 acres had been subjected to improvement cuttings through timber sales or poisoning of undesirable trees. About 230 additional acres were treated during the year, leaving about 1,400 acres to be treated. Most of this untreated area is land being acquired by exchange but not yet legally a part of the forest. The rest is accessible for harvesting commercially, but purchasers have not yet been found.

Of the area treated, 193 acres were improved through timber sales and 40 acres by Forest Service crews. Sales during the year removed 35,547 board feet of timber, with a stumpage value of $1,118.17, plus $940.04 worth of nonconvertible products.

Progress was made in the planting up of the few remaining clearings formerly farmed within the forest. A total of 43 acres were planted, and 48 acres of existing plantations received routine maintenance. A reinventory and mapping of all plantations within the area, completed during the year, showed a total of 676 acres.

The closing in 1951 of the only sawmill serving the Luquillo Forest, delays in planned road construction largely due to unexpectedly high costs, and the unanticipated delay in acquiring some 1,500 acres of land through exchange have made it impossible to meet the level of forest utilization contemplated in the first cycle of this pilot management project. Nevertheless extensive sampling in the areas subjected to improvement cuttings has shown that the treatment has greatly simplified and improved the composition of the forest. The benefits from this treatment will stand on their own merits. In degraded young stands such as these no such treatment would produce much immediate yield, whatever the accessibility and markets. With the poorest trees now removed from the treated stands, better yields can be anticipated from further improvement work.

Forest Plantations in Latin America

The collection of descriptive information regarding promising forest plantations in Latin America, begun in 1959, was intensified in 1960. Studies were made by members of the staff in México, Guatemala, British Honduras, Honduras, Costa Rica, Panamá, Colombia, Ecuador, Jamaica, Martinique, St. Lucía, Trinidad, British Guiana, Surinam, and Brazil. A second report of the Planting Section of the Regional Committee on Forest Research of the Latin American Forestry Commission of FAO was completed in both English and Spanish including descriptions of 257 plantations. It is proposed to study additional plantations in southern South America during the coming year.

FOREST UTILIZATION RESEARCH

Preservative treatment of fence posts continued to be the most important forest utilization research project during 1960. Large-scale experiments already under way were maintained and efforts were made to put new knowledge to use. Also important have been tests of new uses for local woods.

Preservation of Fence Posts

A study of preservative treatment of some 74 species of fence posts, begun in 1958 and 1959, has been continued to determine the gain in service life attributable to treatment. Most of the untreated posts were no longer serviceable 15 months after setting. Similar posts, treated by cold soaking or by the hot-and-cold bath method with either 5 percent pentachlorophenol in diesel oil or a 50-50 solution of creosote and diesel oil had shown no deterioration during the same period. Decay was responsible for most of the deterioration of the untreated posts, although termites contributed to some failures. These are thus already showing the prospects for land-owners in reduced post replacement costs as a result of preservative treatment.

Tests of the double-diffusion technique for fence post treatment were continued. The advantages of this method, in using freshly cut material, without pre-drying, have now led to its commercial application in Florida. Posts of 30 species from the 1960 study were set for determination of their service life. No deterioration has been found as yet.

Chemical analyses to determine penetration and retention have not yet been made.

The satisfactory penetration and retention of preservative in many local species of fence posts, using the hot-and-cold bath method, has led to efforts toward the establishment of commercial facilities for such treatment. With current annual consumption estimated at 11,000,000 posts and with an apparently assured market for 1,000,000 treated posts per year, the operation of several local treating plants appears feasible. Four rural fence-post treatment demonstrations held by the Center cooperatively with the Extension Service during 1960 showed clearly that there is much consumer-interest in treated posts. A series of demonstration fences on private farms is being established by the Center in various parts of the Island. A prospectus for the development of industrial treating facilities was prepared and sent to various interested concerns, including the Economic Development Administration of the Commonwealth. One small commercial plant has now been installed and is ready for operation as a result of information released by the Center.

The Center has frequently been asked for an opinion on the rural belief as to the significance of time of cutting upon wood durability. Analysis of a study of some 2,700 fence posts, set in 1952 after cutting at various times in relation to the moon phase, season, tide, and weather, showed that all posts deteriorated at about the same rate, regardless of cutting time.

Use-Conversion

The demand for forest products continues to rise each year yet this demand is met chiefly from imports. On the basis of imported raw materials a large number of local furniture factories are in operation. Efforts by the Center to strengthen the local furniture and related industries, and to interest them in local raw materials have continued.

The manufacture of Fiberdyne, a locally made wood-fiber and cement building board, has been stimulated further by its use in the construction of low-cost houses. For certain purposes it competes well with other building materials.

Hardwood plywood is one of the more costly items among Puerto Rico's forest products imports, some ten million square feet being imported annually at a cost of about one million dollars. Local interest has recently developed in manufacturing at least a part of this material in Puerto Rico, using if possible local species for core stock. One local species which shows promise is yagrumo hembra, tested at the Forest Products Laboratory in 1960. Excellent particle board was also made experimentally from this wood.

The furniture industry has abandoned the use of local woods because of the more favorable prices and better manufacture of those available on the import market. Puerto Rican woods are not inferior to those imported, but many changes will be required before they can effectively compete with exotic woods. While the supply is being increased by the application of the results of forest management research, efforts will be made to improve the efficiency of harvesting, seasoning, and manufacture of woods now available and to maintain a market receptive to them. To this end several furniture plants were provided during the past year with assistance concerning wood-moisture problems, species selection, machining of wood, and layout of equipment.

A complaint received by a furniture manufacturer as to the poor quality of local plantation-grown bigleaf mahogany, led to preliminary tests of the wood of several trees. A complete study is being planned to relate wood properties to trees of different origins and on different sites. Preliminary tests have shown that wood from trees of intermediate form between bigleaf and small-leaf mahoganies can be of exceptionally high quality.

Since such trees have been found fast growing and well formed, this intermediate mahogany may prove superior to the typical small-leaf species for forest plantations.

The completion of the installation of an experimental kiln at the Center during 1960 will make possible systematic development of schedules for rapid drying of local woods, a major step in increasing their acceptability on the market.

FOREST ADMINISTRATION

The Luquillo Experimental Forest continues as an outstanding multiple-use area under forest management in Puerto Rico. Although its primary use is forest research, it includes many areas of outstanding value for other purposes.

Administration of the forest involves always a number of recurrent tasks, such as boundary maintenance, control of trespass, maintenance of trails and other improvements, the selling of timber, and dealing generally with the public in regard to a number of permitted uses. Nonrecurrent tasks in addition to these in 1960 included the inventory and mapping of all forest plantations, preparation of preliminary data for the remapping of the forest itself, and a survey of recreational resources.

The recreational resources survey, made as a part of the Outdoor Recreation Resources Review, is not yet complete, but suggests that current recreational use of the forest, some 265,000 visits annually and about 60% of all forest recreation use in Puerto Rico, is but the beginning of an expected rapid rise in demand for forest areas for this purpose. It is also apparent that certain additional lands within the Experimental Forest are suited for development as recreational areas.

More than 100 special use permits are operative within the forest, with several new permits issued during the year. These permits are mostly for radio communication facilities, residences, and rights of way. One major road reconstruction project was terminated during the year and another is about to be contracted. One new road is under construction and a second is ready to be contracted.

FORESTRY ASSISTANCE IN PUERTO RICO

The results of research from the Center are a prime source of basic information on forestry for the Commonwealth government and for private forest landowners and processors of forest products. In order to better serve this function, the Center in 1959 began, with the assistance of the Extension Service, a series of Tropical Forestry Notes in both English and Spanish. Four of these were published during the year.

The Center continued direct technical collaboration with the Division of Forests in nursery stock production, tree distribution, survival checks, technical assistance to forest landowners, timber stand improvement operations, plantation management, and recreational area administration. Three members of the personnel of the Division were provided with three months of concentrated forestry training. Technical information was also provided directly to the Forestry Specialist of the Agricultural Extension Service, including joint participation in four field demonstrations.

Contacts with the Puerto Rico Industrial Development Company and with numerous individuals concerned with wood-using industries, existing or proposed, has made the Center a local clearinghouse for technical information on wood utilization.

FORESTRY ASSISTANCE IN THE VIRGIN ISLANDS

The Center continued its direction of a forestry program for the Virgin Islands Corporation, chiefly on the island of St. Croix.

Forest Planting

The chief activity of the forestry program is encouragement of private landowners to introduce mahogany into areas of secondary forest and brush. As a part of this effort nursery stock is produced and distributed without charge, and planting and plantation care on private lands is given technical supervision.

During 1960 previous experience made possible for the first time the successful propagation of 20,000 potted mahogany seedlings, enough to underplant about 100 acres. However, a dry October, normally the best month to plant, precluded full use of this stock. Nevertheless, 105 acres were replanted and 15 acres of new plantings were established. This brings to 152 the total acreage of mahogany plantations established during the six years of the program. An additional 36 acres of teak plantations have resulted from past work under this program.

Weeding of plantations, both those of mahogany under partial shade and those of teak growing in the open, has proved to be much more of a burden than anticipated. As a general rule semi-annual weeding is required for at least three years before the trees are well established. During 1960 one hundred and thirty-two acres of mahogany and 28 acres of teak plantations were weeded.

A study of the comparative development of recently planted trees of four morphological types and three species of mahogany was undertaken. Growth rates to date do not show conclusive contrasts.

Forest Improvement

About 300 acres of dense young natural mahogany forest on St. Croix warrants intensive management and needs improvement cuttings. Most of this forest is in private ownership, but techniques for management are being worked out in the Estate Thomas Research and Demonstration Forest, owned by the Virgin Islands Corporation. The completion of a preservative treating plant for fence posts as a part of the program established for the first time in 1960, a good market for most of the products of forest improvement work. As a result, 29 acres of such stands were liberated from wolf trees and thinned. The yield, both in sawtimber and posts, suggests that adjacent landowners will be interested in improving their mahogany stands as rapidly as the capacity of the program to provide technical supervision will permit.

Sawtimber Utilization

In the absence of other facilities to break down large, valuable logs available in forests and along roadsides in St. Croix, a small sawmill is operated intermittently by the program as a public service. During 1960 about 3,000 board feet of mahogany *(S. mahagoni)* and 1,000 board feet of thibet *Albizzia lebbek* [L.] Benth) were logged and sawn. Although the average size of the logs was only 10 inches d.i.b. at the small end and 7 feet in length, all material, including slabs, found a ready sale. A number of artesans are now using these woods for specialty purposes which bring very high returns per unit of wood volume.

Wood Preservation

An abundance of post-size material in the forests of St. Croix, an apparently assured future for the cattle industry, and a complete lack of experience in wood preservation led to the installation by the program of a small hot-and-cold bath treating plant at the sawmill site. The improvement cuttings already described yielded some 3,000 fence posts during 1960, all of which were treated with 5 percent pentachlorophenol in diesel oil. Retention in the sapwood ranges between 6 and 10 pounds per cubic foot, adequate for good results, and the demand for treated posts is encouraging.

FORESTRY TRAINING

The seventh tropical forestry short course was held during a 12-week period in the fall of 1960. Twenty trainees from eleven countries attended. In addition to this course the Center was host to 12 other foreign forestry trainees. Trainees spent a total of 1,311 man-days at the Center during the year.

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New Methods of Improving Stand Composition In Tropical Forests

by
H. C. DAWKINS
Forest Ecologist, Uganda Protectorate, and
holder of Research Fellowship from the
Nuffield Foundation, 1960-1963

Tropical stand improvement is just about a century old. It began in India seventy-two years ago and appeared as a detailed technique in the first textbook on tropical forestry ever published (Fernández, 1888).

The early efforts were, naturally, attempts to apply European (mostly German) methods to something very different, much hampered by lack of statistical science and chemical weeding which are so essential today. The principal difficulties encountered by European foresters in the tropics are:

(1) great botanical diversity leading to a high proportion of useless species, co-mingling of weeds and desirables within numerous genera and families, all of which confuses sampling (especially aerial), hinders refining and usually prevents integrated utilisation. The demand is generally limited to a very few timber species, thinnings are usually unsaleable, forest policy is therefore often weak and public opinion often hostile.

(2) lack of growth rings except well away from the equator, gross deformities of bole, enormous differences of growth rate, frequent shedding of bark and therefore painted marks, near impossibility of determining heights and of relascope work, all of which together make a nightmare of mensurational control and particularly of repeated inventory.

(3) dearth of operatives with silvicultural discretion and mensurational reliability in any under-developed country, until it has seen a century or so of social evolution and forest education.

(4) difficulty of mechanisation; aerial weed-killer spraying is of little use without intra-generic selectivity; power girdling would commonly be ineffective without poison and for that only very small cuts are required; paint guns are useless on exfoliating bark; trees are often of sizes that make mechanical felling and subsequent clearing quite impracticable.

(5) intrinsic inefficiency of most tropical angiosperms as wood producers, compared to the conifers or eucalypts which these regions usually lack. Diameter increment is sometimes phenomenal, but tree space must be vast to achieve it, making total final stocking low by temperate standards.

Faced with these difficulties the tropical foresters look wistfully but not very hopefully at other recent advances in forestry, such as aerial and relascopic inventory, complete and integrated utilisation, aerial seeding and spraying. Let us admit that we have discovered no new tools or methods of stand improvement since the Fourth Congress at Dehra Dun. The greatest real advances took place in two spurts of activity for a decade after each war, since when there has been plenty of news in the way of management systems, sampling, repeated inventory and stand-structure but no fundamentally new ideas on stand improvement itself.

Improved applications, if not new methods, have occurred in:

- refining
- enrichment
- felling systems
- diagnostic sampling
- dynamic sampling

Tropical Forest Refining

(The term is used in its strict dictionary sense; namely the removal of impurities from a mixture, the impurities being mostly weed-trees, climbers, and shrubs).

Foresters faced with the very mixed natural stands of India and Burma naturally sought to remove the useless species and defective trees, to favour the desirable elements. Thus arose the well-kown *improvement fellings* of Southern Asia, prescribed along with "selection" systems in numerous working plans, and covering very large areas before this century started.

Fellings gave way to girdlings wherever the fuel demand was low, for several reasons including the cheaper kill, lesser damage from falling crowns and more gradual opening thereby achieved. In areas of very high demand it was generally feasible to clear-fell and sell all produce and replace with pure crops —natural or planted— so that refining did not arise.

India paid very little attention to refining of the "wet evergreen" (i. e. tropical rain) forest and it fell principally to Malaya to wrestle with that hellish pair:

(1) the vitality of rain-forest weedtrees which laugh at mere girdling.

(2) the vigour of climbers and shrubs after drastic canopy opening,
as well, of course, as the even worse felling damage caused by the crowns of large rain-forest trees.

Hence the introduction during the twenty years interbellum of arsenical poison-girdling into Malaya, (Sanger-Davies 1919). Queenslanders had been using the method to clear grazing land since the turn of the century, and by the 1930's Malaya came to realise that here lay the essential tool for all systems of rain-forest improvement. Refining, liberation, thinning, all became practicable and by the second World War were proceeding ahead at thousands of hectares per year, and were spreading to other areas of managed forest.

Some objections however remained; arsenic's dangerous toxicity, the near-impossibility of frilling certain Ficus species and other multiple or grossly fluted undesirables, immunity to arsenic of certain legumes and Annonaceae especially in Africa. Hence research into hormonal arboricides (2,4,5-T and 2,4-D) by Uganda, where the above objections are particularly cogent.

The hormonal arboricides (weedkillers if you like, but *not* "silvicides" which is literally incorrect and forest-morally objectionable) may be poured into frills like sodium arsenite but are often lethal when sprayed as esters in diesel solution onto uncut bark, hence the term "contact arboricides." It is the latter type of application which has proved most valuable.

Objections still remain (Dawkins, 1957). Both solvent and solute are more expensive than sodium arsenite, and so are sprayers more expensive and more difficult to maintain than spout cans. Also, thick bark may defeat the penetrant and some species are physiologically resistant. Therefore, even in localities where hormonal arboricides are favoured, methods could still be greatly improved by phytotoxins of greater penetrating power or lesser cost.

Tree-weeds are not the most difficult. Far more baffling have been the dense blankets of climbers, often thorny, stinging or otherwise obnoxious, which arise after heavy felling or violent refining or liberation. The dilemma is whether to:

(1) slash or otherwise tend frequently in the hope of liberating regeneration, or

(2) leave alone in the hope that sufficient desirables will eventually get through.

Malaya first discovered that crops inadvertently treated to (2) and neglected for six years or more produced remarkably healthy young trees in spite of thicket and climbers, which appeared to be a passing phase suffering eventual defeat by trees and taller shrubs. Later Nigeria using method (1) found repeated slashing not only impossibly expensive but definitely rejuvenating to the climber-tangle. Tendings were therefore progressively reduced and now converge with Malayan ideas (Barnard, 1955).

Thus has arisen one great advance of the last decade, the realisation that climber-tangle is frequently a temporary horror and is commonly defeated within three to seven years by trees or shrubs or both. The resulting thicket becomes increasingly susceptible to climber-cutting and tree refining because some degree of tree-and-shrub canopy develops and severed climbers cannot regain full vigour under it. Limited areas still exist, particularly in West Africa and North Borneo, where climber-tangle still reigns supreme. It is significant that in such areas repeated slashing is now in disfavour on the grounds that it makes matters worse, and attention is now directed to prevention of origin and spread rather than belated cure. It has also been pointed out, optimistically perhaps, that climbers generally fruit in the canopy and therefore sufficient attention to forest refining over the years should eventually deprive the climbers of their seedfall. Perhaps that will be the next significant advance in the Tropical High Forest, because the liane kingdom is undoubtedly its greatest drawback at the present day.

Enrichment

Refining is applicable only to a mixture already containing adequate desirable ingredients. Where these are lacking in an environment that yet appears suitable, it is often possible to enrich the community by inducing more regeneration or by sowing or planting, sufficient eventually to take over the site but probably inadequate to dominate at the start. It is still considered good silviculture to try the former first and to use "artificial" means only where natural fails.

In regeneration methods the recent advances have been mensurational rather than silvicultural; firstly, in how many plants are needed; and secondly in how their development may be measured and judged (this latter part will be described later under Diagnostic and Dynamic Sampling).

Pre-occupation with de Liocourt's curve and single or few-species European forests led and still leads foresters to require literally thousands of seedlings or saplings per hectare to produce the relatively few trees needed at maturity. Two recent tendencies have caused a swing away from these requirements.

Experimental work in Queensland (Haley, 1954) and observations in Malaya (Barnard, 1954; Cousens, 1958) have shown that rainforest trees cannot tolerate more than eighteen to twenty-five square meters basal area per hectare (depending on site) if they are to grow reasonably fast towards healthy maturity. Thus only 35 to 50 eight-foot girth timber trees can mature on one hectare and it is futile to try and raise more (Dawkins, 1959).

Secondly, it is being realised that as most regenerated crops are mixed weed and desirable the heavy casualties which result in a decreasing population *a la* de Liocourt can, by proper tending, be concentrated on the undesirable element. Thus if the desirables are even mildly aggressive light-demanders a relatively small number of saplings is sufficient to stock the forest. Only where the principal desirables are slow-growing shadebearers is it still difficult to be content without a carpet of seedlings or a thicket of saplings. And in such areas there is a strong school of thought which would prefer to grow another species of lower immediate per-cube worth but of greater aggressiveness and therefore of greater ultimate economic benefit.

There is therefore now a growing tendency to count about a hundred sapling or pole-size desirables per hectare as a "full stocking" providing they are entirely liberated from undesirable competition and face no hazard except, perhaps, lightning and gale-force winds.

Natural regeneration

Current systems can be divided fairly sharply into two, depending on the regenerative power and stand-curves of the natural forest:

(1) positive stand-curve (de Liocourt type) with adequate juveniles; or negative with inadequate juveniles but ready inducement by felling or post-exploitation treatment.

(2) negative stand-curve with inadequate juveniles, no inducement by felling, and therefore regeneration must be obtained before felling.

The first is naturally the easiest. In Queensland rain-forest (Haley, 1954) and in much of the deciduous woodlands of India, Burma and Africa selection systems operate with continuous regeneration, requiring only liberation or fire-protection for survival and growth. In Nigeria, Ghana, Andamans, the "miombo" of Africa, Trinidad, Uganda and Malaya we have all variations from a shelterwood system with a five-year pre-felling regeneration promotion period, through clear-felling with immediate tending, to delay of tending of up to five years after felling with no previous silvicultural work whatever. There is no doubt, for the sake of certain critics in tropical Africa, that all these countries have had tremendous success over part if not most of the appropriate areas.

Regeneration type (2) is more difficult and the writer doubts if any success has been obtanied except where some —often little— regeneration already existed to imply that favourable conditions do occasionally occur naturally. For instance Queensland, West and Central Africa, and British Honduras have obtained dense seedling regeneration in small areas limited to the vicinity of seed-trees. Such a technique is generally applicable only to species of top-rank "cabinet" value.

Where desirable juveniles are entirely absent the foresters have generally been forced to plant or sow, often after years of failure to induce natural regeneration or to tend it for a reasonable cost.

Planting

Where natural regeneration has failed, or is mistrusted, or has never seriously been considered, innumerable variations of diffuse planting have been tried. By far the most successful is line-planting which simplifies the problem of tending and access by close spacing along cleared corridors which are themselves at full final-crop spacing or more. All variations from 1m x 10m to 3m x 20m have been used with success. The technique is fast developing and although no fundamentally new techniques have arisen recently, considerable clarification of principles (Foury, 1956) has occurred, for instance:

(1) Spacing must be close along the lines to give a wide choice of final crop and a relatively low cost of maintenance per plant.

(2) Lines are best cut exactly east-west for maximum sunshine.

(3) Only vigorous light-demanders are worth using; slow growers cannot be promoted in the matrix of fast growing climbers and shrubs which spring up along the corridors.

(4) The forest should be fully exploited with no further large trees to come out.

(5) The method is unsuitable if large wildlife is common. Elephant, buffalo, and larger antelope can easily wreck such schemes altogether, and have often done so.

(6) It is easy to underestimate the effect of overhead and lateral shade, and competition from the deep and wide roots of any large trees which may remain after felling. There is a common fallacy that rain-forest trees are shallow rooted. In fact they may be extremely deep on raised sites and together with their wide spread are a menace to planted trees until de-activated by girdling or poisoning.

(7) The point has been made that once the plants are established, the whole forest area should be treated just as if naturally regenerated and therefore tended throughout, not merely along the lines. Thus linear establishment may be sound but linear tending becomes unsound long before the crop begins to occupy the whole site.

If Queensland leads tropical selection rainforest, and Malaya the uniform, then French-speaking Western Africa leads enrichment by line-planting. Thousands of hectares of highly successful Terminalia, Tarrietio, Aucoumea, and others are rising to maturity in line-plantings in Gabon, the Cote d'Ivoire, and the Congo. On the other hand the method has been abandoned in some parts owing to depredations of wildlife —mainly elephant and buffalo— in favour of more concentrated and dependable close-planting or less vulnerable natural regeneration.

In some areas there is a conflict between wildlife and forest conservation and only three roads are open. Reduce the wildlife, reduce the forests (as timber producers), or seek tree species that the animals dislike. Uganda is on to all three methods in appropriate areas, but is concentrating on the third alternative if the wildlife population can be kept below a certain, as yet unknown, limiting density.

Felling Systems

Perhaps the greatest recent advance in tropical stand improvement has been the realisation of the quantitative effect of different felling systems.

Most tropical forests were opened up on a polycyclic* system often called "selection" but better "girth-limit", by which all desirables over a certain minimum girth were felled at each cycle. That girth was fixed high to insure against over-cutting and in theory at least left the forests in a state sufficiently valuable to be exploited again when their silviculture should be better known. The trees just below girth-limit were generally healthy-looking and if not fast growing then, again theoretically, accelerable by the felling itself with or without further liberation.

Several factors have caused a swing of thought away from the crude girth-limit system towards either true selection or monocyclic felling.

One factor was eugenic and hygienic. Some foresters realised that the girth-limit system would rapidly remove all the fastest-growing individuals of a given species leaving the slow or stagnant as a permanent drag on the crop (Champion, 1936). Without the European method in selection forest, whereby thinnings remove slow growers of all sizes, (which is impossible without periodic inspection and marking of each tree by skilled foresters) the girth-limit system would infallibly ruin the forests. Queensland is aiming to solve this problem by a remarkable method of all-size thinning which leaves only a very limited number of trees per acre in each size-class. Provided those left are the most vigorous in appearance the forest can hardly fail to improve. Queensland is, however, favoured by

* A polycyclic system allows two or more principal fellings per rotation; a monocyclic only one.

better staffing and marketing than most other tropical territories.

Two other objections to girth-limit systems have been published recently, both of which apply with equal force to true selection, at least in the rain-forest. First, it appears that most rain-forest trees are highly sensitive to canopy crowding and that for a reasonable increment —say over eight feet girth in 80 years— they must have well over one and generally over two thousand square feet of crown space before maturity. The other element in crowding —basal area or root competition— has been mentioned already. Anything like an understorey position in youth or a maintained high stocking throughout life, both of which are inevitable under a high yielding polycyclic system, generally results in small crowns and/or slow growth and long mean rotation (Dawkins, 1958, 1959).

Secondly, it has been shown that the damage done to juveniles and adolescent boles by falling mature crowns averages anything from 0.05 to 0.10 acres per tree depending on size and degree of climber infestation (Uganda Forest Department, 1958). Directed felling is generally i m p o s s i b l e owing to leaning boles or asymmetrical crowns, so that for ten trees felled about half an acre is likely to be reduced to zero years or at least to the first decade of the rotation. The felling damage and crowding factors together severely limit the total possibility of tropical polycyclic forest, and render monocyclic methods more attractive wherever high volume yield is paramount, and the principal species are heliophilous.

Such conditions apply over most of Malaysia, Africa, and the Caribbean, and highly successful monocyclic systems are proceeding in all three. Incidentally, the monocyclic systems are kinder to modern loggers, whose operations demand greater tonnage per acre than animal or hand extraction, and whose needs are difficult to meet by selective fellings in the poorer tropical areas. In Malaya this purely economic factor was one of the most important reasons for reducing a formerly long drawn-out series of improvement fellings into a single operation, now followed immediately by total refining (Wyatt-Smith, 1959).

Diagnostic Sampling

Improvement by liberation involves the removal of impeders. It cannot be justified unless interference is demonstrated, either aerial or radical, and although individual cases of interference may be obvious by visual inspection, anything like quantitative assessment of the need for tending is extremely difficult by eye.

Malaya evolved and applied the first sound system of diagnostic sampling, by which not only the effective stocking —judged according to the limits of which the forest is believed to be capable— but its silvicultural status can be measured (Barnard, 1950). Thus the individual "leading" plants in final-crop-tree size quadrats are scored for their degree of freedom or need for liberation and the whole crop can be expressed as so much impeded or so much free, x% stocked, of y% quality depending on the species composition, and of z sq. ft. basal area or girth-range from the actual measurements. Diagnostic sampling modified from the Malayan original now forms the basis of silvicultural decision in Uganda and has also been used in West Africa (Bergeroo-Campagne, 1957) and Queensland as well as elsewhere in Malaysia. It undoubtedly ranks as tool No. 2 second only to the arboricides.

Dynamic Sampling

Stand improvement moves along a scale and can therefore only be judged and planned if its position of the scale is known. It is only in the last decade that the means of doing this have been worked out on an extensive scale. Queensland led off with dynamic sampling —the estimation of improvement by means of increment— by its system of permanent Yield Plots sited systematically throughout all productive forest types and re-measured by permanent inventory teams at regular intervals. The principle has spread and, although worked out quite independently, is now a routine in at least some parts of Malaya (Cousens, 1958) and in Uganda (Dawkins, 1958). The "yield plots" are true sample plots, not in the sense of experimental research but in the literal context of an actual and representative sample of the whole forest estate. Uganda and Malaya at present prefer a stratified random layout, whereas Queensland prefers systematic.

Plot sizes vary from fifth-acre in Queensland, through one-acre in Malaya to 2.5-acre (nearly one hectare) in Uganda.

The peculiarity of Tropical High Forest dynamic sampling is that all tree stems must be permanently marked, as recruitment and losses are likely to be both continuous and untraceable. Add to this the phenomenal differences in growth-rate from tree to neighbouring tree of the same species — and all Meyer, Prodan, and Seth systems of calculation and prediction become quite unworkable. Tropical sample plots are in fact more likely to be analysed by stand-projection based on growth curves than by calculation of area increment extrapolated by site classes. Fortunately, the tree crown diameters are generally strongly correlated with bole diameters and aerial sampling coupled with ground control is now capable of considerable accuracy in estimating growing-stock over wide areas. Thus the sample plots will serve as precise subsamples for the control of repeated aerial inventory.

PRESENT TREND AND THE FUTURE

The greatest single inhibitor of tropical forest improvement is its vastness compared with its degree of utilisation, and therefore its currently low valuation and the weak policy of its owners. Without demand there is no incentive for higher productivity.

Hence where demand is intense, as in the Asiatic tropics, we find the most advanced development. For instance the far eastern manager is often able to effect complete utilisation even to the sale of grass, bark and roots, let alone all his weed-trees and thinnings for fuelwood. Indeed mere "improvement" is often too slow and he is forced towards total replacement, generally by the taungya method.

This leads to the first of the two major dilemmas which face tropical foresters today, intensive replacement versus extensive improvement. Should the policy be intensive first and extensive if resources allow or the reverse. Economists prefer the first, foresters generally the second alternative as it involves the largest areas and therefore justifies their hold over the forest estate and ensures against its early attrition. Where the land is unsuitable for agriculture or other forms of development there is no particular worry. Where the soil is good, the ultimate choice is inevitable: intensity must prevail. Procedure then depends on urgency; if demands are yet low extensive methods are the best and improvement methods are chosen. If demands are already pressing improvement is usually too slow and replacement (quite possibly by indigenous species) is inevitable.

The second major dilemma, at least in areas of low demand, is what to grow. The choice generally boils down to whether the tropical forest is to be a source just of cellulose or of ornamental and utility woods as such. The first choice means concentrating on phenomenally high yielding fast-growing light-demanders in genera such as Cecropia, Ochroma, Musanga, Trema, Eucalyptus, Pinus, Cupressus and others. The second choice involves the high-class dipterocarps, meliaceae, combretaceae, legumes, moraceae, etc. This is where lack of world planning comes in;

it is quite impossible to make a rational long-term decision without first deciding on regional specialisation. To assist in such planning the following considerations are submitted:

(1) Tropical broad-leaved forest, at least the evergreen variety, is rarely inflammable and in this respect provides a safer investment than temperate or dry-tropical conifer or deciduous forest, particularly under relatively unskilled management.

(2) Much higher annual acre yields of cellulose can be obtained in tropical than in north temperate forest. This is true even without citing the eucalypts. If these and the tropical pines are added, yields are still further increased but we introduce the fire factor again. However in the humid tropics this operates at a much lower hazard than in temperate areas, as an evergreen non-inflammable understorey can be included and evergreen fire-breaks allowed.

(3) Changes of management can be introduced into tropical forests with far greater rapidity and earlier results than in temperate. Clear-felling, taungya, line-planting and even some "natural" methods can raise large saw-timber in a matter of forty years or bulk cellulose in a matter of ten - speeds practically impossible in the temperates. This is a most important point in relation to the rapidly changing patterns of modern technology.

Cynics may comment that one can ruin a tropical forest quicker than a temperate. The optimist will retort that one can also rehabilitate quicker, and what can be quicker than fire?

The fact is that the proper forest planning of every territory awaits the formation of world-wide forest policy. It is perhaps too much to expect such a thing when time has seen only five global conferences on the subject.

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Forest Management in the Caribbean

by

W. A. GORDON

In the British Caribbean there are two islands and two mainland territories that have built up organized Forest Services — Jamaica and British Honduras in the North, and Trinidad and British Guiana in the South.

For whatever reputation the Northern Caribbean may be considered to have gained for itself in forestry, the credit can be claimed by the mainland territory of British Honduras. The possession of large supplies of an outstanding timber, the peculiar history of the country and the unprecedented neglect of agriculture have all served to make Honduras dependent on her forests. The island of Jamaica lacked some of Honduras' advantages in the composition of her natural forests, and proximity to organized sources of timber imports has concealed the need for forest management.

In the southern pair of territories, it is on the island that forestry has advanced, while on the mainland it has been neglected, and in this case the composition of the forests hardly helps to explain the contrast. Greenheart *(Ocotea rodiaei)*, the timber with the reputation, is the monopoly of Guiana, while Trinidad forestry has been built up on timbers which in Guiana are hardly considered to be merchantable.

It might well be argued that, if the forest resources of Guiana had been developed earlier on a sensible plan, they would have sufficed for the supply of the whole of the Southern Caribbean, and forestry in Trinidad might have been relegated to the unimportant position that it holds in Jamaica.

Of the two contrasts, Honduras-Jamaica, and Guiana-Trinidad, the latter seems to offer the more profitable lines of investigation, as it illustrates lessons that could be of interest to other parts of the tropics. The problem of converting the old-growth forests is primarily a problem of transport, manufacture and marketing, and the history of forestry in Trinidad suggests that silviculture may prove to be the least of the difficulties.

Transport and Communications

British Guiana is served by natural communications in the form of rivers navigable for more than 80 miles into the interior. Long before the establishment of a Forest Service the pattern of the logging trade had been set by the Coryantyne, Berbice, Demerara, Essiquibo, and a number of lesser rivers, each one having its network of tributaries and creeks.

It is usual in the early stages of the development of a new country for the coastal fringe of forest to take the brunt of uncontrolled logging, along with such forest as is found near pioneering roads and railways. It has usually happened, however, that initial damage has been limited to these fringes and that, before it has extended any further, some form of forest management has been introduced.

In British Guiana the only limit to the extension of uncontrolled exploitation has been a barrier of rapids on the upper reaches of the main waterways. Since this barrier cannot be outflanked without a considerable outlay of capital, it has helped to isolate more than half of the forest in which greenheart is found, but below it the rivers and their tributaries have laid a substantial portion of the best forests wide open to uncontrolled logging from the earliest times. The existence of these free communications has made it possible to exploit without investment, with the result that thousands of small operators were able to set up as independent loggers with little capital behind them.

For various reasons the Forest Department was slow in obtaining control, so that up to 1953 forest exploitation was controlled by legislation of the 'gold rush' type, introduced apparently from Ontario during the nineteenth century and designed to allow operators to stake their claims to promising stands of timber without too much quarrelling among themselves. The staking of claims large enough to permit sustained yield working was discouraged; an operator was expected to file his claim for two or three years' supply of timber at a time, cut a boundary round it, cream it of the best greenheart and then search for another virgin stand upstream. As a result, most land within haulage distance of rivers and creeks had by 1953 become fragmented into thousands of concessions, many of them no more than a hundred acres in size.

Although Trinidad had none of Guiana's distance problems, difficulties of terrain and lack of navigable streams combined in the early days to keep much of the forest inaccessible. This temporary inaccessibility has now been overcome by an excellent system of forest roads, built by the Forest Service or built by oil prospecting companies and used jointly with the Forest Service. As in Guiana, forest communications are "free", in the sense that the timber trade has been put to no expense over their construction, but there has been little chance for anybody to take advantage of such free assets for uncontrolled exploitation, because control and management have usually been able to keep pace with the opening up of the forests.

Markets

The Guiana timber trade was built up on unmanufactured exports of the single species, greenheart *(Ocotea rodiaei)*, which is found nowhere in the world except in British Guiana. To have continued for so long to export this timber in an unmanufactured state may turn out to have been a serious misuse of a valuable resource.

A large number of pitsaws and a few sawmills were working in Guiana before the war, but the combined sawmill and pitsaw production was still insufficient to meet the local demand, and exports of sawn timber were negligible. Prewar requirements of the local market, small as they were, had to be met largely by imports from North America. In spite of its higher price, imported timber was preferred, since low standards of local manufacture and the lack of any seasoning tradition served to conceal the qualities of some excellent local woods.

Wartime dislocation of imports established greenheart as the best timber for local constructional work and the end of the war saw an influx of sawmilling machinery, mostly of an unsuitable kind. Pitsawyers in fact started to mechanize with the cheapest equipment they could buy. Although the standard of manufacture became deplorable in many of the smaller mills, the local market was usually able to absorb the production, provided that it were marketed under the names of greenheart and crabwood. On the other hand, experimental attempts of various small manufacturers to export did almost irreparable harm to the reputation of Guiana timbers in the Caribbean islands and elsewhere.

Although the specific composition of the forests of Guiana and Trinidad is similar, greenheart itself is not found in Trinidad, and one of the themes of this paper is that the lack of greenheart has not been an obstacle to the development of forest management. Although British Guiana vastly exceeds Trinidad in size, Trinidad's population is larger and more prosperous and her per capita consumption of wood is considerably higher. Since the forest area of Trinidad is barely two percent of that of Guiana, local supply in Trinidad is the primary problem and the question of export to fastidious markets overseas has been of little importance. In the absence of greenheart, there is no species so conspicuously superior to the others as to provide a strong motive for "creaming" and consequently there has been a ready demand for quite a high proportion of the old growth timber.

Manufacture

Poor manufacture has been the only point of resemblance in the forestry of Guiana and Trinidad, and in both countries much of the production has come from light circular mills imported from North America. But although the two industries have developed on similar patterns, the factors which led to this were not quite the same.

Forestry is nationalized in Trinidad more fully than in most other tropical countries. The Trinidad Government owns not only the forests themselves, which is usual, but also the access and extraction roads, which is less usual. Timber is rarely sold for felling until road construction has rendered it accessible so that purchasers of standing timber assume little or no liability for capital investment. By its practice of selling timber in relatively small lots and confining sales to accessible sites, the Forest Service has turned itself in effect into a retailer of standing timber, and small operators have been able to enter the logging business with little capital behind them. On the other hand, since sawmillers have been unable to secure their supplies for more than twelve months ahead, they have had insufficient security for investment and the Trinidad sawmilling industry has developed by the multiplication of small undercapitalized and usually inefficient sawmills.

In Guiana the results have been partly due to racial differences and partly to reliance on river transport. One or two progressive timber companies managed to build up integrated sawmilling industries secured to some extent by logging concessions, although, as a result of the traditional Government suspicion of large leases and long tenures, none of these was adequate for sustained yield working either in size or in length of term. However, even that amount of security has been the exception, and a lack of integration between logging and milling has always been a feature of the Guiana timber trade. Sawmilling has tended to fall into the hands of the East Indian Community, while Africans and Amerindians have shown more interest in the logging side, and the consequent lack of liaison between the two industries has been an important factor in discouraging investment in either. It is not surprising under these conditions that sawmills are under-capitalized and inefficient.

The consequences of bad manufacture have been more serious in Guiana than in Trinidad. In Guiana it has spoilt the prospects for all but two or three species of timber. Very little of the small mill production of any species has been exportable and, although greenheart and one or two timbers sold under the name of crabwood have found ready sales on the local market, few others have been able to overcome the handicap of bad manufacture. In Trinidad, bad manufacture has not been enough to kill a good local market for a wide range of timbers, but sawmill wastage must have helped to increase the gap between demand and supply.

Improved manufacture in Guiana might place another twenty timbers on the market at home and in the nearer Caribbean islands; in Trinidad, it should help to eke out inadequate supplies by reduction of sawmill waste.

Silviculture

Trinidad silviculture, on its small scale, is as good as can be found in any tropical country and it is suggested that the outstanding progress in this field is mainly due to the following circumstances:

(a) There has been a ready market for a number of different species,

(b) There is no species that is too conspicuously superior to a number of others,

(c) Not more than two or three of the desired species are shade demanders.

If Trinidad forests had contained a valuable shade-bearer such as Guiana greenheart, it is doubtful if Trinidad silviculture would have progressed as it has. Silviculture would have been handicapped by 'creaming' operations and delayed by laborious attempts to produce new crops of this one species.

Manufacturing developments are unlikely to have any striking or immediate influence on Trinidad silviculture. Improved manufacture might produce markets for the few of the common species that are still difficult to sell; the sale of a growing volume of teak thinnings might be helped by better milling: and reduction of sawmill waste might reduce pressure for overcutting of yields.

In Guiana the silviculturist will be helpless until manufacture becomes more efficient and, although silvicultural research has been actively carried out over the last twenty years, the chances of applying the results on a field scale have been limited.

Early exploitation took the form of highly selective fellings of the best stems of a single species and, although it covered enormous areas, it was quite light. Since greenheart is a strong shade-bearer and locally gregarious, the establishment of greenheart regeneration in 'lightly-creamed' forest proved to be a practicable proposition. It is true that the technique turned out to be expensive and very slow, so that the area treated for regeneration in the last twenty years can hardly amount to more than one or two percent of that exploited in the same period: nevertheless, if this extensive form of exploitation had continued, it is conceivable that some makeshift system might have been evolved to meet it. Although the old 'Tropical Selection System' based on selective fellings to a girth limit has become discredited in most parts of the tropics it might be acceptable in rare cases, such as this one, where the desired species is a shade-bearer with a gregarious tendency.

Since 1950, however, creaming has become less selective in the sense that almost all the greenheart is now removed from a felling area. In forests where greenheart is scarce, fellings are as light as before but, wherever greenheart is plentiful, drastic openings of the canopy are taking place. These heavier fellings are followed by regeneration, not of greenheart, but of fast growing light demanders of species which are merchantable in Trinidad, but not at present in Guiana. It is possible that greenheart will establish itself under the protection of these early pioneers but, in the writer's opinion, the prospects are poor.

Since greenheart was for so long the only marketable species, it is not unnatural that silvicultural research should have been concentrated on its regeneration. Now, however, with the changing character of exploitation, greenheart regeneration may be too expensive a luxury and, if foresters become unduly preoccupied with it, silviculture may not advance at all. The techniques are expensive, too slow to keep pace with the rate of exploitation and, in the light of foreseeable changes in supply and demand, probably unnecessary as well.

Supplies of greenheart are limited: within thirty years it will have become a scarce timber and much too expensive probably for ordinary constructional work in Guiana. It is a reasonable assumption that, once the ace of trumps is out, far more attention will be paid to other court cards and also that the end of the century the export market will have been replaced by far larger and less fastidious demands in Guiana and the near Caribbean. It is submitted that the silvicultural approach of Trinidad is probably the correct one for Guiana too, and that the Guiana forester should waste no time in tearing up his short list of merchantable species and concentrating instead on the elimination from the forest of the few that are likely to remain unmerchantable.

The Future

In Trinidad, where the sawmill problem is the only black spot, the correct solution is easy to see but, for social and political reasons, quite impossible to put into practice. If national advantage were the only consideration and if all individual interests could be forgotten, the exclusive felling rights over the forests of the island might be divided up on long term licenses between a few selected mill owners or new investors in the timber industry, subject to satisfactory undertakings for expansion. The ultimate objective would be two or three efficient sawmills having their log supplies guaranteed under long-term tenures and absorbing between them most of the yield of the State forests. In spite of obvious attractions, this solution must be discarded.

Another alternative, and one which in Trinidad might be less obnoxious politically, would be further nationalization involving Government participation in wood manufacture. This has been attempted already on an experimental scale and Brickfield Forest Industries provide one of those rare instances of a Government making a profit out of manufacture and trading.

Improvement through natural selection is the solution that will probably be adopted. The Trinidad government must retain its power of preventing, where necessary, any increase in the number of sawmills and of insisting that new mills conform to prescribed standards. Expansion and improvement of the more successful concerns, accompanied by bankruptcy and collapse of the less successful, should lead eventually to reduced numbers and increased size and efficiency of the survivors.

In Guiana the future pattern of development started to emerge in 1950 when the Colonial Development Corporation began to install what has turned out to be one of the largest sawmills in the tropics. Before committing itself to this investment, the Corporation demanded and obtained the long lease of a large concession adequate in old-growth timber OF ALL SPECIES to supply the sawmill until the end of this century at least.

One of the most important effects of this venture has been the explosion of the myth of inexhaustible timber, and the large bite taken by this concession out of the timber reserves of the country has stampeded other sawmillers into securing their own supplies in the same way and accepting quite exacting conditions for the exploitation of the forest allocated to them. A number of developments might be expected to arise from this:

(a) Sawmillers who have failed to secure their position by taking out adequate concessions have poor prospects of expansion. Many of them will be hard put to it to survive at all.

(b) Supplies of old-growth greenheart will not last for much more than 30 years at the present rate of exploitation, and, as the more accessible areas are worked out, the cost of obtaining greenheart is likely to start rising very soon. The future of the main sawmilling companies depends on their eking out the greenheart by intelligent marketing of other species.

(c) As sawmillers meet with increased difficulty in obtaining a satisfactory proportion of greenheart in their log input, the timber trade is likely to combine in questioning the justification for further exports of greenheart in log form.

(d) Eventually, it may be realized by the timber trade that future supplies must be provided by intensive silvicultural operations on the accessible land, where the cream of the old-growth timber has already been worked out.

Possible Methods of Regenerating and Improving Some of the Amazon Forests

by

C. J. W. PITT (F. A. O., Brazil)

The principal object of management may be regarded as being to replace a forest composed of a large number of species, many of which are of little or no known use and in which the more useful species are usually the rarer ones, with a forest composed of a large number of individuals of a few useful and very useful species.

The vast area of the Amazon jungle, some 3.5 million sq. kms., gives many people a false sense of security on account of the apparently limitless supplies of timber. The distances over which first class desirables or economics have to be transported from stump to sawmill is rapidly increasing. The need, therefore, arises for improvement of the forests closer at hand.

Two of the main obstacles to the development of forest management in the Amazon are the lack of silvicultural information about many of even the better known species, and the properties and possible uses of the lesser known ones. It was to assist in the former that a silvicultural section was included in 1955 in the F. A. O. Forestry Mission which first reported in 1953. The terms of reference of the Silviculturist are "To advise and assist the Government in the introduction of silvicultural methods to the Amazon Forests for the purpose of developing the rational utilization of these forests".

To carry out this task various preliminary investigations have been necessary, viz: (1) to provide more information about the silvics and silvicultural requirements of the better known desirables and other important components of the forest; (2) to investigate the properties and possible uses of the lesser known desirables; (3) to investigate the possibilities of establishing pines to improve a possible furnish for pulp; and, (4) to try out various other exotics should it be desired to establish plantations on a large scale.

For such a vast area as the Amazon it is not practicable to investigate all the possibilities; therefore, work has been confined to a few special areas, viz: (1) on the Curuá Una river, 105 kms. from Santarém, (2) near Santarém, and (3) near Macapá. In the discussions later on in this paper the various generalisations will probably apply to most of the region though their possible limitation must be kept in mind.

Climate

There is a definite dry season in the second half of the year varying from about 3 to 6 months according to the locality. The mean annual rainfall may vary from 850 mms. (C. B. A., Santarém) to 2750 mms. (Belém). Mean maximum monthly temperatures vary from 24°C to 35°C, and the minimum from 19°C to 25°C. Nights are usually cool, especially in the forest.

The level of the rivers can vary considerably. At Belém the tidal range is about 2 ms.; at Santarém dry and wet season levels vary by about 3 to 4 ms., at the F.A.O. camp on the Curuá it is over 2.5 ms., and at Manáus it has once reached 16 ms. These changes would naturally affect work on the "varzeas", the periodic or seasonal swamp forests.

Principal Forest Types

1. Swamp
   a. Varzea - seasonal or tidal
   b. Igapó - permanent
2. Terra firme
   a. Sandy soils - generally on Quaternary deposits - "flanco"
   b. Clay soils
      (i) "Planalto" - Tertiary
      (ii) Undulating - may be a more denuded tertiary formation, or over old rocks, usually of the Brazilian shield.

The VARZEA forests, especially in the lower reaches, provide much of the timber today, though exploitation is confined almost entirely to floaters.

The IGAPO forests are poorer and provide little commercial timber.

The SANDY soils carry forest generally low in volume and with few desirables; in places they carry only fairly low savannah.

The planalto CLAYS carry the highest volume (up to over 300 cu. ms. per hectare of trees over 25 cms. d.b.h.) and are rich in species; usually there are very few economics, such as *Cedrela*, in a single hectare, though there may be several desirables.

It is only on the terra firme soils that exploitation by mechanical means is possible over most of the year. The following notes therefore refer only to these soils, and in particular to the planalto.

Possible Degree of Exploitation

1. "Creaming" - as is done at present for *Cedrela* or *Carapa*.
2. "Heavy Selective" - relatively intense (20-40% of the large sized species).
3. "Intense" - fairly complete and integrated utilisation.

CREAMING. The density or stocking of the "economics" is so low, e. g. 10 *Cedrela* per square kilometer, that the forest is virtually unaffected, except for occasional gaps and extraction tracks. Hand labour, with its limited range of about half a kilometer, is usual for moving the logs from stump to stream or river; lorries are sometimes used, and occasionally even tractors for the first stage.

HEAVY SELECTIVE. In the Curuá, where the F.A.O. team is logging, the planalto forest has some 120 different species over 25 cms. d.b.h. with about 35-45 species on any one hectare. Of these some 30-35% are desirables, and represent about 40% of the stems or 50 % of the standing volume. Sound trees of all the desirables are being felled and taken to the Sawmill Training Centre at Santarém, or used locally for camp buildings. The number of apparently young and healthy-looking trees of timber size which have heart rot, occasionally right up into the crown, is comparatively high in some desirables.

INTENSE. This implies more or less clear felling for pulp, with the best logs going to sawmills and/or plywood or veneer mills, and suitable second quality logs going to sleepers. On the planalto area referred to above a 100% inventory over 13 hectares has shown a standing total volume of all trees over 25 cms. d.b.h. of about 250 cu. ms. per hectare (190-315). The method used for this inventory was the same as that followed by Heinsdijk in his Amazon Inventory reports (F.A.O. Nos. 601, 949, 969 and 992). Recently a 100% inventory of trees over 45 cms. d.b.h., but excluding the badly fluted trees, was carried out over a block of 100 hectares by the same method. The average per hectare is 156 cu. ms. In a statistical analysis the means of the sub-plots were calculated per hectare. The standard deviation for 50 sub-plots of 2 hectares is ±34.6; for 10 subplots of 10 hectares is ±18.2; for 5 subplots of 20 hectares is ±19.5. This shows an irregular stocking in the compartment over rather short distances. In this block 6 species, (5 economic and 1 potentially so) gave 60% of the total volume - i.e. some 90 cu. ms. per hectare - a very high figure for a tropical forest.

Silviculture

The value of pure silvicultural research is not to be disputed, particularly in such undeveloped forests as occur throughout the Amazon. However, in view of the terms of reference of the assignment, silvicultural work must bear some relation to the possible degree of exploitation and utilization. The economic considerations for this therefore impose considerable limitations. Valuable work however could be done now to improve the forests for exploitation at some future date ("Refining", vide Dawkins). This is an aspect of management which is usually not considered, especially in tropical forests, owing to budget limitations. There is scope for considerable development in the intensity of the utilization of the planalto forests; until this takes place, the silviculturist can do but little beyond showing how the forests can be improved both before, and after, exploitation.

Possible Methods

Much has been written about Tropical Silviculture, especially in papers read at the last (4th) World Forestry Congress. The methods which are most likely to be suitable to Amazon conditions are:

1. NATURAL REGENERATION
   (a) Inducing NATURAL SEEDLING REGENERATION of desirables prior to exploitation, or encouraging regeneration normally under some degree of shelterwood;
   (b) NATURAL REGROWTH of seedlings, coppice and perhaps suckers, following intensive exploitation.
2. ARTIFICIAL REGENERATION
   (a) ENRICHMENT PLANTING
   (b) PLANTATIONS

1. (a) NATURAL SEEDLING REGENERATION. This would entail some degree of canopy opening by creeper cutting, killing some trees and cutting back the undergrowth of undesirable species, followed later by periodic killing of further undesirable trees and recutting the undergrowth.

1. (b) NATURAL REGROWTH. Unless plantations are envisaged natural regrowth would be encouraged to follow intensive exploitation. The initial seedling regrowth is likely to consist mainly of softer wood light-loving species and will result initially in a forest of a rather different composition. During the first few years it may be advisable to cut back the regrowth of the less useful species 2 or 3 times. An object of management may perhaps dictate favouring only those soft-wooded ones more useful for pulp, or, also of encouraging useful harder timber species.

2. (a) ENRICHMENT PLANTING. This could be on a relatively small area, say 1-2% of a "creamed" area, on the principle of compensatory plantations, i. e. planting say 100 trees per hectare which may give 20 mature trees against the 0.2 to 0.1 as at present. Only valuable species, tolerant to shade, should be used. It could be adopted in those parts of areas where natural regeneration has not been as successful as required. Similarly it would be suitable for accessible areas near centres of population where the present stocking of desirables does not justify exploitation.

2. (b) PLANTATIONS. For these it would be necessary to clear-fell an area and then burn it at the end of the dry season. Normally, a smaller area would be planted than exploited, unless the degree of exploitation is very high. Parts of easily accessible forest already creamed or with only a few desirables could be replaced by this method, particularly if near large centres of population.

It would be necessary to decide whether plantations on a proposed site are biologically possible - on some degraded campos (grassland) trees may not grow at all well. If plantations were possible, would they be economically desirable? The advantages and disadvantages would have to be considered. If plantations were undertaken it would be most important to have a variety of species and to avoid large pure stands.

There is no question of "taungya" at present as there is no land shortage. If intensive exploitation were to start on a large scale, then, there would be definite possibilities to provide food for the labourers and to grow trees at the same time.

Work in Hand

In view of the terms of reference, given above, of the F.A.O. assignment on which the writer is engaged, all the above methods are being demonstrated, often on two or three different sites.

No intensive exploitation is being carried out a present; therefore small areas (2 to 6 has.) have been clear-felled and burnt, after removing the larger economics. These have been used for camp building or sent to the F.A.O. Sawmill Training Centre nearby.

Natural Regeneration

NATURAL SEEDLING REGENERATION. Plots have been laid down in three localities with two or three degrees of canopy opening; the size varies from 1 to 4 hectares, plus a surround. Weed trees have been poisoned with contact arboricides; various concentrations and mixtures have been tried; the most satisfactory seems to be a 1 to 2 mixture of 2,4-D to 2,4,5-T (both 80% acid equivalent) at 3 to 5% in diesel oil, depending on the species and SIZE of the trees to be killed. A few resistant species are frilled before spraying. The degree of opening was controlled by the number and size classes of tree poisoned, and later checked by girth measurements for basal areas (only trees over 25 cms. d.b.h. were girthed). Recently a "Baumzahl" (a prism in a short tube) has been used for measuring basal areas. The original b.a. varied from 18 to 22 sq. ms. per hectare and was reduced to about 11 sq. ms. for a "heavy" opening and to about 15 sq. ms. for a "light" opening. In a "heavy" opening, besides some large undesirables, some understorey trees were also poisoned and the undergrowth of all undesirables slashed back.

Good regeneration of several desirables has been obtained in some plots 2 to 3 years after treatment, particularly in one 1-hectare plot where some 13 economics were felled and extracted soon after the plot was laid down. In this plot it has been considered advisable to cut back the weed regrowth after 2 years, and, to thin out the useful regeneration to intervals of about 1.5 ms. A recent "milacre" survey shows 98% of the quadrats (2 m. square) stocked with generally more than one seedling of the 3 main species, or occasionally with one or two of 11 other desirables.

Plots have been laid down to encourage regeneration of *Cedrela*, probably the most important species of the Amazon; there are three degrees of canopy opening each with 3 ground treatments. A good seed year is awaited.

Gregarious patches of seedlings of *Clarissa* and *Hymenolobium* have been encountered. As these trees are rare in the forest these patches are being observed carefully; over some the canopy is being opened and the seedlings thinned out.

NATURAL REGROWTH. This is being observed in the surrounds of plots clear-felled for trial plantations. In the area first felled, which was lightly burned in December, 1957, good regeneration of *Goupia*, mainly from seed, has been obtained. 62% of 2 m. quadrats were stocked by Aug. 1958, and 59% were still stocked by June 1959 (average height of tallest in each plot was 85 cms.).

Weed growth had to be cut back in April 1959 and a 1.5 m. "stick" thinning was carried out by uprooting the surplus seedlings. Seedlings of several more desirables have also appeared. The plot can be regarded as fully stocked —there are very few gaps of over 10 or 15 metres— though more slashing back of weeds will be necessary for a year or two.

Where the logging unit has been operating, light burns are now being carried out in the open patches. These should result in good regeneration of *Goupia* and a few other desirables. A fierce burn is to be avoided, as in such patches the soil will still be comparatively bare even after two wet seasons.

One of the problems is to recognise the seedlings. Seeds of desirables are being collected as opportunity offers and plants raised in the nursery. Later, the plants are put out into arboreta on the main soil types to obtain more silvicultural information.

Artificial Regeneration

ENRICHMENT. Various spacings and degrees of opening are being tried. Even with shade-tolerant species, growth is usually slower than when these species are planted in the open. The main scope for enrichment planting lies in improving the composition of young secondary growth. It is also indicated in areas of fairly intense exploitation where the natural regeneration of desirables has not been adequate. It is clear however that in virgin high forest, poor in desirables, little can be done to improve it except by a heavy, and therefore expensive, opening of the canopy and by using that rather rare phenomenon, quick-growing shade-tolerant species.

Both contact arboricides and girdling are being used to kill weed trees along the enrichment lines. Direct sowing of *Carapa* shows some promise and so do transplants of *Carapa, Cedrela, Vochysia, Hymenolobium* and *Virola* after one year. Spraying with 2,4-D is being tried to keep down the weed regrowth along some of the lines.

PLANTATIONS. Practically all aspects of this work are being demonstrated. In the nurseries, besides the local soil, seed beds have been made of "terra preta" (black sandy more fertile soil of uncertain origin and a little less acid, pH 5.6 as against 4.4), sawdust and river sand. Transplants are being raised in beds, boxes, galvanised iron tubes and earth pots ("torrao paulista"); plants from the beds are put out as naked rooted, ball rooted, striplings and stumps. Only one or two methods are tried for any one species in one area. Everything is first tried out as naked rooted transplants; in theory some soil is lifted with the plant but in practice very little remains by the time the plant reaches its final home. The only uniform procedure is the spacing, 2.5 x 2.5 ms., giving 1600 plants per hectare. Work on various spacings can follow when the best technique has been established for each species.

Fertiliser trials with P are also in hand. On a poor degraded campos clay soil nothing has succeeded without P, and even here the initial response with P was not maintained in the second and third years, except with some eucalypts. Mulching is done where possible but can prove very expensive if the mulch has to be cut from outside the area. Cover crops *(Crotalaria)* are being sown to help in this respect. Pruning and thinning will come later.

There has been considerable interest in the possibilities of intensive exploitation for pulp. Technical and economic considerations of this subject are outside the scope of this paper. However, if such exploitation starts and silvicultural methods can be introduced to give a forest with fewer species of more uniform properties, then a great step forward will have been made. To this end work is in hand on introducing pines, as these would also improve the furnish very considerably. The best pine is likely to be *P. caribaea;* difficulty was experienced in the first year in obtaining adequate mycorrhiza and postal delays with seed cost us another year. Several trial plots with well inoculated plants were however put out early in 1959; results are promising. *P. khasya* has not succeeded and postal delays twice resulted in *P. merkusii* losing its viability; we were more fortunate with the third lot and have good plants for 1960. Some 40 local species and 30 exotics including eucalypts are also on trial.

The main pest is "saúva", the leaf-cutting or parasol ant; in general, indigenous species seem less delectable, but they too have been attacked. The ant seems more frequent on sandy soils and appears to be more abundant where there is poor or young secondary growth following clearings for cultivation.

Other Operations

PRE-EXPLOITATION. These consist of creeper cutting, freeing young advance growth and freeing and thinning occasional patches of desirable gregarious seedlings. When more information is available as to the density of canopy required to encourage good regeneration of one or more desirables, the poisoning of weed trees will be undertaken.

POST-EXPLOITATION. These consist of further freeing advance growth, cutting back damaged young desirables and cutting young weed trees, which, when larger, are resistant to arboricides. Exploitation, even when fairly intense, leaves some large patches often untouched. In these patches some weed trees are being killed to favour any young desirables. When these are absent, enrichment planting is indicated, provided suitable species have been found; in this case, poisoning of weed trees is necessary to open the canopy over the lines. The burning of branchwood in heavily felled patches has alread been referred to; this is likely to be successful only when seed bearers of certain light-demanding and preferably quick-growing species are present. Some subsequent cutting of weeds is bound to be necessary.

Research

When introducing silvicultural methods to a virgin forest area it is impossible to go straight ahead with only field scale operations. A tremendous amount of information about the composition of the forest has to be found out, and about the silvics and silvicultural requirements, not only of the desirables, but also of the weed trees. This is quite apart from deciding which species are desirables and which are weeds.

A line usually has to be drawn between experimental work and research work. Where that line lies is a matter of opinion. It had been hoped that a forestry section would be developed at the National Research Institute for Amazonia at Manáus (Meijer Drees report F.A.O. No. 756). As nothing has yet developed here, plots of a more definite research nature have been established along with our demonstration and experimental plots. Sometimes a plot has served for more than one experiment, e. g. where the effect of different degrees of canopy opening on securing natural regeneration is being tried out, observations have also been made on the effectiveness of different concentrations of arboricides, and, permanent girth increment plots have been laid down.

Observations or measurements are being made on:

Inducing natural regeneration by canopy opening and, in the case of cedar, by ground preparation.

Resistance of all larger species to different concentrations of arboricides and to girdling.

Amount of slashing back of weed growth to favour established or induced regeneration.

Suitability of various species for enrichment planting.

Various methods of raising transplants.

Various methods of establishing plantations.

Effect of using P fertilisers.

Rates of growth of indigeneous and exotic species in plantations on various soil types.

Rates of diameter growth in virgin and in partly opened forest.

The pedologist with the F.A.O. Mission has visited all the silvicultural centres, studied soil profiles and had samples analysed. The main features have been the very low fertility values as shown by the amount of elements present, and the high acidity (pH 3.9 to 4.9). This high acidity is probably a limiting factor in the introduction of some exotics and may explain why such species as teak have failed in most trials. Much work could be done in tropical forests on the pH requirements of the better known species and thus avoid many of the failures encountered when introducing exotics. The difficulties with mahogany on the tertiary clays may also be due to acidity; where seen growing naturally by the writer on soils of much older geological origin the pH was much higher (about 6).

Conclusions

In these early stages, management must be extensive rather than intensive; stress should be more on natural regeneration than artificial, at least until intensive exploitation for special purposes starts. The principle should be: "Follow Nature; perhaps guide her, but, do NOT dictate to her." The introduction of exotics should be considered, especially if there is any question of future exploitation for pulp.

From the point of view of natural regeneration it is better to have an area with a relatively high volume of a second class desirable, which it is fairly easy to regenerate and encourage, e. g. *Goupia*, than to aim at a first class desirable which can be established only with difficulty, e.g. *Cedrela.*

It is far too soon to weigh the relative values of natural regeneration against artificial regeneration. Much more muddy water must flow down the Amazon before any reputable forester should give his considered opinion on this nice point.

Forestry Training in Latin America[1]

by

GERARDO BUDOWSKI

Inter-American Institute of
Agricultural Sciences
Turrialba, Costa Rica

In the last few years, Latin America has shown a striking interest in forestry. The rapid rate of population increase, advances in technology, especially the new uses developed from mixed tropical forests, emphasis on watershed protection and reforestation, needs for recreation and other reasons have brought about a new view of forestry and the problems involved with the administration of forest resources. Such change of attitude is rather recent but public opinion has been moving fast in that direction.

Not too many years ago, though, technical forestry was almost non-existent. Most forest activities were restricted to the administration of unclaimed land ("baldíos") and granting of timber exploitation rights so as to collect the necessary taxes. Occasionally Government agencies were involved in programs of free distribution of seedlings of timber trees, the results of which have now proved to be of rather doubtful value in most countries. Attention to the evils of such a situation was first brought about through the results of forest destruction affecting adequate supplies of timber and firewood, causing soil depletion, irregularities in streamflow, destruction of scenic values, etc.

1/ This study was submitted in April 1960 using data accumulated in former years. The author is aware that since that date many changes have taken place. Some of these changes refer to the recent opening of new schools of forestry at University level in Brasil and Argentina, confirming the described picture of rapidly changing attitudes toward forestry training in Latin America. A "World Directory of Forestry Schools" published by the Society of American Foresters, Washington, D.C. and the Food and Agriculture Organization of the United Nations, has also been issued in 1960.

It soon became obvious that such steps as new laws or stronger restrictive measures were not sufficient to stop wasteful forest destruction. An increasing number of educated people began to believe that only technical administration of forest resources would ultimately offer the best chance to meet the challenge.

But are there enough and sufficient qualified technicians to face the needs of the population? How is Latin America prepared to meet these and future requirements?

The present paper intends to describe the actual situation with an aim to point out deficiencies and future needs. The opinions expressed are based on the experience acquired in teaching forestry for the last 7 years in connection with the Technical Cooperation Program and the Graduate School of the Inter-American Institute of Agricultural Sciences of the Organization of American States. These activities permitted the writer to get acquainted with most of the existing schools of forestry and a great number of practicing Latin American foresters. Much information was also taken from the programs and activities published by the different schools and the work of Cianciulli[2] who made a survey of Latin American Forest Training Centers.

Forestry Schools and Training Programs

Forestry training in Latin America is dealt

2/ Cianciulli, P. 1958. O ensino florestal na America Latina. Contr. Inst. Interam. Ciencias Agr. e a Camp. Nac. de Educ. Flor. Serv. Florestal, Sao Paulo. 93 pp.

with by different institutions and programs which may vary considerably as to the level of teaching, the length of training and the substance of the training given.

Regular schools may be divided roughly into 3 levels: (1) graduate or post-graduate training, (2) college or university level, and (3) ranger level.

Besides academic training in regular schools, considerable attention has been devoted to short courses or study tours offered to Latin Americans in Latin America or elsewhere.

Many international organizations have allotted funds for regular fellowship programs. Important financial contributions are also made to training centers located in various places. Such financing may account for failure or success of many training programs.

Finally several international organizations dealing with technical assistance are using some of their technicians, invariably with European or U. S. backgrounds, to undertake specific training assignments.

The Graduate or Post-Graduate Level

In all Latin America there are only two institutions presently giving post-graduate training. Only one of them, the Inter-American Institute of Agricultural Sciences at Turrialba, Costa Rica, a specialized agency of the Organization of American States, confers a Master's Degree. The staff of the Graduate School at Turrialba comprises over 50 technicians of which 26 hold Ph. D. degrees. The activities of the Institute involve training, research, and services. Forestry training with emphasis on tropical forestry is given in the Renewable Resources Department where three foresters are active. There are 13 trimestral courses directly related to forestry: dendrology, forest mensuration, tropical meteorology, forest protection, wood technology, photogrammetry, plant ecology, forest management, tropical silviculture, forest policy, forest engineering, utilization of forest products and forest industries, and forest administration.

Other courses on related subjects given by other Departments include such topics as soils, plant physiology, plant morphology, statistics, experimental design, technical editing, use of library, microtechnique and microphotography, special subjects, etc. A minimum residence of 12 months is required to qualify for a master's degree.

Admission requirements include a University title of Ingeniero Forestal or Ingeniero Agrónomo. All students must approve a number of courses to be described by their Committee and write a dissertation on a research project. A good reading knowledge of English is a necessary requisite. A one-month summer camp in the coniferous forests of Honduras and Guatemala is part of the training.

The Graduate School received its first forestry students in 1951. In 1960, ten students from eight American countries have been awarded a master's degree. Fourteen more, including students from two other countries are to be awarded the degree when certain requisities, especially completion of thesis work, have been complied with.

All the forestry students have been awarded fellowships from different organizations, the principal ones being the Organization of American States, the International Cooperation Administration and the Food and Agriculture Organization of the United Nations.

The Latin American Forestry Institute for Research and Training, located at Mérida, Venezuela also offers post-graduate training but no formal degrees have yet been awarded. The Institute is sponsored by the Food and Agriculture Organization of the United Nations (FAO) in cooperation with the Venezuelan Government with financial cooperation from several Latin American countries and is closely connected with the Venezuelan School of Forestry which is located at the same place and will be discussed under a later heading.

All students have fellowships. Since the program is only three years old, the number of technicians who have received some training is still low.

College or University Level

(1) Schools of Forestry

There are at present seven regular schools of forestry in Latin America. They are located in the following countries: México, Colombia (two schools), Venezuela, Chile (two schools), and Argentina. Two more schools are in the process of opening. The degree conferred is generally called INGENIERO FORESTAL except for México where it is called PROFESIONISTA FORESTAL.

MEXICO. In México, training is given at the National Agricultural School at Chapingo, close to México City, a dependency of the Secretariate of Agriculture. The course includes seven years of which the last four are specialization in forestry. Requirements for admittance include six years of primary or elementary schooling and at least three years of either secondary (or high school) or "pre-vocational" studies in agriculture. Several hundred foresters have graduated from the school. Only a very small amount are non-Mexicans.

COLOMBIA. There are two schools of forestry located in the two main cities of that country: Bogotá and Medellín. The school of Bogotá is a section of the Universidad Distrital "Francisco José de Caldas". The "Instituto Forestral" in Medellín has been steadily improving in staff and equipment for the last few years. It also received assistance from the Michigan State University. Like other universities in Latin America, admission requirements include a "bachillerato", roughly equivalent to termination of High School studies in the United States.

VENEZUELA. The Faculty of Forest Science, a dependency of the University of the Andes is located in Mérida and has been functioning since 1951. The school is well equipped and includes a staff of 19 professors, many of them Europeans. Until 1957, fifty-two students had graduated. Most of the students have fellowships. A small number of non-Venezuelans have graduated from the school.

CHILE. There are two schools of forestry, one located in Santiago as part of the Universidad de Chile and the other in Valdivia as part of the Universidad Austral.

The Santiago school is administratively a part of the School of Agriculture and the two first years have similar training. The remaining three years are dedicated to forestry courses. This school is rather new and the approximate number of students who have graduated is about 12.

The school of forestry in Valdivia with a forest curriculum of five years is currently staffed with three European foresters besides technicians from other fields. Nineteen-sixty is due to witness the first graduation.

ARGENTINA. The first school of forestry was initiated in 1958 in Santiago del Estero. No students have graduated to this date. The course includes five years. Another forestry school is due to open soon in La Plata.

(2) Schools of Agriculture with Training in Forestry.

It is a very common pattern in Latin America to offer courses in forestry in schools of agriculture. In fact, in the majority of the countries, the forest services or other organizations dealing with forestry aspects are staffed with agronomists ("ingenieros-agrónomos") generally with some training in forestry.

There is considerable variation as to the amount and quality of forestry training given. Forestry courses are generally given in later years. The following list is based on Cianciulli's data[2] supplemented by personal information:

2/ op. cit.

Country	Number of schools of agriculture with training in forestry
Argentina	5
Bolivia	1
Brazil	10
Chile	1
Costa Rica	1
El Salvador	1
Ecuador	3
Guatemala	1
Haití	1
México	1
Perú	1
Puerto Rico	1
Uruguay	1
TOTAL	28

Ranger Level

There are at the present moment six schools which offer regular training at that level. They are:

1) Escuela Forestal de Pozos Dulces, Habana, Cuba with a 3-year course.
2) Escuela de Guardias Forestales, Uruapan, México.
3) Escuela de Capacitación Forestal, Amatitlán, Guatemala with a two-year course (formerly one).
4) Escuela Industrial de Silvicultura, Universidad del Trabajo, Maldonado, Uruguay, with a 3-year course.
5) Escuela de Capacitación Forestal, Universidad de los Andes, Mérida, Venezuela with a 3-year course.
6) Escuela Forestal, Concepción, Chile, specialized in training young men for forest fire fighting activities, with a one-year course.

There are several other schools which give some forestry training at that level but forestry is not the main subject of training. This is the case of the so-called "vocational schools", such as can be found in Chile, where students receive training in forest machinery.

In the tropics, the Escuela Agrícola Panamericana an agricultural school located close to Tegucigalpa, Honduras, and sponsored by the United Fruit Co., offers courses in forestry under the direction of a graduate forester. This school is due to increase its status to offer a Bachelor of Sciences (U. S. level) degree in the near future.

Other Levels

(1) Short courses

Both the Organization of American States (OAS) and the International Cooperation Administration (ICA), with active support from the Food and Agriculture Organization of the United Nations (FAO) have been offering short courses varying from 1 to 9 months. The pattern varies with the organization and the level of the students.

The longest course considered under this heading is offered by Project 29 of the Technical Cooperation Program of the OAS. This project is called "Evaluation of Natural Resources". Training is given by the Pan American Training Center for Natural Resources, which has been operating since 1954 at the "Universide Rural", close to Río de Janeiro, Brazil. In 1959, nine students from seven American countries took the course which dealt with natural resources with reference to forestry. The courses include the following headings: forestry, conservation, management and utilization, forest engineering, statistics and meteorology. There is also an extensive practice period.

The largest number of short courses offered by a single organization can be credited to project 39 of the Technical Cooperation Program of OAS. These courses are intended for technicians in service from different countries with comparable ecological and social backgrounds. For this purpose, Latin America has been divided into "Caribbean," "Andean," and "Southern" zones. To this date, twelve international forestry courses lasting generally between one and two months have been given in ten different countries. The program has also sponsored and directed "national" courses; that is, for students of one single country.

A similar international course lasting three months has been offered yearly since 1955 by ICA in Puerto Rico. Besides Latin America, other countries of the world are also represented.

In almost all these short courses there is an active cooperation between local and international organizations, especially in connection with funds and teaching staff. The participants are almost always benefited by fellowships that cover all the expenses and are offered to their country. The benefits of such courses are considerable since it is possible to offer an intensive training program within a very short period. Moreover, there is an active interchange of information among participants and many other benefits are derived. A professional association, the "Sociedad Dasonómica de la America Tropical" or "SDAT" (Society of Tropical American Foresters) was founded during one of these courses.

However, it is felt that such short-term training should not be considered as a substitute for a solid college education which requires several years of study. It is, rather, a useful complement.

(2) Study trips

One kind of training which involves a tour, usually to the United States or Europe, but occasionally including other countries, has been sponsored by FAO and ICA. Such tours have been offered to technicians in service or exceptionally bright students. Duration varies according to each case and formal courses are usually not included in the schedule.

(3) Students in Forestry Schools outside Latin America.

A certain number of technicians have studied forestry in universities outside Latin America, almost always the United States. Their number is unknown to the writer but may be estimated between 20 to 30. Most of them hold master's degrees, or to a lesser extent, bachelor's degrees.

Problems Related to Forest Training

(1) Libraries

Libraries with a good coverage of forestry items are scarce in Latin America. Except for a few schools and research institutes, they are deficient in both materials and services.

(2) Lack of textbooks

Few textbooks on forestry are adaptable to local conditions and have been published in the native languages of Latin America. Argentina has made some valuable contributions in recent years. The excellent forestry series issued by FAO and which has been translated into different languages has been most useful and is being used extensively in many training centers.

(3) Lack of research and publications.

Forest training when it is not based on sound research within the country or the region is bound to face serious limitations. At the present moment such research is almost nonexistent in many countries and insufficient in others. This has been attributed to the lack of qualified technicians to carry out such research. Another reason may be the lack of interest and hence of funds budgeted by most governments towards long-term research projects. The Latin American Forest Research and Training Institute, which has been operating in Mérida, Venezuela for the last six years, has already made important contributions towards solving this problem on a regional basis but much more is needed.

(4) Deficiency of teachers

The actual teaching staff is far below the needs. In some forest schools, training is given by visiting technicians who are working in the country under short-term technical assistance agreements. Even if their contribution is a valuable one, their status can only be considered as provisional. Their absence after termination of services often creates an irreparable gap in the training program of many countries that are neither technically nor financially prepared to provide for a replacement. Finally, it must be said that in some schools, forestry courses are given by teachers who do not meet the high academic standards that are required to fulfill their tasks.

FUTURE NEEDS

What are the future needs for professional foresters in a region where the rate of population growth is one of the fastest in the world?

For the immediate future, it appears most urgent to provide for the technical administration of millions of square kilometers of existing forest lands, most of which belong to the governments, so as to avoid further senseless destruction and meet the rising demands for forest products.

Technicians are also necessary to plan for national parks, so as to obtain the largest benefits for recreation, water and soil conservation as well as wildlife, scenic, and scientific values. An increasing numbers of technicians will soon be absorbed by private forest industries that are mushrooming in Latin America, following the trend eloquently shown by many other countries in the world that have passed through similar stages.

Finally, a large number of highly qualified foresters will be needed for research and training activities. Training will have to be carried on at all levels. Extension foresters may well play an important part in such an education program.

It would be impossible to supply the exact number of professional foresters which are needed immediately, but if the expectations of a rising and more demanding population are to be properly evaluated within the framework of general development that is taking place, the adequate number should doubtless pass the 5000 mark. Today, there are probably less than 500 graduated foresters, and half of them probably correspond to México.

Furthermore, it appears obvious that for the time being, the greatest need is for technicians of higher levels. These may do most to promote change in the status of forestry within their countries, influence the Governments and public opinion. It would be highly improper at this stage to provide for technicians with low academic standards and leave the task of planning and high-level administration of forest resources to non-technical persons who often prove to be skillful politicians. It is clear that the long-term goal should be to establish a proper balance between technicians of all levels, but for the immediate future, it is necessary to face a situation of emergency.

All this indicates that a strengthening of forest training at the higher levels is in order. This demands reinforcement of existing schools at the college and post-graduate levels as well as the establishment of new schools whenever the importance of the forest problems warrants such a step.

Such policy will undoubtedly produce the required leaders that history has demonstrated are responsible for major improvements. Provided with the necessary knowledge and prestige, those leaders should produce the necessary changes that will elevate forestry to its proper status, enabling it to better serve the needs of the population.

Pulping Tropical Woods

by
DR. L. J. RYS
Celulosa de Chihuahua
Anáhuac, Chih., México

General Remarks

The steadily growing population and improvement of the standard of living is causing a higher pulp and paper consumption in every country. The necessary wood fibers for paper making will very likely remain the cheapest for a long time. As you well know, in the past the pulp and paper industry did use selected trees only, but due to the scarcity of these selected trees and also to the development of pulping and paper making methods many new cheaper wood species are used today for chemical, semi-chemical, and mechanical pulp and paper manufacture.

According to FAO statistics[1] the world forest land area is divided: (in million hectares)

Latin America	927
Africa	801
U.S.S.R.	743
North America	656
Asia	567
Europe	136
Pacific Area	85
Total	3,915 million hectares

To simplify our problem let us study the condition of only the biggest part, Latin America. There, according to FAO, from 927 million hectares, the productive forest consists of:

727 million hectares of broadleaf trees.
15 million hectares of coniferous trees.
8 million hectares of mixed trees.

1/ F48/CO 1/8-April 19, 1948: ST/ECLA/Conf. 3/L.3.01
ST/ECLA/Conf. /L.4.0
ST/ECLA/Conf. /L.3.0

The first largest group consists of virgin broadleaf forests where we can find on one hectare 50 to 100 or more different wood species. From the total 800 million hectares of forest only about 70 million are utilized, almost exclusively for lumber operation.

The second group, 15 million hectares of coniferous wood, is located in the northern part of Mexico, on the hills in Central America, in Brazil as natural and planted Parana pine, and in Chile as planted forests of *Pinus radiata*. This coniferous wood —except in Central America— is already used for pulp and paper making with satisfactory results.

There exist also planted forests of broadleaf trees in Brazil and Argentina. In Brazil eucalpts were planted originally by railroad and mining companies in Sao Paulo State and Minas Gerais; in the south of Brazil, the acacia negra (black wattle) was planted by the tannin industry. Because of availability of other fuel supply the eucalyptus is free now for paper making but the black wattle wood is not used for pulping as yet. In Argentina the paper industry planted poplar and willow trees for its own use in the Delta of the Parana River. A big part of the natural coniferous forests in Latin American countries is used by the saw-mills for lumber and board making because the broadleaf forest does not have enough species which are soft and durable and which could be profitably extracted from the forest.

The paper industry always did and does like long coniferous fibers which have a universal utilization, and are difficult to replace for the manufacture of certain papers, especially if the product has a low price, like newsprint and strong wrapping paper. There is no problem to make white, higher priced and better quality printing and writing papers from bagasse, straw or short hardwood fibers, but the market for these papers is limited. Therefore, these countries where natural coniferous trees are missing or scarce, have to plant them or look for a method of how to replace them.

The planting of conifers is not always an easy problem. Chile was lucky with its plantation of *Pinus radiata* and has already an export pulp and paper industry based on these forests.

The same wood planted in Brazil and Argentina gave complete negative results due to reverse humidity conditions in winter and summer compared to Chile.

There exist methods for utilizing short-fibered broadleaf trees for newsprint making, but it is still not easy to replace the kraft pulp from conifers with broadleaf wood pulp for manufacture of strong bag papers.

To decide what is best —whether to plant your own broadleaf tree forest or to utilize the virgin forests already existing— is a question of pure economy and some technical consideration.

The main pros and cons for these alternatives are the following: Buying already planted eucalyptus forest and more land for planting the same is pretty expensive, but the total necessary forest area is small due to the high yield per hectare. The mill is built in already civilized country and can get the skilled workers easily. The distance for transporting of raw materials to the mill and finished product to the consumer is short. It is safer and easier to work with only one well known quality of wood than using the variable mixture from a tropical forest.

When the mill is built in the virgin forest the wood is cheap but the construction is more expensive, and the transportation is usually very complicated; people are hard to get even if a new town is built with hospital and schools. The raw material is not uniform and may change its quality daily. To cover better the unproductive investment, the mill has to be built big enough, but the high production usually does not correspond to the consumption capacity of the country.

This is the main reason why the utilization of the virgin tropical forest for pulp and paper manufacture does not develop quickly enough at the present time and why it is limited to utilization of the virgin pine forests only.

It should be investigated whether some combination of pulp making in the virgin forest with another wood or land utilization or other activity may not considerably increase the economy of the project and make it financially safer. Such a possibility depends of course completely on the local conditions.

There is another important problem in connection with the utilization of the virgin tropical forest. What will happen with the cleared up forest land? If left alone, another uncontrollable type of wood or bush will grow there or the rain will wash the humus away. If trees shall be planted there, what kind shall they be? The proper solution of this problem is very important for the economy of the project.

Technological Consideration

As mentioned above, on one hectare of virgin forest sometimes more than 100 different species of wood could be found. The distribution of the species can be very irregular in the different forest districts, some species being more concentrated in certain localities than others.

There are of course certain differences in woods of tropical and subtropical regions. Surveying tropical forest north of Manáus it was found that 3 to 4 trees out of 10 have some sort of latex. Half of the rest is very hard wood, and only the other half is wood of lower specific gravity.

Specific gravity:	24% less than 0.45, lowest 0.23 53% between 0.45 and 0.70 23% higher than 0.70, highest 1.00
Extract alcohol-ether:	1.1 - 16%
Pentosans:	8.4 - 20.1%, average 14.8%
Ash:	Maximum 2%, average 1.15%
Lignin:	18 to 45%, average 28.8%
Fiber length:	0.5 - 2.2 mm. from which are 22% up to 0.8 mm. 52% 0.8 to 1.2 mm. 26% more than 1.2 mm.
Color of the wood:	16 - 40 Photovolt.
Barking loss of 10-20 m. round wood logs:	10 - 21%

The individual cooking of 59 species from Parana by normal sulfate process in the laboratory shows that:

58% give very good strong pulp

25% give medium strong pulp

17% give low strength pulp

The bleached sulfate pulp of +80 Photovolt color from the mixture of 30 unselected Parana woods, beaten to 55°S.R. gives an average strength of: Tensil 8,000; Fold 400; Mullen 4.5; Elmendorf 80.[2]/

The bleached sulfate pulp of +80 Photovolt color from a mixture of 21 species selected by FAO from Amapa Brazil, beaten to 55°S.R. gives: Tensil 8,000: Fold 600; Mullen 4.5; Elmendorf 106.[2]/

The average properties of these 21 Amazonas wood species were:

Specific gravity:	0.35 - 1.1
Extract alcohol-ether:	0.5 - 5.5%
Pentosans:	7 - 12.5%
Lignin:	26 - 33%
Fiber length:	0.8 - 2 mm.

2/ FAO Buenos Aires Meeting 1954 report (Rys, Bonisch, Overbeck, Swarz). In this work details may be found concerning chemical analyses and fiber dimensions and fiber length distribution.

Examination of 126 species of subtropical Parana region gave the following results:

According to the publication of I. R. Ystas and E. L. Rackelboom[3]/ there does not seem to be great difference between tropical wood from Brazil and Africa.

It is interesting that the trees from the Amazonas are rich in latex but the alcohol-ether extract is lower than from the Parana subtropical trees. The high rosin content (10-16%) of some Parana woods has, of course, a big influence on the sulfate cooking of the respective species, because the rosin consumes the big part of the alkali, before the cooking really starts. We did not have the opportunity to study the influence of the similar latex substances on the cooking of the Amazona wood, but we isolated the rosin of some Parana rosin-rich trees. These rosins are highly acid and do polymerize easily. The rosin from the cambui wood (with about 12-16% rosin) gives a hard non-sticking surface after drying similar to shellac.

The selected Parana subtropical woods were also cooked by sulfite and neutral sulfite and bleached. For the normal calcium sulfite cooking the wood must be selected. Many mill cooks were made and pulp bleached.

3/ Contribution a l'étude Chimique des bois du Mayumbe (Publ. de l'Institute National pour l'étude Agronomique du Congo Belge No. 53, 1952).

While using acid cooking, it was observed that some wood has a tendency to give a dirty pulp after bleaching, caused by small black points, especially in summertime. Otherwise the pulp quality was similar to aspen or beech sulfite pulps.

The neutral sulfite cooking was done only in the laboratory using mixed wood. The unbleached yield was 75%, yield after bleaching 58.59%. The chlorine consumption depends on the lignin content of the wood. The bleached pulp beaten to 55°S. R. gave: Tensil 9.6; Fold 535; Mullen 5.9; Elmendorf 63.5.

The sulfate process seems to be the best one for tropical wood because practically any kind of wood may be used. The yield and strength of the unbleached pulp are relatively good and the bleaching in several steps gives good white pulp. This is in agreement with the work of W. Overbeck and C. Agattani[4]/.

For all sulfate cooks mentioned above normal standard sulfate procedure was used, only the temperature was kept lower than normally used for pine. The properties of the pulp from mixed wood are similar to sulfate pulp from eucalyptus, but some selected wood, for example imbauba (cético), gives much superior pulp. Imbauba grows in the Amazonas everywhere, where the virgin forest is cleared up, but the artificial plantation of this tree is not easy and shall be studied. A similar low specific gravity tree in the Amazonas, but with a darker color of wood and special smell is the Sumauma. R. O. H. Runkel[5]/ found excellent strength properties for a similar light African wood, *Musanga smithii.*

It is possible that the application of chip breakers and two stage sulfate cooking, which will improve the penetration and remove the extractives before the actual cooking, may further improve the results obtained.

It should be kept in mind that the standard sulfate cooking, such as is used for conifers, must be properly modified when used for broadleaved wood. Figure I shows clearly how different is the solubility of parana pine wood and black wattle wood in diluted caustic solution at different temperatures. Figure 2 demonstrates the different solubility of lignin, pentosans, and hexosans of the two species under equal conditions. Sawdust of 0.2-2 mm. was used for these tests.

I would like to make a few remarks about black wattle wood. As is well known, this tree is planted for its high tannin content of the bark. In Brazil it is planted in Río Grande de Sul and the wood available today may give about 200 tons of pulp per day. The growth cycle is 7 years. It is not well enough known that pulp made from this wood is better than from eucalpytus and the yield is higher. The reason is a low lignin content —only 22%— and higher pentosan content, 24% aganist 16% of eucalyptus. The yield of sulfate pulp with a Roe No. of 3.6 is 53%; with a Roe No. of 7 it is 60%. It is interesting to note that while this wood has shorter fibers than eucalyptus the Elmendorf test is higher.

The utilization of subtropical and tropical trees for groundwood manufacture is handicapped usually by darker color of the wood itself. The eucalyptus is ground in Australia in commercial quantities and old wood is preferred for groundwood manufacture giving a better fiber strength. The Brazilian newsprint mill project with eucalyptus cold soda pulping is still pending.

There exists also a project to pulp and make groundwood from imbauba on the upper Amazon in Perú for newsprint production. In Brazil sometimes the kapok tree wood *(Paineira branca)* is used for grinding in small quantities.

As is well known, short-fibered wood does not give groundwood pulp suitable for newsprint. Therefore the cold soda process is recommended for these woods, but the lower

4/ Wilhem Overbeck and Cyro Agattani: Uber das Verhalten eingelner Holzsorten, etc. Das Papier 12,371,578 (1958)

5/Roland O. H. Runkel: Pulp from Tropical Wood. Milteilinigen der Bundesanstalt fur Forst und Holwirtschaft No. 29, 62 (1952).

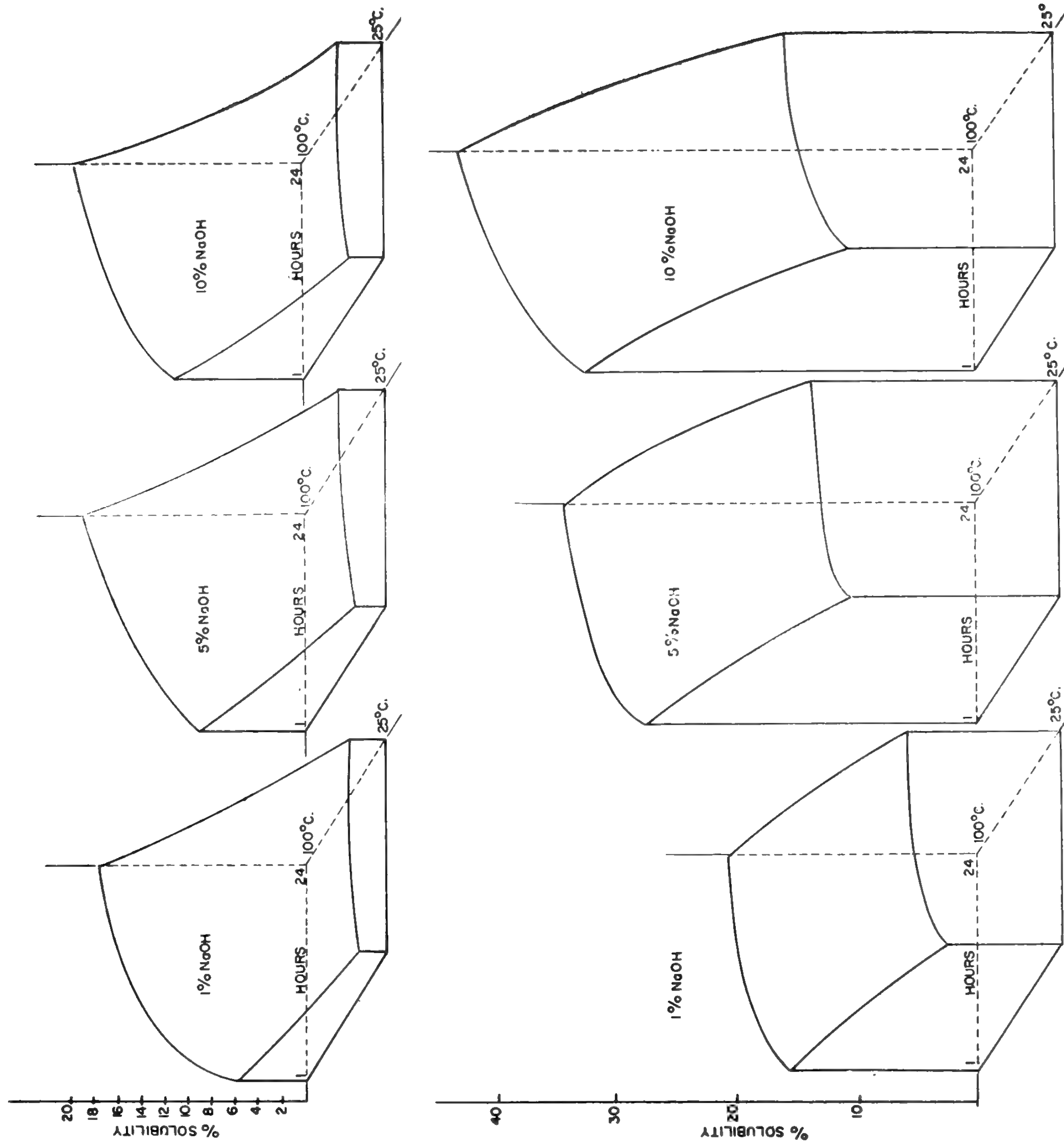

Figure 1. Solubility in NaOH solution. Upper: Paraná pine. Lower: Black wattle

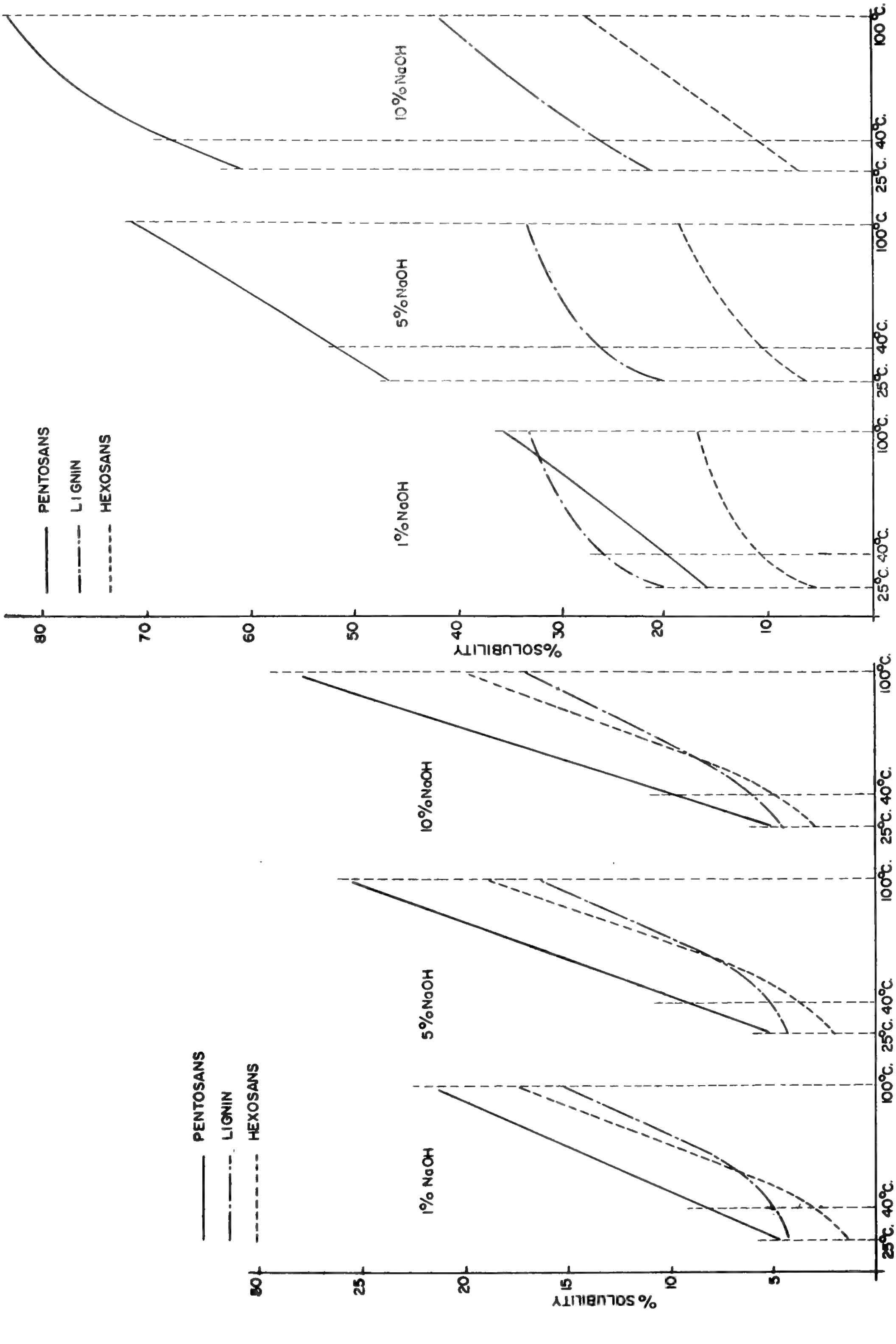

Figure 2. Solubility of lignin, pentosans, and hexosans. Left: Paraná Pine. Right: Black wattle.

yield, chemical treatment and the necessity of bleaching does increase the cost of the groundwood. Another possibility is to cook the chips briefly with sodium sulfite before defibering them. Using Brazilian eucalyptus, groundwood of color 60 without any bleaching could be prepared by this method. The application of the last method for other tropical species is not examined yet.

Practical Aspects

As mentioned before, to build a pulp mill in the tropical broadleaf forest is a question of economy. Such a mill has to make bleached pulp —because nobody will buy unbleached short fibered dark pulp— or still better make and sell paper, because the probable variable quality of the pulp made of non-uniform wood could be better hidden in paper making.

If the mill sells pulp, the same has to be at least as good as eucalyptus or imported birch bleached sulfate pulp and reasonably cheaper. If the country where the mill is located cannot consume all the produced pulp, the mill has to export it for a lower price than on the international market. If the mill makes paper, it has to realize that this can be sold in his own country only, because of the high import duties everywhere else. The only exception would be the newsprint and this paper is not easy to make at present from tropical woods in a satisfactory international standard quality.

The new mill has to be big enough to cut down the investment and production costs. This indicates that such a mill shall be built in a big country with rapidly growing paper consumption. The location of the mill has to be selected to have cheap transportation possible —like the Amazon River— to the main consumer centers..

Due to the difficulties mentioned above, the financial risk is higher for building the mill in a tropical forest than in an already civilized locality. The easier way to start would be to build the mill as a part of an industrial combination. For example, in the Amazon Valley the combination with the jute processing and sugar cane plantation, lumber and rubber business may be considered. Such a commercial activity already exists. In such a combination the paper industry may utilize first, as raw materials, the agronomic products or waste products and successively use more and more wood as future basic raw material.

The utiilzation of subtropical broadleaf trees from mixed forest is already done in Parana, Brazil. The mill started its production using the Parana pine for sulfite cooking and grinding, while the hardwood was used for semi-chemical cooking by the soda-sulphur method with no recovery and commercial paper, mostly top liner, was made on a cylinder machine from this semi-chemical pulp. The further logical development was to cook the hardwood by normal sulfate process with chemical recovery and to bleach the pulp.

As soon as the virgin forest is cleared up and the land eventually cleaned by burning, some decision must be made on how to utilize the cleared up land. If the conditions are favorable for pine plantation, then the solution is an easy one. If not, some other tree species must be selected for planting.

The pulp mill would like to have the forest near the mill, with a high yield per hectare. The wood should be easy to pulp, giving pulp which can be easily bleached and with a good fiber strength.

After the chemical selection of the existing species in this respect is made, then the work of the forester begins. He has to study especially:

Possibility of planting

Speed of growth

Shape of the trunk and its uniformity

Barking possibility

Utilization of the branches

Need and the cost of the cleaning of the plantation

Resistance to the insects and sicknesses of living trees

Danger of decay during the storage of the pulpwood

If pure or mixed culture shall be used

Proper soil quality for different species

In other words, a solution has to be found on how to transform the tropical forest into an industrial forest, producing steadily the best crop suitable for the pulp mill. To solve this problem a generation may be needed to find out and establish the proper conditions.

Of course, a quick solution would be to plant some known trees, like eucalyptus, which grows nearly everywhere and desist on the development of something better and avoid the headaches.

Because we already know that in the tropical forest are trees with a much better fiber quality than the generally known hardwood fibers, I believe that it is really a very tempting proposition as much for the forester as for the pulp maker to develop a new type of forest with a high industrial value and at the same time to introduce civilization to the least known parts of the world.

I hope that such a united effort will be realized with success in the near future and will open new horizons for the forestry as well as for pulp and paper making.

Potentialities of Tropical Forests in the World's Timber Economy

by

C. SWABEY and A. E. CHITTENDEN

Colonial Office, England

Today an increasing area of tropical forest is coming under scientific management and all over the world the tropical forester is having to ask himself the question — what species should I be growing for the markets of the future?

There are, in fact, two main problems:

(a) what species of the natural heterogeneous mixed tropical high forest can be marketed during the current rotation?

(b) in regenerating the forest what species should be favoured for the future?

Marketing the Present Crop

The most marked feature of tropical high forest is the enormous number of species present: for example, in Malaya out of some 3,000 woody species, nearly 600 reach timber size and any one acre of natural forest may contain trees of up to 100 different species. Comparable figures apply to tropical forests in other parts of the world.

Out of this enormous number only a handful can find a market today; in a number of British territories, (for example, Trinidad, Malaya and Uganda) local consumption is reaching a point where an increasing number of species, if of reasonable form, can be marketed locally for timber. This is assisted by the increasing use of preservative treatment. On the other hand in territories such as British Guiana, British Honduras, West Africa, Borneo, and Sarawak current exploitation is based on selective export markets.

Thus, for many years to come, in the latter territories only a small proportion (though gradually increasing) of the natural stand is likely to be utilised for timber. To what extent can the residuals be used for production of pulp or reconstituted building board? It is now generally accepted that there is little technical difficulty in pulping heterogeneous mixtures of tropical hardwoods, by the sulphate process at any rate. This has been ascertained by many research workers and also on a small commercial scale at the Bimbresso project on the French Ivory Coast. The varying densities and chemical composition of these timbers, do, however, impose restrictions on the choice of pulp production processes. For instance, the presence of an appreciable proportion of high density or highly resinous timber would make some semi-chemical processes difficult. Some work on this problem is being done in London and in Australia. This restriction of choice of process may pose further problems in underdeveloped countries owing to the limited range of naturally-occurring chemicals, the use of which is essential, since they play an important part in the economics of pulping. Further, the quality of the pulp is such that it is doubtful whether it could be freely sold on the world's pulp market in competition with that produced from the large managed coniferous forests of North America, Scandinavia, and elsewhere. Many of the countries which are faced with this problem have at present only a small "all grades" pulp and paper consumption and are unlikely, for many years, to be able to utilise more than a small amount of this locally mixed material.

The extraction from the forest of large timber of this type for pulp wood is likely to be expensive; many of the species are non-floaters; so cheap water transport is impossible. Much of the timber is over-mature and often contains a large proportion of fungally attacked timber, which is not discovered until it is chipped, while there is a tendency in tropical conditions for rapid deterioration of the timber on the forest floor or in the log-yard.

All these factors tend to make the cost of pulp wood from this source expensive, while processing costs in an under-developed country tend to be high. In general, therefore, one may conjecture that the probability of economic chemical pulping of these mixed residuals is not high and that better prospects are afforded by the products of managed tropical forests.

Meanwhile further research is needed in the use of semi-chemical techniques on mixtures of these residuals, especially for the production of bleached grades of pulp. The production of bleached or semi-bleached grades (i. e. for newsprint) has proved difficult, since it has been found impossible to eliminate black specks and other blemishes from these semi-chemically pulped mixtures.

As local markets expand the use of this material for the production of coarse unbleached pulps, for the local manufacture of fibreboard (both carton and hardboard), and possibly very coarse wrapping paper, might be possible.

The production of building boards, such as chipboard (particle board) wood slabs, and similar products, from these materials (together with saw mill waste and other residuals) also requires further research. Here again it seems highly doubtful whether these products could be economically disposed of in world markets and must rely on development of local or regional consumption demands.

Forest Regeneration and the Markets of the Future

As these mixed tropical hardwood forests come under more intensive management the forester is forced to take management decisions which will affect the species composition of the crops maturing in 35 - 80 years' time, a composition which, in varying degree, he can specifically control by silvicultural treatment.

To start with the forester must eliminate from the crop those species which:

(a) are intrinsically likely to be unmerchantable owing to inherent poor quality of timber, form of tree, etc.

(b) are so slow-growing as to be uneconomic.

These, of course, are negative aims but, on the positive side, he must try to forecast the pattern of marketing of the crops of the future which he must start raising today.

Here the most significant pointers are to be found in local per capita timber consumption figures and population trends in the under-developed countries.

Rapidly rising standards of living and an increasing rate of industrialisation are coupled with rates of population increase which, in many tropical countries, will see a doubling of the population in as little as 30 years. It is difficult not to foresee a dramatic rise in the gross domestic consumption of wood products in these countries, even if there is a falling off (already evident in some tropical countries) in demand for wood fuel, owing to electrification and use of petroleum products. For example, estimates made in Malaya indicate that her role of timber exporter will be reversed by the end of the century and that she will be a net timber-importer unless the level of forest improvement operations is substantially stepped up.

Imports of tropical timber by OEEC countries over the past six years have been as follows, including logs, sawn, and veneers:

(value in '000 U. S. $'s)	
1953	102,793
1954	122,844
1955	157,189
1956	173,018
1957	204,164
1958	220,977

It is perhaps probable that the ratio of log exports will drop as processing capacity increases in the producing countries, although this certainly is not evident in the European trade figures at present.

It is evident that the tropical forester will, in the first place, have to provide large quantities of general constructional timber for local requirements; with the increasing use of pressure treatment processes he need not confine himself to the traditional naturally durable species.

He will also wish to know whether he can expect a continuation of exports; in this context we are excluding specialized timbers such as teak *(Tectona grandis)*, ebony *(Diospyros* spp.), balsa *(Ochroma* spp.), greenheart *(Ocotea rodiaei)* etc. and are considering only those timbers which can be produced in bulk and can hope to find a bulk market in world trade.

There seems no reason to suppose that there will not be a continuing world demand for the following main groups; examples are given of some of the principal species entering the United Kingdom market:

(a) light constructional, joinery and plywood

Ramin *(Gonystylus* spp.), Obeche *(Triplochiton scleroxylon)*, Abura *(Mitragyna ciliata)*, Agba *(Gossweilodendron balsamiferum)*, Seraya *(Parashorea spp.)*, Idigbe *(Terminalia ivorensis)*, Meranti *(Shorea* spp.), Nyankom *(Tarrietia utilis)*, Gaboon *(Aucoumea klaineana)*.

Increasing interest is being shown in European markets for other light hardwoods such as *Pycnanthus, Antiaris, Pterygota, Celtis, Sterculia,* etc.

(b) decorative and furniture

Mahogany *(Swietenia & Khaya* spp.), Utile & Sapele *(Entandrophragma* spp.)

(c) durable constructional

Keruing *(Dipterocarpus* spp.), Teak, Iroko *(Chlorophora* excelsa), Afrormosia *(A. elata)*, Greenheart.

Within this over-simplified grouping the forester will have to look for species which will give him the highest return; he will probably have to make a choice between the slow-growing, hard, heavy constructional timbers (rotation perhaps 80-120 years), the medium-growth cabinet woods (rotation 60-80 years) and the quick-growing light utility hardwoods (rotation 30-60 years).

In order to make it profitable to produce the slower-growing hardwoods they must attract a proportionate price differential. Regeneration costs have to be carried at compound interest to rotation age: for example the 5 per cent compound interest factor is 4.3 at 30 years but 131.5 at 100 years. It seems most unlikely that he could expect a compensatory premium value of this magnitude and he will have a strong incentive to produce crops maturing in the 30-60 year range.

It would seem therefore that preference should be given to regeneration with species such as *Triplochiton, Terminalia superba,* T. *ivorensis, Aucoumea, Maesopsis eminii, Tabebuia pentaphylla,* etc. There seems little doubt that species such as these would not have much difficulty in finding either export or local markets in the future. Provided that they also have acceptable pulping qualities, forests of this type would appear to be the answer, for the humid tropics. The extent to which this conversion of the natural forest could be secured by natural regeneration will depend largely on local circumstances, but in a number of tropical forests this process has already begun.

The complete utilisation of these managed forests needs outlets for thinnings and grades otherwise useless for traditional industrial purposes; such material would be a near-ideal source of pulpwood since it possesses very few of the inherent disadvantages of the heterogeneous natural stands. There is, in fact, no reason why, in suitable areas, such pulpwood should not be capable of competing in price and quality with that from the established pulp-producing countries. Research is therefore necessary to determine:

(a) the choice of species which will give adequate saw-timber yields and also produce material suitable for pulp-production and

(b) the more efficient utilization for pulp of the material from these forests not otherwise merchantable.

It seems quite certain that increasing attention will be given to the tropical pines, particularly P. *caribaea*, which is capable of high production at low elevations in the humid tropics; under suitable conditions the replacement of mixed forest by conifer plantations will produce a material of the highest flexibility, both for constructional timber and for re-constituted products.

Acknowledgements

We wish to acknowledge the permission to publish this paper given by the Colonial Office and by the Department of Scientific and Industrial Research.

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 [illegible] of the [illegible]. Manuscripts should be typewritten, double spaced, [illegible] [illegible] $8\frac{1}{2}$ x 11 inches [illegible] paper.

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Par les pages de cette revue les personnes qui travaillent aux tropiques peuvent être informées sur les problèmes spécifiques des forêts tropicales et sur les travaux effectués pour réaliser une amélioration [illegible]

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RIO PIEDRAS, PUERTO RICO

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Caribbean Forester

El Caribbean Forester es una revista semestral gratuita publicada en Puerto Rico desde el año 1938 por el Instituto de Dasonomía Tropical 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 Instituto de Dasonomía Tropical 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.

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Los manuscritos deben enviarse al Director del Instituto de Dasonomía Tropical, 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.

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The Caribbean Forester is a free semi-annual technical journal published since 1938 in Puerto Rico by the Institute of Tropical Forestry, 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 Institute of Tropical Forestry 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)
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Caribbean Forester

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Sumario

A Call For Manuscripts

The CARIBBEAN FORESTER is published for the benefit of the entire tropical region, including both hemispheres. The preponderance of articles from local sources in recent years has been partly because more work is now being done locally, but more because of a notable decline in the number of manuscripts submitted from outside sources.

Recently several potential contributors have inquired as to whether manuscripts are desired from outside the Caribbean region, or in the Spanish language.

We wish to emphasize that papers are solicited from throughout the tropics, in English or Spanish, and will receive consideration for publication on their merits without regard to source or language. We regret that we are currently unable to edit manuscripts in French or Portuguese.

Papers are normally printed in the order received, usually within six months. Suggestions for preparing manuscripts are printed inside the cover of every issue.

Se Solicitan Manuscritos

El CARIBBEAN FORESTER se publica en beneficio de toda la región tropical incluyendo ambos hemisferios. Durante los últimos años han predominado los artículos de fuentes locales. En parte esto se debe a que se están llevando a cabo más estudios localmente, pero en gran parte se debe a la notable disminución en el número de manuscritos recibidos de otros sitios.

Recientemente varios contribuyentes potenciales nos han preguntado si deseamos manuscritos de sitios que no pertenezcan a la región del Caribe y en español.

Deseamos aclarar que aceptamos artículos de todo el trópico, en inglés o en español, y se considerarán para su publicación de acuerdo con sus méritos, sin tomar en cuenta su origen y el lenguaje usado. Sentimos informar que por ahora no nos es posible redactar manuscritos en francés o portugués.

Por lo general los manuscritos se publican por el orden en que se reciben dentro de seis meses. En la cubierta interior de cada ejemplar del Caribbean Forester se sugiere como preparar los manuscritos.

Las Implantaciones Forestales en el Sur de la República de Chile[1]

Por

ENRIQUE OSWALDO VIDELA PILASI[2]

Chile, geográfica y ecológicamente es un país interesante por sus posibilidades forestales. Posee territorios fitogeográficos fríos y subtropicales desplazados, escalonada y progresivamente de sur a norte. El centro de vida y difusión forestal se halla en el sur rodeado de una climatología fría y lluviosa. Aquí está el material que Chile debe cuidar fundando emigraciones nativas diversas, centrales y septentrionales, asegurando sabiamente planes silvícolas de proporciones.

Las actuales impresiones objeto de este trabajo, ofrecen un ordenamiento silvícola con el propósito de estimular una práctica racional en el manejo de los suelos y una supremacía paulatina de los recursos forestales, sobre el criterio especulativo del actual hombre de campo.

LAS IMPLANTACIONES FORESTALES

Es necesario, que los agricultores chilenos reconozcan que los suelos del sur de Chile no son agrícolas sino forestales, siendo insostenible pensar en hacer agricultura racional y económica sobre ellos. Es menester no olvidar, que el cultivo bajo este sistema, de un suelo forestal, lo degrada, no por pérdidas apreciables de materia orgánica, sino por compactación y formación de horizontes ferruginosos impermeables en profundidad, siendo después de este proceso, totalmente imposible de inducir regeneración natural de las especies forestales remanentes, como tampoco lograr amplia y productiva movibilidad edáfica, con miras a la obtención de beneficiosas cosechas.

Chile debe, por intermedio de sus esferas gubernamentales o valiéndose de sus empresas privadas, propender al establecimiento de comunidades silvícola-agrícolas o bien a concretar un cooperativismo forestal activo orientado a la implantación, desarrollo y racional aprovechamiento de bosques en estos suelos. Sin duda, que el sistema "taungya", originario de países orientales y de provechosa aplicación en América Latina aporta a este problema seguras y fructíferas bases. La explotación simultánea y temporal, de cultivos estacionales, a las implantaciones forestales, en principio constituídas por especies "pioneers", respaldadas con métodos y técnicas silviculturales racionales y sencillas, facilita la introducción progresiva en la vida forestal, de suelos que hoy se explotan deficientemente con otros cultivos. Estos, se han implantado después de una irracional explotación forestal, cuyos extensos y heterogéneos macizos cubrían suelos de caracteres topográficos diversos, pobremente meteorizados en sus cualidades físicas y químicas. Con la destrucción de estos bosques, Chile, ha perdido una fuente importante de ingresos, que hoy se esfuerza en recuperar.

Hoy, la situación en esas zonas permite la introducción de especies forestales, o el aprovechamiento adecuado de los diseminulos naturales de las que aún subsisten, destinadas a implantaciones ordenadas y devolver paulatinamente la fisonomía fitogeográfica, que por naturaleza, le corresponde a estas latitudes.

1/ Esta publicación es el capítulo I del trabajo que el autor ha denominado bajo el título "Las Implantaciones Forestales y la Rotación Agrícola en el Sur de la República de Chile."
2/ Departamento de Investigaciones Científicas, Universidad Nacional de Cuyo, Mendoza, Argentina.

He constatado el adecuado crecimiento que adquieren pequeños grupos de especies forestales exóticas, como así también la vigorosa repoblación natural de especies forestales nativas sobre suelos abandonados o en la periferia de restos de montes adultos o en aquellos enfrentados a una negativa explotación. Los suelos degradados, como también los macizos forestales irracionalmente explotados, de ostensible difusión en las provincias chilenas al sur del Río Toltén, se reforestan económicamente dejando y cuidando los brinzales de especies indígenas propias de la región. También podría hacerse induciendo técnicas de viveraje adecuadas, destinadas al suministro de nuevos planes de reforestación en tierras fuera del alcance de la repoblación natural.

Cuando estudios y experimentaciones racionales indiquen lo contrario, es económico y técnicamente recomendable acceder a implantaciones forestales con especies exóticas. La mayoría de las especies forestales nativas en el sur de Chile demuestran cualidades sobresalientes en sus maderas para diversas aplicaciones; sin embargo no ha trascendido un conocimiento ordenado de las propiedades tecnológicas de las mismas y mucho menos intentos hacia la utilización de aquellas en implantaciones técnicamente aceptables. Esto es importante que lo tomen en cuenta los principales centros de experimentación e investigación forestal, evitando la desestimación de especies forestales, que se han originado y han evolucionado en el marco de las condiciones ecológicas y fitosociológicas propias de esas regiones y que es imprescindible devolver la primacía en los planes de nuevas implantaciones.

La Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO), Roma, ha publicado el 15 de julio de 1953 el trabajo titulado "The Engel Balled Planting Procedure" (Report of the first Session of the FAO Conference, Quebec, 1945), cuyas consideraciones prácticas en favor de los métodos que analiza, de aplicación también en los Estados Unidos de América, Australia, y otros países, son de inestimable valor en los propósitos de extensión de especies forestales nativas, de remunerativas condiciones de crecimiento y propiedades en sus maderas .

He comprobado directamente sobre el terreno la nobleza del "alerce" *Fitzroya cupressoides* (Molina) Johnston, en la construcción de viviendas y revestimientos exteriores de todo tipo, en confirmación de las propiedades conocidas de su madera, entre las que se destaca su resistencia a las condiciones de intemperie. Sus biocenosis naturales conforman y brindan al estudioso una rica gama de adaptaciones y capacidades selectivas junto a comunidades formadas por el Género Notophagus y sus diferentes especies botánicas, canelo *(Drymis winteri* Forst.), tepa o huahuán *(Laurelia philippiana* Looser), lingue *(Persea lingue* Nees), importantes por sus rasgos estacionales geomorfogenéticos. El hombre encuentra en estas maderas un producto liviano fácil de trabajar, pulir y pintar, dando una nota de sobria delicadeza a interiores y modestos revestimientos.

El maniu *(Podocarpus nubigena* Lindl. y *Saxegothaea conspicua* Lindl.), bajo estas dos formas específicas, son ejemplares de caracteres ornamentales y superando con facilidad y productividad sus aplicaciones en jardínes y forestación de calles. Reacciona favorablemente bajo formas talladas. Es especie de marcada especialización ecológica y predominante dentro de las comunidades forestales. Su aptitud y tendencia a formar macizos puros no excluye la posibilidad de efectuar forestaciones mixtas, siendo sus hábitos compatibles con el crecimiento de las restantes especies forestales nativas. Su madera une a la calidad de sus caracteres estéticos la estabilidad de sus formas aún bajo el influjo de condiciones ambientales marcadamente cambiantes. Es especie favorita en la construcción de viviendas caras y de muebles de valor.

El notro o ciruelillo *(Embothryum coccineum* Forst.), es una especie que se adapta magníficamente a los efectos de la poda. Es especie que tiende a desaparecer en el seno de comunidades cerradas, vegetando libremente en la periferia de ellas o en los costados de caminos. Su profusa floración, confiere a lo vigoroso y denso de su follaje caracteres típicos en el paisaje de estas latitudes. Su madera es de escasa aplicación por el desarrollo tortuoso de troncos y ramas. Por la gran resistencia de sus formas es sin duda una especie apta para colocar en las primeras introducciones (pioneers) sobre suelos a forestar, junto con especies de escaso valor en sus maderas: ulmo *(Eucryphia cordifolia* Cav.), tineo *(Weimannia trichosperma* Cav.), luma *(Amomyrtus luma* [Mol.] Legr. et Kaus.), olivillo o tique *(Aextoxicum punctatum* Ruiz & Pavón), laurel *(Laurelia sempervirens* Juss).

El ciprés de las huaitecas *(Pilgerodendron uviferum* [Dom.] Florin), es una especie marcadamente selectiva por sus exigencias bioecológicas, siendo dentro de sus respectivas estaciones típicamente excluyente e invasora. No es especie dependiente y por su tendencia a vegetar en lugares excesivamente húmedos es de valor para las futuras introducciones de suelos abandonados, dentro de reforestaciones ordenadas. La implantación a orillas de ríos y cursos de agua permite la utilización de suelos generalmente sin explotación alguna como punto de partida para la obtención de disemínulos diversamente adaptados. Esto es posible por las condiciones naturales de la región, propicias para una amplia difusión natural de la especie, que a su vez es acentuadamente valiosa por la intensidad de sus repoblaciones. Con el saneamiento de suelos con destino a la actividad agrícola, ha sufrido irracionales explotaciones, quedando su área de distribución reducida a pequeños islotes situados en lugares bajos e inundados. La madera es resistente a la podredumbre, encontrando aplicación en todo tipo de embarcaciones y construcciones que deben sufrir los perjuicios continuados de la humedad.

El avellano *(Gevuina avellana* Mol.) es una especie forestal intolerante, vegetando en la periferia de comunidades forestales densas, lugar en el que adquiere caracteres morfológicos de neta diferenciación en el paisaje forestal. Es especie difundida y su vida forestal transcurre en uniones sociológicas dependientes, lo que la coloca en situación de convivir con especies forestales nativas de valor económico en sus maderas. Por el valor de esta especie, especialmente en los caracteres tecnológicos de la madera, ha sufrido una explotación negativa desapareciendo paulatinamente sus comunidades puras. Esta modalidad en el aprovechamiento de los recursos forestales, de escoger los mejores ejemplares ha dado paso a especies forestales inferiores, alterando la composición florística y la vida sociológica de las comunidades dendrológicas del sur de Chile.

Esta referencia suscinta de algunas de las principales especies forestales nativas de Chile, la brindo con la convicción de que ella actúe de móvil animador para obras silvícolas de más aliento y eficacia.

Las reforestaciones de la zona central de este país, a base de *Pinus radiata* Don., necesitan en la actualidad formar tallares mixtos con especies forestales nativas, evitando así los riesgos propios de las plantaciones puras. Con notable economía, el sur de Chile, al heredar especies naturales capaces de entrar en las más diversas y productivas combinaciones silvícolas, lograrían macizos de insospechados alcances en la vida y modalidades de estas regiones.

Con ello Chile no haría excepción, pues países como los Estados Unidos han aprovechado de los brinzales jóvenes de pino blanco que crecen en el interior de los bosques adultos, para ampliar sus propósitos de reforestaciones en los parques nacionales del oeste; Costa Rica hace inteligente cuidado de los disemínulos naturales de laurel *(Cordia alliodora* [R. & P.] Cham.) en regiones de praderas; Puerto Rico se esfuerza en encontrar especies nativas que resistan la competencia de matorrales improductivos, para efectuar con amplitud, nuevas introducciones de suelos abandonados, bajo el influjo de la empresa forestal.

El sur de Chile cuenta con innumerables posibilidades de extraer provechosamente el repoblado natural de sus masas adultas y someterlos a procedimientos sencillos y ordenados de viveraje, fundando un productivo material para futuras implantaciones, ya directamente sobre suelos nuevos o abandonados, ya sobre campos de pastoreo bajo distanciamientos compatibles con el máximo beneficio hacia el crecimiento en comunidad con los pastos. Aquí la ganadería y la silvicultura fundarían una unidad en un medio que solamente a ellas les pertenece.

Los suelos que se destinan a nuevas praderas, están frecuentemente cubiertos de jóvenes plantitas. El cuidado oportuno de ellas, evitaría las dificultades que crea en cierta manera el transplante, a la vez que surgirían provechosas circunstancias de estudio que lograrían con el correr del tiempo muñirnos de un conocimiento sincero y productivo hacia recursos naturales que benefician los intereses individuales y nacionales.

La productividad de las existencias forestales naturales se ha encontrado en todo tiempo amenazada por el poder destructivo de los incendios, que junto con las desordenadas irrupciones del hombre, han convertido gran parte de la zona sureña de Chile, con capacidad forestal, en extensas regiones de suelos improductivos.

No deseo abundar en detalles sobre la técnica de prevención de incendios, perfectamente conocidos y analizados por una amplia bibliografía. Solo deseo hacer trascender, que pese a los negativos resultados hasta ahora obtenidos y que continúan, no han mediado conscientes soluciones ni en el medio Particular ni en el medio Estatal. Es necesario recordar, que la conservación de las fuentes naturales de riqueza, dentro de límites razonables, no puede dejarse librado enteramente al criterio de los individuos, sino que muy a menudo está mejor asegurada bajo el control del Estado. Una administración forestal positiva, no solo se impone para el futuro suministro de maderas, sino también para la eficaz protección de los bosques, tan necesaria, ya que su destrucción afecta seriamente el bienestar de la Nación. Es aquí donde las fuerzas constructivas del Estado encuentran segura acogida, aumentando la superficie de bosques de propiedad fiscal y cuidando mejor las posesiones forestales particulares.

La mayor inversión inicial que exige toda implantación forestal, comparada con la agrícola y el mayor tiempo que transcurre desde la plantación hasta la explotación definitiva del árbol, en relación con el corto ciclo vegetativo de los cultivos que actualmente se hallan en la región, ha de ser sin duda la primera objeción hacia la realización práctica y efectiva de estas recomendaciones. No obstante, en un esfuerzo conjunto como es el que demandan las mismas, es dable el logro de una política crediticia que solvente estas primeras erogaciones. La CORMA (Corporación Chilena de la Madera) dependiente de la Corporación de Fomento de la Producción CORFO, y la FAO, asisten económica y técnicamente las implantaciones forestales de la zona entre el Río Maule y Río Bio-Bio y también entre Bio-Bío y Toltén. No debe caer en la indiferencia, porque no surge fortuito, el cumplimiento de idénticos beneficios para las regiones al sur del Río Toltén hasta Chiloé, que ecológicamente son las más propicias para las expansiones forestales.

Reitero, los suelos del sur de la República de Chile deben ser dedicados exclusivamente a la empresa forestal, y en esta onda deben sincronizarse los esfuerzos estatales, particulares, industriales y comerciales.

RESUMEN

Los suelos del sur de la República de Chile son típicos por sus caracteres mecánicos, petrográficos y dinamogenéticos. Al norte del Río

Bio-Bio, se benefician con las previsiones y sistemas de una agricultura mediterránea. Al sur del mismo, están bajo la influencia directa de un cuadro hidrotérmico propio de las regiones oceánicas. En la primera, Chile cuenta con las mejores posibilidades para una actividad agrícola-industrial amplia y remunerativa; en la segunda, los cultivos agrícolas en vías de un exclusivismo deficiente, hacen peligrar los horizontes de estimación hacia las especies forestales nativas que conforman recursos forestales naturales originados y evolucionados en el marco de las condiciones bioecológicas propias de esas regiones y que es imprescindible devolverles la primacía en los planes de nuevas implantaciones.

Las especies forestales nativas del sur de Chile, no solo son sobresalientes por las propiedades de crecimiento y tecnológicas de sus maderas, sino por sus vigorosos repoblados naturales aptos para desarrollar eficientes planes de reforestación aún bajo el auspicio de métodos racionales de viveraje ("The Engel balled planting procedure". Report of the first Session of the FAO Conference, Quebec, 1945). Sin embargo, no ha trascendido un conocimiento ordenado de ellas y mucho menos intentos hacia la utilización de las mismas en implantaciones técnicamente aceptables.

Subsiste en la actualidad una negativa desmovilización del mercado forestal chileno y no pocas cosechas de madera permanecen sin comercializar dentro de una zona, que en sus orígenes contaba con las más valiosas posibilidades para un futuro promisorio de la Dasonomía Forestal, hoy totalmente alteradas y olvidadas.

La CORMA (Corporación Chilena de la Madera) y la FAO (Organización de las Naciones Unidas para la Agricultura y la Alimentación), asisten económicamente y técnicamente a las plantaciones forestales entre los ríos Maule, Bio-Bio y Toltén. No debe caer en la indiferencia, porque no surge fortuito, el cumplimiento de idénticos beneficios para las regiones al sur del Río Toltén hasta Chiloé, que ecológicamente son las más propicias para las expansiones forestales.

No es posible erradicar a corto plazo el actual concepto agrícola que subsiste en la parte austral de este país. Por esta razón doy un ordenamiento silvícola-agrícola con el propósito de dar prioridad a los recursos forestales sobre el criterio especulativo del actual hombre de campo.

SUMMARY

The soils of the southern part of Chile have certain characteristics. North of Bio-Bio River, they are subjected to a Mediterranean climate; south of this same river they are under the influence of an oceanic regime. In the former, Chile has the best opportunities for an ample and remunerative agricultural and industrial activity. In the second, the agricultural activities are endangering the natural forest resources.

The native forest species in the southern part of Chile are outstanding not only for their growth and the technological properties of their lumber, but for their vigorous natural regeneration and suitability for artificial reforestation. However, their characteristics are not well known and few systematic attempts have been made to utilize them.

At present a negative attitude towards the Chilean forest market exists and many lumber crops remain unsold within a zone originally considered to have a promising future for forestry.

Between the Maule, Bio-Bio, and Toltén Rivers CORMA (Corporación Chilena de la Madera) and FAO (Organización de las Naciones Unidas para la Agricultura y la Alimentación) assist economically and technically. Identical benefits should be provided for the regions south of Toltén River to Chiloé, which are ecologically the most favorable for forestry expansion.

It is not possible to eradicate in a short time the present agricultural attitude existing in the southern part of this country. For this reason, I recommend a silvic-agricultural management, to give priority to the forest resources.

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Teak and Fire in Trinidad

C. H. MURRAY, M. A. (OXON.)
Asst. Conservator of Forests, Trinidad & Tobago

Teak *(Tectona grandis* L. F.) was first planted in pure plantations in Trinidad in 1913 (Brooks). Since then the annual area planted has increased, slowly at first, until in 1958, 727 acres were planted bringing the total established at all centres to 11,626 acres. Teak is grown mainly in the south of the island where the terrain in places is steeply undulating. The early plantings were done on heavy calcareous clays with moderate to good drainage; more recently, less fertile soils have been used.

These plantations have been comparatively free from pests and diseases. About 1943 severe attacks by parasitic birdvine, mainly *Phthirusa adunca* (Meyer) Maguire, and to a less extent *Phoradendron piperiodes* (H.B.&K.) Trelease, were reported at most plantation centres. Since then, generally, the attack has not kept pace with the expanding areas of plantations. However at Mount Harris and Tamana, in the north of the island, infestation is still heavy in some coupes probably because of 'shelter-belts' of natural forest left around earlier coupes. These strips are the source of repeated attacks since there are at least 21 species susceptible to birdvine in the natural forest.

Periodically, defoliation by Bachac or Parasol Ants occurs without any noticeable effect on growth of the trees; generally, these ants display a distinct preference for vegetation with more tender foliage.

The most pressing problem associated with teak in Trinidad today is the hot surface fires which sweep through approximately 50% of all plantations each year. Often the same coupe is burnt twice in the same dry season.

At the beginning of the dry season the trees shed their leaves, by the end of March they are bare and the forest floor is carpeted with masses of bone-dry, crumpled, papery foliage ready to be kindled. In 1957 the Conservator reported, "The dry season was severe and prolonged and fires in teak plantations were the worst in the history of the Department. A total acreage of 5,700 acres of teak was overrun by fire and considerable damage in areas of two- and three-year old teak" (Annual Report, 1957). In 1958 approximately 3,000 acres were burnt and in 1959 in one Division alone 3,030 acres of a total of 5,430 suffered from fire.

The cause of these fires is not known with any degree of certainty. There are those who believe that the heat of the sun causes spontaneous combustion; others blame them on accidents, mainly cigarette butts from the users of roads through plantations. Undoubtedly accidental fires do occur, but in my experience these account for a very small proportion of all fires started. Most fires I believe to be deliberate acts. Nor are the plantation labourers themselves completely exonerated; they stand to gain most by way of overtime work to control the fires. It is perhaps significant that during the last twelve or fifteen years there is no record of a single fire having started, by accident or otherwise, in coupes situated near to the plantation office in Brickfield.

Teak is by repute a fire resistant species. This is true where fleeting fires are concerned. However, in Trinidad, these annual fires can be very hot especially in the younger plantations where for various reasons, the taungya cultivators have left unburnt logs behind or after thinning, when lop and top etc. litter the floor of the compartment.

Forest fires are of little public concern except to the owners of property adjoining teak plantations and I have found that many people believe fires in teak plantations to be deliberately set by the Forest Department staff. They confuse these seasonal fires with the controlled burns used in clearing the natural forest to make way for taungya planting.

Plantations up to 3 years old pose no serious problems. Most stems are killed outright by the first fire but are rapidly replaced by extremely vigorous coppice shoots which soon outstrip in height any survivors of the original planting. Even stems which appear to be in check for two or three years coppice vigorously after the fires, producing in two months twice or three times the height growth of the original stems. These observations have led to experiments to prove the hypothesis that a controlled burn at the end of the first or second growing season after planting will produce more regular and more vigorous stands. How long this extra vigour will persist is a matter for future investigation.

From the fourth year onwards fires do permanent damage to the stand; the bark is not really thick enough to withstand excessively high temperatures and the stems are now too large to be economically cut back. In the fifth year, thinning adds extra fuel to what is already present. Scorching causes death of the bark, exposure of the wood and subsequent fluting of the bole. Scars render affected trees susceptible to fungal attack. Occasionally thinnings from 15-year coupes have shown signs of incipient butt rot associated with what appeared to be fire damage at an early age.

As the coupes grow older bark protection is more efficient; at the same time, the intensity of the burns decreases because the amount of fuel wood in the coupe is progressively reduced by repeated burning.

H. R. Blanford found that fires often led to the production of epicormic shoots on teak. He quoted an example of fire epicormics in a plantation in the Toungoo Division in Burma. In Trinidad, this tendency has not been observed, nor are epicormic shoots more common in plantations regularly burnt. Brooks (1941) attributed the presence of epicormics on Trinidad teak to under-thinning. However, the possibility of epicormics being due to heredity rather than environmental differences should not be overlooked. Laurie and Griffiths (1942) suggested that "hereditary differences in the tendency towards the production of epicormic branches and towards fluting may be found."

Over a long period, the cumulative loss of site potential caused by these fires can be considerable. The surface of the soil is exposed to direct insolation when it most needs protection. Moreover, surface temperatures tend to be higher than normal as a result of charring.

Because of the almost complete absence of undergrowth in the fire-ridden plantations, we must ultimately depend on the fallen leaves, twigs etc. from the teak for the renewal of organic matter and mineral nutrients in the soil. Each time the forest floor is reduced to ashes the nitrogenous constituents of the organic matter are volatilised and other mineral constituents notably K, P, Ca, Mg, are released from organic complexes, probably with some loss, and left in more soluble form (Kittredge, 1948). The ash and soluble salts are left exposed on steep slopes either to be blown away by the wind or washed away in solution by the first rains. Loss of phosphorus can be harmful; teak has been shown to be sensitive to phosphate deficiency (Beckman & Beumee, 1956).

Erosion has been a problem wherever there have been pure teak stands. In Java, investigations show that erosion was greatly accelerated when teak forest was burnt or when litter was removed by hand. (Laurie and Griffiths, 1942). In Burma the situation has been described as "truly appalling"; the worst examples were to be definitely correlated with the absence of undergrowth and with fires (Blanford, 1933).

In Trinidad, the effects of erosion are becoming increasingly obvious. Direct damage to the crop is probably not very great. Roots are exposed to direct insolation and they may be killed completely or in part by subsequent fires; in either case a temporary check in growth at the beginning of the growing season results. Yet the most disturbing aspect is not so much the injury from which the tree soon recovers but the gradual removal of top-soil with the progressive loss of soil fertility and growth potential, particularly on the slopes.

A study of runoff and erosion started in July, 1954 by the Soil Survey Section of the Central Experimental Station, Trinidad gave the following preliminary results:

Table 1. *Average runoff and soil loss under natural forest and teak, from July, 1954 to end of 1957.*

Location of Plots	Date Established	Size of Plot (Acres)	Average Rainfall/ann. (in.)	Runoff/in. of rain	Soil loss (lb./acre)
Natural Forest	July 1954	3.15	93.55	0.32	75
1946 Teak Coupe	June 1955	2.15	88.59	0.34	817

Erosion under teak is taking place at 11 times the rate under natural forest. This constant soil loss can have serious and far reaching effects on the establishment and health of the second rotation.

Before the canopy is reformed the first rains strike the ground with full force. After canopy formation the soil is then exposed to the heavier drops from the very broad teak leaves. Thus, the surface soil is not only compacted but is also broken up into finer particles which effectively seal off the surface pores with a clayey film, facilitating excessive runoff and reducing aeration. This sealing effect is greater in clays and clayey loams than in coarse textured soils (Kittredge, 1948). In assessing the effect on teak growth of compaction and poor aeration, it should be remembered that teak roots may have a specially high oxygen requirement necessitating a shallow root system in well aerated soils (Coster, 1933).

Most of the ill effects discussed above would disappear with the appearance of an undergrowth in our teak plantations. In Java, it has been found that underplanting with *Leucaena glauca* (L.) Benth. eliminates the undesirable effects mentioned and also "has a favourable influence on the production of teak" (Becking, 1928). In Trinidad it should not be necessary to underplant teak; there is ample evidence that an undergrowth comes in naturally. But until plantations can be given protection from fire, no undergrowth will survive.

Fire protection in Trinidad is still very rudimentary. Many a serious plan has been shelved because of the lack of funds. As the fire hazard season approaches the boundaries between Forest Reserve plantations and private property are cleared. In the plantations themselves labourers are detailed to patrol the area on foot or bicycles. On discovering a fire, the patrol sends or brings word to the Ranger who then commandeers as many men as possible and attempts to contain the fire by beating it out with or without a fire trace. Their efforts are usually defeated either by the natural configuration of the ground or wind or both. Traces as permanent fire breaks are useless unless they can be kept free of fallen leaves.

In 1960, in recognition of the problem, money was finally made available by the Government to implement a pilot scheme in the South West Division involving the use of fire-towers, tanks trucks, radio communications etc. — the nucleus of a Forest Fire Brigade in fact. The scheme had its first test in the dry season of 1961. If the plan is to succeed all plantations must be well served with roads and each coupe easily reached by rides capable of accommodating wheeled vehicles in the dry season. When planning new plantations this need should be borne in mind and each coupe bounded at least by a substantial fire trace.

The real answer to the fire problem lies in the education of the general public. As early as 1924 the then Conservator referred to the unfortunate and frequent occurrence of 'bush fires' in second growth forests. "There is no reasonable doubt", he stated, "but that these fires are caused by human agency". In his Report for that year he warned that "the surest safeguard is an enlightened public opinion combined with a practical application thereof by helping to extinguish such fires if and when they do occur". Today the need is more urgent.

The ordinary citizen must be made aware of the cumulative effects of fires on soil and vegetation; the public conscience must be aroused. This need was recognised by the Sub Committee on Agricultural Fires. In June 1957 the Committee recorded "the apathetic attitude of the public towards vegetation fires" and recommended:

> "that intense propaganda be undertaken by the Department of Agriculture just before the advent of the dry season, stressing the damage done to property and soil fertility by the indiscriminate setting of fires and funds be made available for the purpose".

Such a propaganda campaign should be undertaken jointly by the Departments of Agriculture and Forestry and should be intensified *during* the dry season.

Every available avenue should be employed. Eye catching warning notices can be placed in prominent positions along roads through plantations, as is done by the Forestry Commission in the U. K.; brief warnings may be broadcast over the local radio stations; postage stamps on letters may be cancelled with such slogans as 'Prevent bush fires'. Senior Officers of the Department may be allowed broadcasting time on the Government programme to put the case against bush and forest fires and to discuss the work of the Forest Department generally. In addition Forest Officers should visit schools, paritcularly those in and around forested areas, to lecture to pupils and staff and attempt to win their sympathy.

If, as I believe, most vegetation fires are the doing of thoughtless persons, the type of propaganda advocated may result in an increase in the incidence of fires. This increase must be accepted as a temporary hazard on the way to the achievement of a better informed and more sympathetic public. This prospect should not be allowed to deter us from attempting to arouse the public conscience. Once this objective is achieved this hazard will disappear.

For the present and until the risk of fires in teak decreases, policy must continue to aim at keeping teak concentrated in solid contiguous blocks rather than have isolated coupes and compartments scattered over the countryside. Such isolated compartments as do exist either act as deterrents to proper utilisation of adjoining land or involve Government in numerous compensation claims for damage from fires originating in the coupes. Also, these blocks are exposed to heavy attack by parasitic birdvine which spreads from infested trees in the natural forest or on cocoa estates.

SUMMARY

In Trinidad fires in teak plantations have become a perennial problem. The causes of these fires and their effects on the tree crop

and the site are discussed. The view is advanced that while the present crop appears to be healthy, the absence of undergrowth and loss of topsoil and fertility are undesirable. An intense propaganda campaign in the dry season against fires is advocated.

RESUMEN

En Trinidad los fuegos en las plantaciones de teca se han convertido en un constante problema. Se discuten las causas de estos fuegos y sus efectos en los árboles y en el suelo. Aún cuando se espera que la presente cosecha sea vigorosa, la ausencia de un sotobosque y las pérdidas del suelo y su fertilidad son indeseables. Se aboga para que durante los meses de sequía se haga una intensa campaña de propaganda contra los fuegos.

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Estimating Total Volume of Some Caribbean Trees

H. C. DAWKINS
Nuffield Foundation Research Fellowship, Oxford

Fundamental yield studies and those concerned with output of cellulose often require estimates of total above-ground volume including all branches. Few such estimates are available for tropical high-forest trees, though their lower degree of branching makes them an easier proposition than most temperate species.

Some recent, though limited, measurements in the Caribbean suggest that total volume is so very nearly linear on the product of basal-area and total-height, that it may be estimated considerably more accurately from these dimensions than any assortment volume. Saw-log volume for instance is often poorly correlated with whole-tree dimensions, largely because of varying ratio of crown to bole height between individuals and sites. As the proportions of crown and bole within a height class are complementary, it is reasonable that their sum holds steadier than each of them separately.

The Caribbean data were collected from fellings of thirty trees distributed as follows:

Trinidad, Arena:
- 3 *Byrsonima spicata*
- 4 *Didymopanax morototoni*
- 3 *Terminalia superba*
- 3 *Simarouba amara*

Puerto Rico, El Verde:
- 3 *Manilkara nitida*
- 2 *Ormosia krugii*

Puerto Rico, Río Abajo:
- 5 *Swietenia macrophylla*

Silkgrass and Commerce Bight, British Honduras:
- 3 *Swietenia macrophylla*
- 4 *Ochroma lagopus*

Boles were measured for breast-height, intermediate and distal diameters and for length. Crowns were treated as a series of internodes, each being measured for length between fork-centres and for end diameters, the latter with care to avoid any visible fork-swell. Terminal branchlets were measured for length from ultimate fork to tip and for diameter above fork, and higher as well if the first measurement considerably exceeded 4 cm. Branchlets under 4 cm. diameter and one metre length were ignored if in a markedly lateral, i.e. inferior, position.

Volumes were calculated from mean section-area times length, to avoid the location of innumerable mid-points on all crown internodes.

In spite of the wide differences of form between the eight species sampled, an astonishingly close relation emerged.

Where: V = total above-ground over-bark volume in cubic metres.
g = "basal-area" in square metres over-bark at 1.3 metres height.
h = total height in metres.

Then $V = 0.0368 + 0.545\ (gh)$, with a correlation coefficient of 0.986 and a standard error of 0.017 on the regression coefficient of 0.545. The relation was, therefore, so close to the line indicated as to make other fittings practically unnecessary. Converted into so-called British true-measure units the equation becomes

Cubic feet o. b. = 1.30 + 0.00378 [g (sq. inches) x h (feet)]

The equations indicate that total volume form factor decreases with tree size. The range studied was from 0.15 to 0.48 metres diameter, 15 to 34 metres height, 0.9 to 3.3 cubic metres volume, and from 0.68 to 0.55 form-factor respectively. Thus an approximate over-bark above-ground total-volume form factor for the trees in question is 0.6.

Measurements in the field after de-barking gave wood proportions from 0.8 in *Didymopanax* to 0.9 in *Simarouba*, the sample mean being 0.85. Hence 0.5 gh give an estimate of total above-ground under-bark volume, based on the over-bark basal area.

SUMMARY AND CONCLUSIONS

Total above-ground volume of thirty trees of eight widely differing Caribbean species proved so closely linear over basal area times total height that the relations may be generally applicable to tropical broad-leaved trees.

The equation derived was:

$$V\ (\text{overbark, } m^3) = 0.0368 + 0.545\ [g\ (m^2) \times h(m)]$$

Under-bark volume form-factor based on over-bark basal-area averaged 0.5. This may be useful for estimates of total cellulose production.

RESUMEN Y CONCLUSIONES

El volumen total sobre el nivel del terreno de 30 árboles de ocho especies bien distintas del Caribe demostró estar tan cerca lo linear sobre el área basimétrica x la altura total, que la relación puede ser aplicable en general a árboles tropicales de hoja ancha.

La ecuación derivada fué:

$$V\ (\text{incluyendo corteza, } m^3 = 0.0368 + 0.545\ [g\ (m^2) \times h(m)]$$ [1]

El promedio del factor del volumen excluyendo la corteza basado en el área basimétrica incluyendo la corteza fué 0.5. Esto puede ser de utilidad para los estimados de la producción total de celulosa.

1/ g = área basimétrica
h = altura total

Ensayos de Plantación Estadísticamente Válidos[1]

C. B. BRISCOE
Instituto de Dasonomía Tropical
Río Piedras, Puerto Rico

En la América Latina se plantan cada año más de cien millones de arbolitos y por lo menos se deberían plantar diez veces esta cantidad.[2/] El control y desarrollo racional de un programa de tal magnitud requieren que se establezcan y se interpreten ensayos de plantación cuidadosamente planeados. Dichos ensayos cuidadosamente planeados rendirán resultados estadísticamente válidos que satisfagan interrogantes reales y de importancia.

Desgraciadamente, muchas de las plantaciones forestales que se establecen ahora en esta región han sido concebidas y establecidas por personas que carecen por completo de conocimientos sobre estadísticas, o por hombres que recibieron su entrenamiento estadístico muchos años atrás. Muchos de ellos comprenden cabalmente las ventajas que se derivan de proyectos experimentales apropiados y les gustaría establecer sus ensayos en una forma que más tarde les sea posible someter los resultados obtenidos a pruebas estadísticamente válidas. En muchos casos, sin embargo, no hay un estadístico competente a quien ellos puedan consultar, y por una u otra razón no les es posible obtener por si mismos conocimientos apropiados de estadística. Este estudio fué preparado para el uso de estos hombres que desean establecer proyectos de ensayos de plantaciones diseñados correctamente pero que desconocen por completo la teoría estadística.

Hacemos hincapié en que el diseño de ensayos de plantación par obtener datos confiables sobre relaciones complejas a un costo mínimo, requiere técnicas especializadas que no podemos discutir aquí. Cuando haya disponible un estadístico competente, no debe omitirse esfuerzo en consultarlo ANTES de dar comienzo al trabajo de campo.

DISEÑO DEL ESTUDIO

Los fundamentos de la planificación de experimento son muy pocos. Primero, limite el estudio a la contestación de una pregunta específica. Segundo, estudie la variación de condiciones replicándolas dentro del alcance del problema. Tercero, localice las parcelas al azar para evitar toda posibilidad de una predisposición personal o sistemática.

Eso es todo. Si se siguen estas tres reglas, cualquiera puede diseñar un ensayo de plantación que produzca resultados estadísticamente válidos. El costo podría ser algo más alto de lo estrictamente necesario, algunos efectos indirectos podrían pasar inadvertidos, y quizás algunas interacciones ni se adviertan ni puedan probarse si son descubiertas, pero la pregunta o el problema básico bajo estudio se contestará concluyentemente.

Ahora pasaremos a considerar cada uno de los tres puntos un poco más detalladamente.

LIMITAR

El paso más importante de todo es decidir con exactitud que es lo que se va a determinar. Procede hacer una pregunta antes de hallar su solución, y la pregunta debe indicar claramente lo que se incluye y lo que se excluye.

1/ Statistically Valid Planting Trials. Proceedings of the 2nd Eucalyptus Conference, Sao Paulo, Brazil.
2/ Food and Agriculture Organization. 1959. Tree Planting practices in Latin America. FAO Forestry Development Paper, Draft. p. 79.

Por ejemplo, si se va a introducir eucaliptos en un área donde estos no son nativos, inmediatamente surgen varias interrogaciones que deben contestarse: ¿Qué especies deben cultivarse? ¿Qué lugares son más apropiados para las especies bajo consideración? ¿Cuánto tardarán las especies en crecer en los distintos lugares disponibles? Como casi todos ustedes saben, las preguntas nunca se acaban; un estudio no las contesta todas. Mientras más limitada sea la pregunta, más completa puede ser la contestación.

Quizás las dos preguntas más comunes son: "¿Qué especies pueden cultivarse?" y "¿En qué lugares puede esta especie aventajar aquella?"

Asúmase que luego de considerar la latitud, el régimen de la precipitación, la elevación, y otras características del área a plantarse la selección se limita a tres especies: *Eucalyptus saligna*, Sm., *E. robusta* Sm., y *E. citriodora* Hook. Los sitios dentro del área de plantación pueden dividirse en tres posiciones topográficas principales: valle, ladera, y cresta.

Entonces, hay que determinar si *E. saligna*, *E. robusta*, o *E. citriodora* se adapta mejor a cada uno de los tres sitios.[3/]

REPLICAR

Para investigarlo, las tres especies deben plantarse replicándolas en cada uno de los tres sitios. Por lo regular esto se hace en tres formas que se complementan entre si.

REPLICACION DEL LUGAR: Esto se obtiene estableciendo parcelas en cada sitio con un mínimo de por lo menos dos[3/] lugares o localidades. Los sitios en el valle pueden identificarse como Valle X, Valle Y, y Valle Z.

Los lugares de ensayo por lo regular se seleccionan siguiendo uno de estos tres métodos:

3/ La determinación del número óptimo de replicaciones, especies, tamaño de la parcela y otros detalles estan fuera del alcance de este estudio, pero vale la pena indicar que es más eficiente ensayar con más de tres especies a la vez. El número posible de lugares, por supuesto, esta limitado solamente por el número de arbolitos y fondos disponibles.

1. *Al azar.* A cada valle apropiado para ensayo se le asigna un número. Luego se sacan de un sombrero los números suficientes para completar el número de lugares de ensayo.

Los lugares seleccionados al azar tienen la misma oportunidad de pertenecer a cualquier sitio en toda el área bajo estudio. Esto significa que si el área a plantarse fuese Puerto Rico, las parcelas en los valles tendrían la misma oportunidad de incluirse en cualquier valle de Puerto Rico. Normalmente esta selección de lugares no resulta en una distribución uniforme, y muy bien los lugares podrían aglomerarse hasta un punto indeseable. Esto fácilmente podría resultar en un estimado erróneo especialmente si solamente se seleccionan algunos lugares. Un grupo de lugares en la parte árida del suroeste de Puerto Rico podría sugerir conclusiones muy diferentes a aquellas sugeridas por un grupo de lugares en la zona lluviosa de las montañas del este, y ninguno proporcionaría un buen estimado para Puerto Rico en general.

Además, un sorteo completamente al azar resulta costoso e inconveniente.

2. *Sistemático.* La localización sistemática es una distribución planeada, geográficamente uniforme en el área de plantación. Se espera que esta incluya todas las condiciones posibles y así se obtiene un cuadro más completo del todo.

3. *Estratificado.* En vez de utilizar una base sistemática geográfica, la localización puede planearse basándose en tales datos como la precipitación, la elevación, la roca madre, los usos anteriores del suelo, o cualquier otro factor importante o identificable, o combinación de factores, que afectan el crecimiento de los árboles.

Por ejemplo, si quisiéramos estratificar un lugar tomando como base la precipitación en Puerto Rico podríamos establecer una localidad en la región montañosa del este donde la precipitación es aproximadamente 150 pulgadas, otro lugar en las montañas del centro donde es aproximadamente 100 pulgadas, y aún otro lugar en una ladera del sur de la Isla donde la precipitación es aproximadamente 50 pulgadas al año.

En cambio, si fuéramos a estratificar basándonos en los tipos principales de suelos podríamos establecer lugares en suelos franco arenosos, arcillosos profundos, y arcillosos poco profundos.

El problema principal en la estratificación de lugares es evitar la confusión de dos o más factores. Por ejemplo, si el lugar en el suelo arcilloso profundo tiene 150 pulgadas de precipitación, el lugar en el suelo arcilloso poco profundo solo tiene 50 pulgadas, y el lugar en el suelo franco arenoso tiene 100 pulgadas, sería imposible determinar si las diferencias existentes en las plantaciones forestales se deben a la precipitación o al suelo.

La solución, si posible, es seleccionar lugares en todos los tipos de suelos en regiones con la misma precipitación o seleccionarlos dentro de una distribución amplia de precipitación en cada uno de los tipos de suelos. Por lo regular lo segundo es más fácil de hacer en la práctica.

REPLICACION DE PARCELAS: Esto se obtiene estableciendo por lo menos dos parcelas de cada especie en cada sitio de cada lugar o localidad. Por ejemplo, en el Valle X se plantan por lo menos dos parcelas de *E. saligna*, dos de *E. robusta*, y dos de *E. citriodora*. Esto no implica que dos es la cantidad más indicada de replicaciones; dos es la cantidad mínima.

Vale la pena mencionar que en estudios de adaptabilidad (por lo cual se entiende la selección preliminar de muchas especies sobre las cuales se sabe poco acerca de sus características silvícolas o exigencias por el sitio) las comparaciones entre los árboles individuales son más sensitivas y se obtienen más económicamente, que las comparaciones entre los grupos de árboles de una sola especie.

REPLICACION DEL TIEMPO: Esto se obtiene estableciendo plantaciones durante por lo menos dos épocas de plantación diferentes. La importancia de la replicación debido al tiempo depende de la variabilidad del clima de año a año en el área a plantarse. Casi dondequiera el clima varía lo suficiente entre años como para que surjan dudas sobre las conclusiones basadas en plantaciones hechas solamente durante un año; en casos extremos, el observador más casual podría reconocer que los resultados fueron influenciados por condiciones climáticas anormales.

DISTRIBUCION DE LAS PARCELAS AL AZAR

El tercer paso esencial es hacer una distribución al azar. Generalmente esto se lleva a cabo asignando las posiciones de las parcelas individuales al azar en cada sitio de cada lugar o localidad.

El sorteo de las parcelas completamente al azar frecuentemente resulta en una distribución desigual y en resultados incorrectos; por lo tanto, normalmente las parcelas se agrupan en bloques que ocupan un área relativamente uniforme. Cada bloque contiene un número fijo de parcelas de cada especie.

Por ejemplo, cuando se va a establecer un número de parcelas en una ladera, casi siemper se puede asumir que la parte más baja de la ladera es un lugar más productivo que la parte más alta. Por lo tanto, deberá establecerse un bloque de parcelas con todas las especies distribuídas al azar en la parte más baja de la ladera. Otro bloque de parcelas con todas las especies igualmente distribuídas al azar deberá establecerse en la parte más alta de la ladera.

Lo que sí debe evitarse cuidadosamente en esta etapa es asignar las parcelas basándose en las exigencias de las distintas especies. Esto es, aunque usted esté seguro que el *E. saligna* requiere un sitio mejor que el *E. robusta*, nunca asigne las parcelas buenas a *E. saligna* y las malas a *E. robusta*. Tal acción impediría por completo una comparación verdadera de la adaptabilidad o productividad de las dos especies, y por lo tanto anula el estudio.

Existe un número de arreglos sistemáticos de parcelas en los bloques de uso corriente, pero desgraciadamente solo pueden ser usados adecuadamente por un estadístico competente que esté bien familiarizado con las condiciones locales. Por lo tanto, no los discutiremos aquí.

EJEMPLO

Para aclarar, consideremos el programa de introdución de especies en Puerto Rico.

LIMITES DEL PROBLEMA

Asumamos que varios cientos de miles de acres en los suelos arcillosos profundos de las montañas que sostienen plantaciones de café serán relevados de cultivo durante las próximas dos décadas. Aunque muchas especies nativas crecen como árboles individuales o son usadas como sombra de café, los bosques naturales han sido virtualmente eliminados. Por lo tanto, estamos interesados en saber que especies se adaptan mejor a este sitio de importancia.

Debido al alto costo de establecimiento, estamos interesados en establecer solamente especies de vigor o calidad superiores, o que produzcan algo que no se produce ahora.

Además, debido al crecimiento profuso y rápido de yerbas, yerbajos, y trepadoras, y el costo relativamente alto del trabajo, solamente nos interesan especies que tengan un crecimiento inicial bien rápido. Nuestro mínimo absoluto de altura es seis pies en dos años. Debido a que se cree que dicho crecimiento requiere completa exposición a la luz del sol, estamos más interesados en especies que puedan establecerse a campo abierto.

Tomando en consideración todos estos factores, entonces nuestro principal problema es este: ¿Qué especies producen árboles de vigor superior o madera de calidad superior o que den un producto nuevo, tendrán un crecimiento inicial bien rápido, se desarrollarán satisfactoriamente a campo abierto, y alcanzarán un tamaño comercial en los suelos arcillosos profundos de las montañas?

Para simplificar el planteamiento solo mencionaremos cuatro de las especies bajo ensayo.

ESPECIES	*PROPOSITOS*
Eucaliptos (*Eucalyptus patentinervis* R. T. Baker)	vigor bien alto, madera con poca demanda
Cadam (*Anthocephalus cadamba* Miq.)	vigor alto, madera usada para enchapes corrientes
Pino (*Pinus caribaea* Morelet)	vigor alto, madera de utilidad general y de fibra larga
Primavera (*Cybistax donnell-smithii* [Rose] (Seibert)	vigor alto, madera usada para enchapes de calidad

REPLICACION

La literatura y experiencia local solamente sugieren ideas muy generales sobre el vigor y la calidad relativa de cada una de las especies que pueden obtenerse en la variación de precipitación y elevaciones incluídas en la región montañosa de suelo arcilloso profundo.

Por lo tanto se hace necesario establecer ensayos comparativos de plantaciones.

REPLICACION DE LUGAR: Dentro de la región reconocemos ocho lugares que cubren la variación completa de elevaciones que están geográficamente esparcidos, que cubren la variación de la lluvia, y que representan otros factores ambientales, como suelos erosionados y microclimas secos y húmedos.

REPLICACION DE PARCELAS: En cada lugar, cada año, establecemos por norma diez y seis hileras de plantas siguiendo el contorno del terreno. Cada una de estas hileras puede considerarse como un bloque, o los datos de dos o más hileras contiguas pueden considerarse como un bloque al momento del análisis.

Cada hilera se divide en tres parcelas separadas, cada una de las cuales contiene un arbolito de cada especie bajo ensayo. Nunca ensayamos con menos de tres especies en una parcela y no hemos ensayado con más de diez y seis.

Como cada parcela tiene un árbol de cada especie, hay tres parcelas en una hilera y diez y seis hileras, se requiere un total de 3 x 16, o sea, 48 arbolitos de cada especie, en cada lugar y por cada año. Para cuatro especies, se necesitan 48 x 4, o sea 192 arbolitos.

REPLICACION DEL TIEMPO: Cuando las exigencias en la obtención de semillas lo permiten, generalmente ensayamos con una especie durante tres años calendarios.

CONSIDERACIONES GENERALES

El espaciamiento o distancia de plantación es de 2.5 x 2.5 metros; por lo tanto el ancho de la plantación a lo largo del contorno para cuatro especies es de 4 x 3 x 2.5 ó 30 metros, y el largo hacia arriba y hacia abajo de la ladera es de 16 x 2.5, ó 40 metros. Esto hace un total de 30 x 40 metros ó 1200 metros cuadrados por localidad.

El número de arbolitos necesarios para ocho localidades es 192 x 8, ó 1536, y el área total ocupada es 1200 metros cuadrados x 8, ó sea 9600 metros cuadrados. Así, es obvio que este diseño experimental nos permite ensayar con cuatro especies en ocho localidades en menos de una hectárea de terreno.

Esta economía en el área bajo ensayo nos permite concentrar en técnicas más intensas que aseguren una supervivencia inicial alta y darle un buen cuidado inicial, lo cual nos sería imposible si usáramos parcelas grandes, cada una con una sola especie.

Por supuesto, tenemos además una comparación más sensitiva entre especies que la que se obtiene usando muchos más arbolitos sembrados en parcelas puras.

SELECCION AL AZAR

Como hemos indicado antes, cada parcela contiene un arbolito de cada especie. La selección al azar se hace utilizando bloques de madera numerados para decidir los lugares de las especies dentro de cada parcela.

RESUMEN

Lo que sigue incluye los puntos esenciales en el diseño de estudios de plantación estadísticamente válidos:

LIMITAR la prueba a un grupo de condiciones definidas.

REPLICAR cada combinación de condiciones a ensayarse.

SELECCIONAR AL AZAR para eliminar inclinaciones sistemáticas e inconscientes.

Limitar, replicar, y selección al azar: esas son las tres reglas indispensables para realizar plantaciones de ensayo.

SUMMARY

To design statistically valid planting trials it is necessary only to restrict the test to a defined set of conditions, replicate each combination of conditions to be tested, and randomize to eliminate systematic or unconscious bias. The basic design used in Puerto Rico is described briefly.

The Introduction of Conifers to the State of Sao Paulo

ENG° AGR° PEDRO LUIS CIANCIULLI

Head of Introduction Plant Section

Forest Service - Sao Paulo

1959

BRAZIL covers an area of 8,513,189 square kilometers (3,255,000 square miles).

Compared with several other South American countries it has a relatively limited amount of Forest Reserves and National Parks.

According to the FAO's survey (1948), forests in Brazil may be divided as follows:

Inaccessible forests	(Coniferous	3,500,000 hect.
	(Deciduous	221,052,000 hect.
Accessible forests	(Coniferous	5,250,000 hect.
	(Deciduous	147,368,000 hect.
	Grand Total	377,170,000 hect.

As in many other Latin American countries Brazil's primitive forests were removed principally in order to provide land for cultivation and pasture.

Most technicians who strive for the preservation of nature now think that the best remedy against further destruction is to make a thorough study of the existing forest to promote their wisest use.

This implies a large program of education and extension.

One other way of attacking the problem of forest destruction is the introduction of promising exotic trees to promote their cultivation in areas where they are most needed.

This may prove especially successful in many regions of Brazil, particularly in the State of Sao Paulo where forest resources have been almost totally exhausted as a result of increased demands for fuelwood while other areas have been clearcut and cleared for cultivation and grazing.

Together with this trend, current demands for timber, pulp, and resin have increased steeply while exploitation areas are getting farther away from markets.

Literature indicates that many conifers, especially *Pinus, Cupressus, Podocarpus, Taxodium, Agathis*, and *Araucaria*, may play an important role in reforestation programs under a great variety of conditions.

DETERMINATION OF ECOLOGICAL HABITATS IN THE SAO PAULO STATE, ESPECIALLY IN THE EXISTING FOREST EXPERIMENTAL STATIONS.

We believe that it is first necessary to give a general explanation about our type of soils. All zonal soils from Sao Paulo State, are strongly lateritic. Alluvial soils are very high in organic matter (up to 14% total C, but very acid (pH from 5.0 to 3.8). The territory possesses a very varied geology. Igneous rocks range from very acid coarse granites to basaltic lava flows, diabases, and gabbros. Metamorphic metaschists and quartzites occupy considerable part of the territory; amphibolites are also present.

Sedimentary rocks, chiefly sandstones, shales and chert, occupy more than half the State. Limestones, sedimentary and metamorphic, occur in less than 1% of the territory, but fine sandstones with calcareous cement cover more than 10%.

Preliminary soil classification was made by Ing° José Setzer, numbering soil types according to the most important types of parent material, instead of geographical names preceded by texture designation. The virgin soils were everywhere covered by forests, which had large trees among dense vegetation in very sandy deep soils.

Excluding steep slopes of mountains of maritime sierras, about 90% of the forests were cut, and after some years of cropping the land was utilized under natural pastures with yearly burning of vegetation. In this way almost all soils were quickly impoverished, promoting migration of rural population. More than 20% of the territory, with soils from poor sandstones, now exhibit almost useless fields of short hard grasses with dry shrubs.

BOTANICAL AND ECOLOGICAL STUDIES OF SOME CONIFERS, WITH DATA ON SILVICULTURE AND UTILIZATION.

Introductions in the Sao Paulo State started twelve years ago (September 1948) when the first arboretum was planted on grounds belonging to the Forest Service.

The following species of pine were tried. All seedlings were potted and the arboretum received good post-planting care:

(1) *Hard pines for timber and miscellanea.* 1/

Grade A:	*Pinus palustris*	1950, doing well
	Pinus caribaea	1949, doing well
	Pinus elliottii	1949, doing very well
	Pinus canariensis	1949, doing fairly well
Grade B:	*Pinus sylvestris*	1955, not doing very well
	Pinus resinosa	1955, doing poorly
	Pinus thunbergii	1956, doing poorly
	Pinus nigra (P. laricio)	1955, died
Grade C:	*Pinus echinata*	1956, doing well
	Pinus ponderosa	1956, doing bad
	Pinus taeda	1949, doing well
Grade D:	*Pinus pinaster*	1949, doing very well
	Pinus pinea	1949, not doing very well
	Pinus halepensis	1952, not doing very well
	Pinus radiata	1949, not doing very well
Grade E:	*Pinus banksiana*	1951, died
	Pinus virginiana	1950, died
	Pinus sabiniana	1950, died

1/ See: Dellimore and Jackson (1948), Din Aung (1958), Martinez (1948), and Mejorada (1959).

(2) *Soft pines for timber*

Grade A:	*Pinus strobus*	1950, died
	Pinus monticola	1950, died
	Pinus lambertiana	1950, died
Grade B:	*Pinus cembra*	1950, died
	Pinus peuce	1950, died
	Pinus gerardiana	1950, died
Grade C:	*Pinus flexilis*	

(3) *Pines from which turpentine and rosin are obtained.*

Europe:	*Pinus pinaster*	1949, doing well
	Pinus nigra (P. laricio)	1955, died
	Pinus halepensis	1952, not doing very well
	Pinus sylvestris	1955, not doing very well
United States:		
	Pinus elliottii	1949, doing very well
	Pinus palustris	1950, doing well
	Pinus echinata	1956, doing well
	Pinus taeda	1949, doing very well
	Pinus ponderosa	1956, doing poorly
Cuba and Haiti:		
	Pinus caribaea	1949, doing well
	Pinus occidentalis	1955, doing well
	Pinus tropicalis	1958, doing well
	Pinus cubensis	
India, Philippines and Indonesia:		
	Pinus merkusii	1956, doing well
	Pinus insularis (P. khasia)	1957, doing well
	Pinus longifolia	1955, doing well
Central America Region:		
	Pinus caribaea (P. hondurensis, from Guatemala and Honduras)	1958, doing well
	Pinus oocarpa	1958, doing well
	Pinus montezumae	1958, doing well
	Pinus pseudostrobus	1958, not doing well

PROMOTION AND INCREASE OF THE AREA OF ARBORETA FOR BETTER BIOLOGICAL OBSERVATIONS.

Concerning this question, we have some areas for biological observations established with pine plantations in several Forest Experiment Stations.

DETERMINATION OF AREAS WORTHY OF TRIAL PLANTATIONS.

Our introduction of conifers is generally done in the Forest Experiment Station as arboretum's area. We have the following sites where plots of pines have a good development, generally without pests and diseases; (all inside Sao Paulo State):

(a) *Sao Paulo City* (Serra Cantareira) — Forest Service.
Lat.: 23° 32' 35'' 1 S — Long.: 46° 38' 02" 5 — Alt.: 817 m.; Yearly Rainfall: 1,500 mm., dry winter and rainy summer; Soil: gneiss, lateritic and granitic soils.
Principal species tried:
Pinus echinata, P. elliottii, P. palustris, P. taeda, P. canariensis, P. thunbergii, P. densiflora, P. pinaster, P. halepensis, P. torreyana, P. pinea, P. radiata, P. insularis (from Philippines), *P. khasia* (from India), *P. merkusii* (from Indonesia), *P. longifolia, P. ponderosa, P. caribaea* (Guatemala), *P. caribaea* (Cuba), *P. caribaea (P. hondurensis)* from Honduras, *P. oocarpa*, P. *pseudostrobus, P. montezumae, P. patula* (seeds from Mexico and South Africa, *P. occidentalis, P. tropicalis, P. excelsa* and *P. engelmanni.* We also have small plots of *Agathis australis* (kauripine), *Cupressus macrocarpa, C. lusitanica, C. sempervirens* var. *stricta, Taxodium distichum, Callitris calcarata,* and *Thuja* sp.

(b) *Campos do Jordao:* Lat.: 22° 43' S. — Long.: 45° 35' W. — Alt.: 1.481 m. Yearly Rainfall: 2.238,4 mm. — Soil type: gneiss and granitic soils. Indicated species: *Pinus pseudostrobus, P. ayacahuite, P. douglasiana, P. lawsonii, P. pringley, P. michoacana, P. montezumae, P radiata, P. longifolia, P. insularis, P. elliottii, P. oocarpa, P. halepensis,* and *P. patula.*

(c) *Avaré:* Lat.: 23° 05' 48" 5 S — Long.: 48° — Alt.: 752 m. Yearly Rainfall: 1.361 mm. — Soil type: diabasic soils. Indicated species: *Pinus oocarpa, P. taeda, P. palustris, P. elliottii, P. montezumae, P. patula, P. canariensis, P. insularis, P. cembroides* and *P. pinaster.*

(d) *Baurú:* Lat.: 22° 19' 95". — Long: 49° 04' 13" 5 W — Alt.: 449 m. Yearly Rainfall: 1.170 mm. Soil type: arcillaceous and sandy soil. Indicated species: *Pinus caribaea* (from Cuba, Guatemala and Honduras), *P. oocarpa, P. pinaster, P. occidentalis, P. insularis, P. elliottii, P. merkusii, P. taeda, P. canariensis, P. halepensis, Cupressus lusitanica, C. macrocarpa,* and *Callitris calcarata.*

(e) *Guaratinguetá:* Lat.: 22° 48, 43", 1 S. Long.: 45° 11' 39", 9 W. Alt.: 527 m. — Yearly Rainfall: 1.370,9 mm. — Soil type: acid, gneiss and granitic soil. Indicated species: *Pinus taeda, P. caribaea, P. elliottii, P. caribaea* (from Cuba and Guatemala), *P. hondurensis (Pinus caribaea* from Honduras), *P. douglasiana, P. leiophylla, P. engelmanni, P. montezumae, P. patula, P. pseudostrobus, P. pinaster, P. strobus* var. *chiapensis, P. tenuifolia, P. echinata,* and *P. palustris.*

(f) *Itapetininga:* Lat.: 23° 35' 09" — Long.: 48° 02' 51". — Alt.: 636 m. Yearly Rainfall: 1.117 mm.—Soil type: arcillaceous and acid soils. Indicated species: *Pinus caribaea, P. taeda, P.*

pinaster, P. elliottii, P. canariensis, P. oocarpa, P. insularis, P. merkusii, P. longifolia, P. occidentalis, P. patula, P. khasia, P. engelmanni, and *P. palustris.*

(g) *Mogi Mirim:* Lat.: 22° 26' W. — Long.: 46° 57' W. — Alt.: 611 m. Soil type: Brown podzolic soils. Indicated species: *Pinus hondurensis (P. caribaea), P. elliottii, P. taeda, P. canariensis, P. montezumae, P. echinata, P. occidentalis, P. merkusii, P. palustris, P. insularis,* and *P. oocarpa.*

(h) *Piracicaba:* Lat.: 22° 42' 30" 9S — Long.: 47° 38' 00, 8W. — Alt.: 512 m. Soil type: Podzolic red soils. Indicated species: *Pinus caribaea, P. elliottii, P. greggii, P. merkusii, P. taeda, P. canariensis, P. patula, P. insularis, P. thunbergii, P. densiflora, P. oocarpa, P. occidentalis,* and *P. tropicalis.*

(i) *Santa Rita do Passa Quatro:* Lat.: 21° 41' S. — Long.: 47° 29' W. — Alt.: 759 m. — Yearly Rainfall: 1.379 mm. Soil type: Savannah and yellow podzolic soils. Indicated species: *Pinus oocarpa, P. elliottii, P. ayacahuite, P. montezumae, P. patula, P. taeda, P. michoacana, P. tropicalis, P. insularis, P. merkusii, P. leiophylla, P. pseudostrobus, P. strobus* var. *chiapensis, P. caribaea, P. tenuifolia, and P. occidentalis.*

(j) *Sao Simao:* Lat.: 21° 28'S — Long.: 47° 33' W. — Alt.: 632 m. — Yearly Rainfall: 1.380 mm. — Yellow podzolic soils. Indicated species: *Pinus taeda, P. canariensis, P. caribaea, P. oocarpa, P. merkusii, P. tropicalis, P. pinaster, P. michoacana, P. duranghensis, P. chihuahuana, P. strobus* var. *chiapensis, P. elliottii, P. palustris, Cupressus lusitanica,* and *C. macrocarpa.*

(k) *Paraguacú Paulista:* Lat.: 22° 24' 52" 5S — Long.: 50° 34' 35" 9W. Alt.: 481 m. — Yearly Rainfall: 1.161,6 mm. Yellow podzolic soils. Indicated species: *Pinus caribaea, P. elliottii, P. taeda, P. oocarpa, P. palustris, P. patula, P. insularis, P. tropicalis, P. duranghensis, P. strobus* var. *chiapensis, Cupressus lusitanica,* and *C. macrocarpa.*

(l) *Iguape:* Lat.: 24° 42' S — Long.: 47° 33' W. — Alt.: 6 m. Yearly rainfall: 1.711,44 mm. — Loams and alluvial soils. Indicated species: *Pinus caribaea, P. elliottii, P. pinaster, P. strobus* var. *chiapensis, P. khasia, Taxodium distichum, Cupressus lusitanica,* and *C. macrocarpa.*

(m) *Registro:* Lat.: 24° 27' 15" S. — Long.: 47° 49' 37" W. — Alt.: 30 m. Yearly Rainfall: 1.358,0 mm.—Alluvial and poor sandy soils. Indicated species: *Pinus caribaea, P. pinaster, P. elliottii, P. taeda, P. tropicalis, P. cubensis, P. insularis, P. strobus* var. *chiapensis, Cupressus macrocarpa, C. lusitanica,* and *Cryptomeria japonica.*

(n) *Caraguatatuba:* Lat: 23° 37' 32" 3S. Long.: 45° 24' 46" 6 W — Alt.: 1m. to 700 m. Alluvial and poor sandy soils. Indicated species: *Pinus caribaea, P. elliottii, P. taeda, P. tropicalis, P. pinaster, P. strobus* var. *chiapensis, P. canariensis, Cupressus lusitanica, C. macrocarpa, Callitris calcarata, C. glauca,* and *Taxodium distichum.*

(o) *Ubatuba:* Lat.: 23° 26' 11" S. Long.: 45° 04' 00" W. — Alt.: 3,85 m. Yearly Rainfall: 1,630,6 mm. — Alluvial and poor sandy soils. Indicated species: *Pinus caribaea, P. strobus* var. *chiapensis, P. taeda, P. elliottii, P. pinaster, P. palustris, P. cubensis, P. patula P. oocarpa, Cupressus macrocarpa, C. lusitanica, C. macrocarpa,* and *Taxodium distichum.*

EARLY GROWTH

Information on rate of growth of trees is valuable to foresters in managing forests under sustained yield.

With sufficient and reliable growth data, they will be able to predict the quantity of wood that can be removed from a forest within a given period of time. Our information is based on only 20 to 30 trees per species. The data used in this work were the measurements and records of the seedlings before planting 1949, 1950, 1952, 1955, 1956, 1957, and 1958 and measurements of the same trees taken on sample plots in different months of each year. Several species show remarkable initial development even in poor sandy soils, as *Pinus caribaea* (from Cuba, Guatemala, and Honduras), *P. elliottii*, *P. insularis*, *P. patula* (seeds from South Rhodesia), *P. taeda*, *P. merkusii*, *P. khasia* (from India), *P. pinaster*, *P. palustris*, *P. echinata*, and *P. radiata*.

MEASUREMENTS

(a) *Pinus radiata:* This species planted in 1949, not doing very well, but the Companhia Melhoramentos (Paper Manufacture) in Cayeira's town, has given the dimensions of two arboretum-grown trees as height 18 m. (59 ft.) diameter 32 cm. (12.6 in.) at 12 years of age (measurements made in 1953), and height 19.5 m. (64 ft.) diameter 45 cm. (17.7 in.) at 21 years of age.

The next pine species, were not attacked by *Diplodea pinea* and other fungus species, except in seed beds with "die back".

(b) *Measurements of some pine trees*
Site: "arboretum" of Plant Introduction Section — Sao Paulo-Serra Cantareira.

Table 1. *Species in Serra Cantareira Arboretum*

Species	Number of Trees	Planted		Measured		Height (average) Meters	Diameter Breast High Centimeters	Seed Source
Pinus elliottii	30	Sept.	1949	April	1959	10.63	17	U.S.A.
Pinus palustris	20	May	1950	Sept.	1956	3.82	6.3	U.S.A.
Pinus taeda	29	Sept.	1949	Feb.	1957	7.18	14.5	U.S.A.
Pinus canariensis	30	Sept.	1949	Nov.	1954	6.79	12.6	Canary Island
Pinus patula	20	Nov.	1952	April	1955	3.73	3.2	South Rhodesia
Pinus halepensis	24	Nov.	1952	Aug.	1956	1.64	—	Morocco
Pinus caribaea	30	Sept.	1949	Nov.	1954	7.12	12.5	Cuba
Pinus oocarpa	33	June	1956	May	1957	1.05	3.4	Honduras
Pinus longifolia	22	Nov.	1955	Aug.	1959	2.35	6.1	India
Pinus insularis	18	Sept.	1957	Sept.	1958	1.10	—	Philippine
Pinus caribaea	33	March	1958	April	1959	1.20	—	Guatemala
Pinus occidentalis	20	April	1955	Sept.	1958	1.80	9.2	Haití
Pinus merkusii	11	May	1956	June	1959	3.14	3.8	Indonesia
Pinus pinaster	30	Sept.	1949	April	1959	8.52	12.8	Portugal
Pinus pinea	30	Sept.	1949	April	1959	2.25	6.4	Portugal
Pinus echinata	30	May	1956	June	1959	2.25	2.9	U.S.A.
Pinus thunbergii	20	May	1956	June	1959	1.35	—	Japan

FIELD STUDIES OF THE PRINCIPAL CONIFERS OF CENTRAL AMERICA AND MEXICO AND PROMOTION OF CONTACTS WITH REGIONS OF THE WORLD WHERE PROMISING CONIFERS ARE FOUND.

According to Sánchez Mejorada and Huguet, Mexico extends on both sides of the Tropic of Cancer from latitude 15° to 32° North. The pines, firs, cypresses, and other genera have a potential value as exotics for planting programs comparable with the program of introduction of *Eucalyptus* that was made here by Navarro de Andrade. They occur over a wide range of ecological conditions and present a diversity of characteristics and technological qualities. A trip was made to Central America in 1957 to introduce the most important species of pines from Mexico:

Pinus strobus var. chiapensis
P. oocarpa
P. douglasiana
P. herrerai
P. lawsoni
P. leiophylla
P. michoacana
P. tenuifolia
P. patula
P. duranguensis
P. chihuahuana
P. engelmanni
P. montezumae
P. oocarpa var. *trifoliata*
P. flexilis
P. greggii
P. teocote
Taxodium mucronatum
T. distichum
Abies religiosa
Cupressus lusitanica

At the end of the last century, Mexican pines were introduced into South America, Australia, and New Zealand, and since the beginning of this century, various countries have tried conifers from Mexico. In general, however, the seed supply available was inadequate and not satisfactory in quality. Often the seeds received were of species different from what labels indicated. For this reason the Forestry Department of the Union of South Africa sent Mr. E. E. M. Loock, author of "The Pines of Mexico and British Honduras", to Mexico in 1947-1948 to collect seed of known origin. Due to many difficulties Loock was only able to collect in one year 158 kilograms of seed, principally of *Pinus pseudostrobus*. The same work was done by Elmo Montenegro from the Forestry Department of Colombia and by Lamberto Golfari, working in the Forestry Department of Compañía Celulosa Argentina, that has plantations of pines in the Province of Entre Rios (Delta del Paraná) and Misiones (Puerto Piray), and by Wilfredo Barrett, from Botanical Garden of Buenos Aires.

Louis Huguet, Technical Assistance Officer FAO and Sánchez Mejorada, Chief of Forestry Department, Celulosa Michoacana, during their inventory of 300,000 hectares of coniferous forests in the State of Michoacana, began in 1952 to organize on a modest scale the collection and shipping abroad of certified seeds. During the past four years about 40 to 50 kilograms of seed have been sent each year to a number of countries including the Rhodesias, Tanganyika, Cameroons, Madagascar, Nyassaland, Colombia, Argentina, Chile, Paraguay, Brazil, New Zealand, Australia, Venezuela (principally in the Instituto Florestal Latino Americano — Merida), and the Belgian Congo. The species most often sent were not the most important of all the conifers from Mexico, but had to be limited to those which could be found in the area under reconnaissance. These include *Pinus pseudostrobus*, *P. tenuifolia*, *P. oocarpa* and *P. oocarpa* var. *trifoliata*, *P. michoacana*, *P. duranguensis*, *P. patula* (the most important for us), and *P. montezumae*.

The same authors advise that for the moment it is difficult to extend this activity for lack of time, capital, and means.

In order to satisfy all requests and to guarantee the origin and quality of seeds, said Mr. Huguet, a special organization with certain resources at its disposal would be indispensable for the following reasons:

"(a) The large number of species, varieties or races which would require close supervision during the collection.

(b) The distance between the zones of collection and their relative inaccessibility. These zones are scattered for more than 2,000 kilometers from north to south and 600 kilometers from east to west, requiring much rough travel.

(c) A great variation in ecological conditions within short distances.

(d) The irregularity of seeding. It is estimated that for each species there is one good seed year in five years.

This involves the necessity of having available an establishment not only for extraction and cleaning of seeds, but also for proper storage in a cold chamber".

We hope that within the next few years, it will be possible to find the resources to establish such an organization.

SUMMARY

The conifer introductions to Sao Paulo, Brazil, are reviewed, following a brief description of the geology and soils of the state.

Studies have been established of 55 species of the genus *Pinus*, 3 of *Cupressus*, 2 each of *Taxodium* and *Callitris*, and 1 species each of *Abies*, *Agathis*, *Cryptomeria*, and *Thuja*, at one or more of 16 locations, each of which is described. Some growth data are presented for 17 species of pines.

The potential importance of Mexico as a seed source is discussed.

RESUMEN

En este estudio se discute la introducción de coníferas en Sao Paulo, Brazil, siguiendo con una breve descripción de la geología y de los suelos del estado.

Se han establecido estudios sobre 55 especies del género *Pinus*, 3 de *Cupressus*, 2 de *Taxodium*, 2 de *Callitris*, y 1 de cada uno de los géneros *Abies*, *Agathis*, *Cryptomeria* y *Thuja*, en una o más de 16 localidades, describiéndose cada una. Se presentan algunos datos sobre el crecimiento de 17 especies de pino.

Se discute la importancia potencial de México como una fuente de abastecimiento de semillas.

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Tamaño de las Parcelas de Ensayo en Investigaciones de Genética Forestal[1]

JONATHAN W. WRIGHT y F. DEAN FREELAND, JR.
Universidad del Estado de Michigan
Traducido por
José Marrero
Instituto de Dasonomía Tropical

INTRODUCCION

En las etapas iniciales de un programa de genética forestal el investigador está en la necesidad de someter a prueba numerosas progenies de diferentes individuos, clones, ecotipos o especies, a veces a cientos de éstos. No es difícil llevar a cabo pruebas de vivero incluyendo 100 orígenes diferentes valiéndose de 4 replicaciones de 100 plantas cada una o sea un total de 40,000 plantas o arbustos. Sin embargo, es más costoso trasplantarlos al campo y todavía más medir éstos 40,000 árboles cuando hayan alcanzado 30 ó 40 pies de altura. Francamente preferiríamos no tener que bregar con 40,000 árboles si utilizando un diseño experimental adecuado podemos obtener los mismos o aun mejores resultados con mil o dos mil árboles.

El ensayo o prueba de uniformidad objeto de este trabajo constituye un medio de abordar el programa de eficiencia experimental. Las pruebas de uniformidad se han llevado a cabo usando plantas de diversas cosechas agrícolas. (Keller, 1949; Fleming y otros, 1957). La mayoría de las pruebas de uniformidad han demostrado que los experimentos utilizando pequeñas parcelas de ensayos son más eficientes.

PROCEDIMIENTO

Se seleccionaron dos plantaciones para el estudio. Ambas habían sido establecidas utilizando plantas de tipo comercial. En ambas la variabilidad genética estaba distribuída uniformemente.

La primera plantación constaba de pino rojo *(Pinus resinosa* Ait.) localizado en la Sección 34 en la Municipalidad de Ingham, en el condado del mismo nombre, en el estado de Michigan y en terrenos propiedad del Departamento de Conservación de Míchigan dedicados a la protección de la vida silvestre. La mortalidad había sido relativamente baja. La localidad era típica de muchos sitios disponibles para ensayos en plantaciones en el sur del estado de Míchigan. La topografía variaba de llana a ondulada con declives máximos de aproximadamente 5 por ciento. En las partes más altas árboles de 6 años (contando desde el tiempo de la plantación) variaban entre 4 y 8 pies de altura y en los sitios bajos y pantanosos variaban de 2 a 5 pies de altura.

La plantación consistía de 50 hileras de 7 árboles cada una. No se notaba efecto sobre el crecimiento debido a la localización de los árboles en las orillas de las plantaciones. La altura de todos los árboles se midió hasta el décimo de pie más próximo. En el laboratorio dichas medidas se consideraron como si la plantación hubiera consistido de 350 parcelas individuales de un árbol cada una, o 175 parcelas de dos árboles o 50 parcelas de 7 árboles y así sucesivamente. La variación entre las parcelas para cada serie de promedios se computó usando la siguiente fórmula:

1/ Plot size in forest genetic research. Papers of the Michigan Academy of Science, Arts, and Letters 44, 1959 (1958 Meeting).

$$V = \frac{SX^2/n - (SX)^2/nr}{r}$$

Aquí V = variación entre parcelas, X = altura promedio de los árboles de una parcela, n = número de árboles por parcela y r = número de parcelas o replicaciones. Se usó r en vez de r-1 porque estabamos trabajando con un universo de 350 árboles en vez de con una muestra.

Para calcular la eficiencia estadística relativa de parcelas con n número de árboles en términos de parcelas de 1 árbol cada una, usamos la fórmula: $\frac{V_1}{Vn}$ = eficiencia, donde V_1 y Vn equivalen a las variaciones de las sumas de las parcelas con 1 —y con n— árboles respectivamente.

El número de replicaciones necesarias para demostrar si la diferencia entre los promedios de distintas variedades es significativa, se calculó de acuerdo con la fórmula siguiente:

$$t = d/\sqrt{V2/r},$$

la que se reduce a

$$r = 8V/d^2$$

si t = 2 = t de Student, V = la variación, r = número de replicaciones y d = la diferencia mínima perceptible.

El segundo rodal estudiado consistía de una plantación de tulipífero amarillo *(Liriodendron tulipifera* L.) en el Monte Russ en el suroeste de Michigan, perteneciente a la Universidad del Estado de Michigan. Dicha plantación fué establecida en el año 1941, usando una distancia de 6 pies x 6 pies. Ahora los árboles varían entre 5 y 30 pies de altura. En relación a la topografía y al suelo superficial, el medio o sitio era tan uniforme como es posible conseguirse en el sur del estado de Míchigan. En el interior de la plantación se midió el diámetro de cada árbol incluído en un cuadrado que contenía 32 árboles en cada lado. Las medidas fueron analizadas estadísticamente siguiendo el mismo procedimiento ya descrito para el pino rojo.

En ambos plantíos faltaban unos pocos árboles. Se eliminaron del análisis estadístico todas las parcelas en las cuales faltaron la mitad o más de la mitad de los árboles. En aquellas parcelas en que la mayoría de los árboles estaban presentes, se sustituyó un valor igual al promedio de la parcela por cada árbol ausente. La única consideración teórica envuelta en este reajuste fué que los árboles ausentes hubieran desarrollado igual a los árboles vivos en las mismas parcelas.

RESULTADOS

Los resultados de dichos análisis se ofrecen en las Tablas 1 y 2. La eficiencia estadística o la información relativa se redujo rápidamente con un aumento en el tamaño de la parcela. La reducción fué más notable en el pino rojo porque esta especie estaba localizada en un sitio marcadamente variable. Los resultados con esta especie indican que una prueba de variedades consistentes de 23 parcelas de 35 árboles cada una por variedad (o sea 805 árboles por variedad) daría la misma precisión estadística que una prueba de variedades consistente de 100 parcelas de 1 árbol cada una por variedad (100 árboles por variedad). En otras palabras, el estudio usando parcelas grandes requeriría 8 veces el esfuerzo necesario para establecer el experimento usando parcelas pequeñas.

La rápida disminución en la eficiencia estadística en el caso del estudio del tulipífero amarillo es especialmente notable considerando que este rodal crece en un sitio muy uniforme. Si el tulipífero amarillo hubiera que probarlo en un sitio más variable, resultaría aun más la ventaja en sentido estadístico de los estudios usando parcelas pequeñas.

Tabla 1. *Relación entre el tamaño de la parcela y la eficiencia experimental usando pino rojo*

Ancho de la parcela por largo árboles	Arboles por parcela número	Información relativa por ciento	Medidas necesarias[1] parcelas	árboles
1 x 1	1	100 0	100	100
2 x 1	2	79.3	63	126
4 x 1	4	51.2	49	196
5 x 1	5	49.5	40	200
1 x 7	7	33.1	43	301
2 x 7	14	28.8	25	350
4 x 7	28	11.7	30	840
5 x 7	35	12.2	23	805

1/ Para que una diferencia de 0.34 pies de altura entre los promedios de la progenie demuestre ser significativa.

Tabla 2. *Relación entre el tamaño de la parcela y la eficiencia experimental usando tulipífero amarillo*

Ancho de la parcela por largo árboles	Arboles por parcela número	Información relativa por ciento	Medidas necesarias[1] parcelas	árboles
1 x 1	1	100.0	100	100
1 x 2	2	85.4	58	116
2 x 1	2	86 6	58	116
1 x 4	4	61.2	41	164
4 x 1	4	75.6	33	132
2 x 2	4	60.7	41	164
5 x 1	5	54.6	37	185
2 x 4	8	38.0	33	264
4 x 2	2	42.8	29	232
5 x 2	10	21.8	46	460
4 x 4	16	27.3	23	368
4 x 8	32	22.6	14	448
8 x 4	32	19.4	16	512
8 x 8	64	18.5	8	512

1/ Para que una diferencia de 0.29 pulgada de diámetro, a la altura del pecho, entre los promedios de la progenie demuestre ser significativa.

CONCLUSIONES

Fleming y otros (1957), Keller (1949) y muchos otros agrónomos han demostrado la superioridad estadística de los experimentos usando parcelas pequeñas bien replicadas. Los geneticistas forestales sin embargo, han continuado en el uso de parcelas relativamente ineficientes de 50, 100 ó 200 árboles debido a dos razones. La primera es que se conocen solo dos trabajos estableciendo comparaciones entre parcelas de distintos tamaños (Strand, 1952; Wright y Baldwin, 1957). El presente trabajo constituye el primer esfuerzo en asignar valores numéricos a las eficiencias relativas de experimentos que incluyen parcelas de varios tamaños diferentes. La segunda razón es que los geneticistas que trabajan con árboles han mostrado cierta inclinación a subordinar la parte estadística a otras consideraciones. En realidad los valores estadísticos deben siempre considerarse con prioridad. ¿Porqué debemos tomar tiempo en explicar la diferencia en la manera de ramificar entre las variedades A y B si no existe prueba de que dichas variedades son diferentes?

A veces se ofrecen razones tales como mortalidad de las plantas y por consecuencia valores perdidos para justificar el no usar diseños de parcelas pequeñas. Sin embargo, un número pequeño de valores perdidos no es asunto muy serio. Esta deficiencia puede corregirse de varias maneras. Con una mortalidad de 10 por ciento, un aumento de 1 a 2 árboles por parcela reducirá el número de valores perdidos de 10 por ciento a solo 1 por ciento. Existen procedimientos reconocidos para computar los valores perdidos para incorporarlos en un análisis de la variación. Estos métodos son laboriosos pero válidos estadísticamente. Si las diferencias entre las replicaciones son pequeñas, entonces la variación atribuída a diferencias entre replicaciones y los valores perdidos pueden ignorarse en el análisis de la variación. Si la mayor parte de los valores perdidos caen en una replicación en particular, entonces dicha replicación puede omitirse de los cálculos de la variación. Si la mayor parte de los valores perdidos caen dentro de una variedad ésto es conveniente, porque entonces sometemos los datos de mortalidad a un análisis de la variación olvidándonos del crecimiento de la variedad en cuestión.

Realmente, no hay excusa para tener una mortalidad inicial mayor del 10 por ciento en pruebas de campo. Los costos de establecer un experimento constituyen una pequeña fracción del total de los costos por lo que se deben tomar precauciones razonables tales como eliminación de malezas, uso del arado en terrenos cubiertos de césped, uso de plantas de mayor tamaño que de costumbre y reemplazo de plantas durante el primer año, si existe alguna razón para creer que la mortalidad durante el primer año va a ser alta.

A menudo se quiere justificar el uso de parcelas, estadísticamente ineficientes, las que incluyen 49 árboles, o aun mayores y en las que la mayoría de los árboles están localizados en el interior de la parcela. Esto se hace basándose en la necesidad de someter árboles a pruebas en competencia con otros árboles de genotipo similar. Durante sus primeros 10 ó 15 años[2/] una plantación es poco más que una colección de árboles individuales creciendo en campo abierto. Cual sería el efecto de distintos arreglos de los árboles sobre la rapidez de crecimiento, si la diferencia entre el crecimiento de las mejores y las peores progenies es de solo 10 por ciento, como es de esperarse en la mayoría de las selecciones a base de un solo árbol? Solamente dos características de importancia de los árboles sobre las cuales interesamos obtener información de carácter genético, deben probarse en un ambiente forestal. Estas son el factor de forma del tronco y la habilidad del tronco de podarse por sí mismo. Diferencias tales como en crecimiento en altura y en diámetro, en la rectitud del tronco, en el diámetro de las ramas, y en resistencia al ataque de plagas, pueden determinarse en árboles en campo abierto. Por lo tanto, el uso de diseños de parcelas grandes generalmente reducirá la eficiencia estadística y aumentará los costos pero no la información a obtenerse.

El entresaque en una parcela experimental de 1 ó 2 árboles requiere la eliminación de parcelas por completo. Por ejemplo, si la intensidad del aclareo es de un 75 por ciento, el rodal remanente incluirá todas las mejores progenies (25 por ciento de la población original) y ninguno de las peores progenies (75 por ciento de la población original). Esto es genéticamente muy beneficioso porque da información completa acerca de las mejores progenies desde principio a fin y además retiene todos los árboles de las mejores progenies para utilizarse como material de propagación. En el futuro los geneticistas forestales estarán muy ocupados con árboles de buena progenie por lo cual no considerarán para árboles padres aquellos de progenie pobre.

El aspecto económico debe considerarse. Según los árboles aumentan en edad también aumentan en altura y son por consiguiente, más difíciles de medir. A la edad de 50 años un experimento que incluya 10,000 árboles de pino rojo podría costar $10,000 para medir. En primer lugar, si no va a medirse correctamente no debe sembrarse. Sería mucho mejor usar esa misma cantidad de dinero y obtener datos de la misma corrección para diez en vez de para una sola especie.

RESUMEN

Los autores llevaron a cabo ensayos o pruebas de uniformidad en plantaciones de pino rojo y de tulipífero amarillo en el sur del estado de Michigan. En ambas especies se redujo rápidamente la eficiencia estadística al aumentar el tamaño de las parcelas. Por ejemplo, parcelas de 35 árboles de pino rojo mostraron solamente el 12 por ciento de la eficiencia de parcelas de solo un árbol. El uso de diseños de experimentos con parcelas pequeñas es también preferible desde el punto de vista de costos y de los aclareos y no presenta ningún problema especial de valores perdidos o de competencia. Esto es desde luego, siempre que las plantaciones de pruebas o de ensayo se establezcan con el debido cuidado.

2/ Nota del editor: los primeros 2-5 años en las áreas tropicales.

SUMMARY

Uniformity trials on red pine and yellow-poplar plantations were conducted in southern Michigan. In both species there was a rapid decrease in statistical efficiency with increasing plot size. For example, 35-tree red pine plots were only 12 percent as efficient as 1-tree plots. Provided that test plantings are carefully established, the use of small plot designs is also advantageous from the cost and thinning standpoint, and poses no special missing plot or competition problems.

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Kiln Schedules For Puerto Rican Yagrumo Hembra

By

J. M. MCMILLEN, TECHNOLOGIST

Forest Products Laboratory,[1] Forest Service

U. S. Department of Agriculture

Yagrumo hembra *(Cecropia peltata L.)* is available in larger volume than any other Puerto Rican species of tree, and it also grows plentifully in other Latin American countries. It can be easily propagated. As yet, however, it has only limited use for matchsticks, boxes and crates, interior boarding, and the like.

Longwood[2/] reported that this very fast growing wood is light in weight (22 pounds per cubic foot) but tough and strong for its density. The texture is coarse and the grain generally straight. When it is air dried under cover in the San Juan area, its moisture content drops form 110 percent to 17 percent in less than 4 months without surface checking, end checking, or collapse. It may suffer some degrade because of cup, bow, crook, and twist.

A high ratio of tangential to radial shrinkage has been reported. Although problems are encountered with it in sawing, shaping, and turning when it is green or too wet, Longwood reports, it takes screws and nails readily and holds them firmly. It has been suggested as a substitute for balsa in the manufacture of toys, models, and other commercial articles where the moderately heavy grades of balsa are used.

In view of the above, the Institute of Tropical Forestry of the U. S. Forest Service in Puerto Rico asked the Forest Products Laboratory to evaluate certain basic properties of this species, recommend kiln schedules, and determine its suitability for veneer and particle board.

This report gives kiln schedules for 1-inch boards, 2-inch flat pieces, and two sizes of hardwood dimension. It also gives information on specific gravity and shrinkage of the material used in the drying experiments and some moisture meter correction values. Since this material came from a number of trees grown on different sites, the kiln schedules are believed to be suitable for yagrumo hembra growing in Puerto Rico and probably also will apply to wood of this species grown elsewhere.

MATERIAL AND METHODS

MATERIAL

The material for seasoning experiments comprised essentially all of the lumber that could be sawed from 10 logs shipped to the Laboratory for kiln schedule work. The material came from five different sites in the Sabana working circle of the Luquillo Experimental Forest, Puerto Rico. These sites were located from 100 to 1,000 meters from a stream. Data on the trees and seasoning study log sections are given in Table 1.

Upon arrival at the Laboratory in early July the logs were found to be partially free of bark. Therefore, some surface checks 2 to 3 inches deep were present, and blue stain had penetrated below the surface and into wood around the checks. The logs were piled together and protected with a cold-water spray until sawed several days later.

Taper sawing was done to remove thin slabs and then a layer of wane-edged 1-inch boards

1/ Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

2/ Longwood, F.R. 1961. Puerto Rican Woods. USDA Agri. Handbook 205. 98 pp.

Table 1. *Characteristics of the seasoning test material from 10 different 8-foot logs of Puerto Rican yagrumo hembra* (Cecropia peltata L.)

Tree No.	Diameter at breast height outside bark	Log section	General characteristics	Height of lower end above ground	Diameter inside bark		Specific gravity[1] of test specimens			Green moisture content of test specimens		
					Bottom	Top	Minimum	Maximum	Average	Minimum	Maximum	Average
	In.			Ft.	In.	In.				Percent	Percent	Percent
1	17	A	Large twist	8	16	14	0.11	0.29	0.19	101	135	118
2	15	A	Smooth	9	13	12	.28	.41	.34	58	85	74
3	17	A	Smooth	3	17	15	.20	.31	.27	74	126	93
		C	Knotty	16	14	13	.25	.37	.31	61	82	75
		D	Knotty	24	13	12	.28	.34	.31	64	124	95
4	17+	A	Medium Twist	8	14	13	.31	.39	.36	66	121	76
5	15	C	Large crook	26	14	13	.32	.41	.37	64	98	78
6	15	A	Medium Twist	7	14	13	.17	.27	.23	67	120	102
8	16	A	Smooth	7	15	14	.17	.33	.25[2/]	86	107	96[3/]
10	16	A	Large crook	13	16	14	.20	.27	.24[2/]	78	137	104[4/]
Average									.29			91

1/ Based on volume when green and weight when ovendry.

2/ Sectors from pith to bark from 3-inch cross sections of logs 8A and 10A both had specific gravity values of 0.27.

3/ Moisture content values for cross section sectors were: outer portion 102 percent, inner portion 120 percent, average 109 percent.

4/ Moisture content values for cross section sectors were: outer portion 55 percent, inner portion 97 percent, average 62 percent.

that included most of the blue-stained layer. Then at least one good 1-inch board and one good 2-inch flat piece of lumber were sawed from each log. This flat lumber was edged to about an 8-inch width. Additional good 1- or 2-inch pieces were sawed when possible. This left a thick dog-board containing the large septate pith of the tree. Such material was ripped into rectangular dimension lumber that was sorted into two groups, one roughly 2 by 3 inches and the other roughly 3 by 4 inches in cross section.

From the 8-foot lengths of flat material or dimension, two or three seasoning specimens 27 inches in length were cut. The number cut depended upon the depth of blue stain penetration from the ends. Major amounts of blue stain were not present in the finished specimens.

Specimens and moisture sections were weighed and the specimens end coated in accordance with standard kiln sample procedure (U.S. Forest Products Laboratory, 1954). During preparation of the specimens, wet cloths were laid on the material to protect it from drying. After preparation, the specimens were stored under wet cloths in a room at 36°F and 80 percent relative humidity. One specimen from each log was placed in each seasoning group, with the specific group being selected by means of random numbers.

METHODS

The general method of experiment consisted of successive trials of complete preselected kiln schedules. The objective was to make one kiln run with a schedule known to be safe for a familiar North American wood of similar physical characteristics, then succeeding runs with other complete schedules selected for severity in accordance with the results of preceding runs.

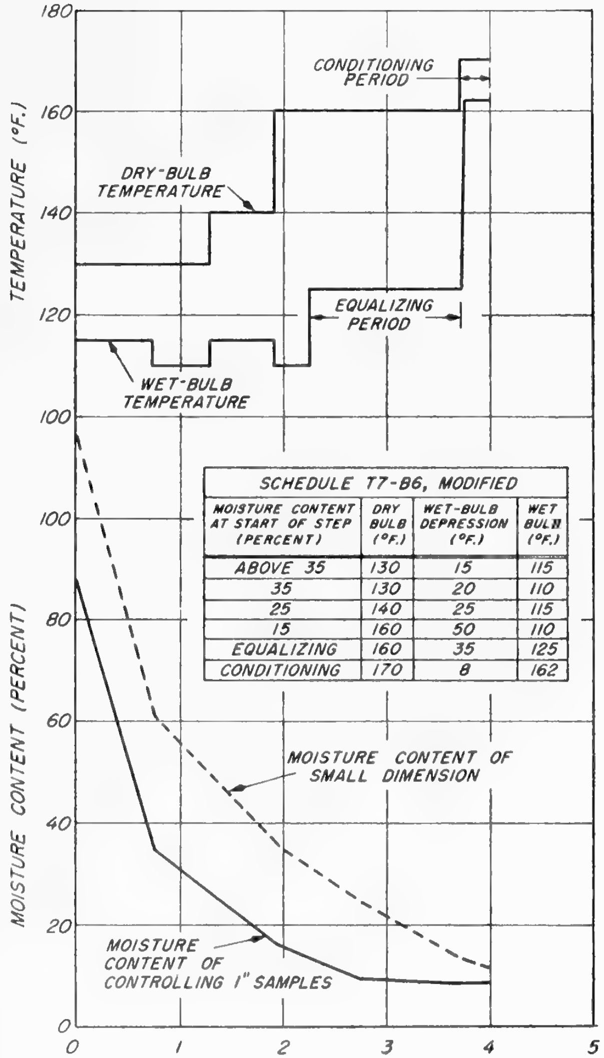
In this study, the blue-stained outer 1-inch boards were kiln dried in a pilot run using the hardwood T7-B6 schedulue (U.S. Forest Products Laboratory, 1960). No new checking occurred. Two sample boards in the charge dried from an average moisture content of 59 percent to 7.4 percent in 3-3/4 days.

On the basis of this result and the more severe schedules permissible for North American basswood and aspen, schedule T9-B6 was selected in modified form for experimental kiln run No. 1 on the 1-inch specimens. The small dimension was included in this run as well as in run No. 2. At intervals during the drying, the kiln was shut off and the specimens removed one or two at a time for weighing and examination. Changes in drying conditions were based on the average moisture content of the wetter half of the 1-inch specimens.

Runs Nos. 2 and 3, also on 1-inch stock, were made with modified schedules T5-D7 and T7-B6, respectively. Run No. 2 had a lower dry-bulb temperature but a larger, more severe wet-bulb depression. Run No. 3 was similar to the pilot run, intermediate between Runs 1 and 2 in dry-bulb temperature.

Two experimental runs, Nos. 4 and 5, were made with the flat 2-inch lumber, for which slightly modified Forest Products Laboratory kiln schedules T5-E5 and T7-B5 were used. In both of these runs, the large dimension was included, but the kiln operation was governed by the moisture content of the 2-inch flat lumber. Since the 3- by 4-inch dimension dried considerably more slowly than the 2-inch flats, special methods of handling the dimension were required. In run No. 4, the dimension was removed from the kiln when the 2-inch flat stock was ready for the high final temperature. Drying of the dimension was completed in its own kiln. For run No. 5, the large dimension was started 2 days before the 2-inch material, then dried along with it until the 2-inch material was dry.

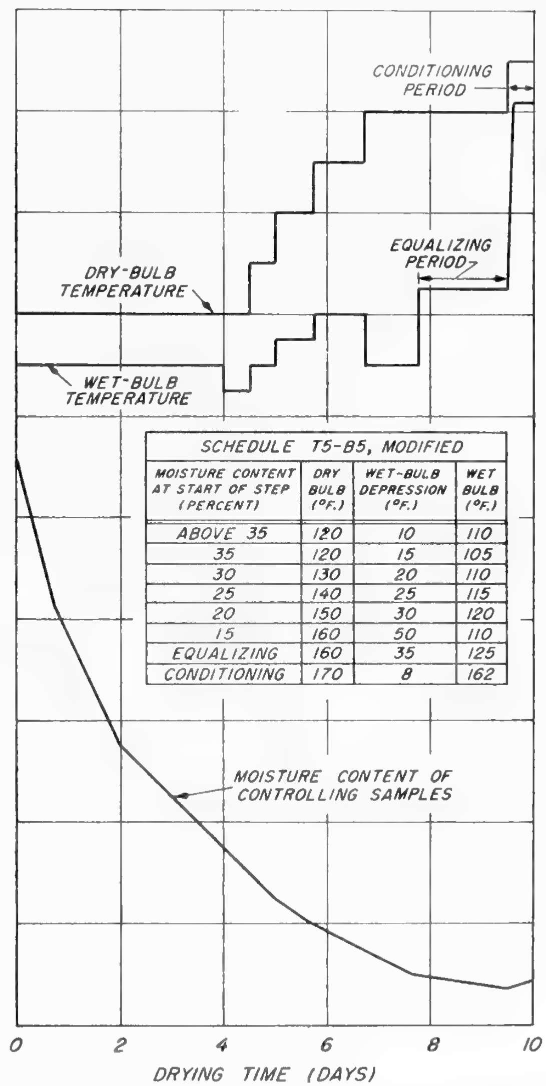
Each seasoning group for the flat 1-inch and 2-inch lumber contained 11 to 13 specimens. For the 2- and 3-inch dimension, 5 to 9 specimens comprised each group. In most cases



SCHEDULE T7-B6, MODIFIED

MOISTURE CONTENT AT START OF STEP (PERCENT)	DRY BULB (°F.)	WET-BULB DEPRESSION (°F.)	WET BULB (°F.)
ABOVE 35	130	15	115
35	130	20	110
25	140	25	115
15	160	50	110
EQUALIZING	160	35	125
CONDITIONING	170	8	162

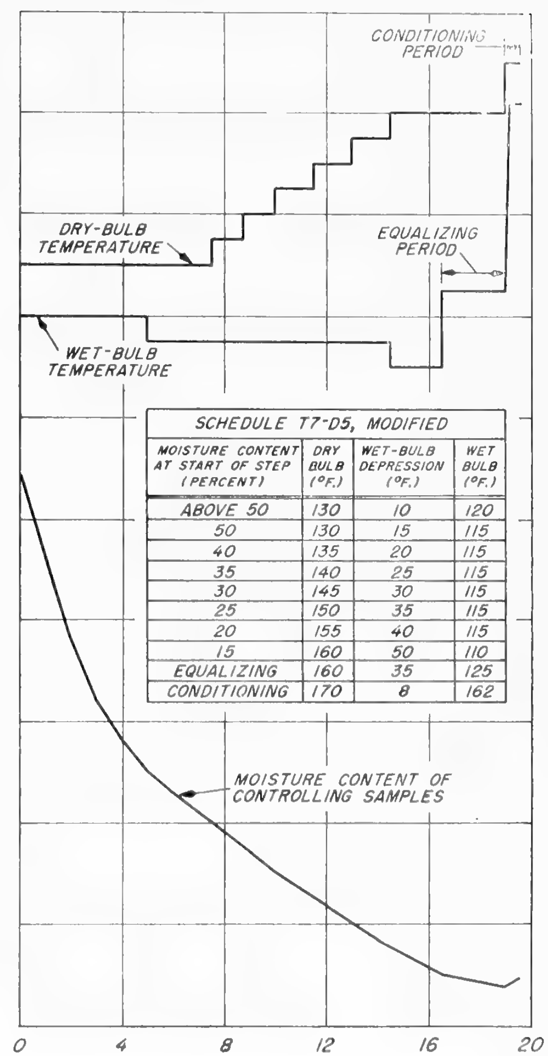
Figure 1. Recommended kiln schedule and drying curve for 1-inch and small dimension yagrumo hembra.



SCHEDULE T5-B5, MODIFIED

MOISTURE CONTENT AT START OF STEP (PERCENT)	DRY BULB (°F.)	WET-BULB DEPRESSION (°F.)	WET BULB (°F.)
ABOVE 35	120	10	110
35	120	15	105
30	130	20	110
25	140	25	115
20	150	30	120
15	160	50	110
EQUALIZING	160	35	125
CONDITIONING	170	8	162

Figure 2. Recommended kiln schedule and drying curve for 2-inch yagrumo hembra.



SCHEDULE T7-D5, MODIFIED

MOISTURE CONTENT AT START OF STEP (PERCENT)	DRY BULB (°F.)	WET-BULB DEPRESSION (°F.)	WET BULB (°F.)
ABOVE 50	130	10	120
50	130	15	115
40	135	20	115
35	140	25	115
30	145	30	115
25	150	35	115
20	155	40	115
15	160	50	110
EQUALIZING	160	35	125
CONDITIONING	170	8	162

Figure 3. Recommended kiln schedule and drying curve for 3-inch and 4-inch yagrumo hembra.

the specimens were end coated. The small experimental kilns used developed an air velocity of about 300 feet per minute through the load. Dry- and wet-bulb temperatures were automatically controlled.

Volumes of the green material were obtained by the water displacement method. Shrinkage information was not of primary importance in this study, but some was obtained. Initial measurements of the green dimensions of the specimen were made roughly with a steel rule. Final measurements of the kiln dried dimensions were made with a dial micrometer.

SEASONING RESULTS

The experimental work showed that yagrumo hembra is easy to kiln dry without collapse. Generally good results were obtained with all schedules tried. Shrinkage and warping were not excessive, and the desired final average moisture content, moisture uniformity, and relief of drying stresses were readily attained.

Run No. 1 was generally satisfactory, but some short end checking and surface checking occurred in decayed areas. The schedule used in run No. 2 was too severe. There was more surface checking than in run No. 1 and probably more than would be commercially acceptable. Run No. 3 was satisfactory. One end of each specimen had been left uncoated, and some uncoated ends checked. The end checks generally did not extend more than 1.5 inches. Some slight surface checking also was associated with the uncoated ends but did not run more than 12 inches. Such stock should be commercially acceptable.

Results for the 2-inch stock in run No. 4 were unsatisfactory. Much surface checking occurred between 48 and 97.5 hours after the start. There was not honeycombing, but a very small amount of collapse may have occurred in one specimen. Run No. 5 was considered generally satisfactory for the 2-inch stock, although three specimens surface checked somewhat. There was no honeycombing.

The wet-bulb depression schedule was too severe for the 3- by 4-inch stock in run No. 4, but the temperature schedule was satisfactory. One specimen developed a rather severe surface check in sound wood. Drying results were good on the 3- by 4-inch material in run No. 5, but the drying time was too short and the stock finished at a high moisture content No collapse or honeycombing occurred in this stock in either run.

KILN SCHEDULE RECOMMENDATIONS

The recommended kiln schedule for 1-inch and small dimension yagrumo hembra is given in Figure 1. Kiln samples should be used in following this schedule (U. S. Forest Products Laboratory, 1954). If both types of material are included in the kiln charge, samples from each should be used. Changes in kiln conditions should be based on the average moisture content of the wettest half of the samples, which are the controlling samples, from the slowest-drying size. When excessively wet material near knots or other irregularities is included in the drying charge, some of this material should be included in the samples.

The kiln conditions and drying curve for the recommended schedule are shown in Figure 1, based largely on run No. 3. Drying to 35 percent moisture content is so fast that wet-bulb depression schedule B6 is used instead of D6. The hardwood dimension in this case was roughly 2 by 3 inches in cross section, and its drying curve is a composition of runs Nos. 1 and 2. Besides having an initial moisture content higher than that of the 1-inch boards, there was some indication that it dries more slowly than the 1-inch stock. It is estimated that the drying time in a commercial forced-air-circulation dry kiln would be 5 days for 1-inch stock and 6 days for 2- by 3-inch stock. These times should produce stock dried to an average moisture content of 9 percent free of drying stresses.

The recommended kiln schedule, kiln conditions, and the drying curve for 2-inch yagrumo hembra for this schedule are shown in

Figure 2. These are based mostly on the results of run No. 4. The defects occurring with the early use of a 15°F. wet-bulb depressions in run No. 4, in contrast to the better results with the B5 wet-bulb depressions of run No. 5, make the B5 schedule preferable. It is estimated that 11 days in a commercial forced-air-circulation dry kiln would bring 2-inch stock to an average moisture content of 9 percent free of drying stresses.

The equalizing and conditioning procedures in Figures 2 and 3 are modifications of the recommended procedures (U. S. Forest Products Laboratory, 1960). Slight modifications or changes in the conditioning time may be necessary to obtain full stress relief at the 9 percent final average moisture content. Greater modification would be needed to achieve stress-free stock at a higher or lower moisture level.

A suggested kiln schedule for approximately 3- by 4-inch yagrumo hembra and a postulated drying curve for dense material of this size in an experimental kiln is shown in Figure 3. Lower density material would take the same schedule but would probably dry faster. This schedule is somewhat more severe than the schedule for 2-inch stock, and some of the stock will develop seasoning defects. The experimental work indicates the amount of degrade would not be large. If less degrade is required, the schedule for 2-inch stock can be used. Drying time will be considerably longer, however. Probably the higher density and wetter material of this size should first be partially air dried, then kiln dried with lighter stock of the same size. All such thick stock should be well end coated (McMillen, J. M., 1956; U. S. Forest Products Laboratory, 1957) before either air or kiln drying is started.

The moisture content-time curves shown in Figures 1 through 3 are for the experimental kilns with high-velocity air circulation through the load and kiln conditions, under close control. They should not be used for time schedules in commercial operations. Time schedules can be developed by a commercial operator, however, after he has run several charges on the moisture content basis.

SPECIFIC GRAVITY AND SHRINKAGE

Specific gravity data for the seasoning test material are given in Table 1. These data are taken from 6 to 10 sections for each log. They indicate that only a small amount was as light as balsa and a similarly small amount as heavy as yellow-poplar. The bulk was a little lighter than basswood; its average specific gravity was 0.29.

The shrinkage data given in Table 2 are not accurate because of the lack of precision discussed under "Methods". They have a limited value, however, to indicate the approximate shrinkage values to be expected in lumber and dimension stock dried under the recommended schedules. For the flat lumber, width shrinkage is mostly tangential and thickness shrinkage mostly radial. This orientation does not hold for the dimension. In general, it would appear that the relationship of tangential to radial shrinkage is approximately the same as for other woods, although a few specimens with practically no radial shrinkage were observed. The shrinkage and warping were not abnormally high, and only slightly more, if any, allowance for shrinkage needs to be made in sawing out the green stock than for typical North American hardwoods.

Table 2. *Average shrinkage results for material in some of the experimental kiln runs on yagrumo hembra.*

Run. No.	Average shrinkage: Width	Average shrinkage: Thickness
	Percent	Percent
	1-INCH LUMBER	
1	3.4 1/	4.1 1/
2	5.4	2.4
	2-INCH LUMBER	
4	5.6	2/
5	5.9	2.6
	SMALL DIMENSION	
1	6.1	5.5
2	2.9	4.8

1/ Data of smaller reliability.

2/ No data.

MOISTURE METER CORRECTIONS

A brief study of resistance-type moisture meter readings at different relative humidities was completed by a Research Associate.[3/] The moisture meter correction values indicated for 80°F. are given in Table 3, below.

Table 3. *Moisture meter corrections at 80°F.*

Resistance meter reading	Correction	Actual moisture content
Percent	Percent	Percent
6.0	-1.0	5.0
8.0	-1.4	6.6
10.0	-1.8	8.2
12.0	-2.2	9.8
14.0	-2.5	11.5
16.0	-2.8	13.2
18.0	-3.2	14.8
20.0	-3.6	16.4
22.0	-4.0	18.0

The minus sign indicates the value is to be subtracted from the meter reading.

CONCLUSIONS

Yagrumo hembra *(Cecropia peltata* L.) is easy to kiln dry as 1- and 2-inch flat lumber or small to moderate sized dimension. No significant collapse or excessive seasoning degrade occurs. Kiln schedules are recommended for the 1- and 2-inch lumber and the 2- by 3-inch dimension. A schedule is suggested for 3- by 4-inch stock. Estimated commercial kiln drying times are: 5 days for 1-inch lumber; 11 days for 2-inch flat lumber; 6 days for 2- by 3-inch dimension; and 21 days for 3- by 4-inch dimension of comparatively high density. No problems are encountered in achieving stress-free lumber.

Shrinkage is not large nor is warping excessive except in a very limited portion of the material. The average specific gravity is 0.29, slightly lower than that of North American basswood.

Moisture meter corrections of -1.0 to -4.0 appear to be needed for the resistance-type moisture meter.

RESUMEN

El yagrumo hembra *(Cecropia peltata* L.) es fácil de secar al horno en maderas planas de 1 y 2 pulgadas de espesor o en dimensiones pequeñas y moderadas. No ocurre ningún encogimiento o secamiento significante ni degradación excesiva. Para madera de 1 y 2 pulgadas y para la dimensión de 2 x 3 pulgadas se recomienda seguir programas de secado al horno. También se sugiere seguir una tabla para secar material de 3 x 4 pulgadas. Los periodos comerciales estimados para secar al horno son: 5 días para madera de 1 pulgada; 11 días para madera plana de 2 pulgadas; 6 días para madera de 2 x 3 pulgdas; y 21 días para una dimensión de 3 x 4 pulgadas con una densidad comparativamente alta. No surgen problemas para obtener madera libre de tensión.

La madera no encoge demasiado ni el alabeo es excesivo excepto en una porción limitada del material. El promedio de la gravedad específica es de 0.29, ligeramente más bajo que el del tilo de Norte América.

Las correcciones de -1.0 a -4.0 del metro de humedad parece que son necesarias para el metro de humedad del tipo de resistencia.

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El Pino Monterrey en Cundinamarca [1]

Por

ELMO MONTENEGRO

Desde hace algunos años se ha venido sembrando en varios lugares de Cundinamarca, al igual que el eucalipto y el ciprés aunque en menor escala, el árbol llamado comúnmente pino Monterrey y pino candelabro *(Pinus radiata* D. Don) cuya utilización hasta la presente ha sido ante todo ornamental. Los agricultores lo usan como árbol de sombrío en potreros, cercas, y rompe-vientos. Algunos proyectos oficiales han comenzado a emplearlo en cuencas hidrográficas y áreas erodadas.

Con esta especie, como sucede con la mayoría de las que se han introducido a Colombia, es muy poco o nada lo que se sabe sobre su ecología, silvicultura, utilización, e inclusive identificación. Entonces los principales objetivos de este estudio fueron:

a. Observaciones sobre características ecológicas, silviculturales, y de utilización de esta especie.

b. Preparación de una tabla local de volumenes y otras mediciones de interés dasométrico.

El trabajo se ha basado en observaciones y mediciones en varios lugares del Departamento de Cundinamarca, aprovechando en parte la comisión del Instituto Geográfico para el levantamiento del Mapa Ecológico de Colombia.

ECOLOGIA

De acuerdo con los lugares donde actualmente prospera el *Pinus radiata,* la vegetación, y los correspondientes datos metereológicos de que dispone, esta especie muestra su desarrollo óptimo en alturas comprendidas entre los 2,400 y 2,700 metros sobre el nivel del mar; temperaturas medias anuales de 13 a 15 grados centígrados y precipitaciones medias anuales entre 700 y 1,500 milímetros. Estos datos corresponden a las formaciones Bosque Seco y Bosque Húmedo de la Faja Montano Bajo en la Región Tropical, de acuerdo al Sistema de las Formaciones Vegetales del Mundo de Holdridge (1). Sin embargo, esta especie sube a Bosque Húmedo y Muy Húmedo de la Faja Montano con resultados satisfactorios.

Los suelos preferidos para su desarrollo son los que tienen buena profundidad, algo húmedos y fértiles, con topografía ondulada. También prospera en suelos erosionados como los que circundan el Valle de Ubaté, cuenca del Río Checua y las laderas de Monserrate, lugares donde se puede observar un interesante proceso de recuperación de los suelos y de la vegetación nativa, gracias al ambiente que propician las masas de pino Monterrey.

En Monserrate, la asociación de *Acacia melanoxylon* y *Pinus radiata* ha dado muy buenos resultados; así mismo en Usaquén la mezcla de *Pinus patula* con *Pinus radiata* parece favorecer a las dos especies en su forma de crecimiento, aunque el *Pinus patula* con su follaje menos denso ha demostrado resistir más a la acción de los vientos.

La tolerancia a la sequía la ha demostrado esta especie en las plantaciones de Sutatausa, donde resiste veranos prolongados en suelos carentes totalmente de vegetación. Su desarrollo, sin embargo, no se puede comparar a Usaquén, Monserrate, y la Sabana donde hay un poco más de precipitación, mejores suelos, o ambiente forestal. Es de anotar, que los pinos plantados en Sutatausa, Ubaté, Sisga, Río Checua y Neusa, presentan en sus primeros años

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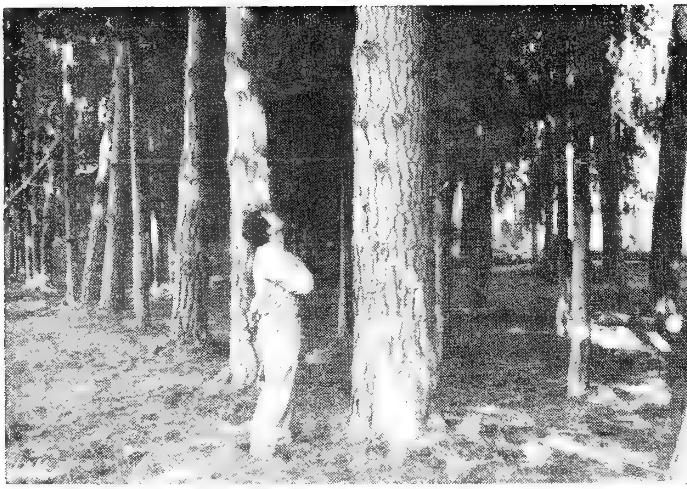
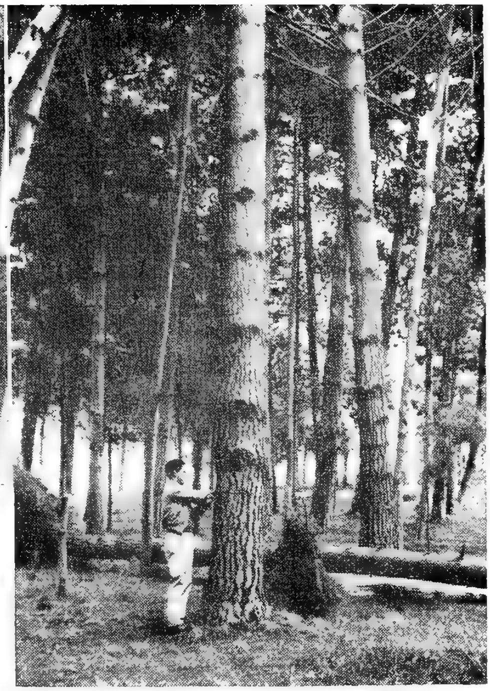
1/ Adaptado de una tesis sometida a la Universidad Distrital de Bogotá "Francisco José de Caldas".





Izquierda: P. radiata con DAP de 54 cms, altura total de 25m. y 22 años de edad, en Usaquén, Colombia. (Foto W. Bender)

Derecha: P. radiata con una altura total de 30 m., DAP 49 cm. y 22 años de edad, en Usaquén, Colombia. (Foto W. Bender)

de crecimiento una necrosis de la yema terminal o "puntas secas". Esto retrasa notablemente el desarrollo como la buena forma del árbol.

Como ornamental, cercas, rompe-vientos, o en rodales, el pino Monterrey tolera fácilmente los pastos, arbustos y otros árboles.

SILVICULTURA

En las observaciones realizadas se pudo ver que esta especie no tiene buena producción de semillas en árboles que no han alcanzado edades superiores a los 20 años. Los lugares que resultaron ser algo propicios para su recolección fueron Usaquén y la Ciudad Universitaria, en árboles de altura promedio de 15 metros. La extracción se hace secando los conos en estufa o al sol. Un kilogramo de semillas con un 10% de impurezas tiene aproximadamente 30,000 semillas. De las muestras examinadas se comprobó un 80% de viabilidad y un 70% de poder germinativo. Estos porcentajes pueden subir cuando la cosecha se hace en árboles completamente adultos.

A pesar de las buenas condiciones de las semillas, la regeneración natural de esta especie es casi nula. Esto se debe sin duda a la falta de fuegos en el piso o a la falta de cualquier otro tratamiento silvicultural que ayude a la germinación de la semilla. El sistema corriente de propagación es por plántulas obtenidas en viveros. Las eras, según la experiencia de varios lugares de Cundinamarca, deben tener suelo suelto, franco arenoso, con buen drenaje, pues los lugares muy húmedos o abuso del riego facilitan el ataque de hongos. En el vivero de Tibaitatá el damping-off produjo casi la muerte total de 50,000 arbolitos de 8 semanas de edad. Se ensayaron seis fungicidas para controlar este ataque, dando los mejores resultados aquellos que estaban hechos a base de cobre.

Para producir un arbolito de 20 cms. de alto, en la Sabana y Ubaté, se necesitan generalmente 10 meses; en Neusa y Sisga un año. La siembra se hace en los meses de enero a junio con el fin de que las posturas estén listas para los inviernos de octubre y abril, respectivamente. Para obtener 500 arbolitos de

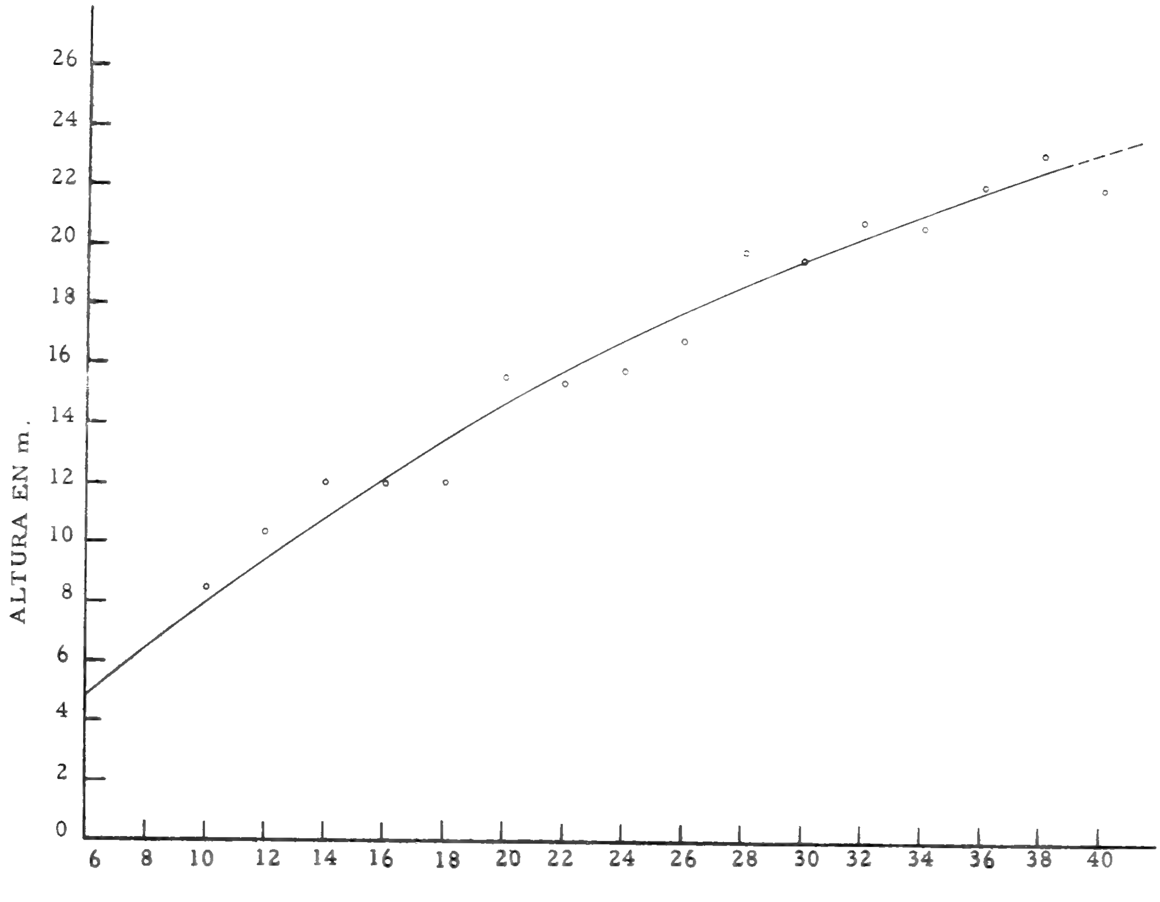


Figura 2. *Relación entre la altura y el Diámetro a la altura del pecho,* Pinus radiata, *Cundinamarca, Col.*

transplante por metro cuadrado, se necesitan aproximadamente 35 gramos de semillas.

La plantación en sitio definitivo puede hacerse a raíz desnuda, si el suelo y el clima se prestan para esto y si no es mejor usar empaques de cartón, papel periódico, polietileno o vástago de plátano. A raíz desnuda, un hombre en 8 horas de trabajo, puede plantar un promedio de 800 árboles. Las distancias normales en las plantaciones son de 2 x 2 metros o lo que es igual a 2,500 árboles iniciales por hectárea. De las observaciones hechas parece que esta distancia, para una mejor protección de la humedad del suelo y forma de los árboles, se debía acortar a 1.70 x 1.70.

En el primer año de la plantación los cuidados requeridos solamente son para observar el porcentaje de prendimiento y replantación, como también algunas cortas de arbustos o malezas con los cuales no pueda competir el arbolito.

Al cuarto año, el árbol alcanza una altura promedio de seis metros en la Sabana y 4 en Neusa y Sisga. Entonces viene la primera poda, que es particularmente en plantaciones de pino Monterrey, puesto que esta especie es de difícil poda natural. Si se demora demasiado la poda, la parte nudosa del árbol será bastante gruesa y por lo tanto producirá menos madera de buena calidad. Cuando la espesura lo

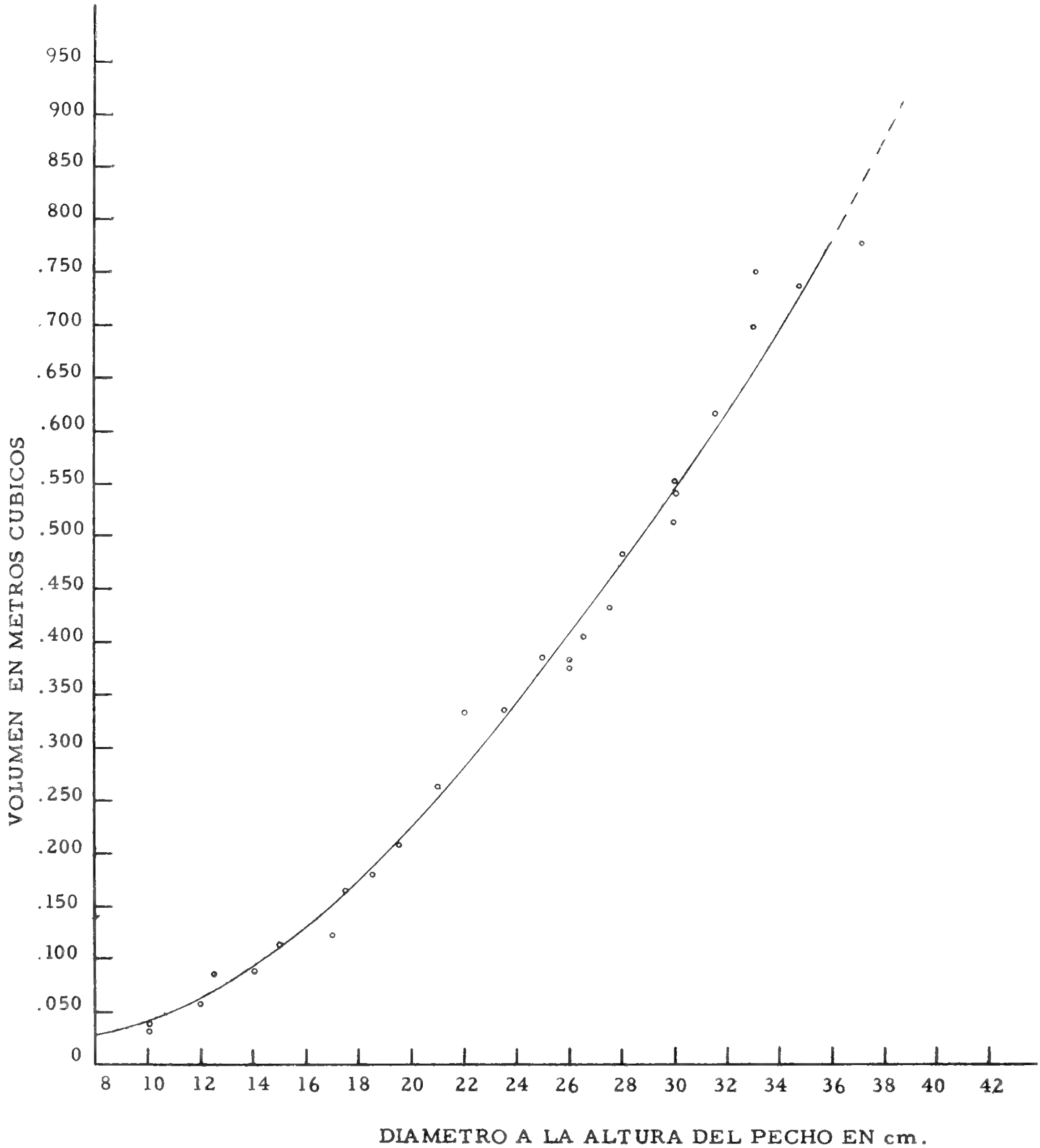


Figura 3. *Relación entre el volumen y el diámetro a la altura del pecho*, Pinus Radiata, *Cundinamarca, Col.*

permite antes de hacer la poda se puede hacer el aclareo. Esto, dá la ventaja de seleccionar fácilmente los árboles que se van a podar y además facilita el tránsito en el bosque. Es pre ferible hacerla al principiar el invierno, pues así se tiene las ramas casi descompuestas para el verano, lo cual disminuye el peligro de incendios.

La poda en Cundinamarca generalmente adolece de varios defectos o no se hace nunca, esto último acontece especialmente con los árboles ornamentales. Pero si se poda debería usarse herramientas como el serrucho y no el hacha y el machete y cortar las ramas a ras de tronco y no dejar ganchos con el objeto de ascender al árbol para podarlo en exceso. Además la poda solo sirve hasta una altura aproximada de 8 metros de tronco, como tampoco vale la pena podar los árboles completamente adultos o los que tienen menos de una pulgada a la altura del pecho. La densidad final promedio por hectárea y de acuerdo a la calidad del sitio pueden ser de 500 árboles, aproximadamente.

El pastoreo en los bosques de pino Monterrey sería mejor rotando las áreas y con árboles no menores de 2 metros de altura. Se observó en algunos lugares degradación del suelo por excesivo pastoreo.

En cuanto a plagas, hace poco se presentó en Neusa un lepidóptero que atacó las ramas terminales, se controló oportunamente con un insecticida orgánico.

De los pinos que se cortaron difícilmente se les pudo observar los anillos, los cuales estaban a espacios muy variables.

UTILIZACION

Actualmente en Cundinamarca, la utilización más común del *Pinus radiata* es principalmente ornamental. En algunas fincas lo usan como rompe-viento, cercas vivas, sombra para el ganado, aunque algunos finqueros se han propuesto hacer plantaciones con sentido comercial. Actualmente, tal vez el papel más importante lo tenga como especie forestal protectora de los suelos y aguas y como tal se encuentra plantada extensamente en Sutatausa, Ubaté, Sisga. Neusa, Usaquén y Monserrate.

Sin embargo, se hizo aserrar una troza de pino Monterrey y los aserradores la encontraron con fibra algo pegajosa, pero lo liviana de la madera y la facilidad para el clavado, favorecieron su aceptación especialmente para cajonería. Esta industria actualmente ocupa retal de maderas tropicales generalmente pesadas. Muchos aprovechan los restos de las tablillas de pino de la cajonería de importación. Por este aspecto parece que las coníferas en el futuro, tendrán en Colombia un gran consumo.

VOLUMEN DE LA CORTEZA

Medidos los 28 árboles que sirvieron para la confección de la tabla local de volumenes, se encontraron en los mismos los siguientes datos para el volumen de la corteza.

Porcentaje de corteza	Número árboles
25 - 20%	3
19.9 - 15%	8
14.9 - 10%	15
9.9 - 5%	2

CLASE DE FORMA

De las mensuraciones realizadas se pudo observar que hay una gran variación en los individuos según su espaciamiento, diámetro y altura. Así, se encontró como mínima forma de clase 65 y como máxima 90, el promedio fué 80, dato con el cual fueron calculados los volumenes (4).

VOLUMEN POR HECTAREA

Según las informaciones suministradas por los propietarios de los rodales de Usaquén, las plantaciones tienen en la actualidad 22 años. En proporción de una hectárea los rodales medidos tienen un volumen de 524 m^3, lo que nos daría un volumen promedio por hectárea de 24 metros cúbicos.

ECONOMIA

Se pueden hacer algunos cálculos hipotéticos para plantaciones de pino Monterrey en Cundinamarca, aunque se puede pensar en otras especies que inclusive pueden dar mejores rendimientos (3), (5).

Si pensaramos en una fábrica de papel para producir 300 toneladas diarias de celulosa se necesitarían 1,500 metros cúbicos de madera. El rendimiento en Chile (6) es alrededor del 47 por ciento, ó sean 210.6 kilogramos de pasta seca por metro cúbico de madera verde.

En un año se emplearían el producido de 1,000 hectáreas aproximadamente, presumiendo conservativamente un volumen anual de 20 m^3 por hectárea. Con un turno de 25 a 30 años, el total de superficie a plantar sería entre 25,000 y 30,000 hectáreas que actualmente tiene Cundinamarca como tierras no aptas para agricultura.

El costo de plantación, mantenimiento y tratamiento silviculturales, varía de acuerdo al lugar, suelos, clima etc., pero se puede apreciar en promedio el valor de $3,000 por hectárea.

RESUMEN

Las plantaciones de pino Monterrey o pino candelabro *(Pinus radiata* D. Don) en Cundinamarca, son generalmente ornamentales. Sin embargo, algunos proyectos oficiales lo están usando con buenos resultados para recuperar la cubierta forestal en cuencas hidrográficas y áreas erosionadas. Como la especie ha demostrado tener un buen crecimiento y condiciones para suministrar buena madera, posiblemente en el futuro entre a figurar en los mercados de madera y aún servir como materia prima para la fabricación de pulpa y papel.

Los resultados y conclusiones del presente estudio mostraron lo siguiente:

(1) Ecológicamente, la formación en que tiene su óptimo desarrollo es en Bosque Húmedo y Seco de la Faja Montano Bajo en la Región Tropical (1).

(2) Silviculturalmente se comporta como una especie tolerante a la mezcla de otros árboles. Su regeneración natural es casi nula, teniéndose que obtener los nuevos rodales por métodos artificiales. Sin embargo, faltan por aplicar sistemas que faciliten esta regeneración por medio de cortas o fuegos controlados. La producción de semillas es satisfactoria. No se poda naturalmente. La rotación para madera aserrada no debe ser menor a los 25 años; para otros menesteres puede ser de acuerdo al diámetro necesitado.

(3) Se preparó una tabla local de volumenes y otras mensuraciones de interés dasométrico.

ENGLISH SUMMARY

The plantations of Monterrey pine or candelabro pine *(Pinus radiata* D. Don) in Cundinamarca are mostly ornamental in purpose. Nevertheless this tree is being used with good results in some official projects for the reforestation of watersheds and badly eroded lands. Inasmuch as it grows rapidly and demonstrates good resistance to adverse site conditions it may very possibly enter into future sawnwood markets and even serve as raw material for the manufacture of pulp and paper.

The results and conclusions of the present study show the following:

(1) Ecologically, the plant formation in which it attains its best development is in the *lower montane moist forest* (1).

(2) Silviculturally, it grows well in mixture with other species. Although viable seed is produced, natural regeneration is not noteworthy in existing stands and artificial production is contemplated for the immediate future. The tree does not prune itself well naturally. The rotation for the sawn lumber should be no less than 25 years, for other purposes it should be in accord with the necessary diameter.

(3) A local volume table and other measurements of interest to foresters have been compiled and included.

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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 Institut de Foresterie Tropique 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.

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