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*MANAGEMENT OF THE FORESTS OF TROPICAL AMERICA: PROSPECTS AND TECHNOLOGIES*

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## I. Introduction

The major objectives set out for this conference were to assess and consolidate, through expert presentation and audience discussion, a summary of pantropical progress and experience as to prospects and technical practices for forest management in the neotropics.

The goal was to attract to the Conference and further reach through publication of the proceedings, practicing foresters in the region, forestry scientists and leaders, forestry school faculties, students and representatives from international donor agencies.

The conference was sponsored by the U.S. Agency for International Development, the USDA Forest Service and the International Society of Tropical Foresters. The activity was presented and hosted by the Institute of Tropical Forestry, Southern Forest Experiment Station at San Juan, Puerto Rico, and received the cooperation of the Puerto Rico Departments of State and Natural Resources.

## II. Attendees

The Conference attracted a very diverse and experienced group of participants. Table 1 points to the diversity of origins of the participants that attended, showing that the American tropics were very well represented. The vast majority of those attending from Latin America were middle-, and upper-level foresters with direct interest in the topics presented. This characteristic, together with the assured presence of assorted international agency types and the general high quality of speakers was responsible for a uniform high attendance throughout the week.

## III. Topics

### A. The Forest Management Outlook

The Future Environment for forest Management in Latin America. Alan Grainger, Oxford Forestry Institute. United Kingdom.

Latin America's forests will become the major source of tropical hardwood exports by the end of the century, according to the results of simulations with a model reviewed in this paper. Deforestation will continue and could still be half its current rate by the year 2020. In the best case it could fall to almost zero. If the region's forests are to be more intensively exploited for commercial timbers, more integrated multi-sectoral land use planning is required to protect them from clearance by encroaching cultivators. All countries in the region will have to introduce strict protection and management of forest reserves by the end of the century. Conservation of forests for ecological values will depend upon much closer cooperation between forestry and agricultural departments than exists at the moment.

Table 1. Geographic distribution of conference participants.

<i>Country</i>		<i>Total participants</i>
<i>North America</i>		<i>56</i>
<i>Canada</i>	<i>1</i>	
<i>USA</i>	<i>55</i>	
<i>Central America</i>		<i>50</i>
<i>Mexico</i>	<i>13</i>	
<i>Guatemala</i>	<i>9</i>	
<i>El Salvador</i>	<i>2</i>	
<i>Honduras</i>	<i>5</i>	
<i>Nicaragua</i>	<i>5</i>	
<i>Costa Rica</i>	<i>13</i>	
<i>Panama</i>	<i>3</i>	
<i>Caribbean</i>		<i>32</i>
<i>Jamaica</i>	<i>4</i>	
<i>Dominican Republic</i>	<i>10</i>	
<i>Puerto Rico</i>	<i>11</i>	
<i>Haiti</i>	<i>3</i>	
<i>Lesser Antilles</i>	<i>4</i>	
<i>South America</i>		<i>28</i>
<i>Suriname</i>	<i>1</i>	
<i>Venezuela</i>	<i>5</i>	
<i>Colombia</i>	<i>2</i>	
<i>Peru</i>	<i>11</i>	
<i>Bolivia</i>	<i>1</i>	
<i>Brazil</i>	<i>5</i>	
<i>Argentina</i>	<i>2</i>	
<i>Ecuador</i>	<i>1</i>	
<i>Europe</i>		<i>6</i>
<i>Italy</i>	<i>1</i>	
<i>Netherlands</i>	<i>4</i>	
<i>England</i>	<i>1</i>	
<i>Africa</i>		<i>1</i>
<i>Liberia</i>	<i>1</i>	
<i>Asia</i>		<i>6</i>
<i>Malaysia</i>	<i>1</i>	
<i>Hawaii (USA)</i>	<i>2</i>	
<i>Sri Lanka</i>	<i>3</i>	
	<i>Total</i>	<i>179</i>

The Rationality of Tropical Forest Destruction. Marianne Schmink,  
University of Florida, USA.

This paper analyzes the causes of tropical deforestation as results of human decision. It concludes that deforestation, with all its ill effects, is not done in ignorance but for compelling pragmatic reasons.

Three levels of factors are recognized that determine patterns of resource use: behavior of individuals (or firms); interactions between social groups; and the goals and structures of the social systems. Individuals may make rational choices within given constraints or preferences. Social groups produce interactions or conflicts that lead to "emergent" outcomes. Socioeconomic systems shape "emergent" outcomes and defines frameworks for individual choice.

With special reference to the Brazilian Amazon this paper describes the rationality of shifting cultivation, population displacement, and the magnitude of small-farmer deforestation. On a larger scale investments in cattle ranching and industrial wood production are described as being strongly influenced by government incentives rather than private capital.

It is asserted that the most direct threat to the Amazonian forests is the struggle for the land and other forms of public capital. Brazilian law encourages use of the land, and cleared land is in itself an asset. The land markets, one governmental and the other illegal, result in competing claims and pressures to clear the forests.

Government policies tend to favor the economic interests of dominant social groups. Private investors receive subsidies and massive public investments are made on colonization projects. There is a fundamental contradiction between the social goal of distributing land to resource-poor settlers and the economic goal of increased agricultural production. Government policies are directly responsible for at least 35% of the forest alteration in the Amazon.

A need is seen to link forestry to the realities of rural development. Plantation forestry is crucial to efficient wood production and to relieve pressures on the remaining natural forests. Agroforestry is a promising supplement. More research is needed to implement and adapt these alternatives. The author sees some prospect that concepts being applied on Kaiti, where incentives for fuelwood production are a driving force, may have broader application.

The Economic Outlook for forestry in Tropical America: A Hazardous Period for Projections. Jan Laarman, North Carolina State University, USA.

The economic outlook for forestry requires synthesis of events and trends at three levels. The first level refers to international and national macroeconomic forces; the second to national priorities and policies; and the third to local markets, technologies, and institutions.

The various themes advanced in this paper have concentrated on the first level. It has been assumed that the economic performance of forestry in tropical America will continue to be governed by forces above and outside of the sector and region. The economic perspective for forestry in tropical America can be summarized as follows:

First and most obviously, economic and social growth in most countries of the region has been severely retarded by the widespread post-1980 economic recession. Forest-based sectors--like other sectors--have had to be content with a chaotic economic environment of high inflation, falling export prices, reduced capital inflow, and shrinking government expenditures.

Second, although partial economic recovery began in some countries in 1984, improvements have not been evenly distributed across the region. Moreover, the recovery process is fragile and highly vulnerable to reversals. This is dramatically illustrated by the new and difficult adjustment problems in the region's principal petroleum-exporting countries.

Third, during the worst years of the economic recession the forest-based industries exhibited widely varying performance across countries and among industries. Contractions in output were most pronounced in the solidwood industries and least apparent in pulp and paper.

Fourth, the economic recession profoundly affected Latin America's trade in forest products. Large importers like Argentina, Mexico, and Brazil reduced their forest products imports by almost one-half. Brazil and Chile, large forest products exporters, found their export earnings eroded by falling unit values for key export products like pulp.

Fifth, the macroeconomic outlook in the majority of Latin American countries is now better than it had been in the years immediately preceding 1985-1986. International financial institutions are engaged in earnest efforts to resolve the region's debt problems, and central banks of major industrialized countries have been cooperating to decrease the value of the U. S. dollar. The 1985-1986 decline in value of the dollar is coincident with declining

international interest rates, and both coincide with a precipitous fall in petroleum prices.

Sixth, not all components of the forest-based sectors stand to gain from the general stimulus noted in the point immediately preceding. A low value of the U.S. dollar implies that Latin American exporters of forest products lose competitiveness against U. S. producers and exporters of competing products. Producers of forest products in Mexico, Venezuela, and other petroleum-exporting countries find themselves caught in the general economic disarray caused by depressed petroleum prices.

Seventh, forest-sector analysts need to define and focus on special critical issues during the current transition from recession to plausible recovery. To what extent will government agencies with programs in the forest-based sectors increasingly turn to market-oriented policies and "privatization" strategies? How and where can liberalized policies to attract investment capital be made effective? What consequences do low petroleum prices have for wood-for-energy projects and for the cost structure of forest-based industries?

In conclusion, the economic outlook for forestry in tropical America is both troublesome and favorable. The troublesome aspects refer to the enormous adjustments still ahead on many elements in the forest-based sectors before economic stabilization returns. Optimism stems from hopeful signs that much of Latin America will be propelled forward by the economic strengthening in the world economy.

Tropical Forest Management in Latin America. Kari Keipi, Inter-American Development Bank.

This paper examines the role played by international private donor organizations that finance forestry projects for development in Latin America. The objectives pursued are to promote specific investment projects that satisfy the basic forest management and conservation requirements; include forestry components in watershed management, rural development and energy projects; encourage a balance between the utilization of existing forest resources for short-term needs and forest and soil conservation measures for the long-term benefits; and, to strengthen institutions executing forestry projects.

#### B. The Current Management Scene

Management of Forest Resources in Brazil (in Spanish). Jose F. Guerra da Silva, Departamento de Medio Ambiente y Recursos Naturales. Brazil.

Brazil contains close to one-third of the global tropical forest area which in turn contains 15-20% of all known tree species, yet

deforestation is accelerating at an exponential rate. Close to 0.6% of the area within forest reserves in Amazonia had been altered by 1975, reaching 3.0% in 1983.

The network of protected areas designed to guarantee the integrity of the biological diversity contained within these areas has not been endowed with the necessary human and financial resources to ensure effective controls.

Private Forest Management (in Spanish). Victor Giraldo, Carton de Colombia. Colombia.

This paper discusses the particular conditions that characterize the problems confronted when attempting to manage natural forests as renewable resources throughout the American Tropics.

The role of the private sector as concessionaire in the management of forests on public lands is examined through examples from a large private enterprise in Colombia that leases 54,000 ha of public forests which generate 113,000 m<sup>3</sup> of wood per year.

This example is presented as a possible model for similar application throughout the region.

### C. Management of Natural Forests

The Importance of Mammals in Neotropical Forest Management. N. Smythe, Smithsonian Tropical Research Institute. Panama.

This paper describes the benefits of including animals in planned management of neotropical forests. They are in themselves an economic resource whose yield may be sustained, and they may be essential to the survival of the forest as a whole.

The extinction of any species of organism may have far reaching consequences throughout the community but knowledge of interdependancies among the organisms of tropical forests is still too scanty to demonstrate this. Extinction of some animal species, those requiring extensive mature forest, seems inevitable.

The complex relationships between plants and animals are illustrated by a discussion of seed dispersal mechanisms and the role of mammals and insects in their destruction.

The elimination of one mammal species does not merely increase the food available for the others. It could favor some and reduce others due to differences in their respective foraging capabilities or habits. Where one species is eliminated commonly others are also reduced by the same external force. This can give rise to changes in

population of other organisms, some favored, some affected adversely, disturbing further the balance of the ecosystem.

Strategies for the Ordination of Watersheds in the American Tropics  
(in Spanish). L. S. Botero, FAO. Italy.

The management of watersheds in Latin America and the Caribbean has experienced vigorous technological expansion over the past twenty years. This paper discusses mechanisms that have proven successful to the dissemination and refinement of methodologies and techniques in the management of watersheds throughout the region.

Watersheds of moderate expanse, such as those of the rivers Guadalquivir (Bolivia), Parrita (Costa Rica) and Paute (Ecuador), and some of major expanse such as the watershed system used for the operation of the Panama Canal and those of the Panama River in Argentina, are used to illustrate the lessons learned and strategies being implemented in the management of watersheds.

Recreation in National Parks in Brazil. Angela Tresinari, IBDF.  
Brazil.

Although the Brazilian National Parks System is almost 50 years old, the majority of the Brazilian people ignore the existence and purpose of these protected areas. Though very few studies have been developed concerning recreational practices in the National Parks, it is still possible to appraise the effects of social changes and their relation to modifications in the use of natural resources.

Programs for recreation and leisure inside these designated protected areas contribute to change established patterns in the relationship between man and his natural environment. Educational, interpretive and recreational activities that aim towards the improvement of the environmental conscientiousness of the visitors, should be considered of high priority along with those specifically for protection.

The Management of Humid Tropical Forests to Produce Wood. Ian D. Hutchinson, New Zealand.

The paper draws attention to the importance in management of the residual forest which survives selective logging but is often overlooked. It indicates simple and inexpensive ways by which to improve the quality of this resource, thereby placing natural tropical forestry in a better competitive position relative to other forms of land use.

The key to the future in natural tropical forests lies with the public and private institutions responsible. Protection and management can be met satisfactorily only by means of comprehensive

programs directed towards strengthening, stabilizing these institutions involved.

Prospects for Sustained Yield Management of Tropical Rain Forest in Suriname. W. B. J. Jonkers, Agricultural University of Wageningen, The Netherlands.

This paper presents the forestry background that led to the testing of a new series of silvicultural practices for rainforest in Suriname and describes early results.

Tests of refinement eliminating undesirable trees larger than 5 cm dbh did not result in faster growth of commercial tree species but rather permitted the invasion of more rapidly growing species requiring further tending, and costs were unacceptable.

Subsequent studies led to testing lighter refinements at 1 year, 8 years, and 16 years after logging, directed toward a polycyclic system, with a second harvest projected after 20 years. When costs of planting rose, further attention was given to this type of management; a new polycyclic management system designated "Celos" was developed.

The Celos Harvesting System followed a series of ecological studies, and centers on reduction of damage to the residual stand through better planning and supervision, and the use of winching where possible instead of skidding with tractors.

In one test, the harvesting of 23 m<sup>3</sup>/ha of usable wood meant extraction of only 200kg/ha of nutrients, believed recoverable between cuttings. Diameter growth of residual commercial species increased only slightly, suggesting slow recovery.

The residual forest is refined by removal of non-commercial trees above a minimum diameter limit of 20 cm or 30 cm and also lianas. Early indications suggest that the commercial species respond to refinement; volume increment is predicted to be 2m<sup>3</sup>/ha or more. Refinement must be repeated after 8-10 years to maintain the growth rate.

Economic Considerations in the Management of Tropical Forests (in Spanish). Ronnie de Camino, CATIE. Costa Rica.

This paper discusses general economic criteria that must be taken into account when designing sustained-yield management in tropical forests.

Land-use planning, efficient identification and evaluation of all costs and benefits from forest management and the establishment of complementary measures, use of available silvicultural techniques and criteria, and the determination of necessary financing are discussed for their relevance in sound forest management.

A Time for Secondary Forestry in Tropical America. Frank H. Wadsworth, Institute of Tropical Forestry.

Secondary forests in tropical America are an increasingly important supplement to primary forest plantations. The decline in the area of primary forests and the less than compensating yields of prospective plantations leaves a critical future role for secondary forests. They may become the chief refugia for native fauna and flora and prospect for restoring the protection of abandoned clearings.

Secondary forests already cover 30% of the productive forest land of the region and are increasing 1% per year. Many, as did 50% of those in Puerto Rico, may contain adequate immature trees that will be markable in the future to favor the management of these instead of their transformation into plantations.

Inventories are suggested to identify adequately stocked stands and a conservation treatment of such is outlined. Research is suggested on the ecological stability of secondary forests under treatment, the potential of secondary forests as germplasm refugia, new markets for secondary species, identification of trees of last potential growth, quantification of growth response, and benefit/cost relationships.

Sustained Yield in the Amazon Region. Carlos E. Thibau, Renato Morales de Jesus, and Marcos Souza. Menandro, FRDSA.

In order that the conservation principles may be respected, as well as the economic ones, tropical forests must be managed so that the largest amount of products may be obtained along with the lowest risks for the environmental conditions. The rotation cycle is long and the several steps of the coppice are well known.

The exploitation of tropical forests has been selective if not predatory. This is due to forest heterogeneity, lack of information on tropical timbers and forest management techniques as well as a general trend towards alternative uses of the land.

Recent IBDF legislation regulates harvesting practices and induces the establishment of exploitation systems based on sustained yield, especially in the tropical forests of the Amazon Region. Forest management methods designed by Florestas Rio Doce S/A aim at the utilization of increased proportions of the standing timber volume of the forest both for fuelwood (charcoal) and industrial timber productions.

These methods have been tried in various Cerrado and Atlantic forest areas in Southeastern Brazil and are now being implemented in the Amazon Region.

Utilization of Natural Forests in the Pacific Coast Region of Colombia  
(in Spanish). Carlos Barreras, Carton de Colombia. Colombia.

The tropical forests of Colombia, particularly those along the Pacific coast, are characterized by their high degree of heterogeneity. Since utilization of forest resources is dependent on various factors: namely, floristic composition (quantitative and qualitative), location, topography, climate, forest dynamics and development, harvesting and modifying techniques, the demand for products and pressure from colonizers, it is easy to understand why those with the least complex makeup are first in the utilization process. With the availability of more economic alternatives, the forest is being substituted by plantings of bananas, oilpalms, pasture and others. In some areas, with over 7000 mm of average annual precipitation, acid soils and low fertility, forests have proven the most appropriate use of the land. These forests support a paper industry that is currently processing and producing homogeneous cellulose raw material from over 150 tree species, and establishing a cable harvesting system suited to the fragility of the soils and the complexity of the environment.

Management for Sustained Yield of National Forests. Gary S. Hartshorn, Robert Simeone, and Joseph A. Tosi, Jr. Tropical Science Center.

This paper describes the beginning of a new approach to sustained yield management of humid tropical forest in the Paicaza valley of Peru. Past difficulties on such management are described. Improved opportunities are expected to arise from the much improved markets for heretofore unused species. Also of significance are recent discoveries of gap dynamics in which regeneration of the forest takes place normally in gaps created by dead or fallen trees.

Using the gap size as a guide, strips of 20 to 50 m in width are harvested as completely as is economic and then are cleared to the ground but not burnt. Early results indicate a very strong and rapid response of natural regeneration. This requires complete removal of slash, and a good local market for diverse forest products. Early indications are that the returns from the cutting should support subsequent silvicultural work. The programmed cutting of additional strips each year promises to sustain yields while assuring a future crop.

Enrichment Plantings in Tropical America. Peter L. Weaver, Institute of Tropical Forestry.

At least 163 species in at least 12 countries of the neotropics have been established through enrichment plantings. In three countries, these plantings have been tried on a management scale, and in all of the countries, on an experimental basis. About 25 of the species proved suitable for planting by this method.

The apparent bad reputation and expensive failures associated with the method are largely attributable to a lack of adherence to sound establishment practices. Most practitioners either selected species that were ill-adapted to the method, or did not open the forest adequately for the survival and growth of the planted trees.

There are biological, economic, and environmental arguments in favor of enrichment plantings. Of the numerous techniques, conversion line planting appears to be among the best. Other techniques have also been successful in certain situations.

#### D. Plantations

Research Methodology Applied to Forest Plantations (in Spanish).  
William E. Ladrach, Zobel Forestry Associates, Inc. U.S.A.

The product of forest research is information which improves the productivity and quality of the forestry investment, and it is also a means for reducing risk in plantation forestry. Effective research requires well-trained personnel that have permanence in their positions, well-established field work and good communications with colleagues worldwide through the literature and by attending symposia.

The research forester must define his priorities and allocate his budget and human resources where they are most effective. He must allow sufficient time to analyze data and write reports. Terminations and reporting of studies already established takes priority over the establishment of new studies.

There are three stages in the development of a research project: 1) the pilot research trial, 2) the research study, and 3) the operational demonstration. Several small, specific studies are preferred over one large global study with multiple variables. A field study requires a working plan before initiation, an establishment report after planting, and a research report when there are measurements and operational results to report.

Site and Species Selection: Changing Perspectives. Julian Evans, I.  
I. E. D. United Kingdom.

Plantation forestry in the tropics today is characterized by increasing refinement of matching species with site and increasing emphasis on non-industrial purposes for growing trees. The forester is called upon to satisfy many more objectives, environmental and social as well as industrial, and this leads to a need to reappraise choice of species. It is not sufficient to cultivate the trees which grow best, with a reasonably amenable industry using his product, but to grow species suited to the villagers' needs or the requirements of erosion control.

The variety of site types for tree planting in the tropics is widening. This includes restocking as well as new planting, agroforestry opportunities and planting around farms, increasing needs to reforest eroding lands and the challenge of preventing the complete transition from forest to grassland of the millions of hectares affected by over-intensive shifting cultivation, by judicious tree planting before grass dominates.

Priorities and perspectives are changing as the value placed on trees and tree cover increases. It remains essential silviculture that species and sites are matched, but the resulting forest must be appropriate, whether for product grown, or for benefit conferred, or for both.

Cloning Eucalyptus Species. Edgard Campinhos, Jr. and Yara Kiemi Ikemori, Aracruz Florestal, S. A. Brazil

The cloning of *Eucalyptus* spp. through rooted cuttings produced from coppice sprouts (macropropagation), is a practical method. It is being employed so as to establish high quality forests for high volume productivity and desirable wood characteristics.

Another type of *Eucalyptus* cloning, the *in vitro* propagation technique (micropropagation), is also raising great interest. Some laboratories are working on this technique in order to make it practical on an operational scale.

Site Preparation and Regeneration in the Lowland Humid Tropics: Industrial Plantation Experience in Northern Brazil. John C. Welker, North Carolina State University, U.S.A.

General recommendations about site preparation and regeneration systems for the lowland humid tropics are of limited usefulness due to the range of biological, economic, social, and political factors which determine the correct decision. This paper focuses on those factors which lead to optimal decisions in the various plantation management contexts of Tropical Latin America. An historical sketch of industrial plantation experience in northern Brazil over an 18-year period provides a basis for discussing some of these factors.

The response from different site preparation treatments is influenced largely by the type and intensity of weed competition. Site preparation alternatives and responses are quite different for native forest, savanna and clearcut plantation vegetation. The slash and burn treatment provides growth responses which justify its expense over a wide variety of vegetation types and soils.

Windrowing must generally be justified on the basis of on reducing weed competition and permitting mechanization of forest operations. This treatment will generally have negative effects on

soil properties so that other silvicultural treatments (e.g. disking and fertilization) will be required to maintain productivity.

Vegetation competition, rainfall patterns, and plantation species will be the most important factors in determining regeneration methods. The disadvantages of coppice melina growth at Jari (increased disease, difficult stocking control) outweigh the advantages from reduced establishment costs. Direct seeding is the superior method of regeneration where weed competition permits. The advantages of vigorous planting stock of pine favor the use of container grown material except under relatively weed-free conditions and favorable rainfall patterns.

Consideration should be given to the specific objectives of each site preparation and regeneration method as well as what other management options exist for achieving them. It is important that forest managers, researchers, economists, and planners evaluate the effect of different expectations about growth responses, in a common economic framework. In this manner the "optimal decision" at a given moment will be consistent with current production possibilities and expectations.

Management Options for the Humid Forests of Tropical America and Trends in Forest Silviculture Research (in Spanish). Leonidas Vega, Forest Service. Suriname.

This paper presents a description of systems developed in Suriname for the utilization of secondary humid tropical forests. Emphasis is on available information concerning management techniques based on natural regeneration, enrichment plantings, forest conversions and agroforestry. The merits and limitations for the present application of these systems discussed for Suriname, as well as for neighboring countries with tropical ecosystems. For each management option advanced examples from Brazil, Ecuador, Colombia, and Venezuela are also presented.

A review of management schemes tried in countries of the American Tropics indicates that over the past 20 years there has been significant progress in the regeneration of forests through plantations. Yet, technical and economic returns from options on forest plantations indicate that there is insufficient, and many times contradictory information, which requires additional trials. In the search for new alternatives, the need to integrate the rural population is emphasized as a way of assuring their participation in the development of the forestry potential of a given area.

Site Maintenance in Forest Plantations in the American Tropics (in Spanish). Gonzalo de las Salas, Carton de Colombia. Colombia.

The soil is conceived as a production factor within the ecosystem. Important soil characteristics for forest productivity are pointed out: water retention, internal drainage, effective depth and

nutrient content. In addition to these factors, others like quality of humus and its decomposition rate, and presence of micorrhizal fungi are mentioned as important biological factors for the growth of forest plantations.

Some risks associated with the establishment of plantations on poor soils are pointed out, notably erosion hazards, lack of adequate depth, alkalization and toxicity due to salts, and declining fertility.

The nutrient balance is outlined with the following components: throughfall (gain): immobilization, removal and uptake of nutrients (loss). This balance is illustrated with examples from the tropics. The bioelement losses are not so large as those of the agricultural crops, notwithstanding the fact that they can be significant for soils of a low fertility. Figures of the mean annual nutrient uptake are given for Eucalyptus grandis, Pinus patula, Cupressus lusitanica, Pinus caribaea, Gmelina arborea, Tectona grandis and Pinus oocarpa.

Fertilization as an important complement to improve the growth of forest species is stressed, particularly to achieve: better yields ( $m^3/ha$ ), more vigorous trees, better wood quality and costs compatible to the desired product.

It is concluded that soil fertility, nutrient balance and site productivity can be conserved with fertilization techniques and proper management of the rotation.

Tree Improvement. Rodolfo Salazar, CATIE. Costa Rica.

This paper reviews the steps taken in a planned program of genetic tree improvement. Benefits to forestry are seen in increased yields, better product quality, and insect and disease resistance. Past work with Eucalyptus grandis has increased tree height by 66% and volume by 164%.

Basic steps outlined by Burley and Wood are outlined. Species selection should be a response to the objectives of planting. Because of the long growth period involved species should be selected that may be used during more than one of its growth stages. Selection may be done systematically by elimination trials over a period ranging from 6 months to 2 years, depending on the product desired.

The next phase compares the 2 or 3 outstanding species from the elimination trials. This phase may last 10 or 15 years and leads to a decision as to which species merit genetic improvement.

Selection of provenances follows, for the species selected, throughout the natural range of the species. Seeds are collected from at least 50 trees in each location. Studies of provenances may be made of the trees in their natural habitats, in the nursery, and in test plantings. The latter should be made in more than one location representative of the planting site. Within plantings of the better provenances plus trees of good form, growth, health, and seed production are identified. These are the source of stock for seed orchards. Yields may be 3 times the level of unselected trees. From seed orchards come large quantities of seeds for improved trees.

Insects and Diseases Affecting Forest Plantations in Tropical America. Charles S. Hodges and Max W. McFadden, USDA-Forest Service, U.S.A.

Despite the risks associated with the large-scale planting of single-species monocultures there have been surprisingly few examples of serious losses from insects and diseases in tropical American forest plantations. By far the most serious insect problem is leaf-cutting ants (Atta spp. and Acromyrmex spp.) which have caused severe defoliation on a wide variety of native and exotic coniferous and hardwood species. Species of Eucalyptus and Pinus, the most widely-planted tree species in tropical America, have been attacked by a wide variety of defoliating insects but damage has been only locally heavy. Among these insects might be mentioned Euselasia euploea eucerus and Sarcina violascens on Eucalyptus spp., and Oxydia trychiata, Glena spp. and Melanolophia spp. on pine. Among the diseases, canker (Cryphonectria cubensis) and rust (Puccinia psidii) of Eucalyptus spp. and needle blights of Pinus spp. (Mycosphaerella pini and Cylindrocladium pteridis) have been the most damaging. Trees growing under stress because of factors such as drought, nutrient deficiency, competition, etc. are often predisposed to attack by secondary organisms; for example the eucalyptus borer (Phoracantha semipunctata) and the fungus Lasiodiplodia theobromae on Pinus spp. These organisms are usually unable to attack vigorous trees.

Performance of Selected Exotic Tree Species in Puerto Rico. John K. Francis, Institute of Tropical Forestry.

Systematic trials of exotic timber trees have been carried out by the Institute of Tropical Forestry since the 1930's. This report lists non-native tree species which fit into one or more of the following categories:

1. Species that have been systematically evaluated for wood-producing potential.
2. Species that have been widely planted as ornamentals or fruit trees and in addition demonstrate significant wood-related uses (at least in other parts of the world).

3. *Species that have naturalized or escaped from cultivation on a large scale and have the potential to at least produce fuelwood.*

*An intrinsic weakness of this type of evaluation is recognized: that a species may have been recorded as a failure in tests when in fact solid potential exists. The failure might have been the result of planting on unsuitable sites, incorrect planting practice, or use of seed from the wrong provenance.*

#### *E. Social Forestry*

*The Contribution of the "Campesino" to the Development of Andean Forestry (in Spanish).* Marco Romero Pastor, Ministerio de Agricultura. Peru.

*The mountainous Andean Region of Tropical America is being promoted for ambitious forestry initiatives as alternatives to improve the plight of the farmers of the area.*

*This paper evaluates reforestation projects in South America where the participation of the "campesino" has been traditionally absent, with no real say as to what, when and where to plant. This practice has led to a general attitude of apathy towards the massive reforestation projects and consequently to an insignificant contribution of the forest towards satisfying the populations needs.*

*Alternative programs stress farmer participation and a concerted effort to incorporate forestry in a bigger way to the rural economy. Specifically, Peru, has initiated such a program that seeks to involve men, women, and children in different stages of communal forestry promotion.*

*Management of Agroforestry Systems: Examples from Asia and the South Pacific.* Napoleon T. Vergara, East-West Center. U.S.A

*Expanding populations and shrinking land resources have led to extensive cultivation of fragile uplands for subsistence. However, rapid site deterioration and loss of productivity often negate the incremental yields from newly opened uplands. Agroforestry seems able to achieve sustainability, as shown by examples of indigenous and "modern" systems managed in the Asia-Pacific context.*

*Swidders which have lost their sustainability due to short fallows have regained it through innovative use of nitrogen-fixing and leucaena coppice; and by use of slashed but unburned leucaena biomass as mulch, green manure and erosion barriers. Steep slopes which, in the past, could not be cropped without costly terracing, are now sustainably cultivated by planting trees among the annual crops in contour hedgerow fashion for slope stability, erosion control and nutrient conservation. Former single-use tree plantations are now*

*being converted to annual/perennial or even perennial/perennial agroforestry combinations to increase aggregate yields while taking advantage of the soil conservation and nutrient cycling roles of the perennial components. Livestock are being gradually integrated with plantations not only to reduce costs of weeding and maintenance but also to produce needed protein while producing wood, fiber, fruits or latex.*

*Asia-Pacific farmers seem able to practice sustainable agroforestry on fragile upland sites provided supporting policies related to security of tenure and distribution of benefits are firmly in place, and economic incentives are sufficiently attractive.*

*Incentives for Private Forest Investment.* Loren Ford, USA Forest Service.

*Governments justify the expenditure of public funds to promote forest management on private lands because of the benefit this practice implies to society. Many different incentive programs have been tried with varying degrees of success. Future incentive designs should consider the success and failure of past efforts.*

*This paper examines conditions that must exist before governments of developing countries will adopt regulations and promote forest management.*

#### *F. Communication Outreach*

*Managing a Social Forestry Program: An Experience in Communication.* Charles B. Kenny-Jordan, USAID. Peru.

*This paper begins with a discussion of three vital factors involved in managing social forestry programs in least developed countries: approaches taken to development, techniques employed in program administration, and organization strategies used in communicating with farmers and the rural communities.*

*Through the examination of the Andean forestry project of Peru, the need for an eclectic approach to administrative management of forestry programs is suggested. The eclectic approach borrows administrative strategies and techniques from both top-down and bottom-up management procedures and argues that any attempt to satisfy the interests at both ends of the rural forestry development program must recognize the organizational goals at the local, regional and national levels and be willing to compromise power for the sake of long term gains.*

*The paper also shows how many fundamental concepts espoused by Jon Moris in managing induced rural development programs have been*

*used successfully in the Peru project and how it has been possible to build on his recommendations as a result of implementation realities.*

#### *G. Future Markets*

*Forest Products Technology Affects Tropical Forest Requirements.*  
*James F. Laundrie and Henry M. Montrey, USDA-Forest Service. U.S.A.*

*Five new technologies, developed or studied by the USDA Forest Service, Forest Products Laboratory, were selected and used to illustrate how they might affect the utilization of the present tropical forest resource, and place new requirements on future tropical forest resources. The five new technologies are:*

- 1. The utilization of mixed tropical hardwoods for a variety of reconstituted products;*
- 2. The press-dry papermaking process using high yield unrefined hardwood pulps;*
- 3. The saw-dry-rip process for producing structural lumber from hardwoods;*
- 4. Efficient and low-cost solar/wood energy kilns for drying lumber; and,*
- 5. The truss-framed building system for lower cost housing.*

*None of these technologies is specifically aimed at increasing the use of coniferous species. This trend away from the conifers will probably continue as new research being conducted by the Forest Products Laboratory and others is focused on species-tolerant processing systems.*

*Prospective Markets for Tropical Woods.* *Walter G. Kauman, CTB/CT II. France.*

*South America is endowed with half the world's tropical forests, but its harvest of industrial roundwood is only one third and exports of sawnwood 12% of the total of tropical regions. On the other hand, the Sub-Continent contributes 80% of the total value of pulp and paper exports from the tropics. South America has been a leader in reducing the export of unprocessed logs, except for Guyana and Surinam. The explanation for the low volume of exports of mechanically converted forest products include the heterogeneity of the forests, and in some cases, poor marketing.*

*Projections of supply and consumption of tropical logs on a world-wide basis show that tropical forests are likely to be able to meet the demand for the next two decades, but shortages may arise in particular locations and with particular species. Efforts to explore the commercial introduction of new or little-known species to world*

markets should be better targeted, starting first with domestic utilization.

Trade flows of exports from tropical South America go mainly to Europe, North America being in second place. Japan is not yet an important customer, except for Brazil. Intra-regional exports are mainly sawnwood from Paraguay and pulp and paper from Brazil to neighboring countries. Exports are subject to considerable volume and price fluctuations due in large part to the uncertainty of international exchange rates.

Domestic consumption in tropical South American producer countries is projected to increase by the year 2000 by about 30% for sawnwood, but by 300 to 400% for panels and paper. If living standards rise quicker than expected, domestic demand might lead to a decrease in the availability of wood for export.

An appreciable part (about 16%) of hardwood production in tropical South America is already derived from plantations (mainly eucalypts in Brazil) and this is expected to increase to nearly 30% by year 2000.

South American tropical forests should be able to supply enough wood for domestic demand and export until at least the year 2000, provided the indiscriminate destruction of the forest for subsistence agriculture, grazing and urban sprawl can be brought under control. Political action is required, but also action to improve utilization by appropriate technology and better marketing.

Producer and consumer countries should work together to ensure that trade in forest products benefits all concerned.

#### IV. Overview of Forestry in Puerto Rico

Two full days of field activities and workshops were incorporated into the agenda of the conference. They are described here:

##### A. Field Trips

Long-term Natural Forest Growth Plots - F. Wadsworth (ITF) and J. Figueroa (ITF) conducted a field trip that focused on the Institute of Tropical Forestry's unique assemblage of long-term natural forest research plots where the growth of thousands of trees has been followed (some since 1943) under a variety of conditions within the subtropical wet forest; long-term growth plots located within stands of virgin, secondary (early and late), and cut-over forest.

Visits were made to several sites that have provided data for numerous studies into aspects such as growth, structural dynamics, succession, species-site relationships and the periodicity of growth increments. Also visited was a plot currently providing data for a

study concerning tree growth predictability as a guide to management of secondary tropical forests. Preliminary results and trends in the data were discussed.

High Elevation Forests of the Luquillo Mountains - P. Weaver and C. Rivera conducted a field trip to the high elevation forests of the Luquillo Mountains in northeast Puerto Rico, locally known as the colorado and dwarf forest types (also called upper montane and dwarf forests by Beard and lower montane wet and rain forests by Holdridge).

The colorado forest type is home to the rare and endangered Puerto Rican parrot and is characterized by vegetation that rarely exceeds 15 m in height. A visit was made to a representative stand to discuss recent investigations of species composition changes related to hurricanes, species-site relationships, forest productivity and periodic annual growth increments.

The epiphyte-laden dwarf forest visited is within the wettest area on the island. The vegetation occurring on exposed upper slopes and ridges is low, rarely exceeding 5 m, dense, contorted and continuously intercepts moisture from the air. Visitors were able to observe typical vegetation along a high elevation ridge, and at a 1986 airplane crash site, the slowness of recovery. Discussions also covered climate and tree growth within these forest types.

Wildlife Management and Research in the Luquillo Experiment Forest (LEF) - J. Kalina, W. Arendt and M. Bosch briefed visitors on the integrated conservation program to halt the population decline of the critically endangered Puerto Rican parrot. Habitat management efforts have focused on exclusion of human interference and artificially improving nest cavities. The Recovery Program has achieved significant increases in nesting success, but the number of nesting pairs is still too small.

Visits were made to typical parrot habitat to observe nest site characteristics, describe ongoing efforts to provide optimum nest structures, and coordination of other National Forest Resource Management with parrot habitat management.

Because of the parrot's densely forested habitat and elusive behavior and, it has been difficult to monitor parrot movements using conventional means. The use of radio-telemetry on recently fledged young birds was tested during this year.

Discussions also focused longterm research on the reproductive ecology of thrashers (a predator of the parrots) and the effect of botfly parasitism on thrasher nestlings, and how management has reduced similar infestations in parrot nests.

The Institute of Tropical Forestry Arboretum - J. Francis and A. Rodriguez led a group through the Institute of Tropical Forestry Arboretum, established in 1960 in the Caribbean National Forest. Its main purpose was to compare a large number of species in a single area. Sixty-eight (68) species from all over the world were planted at the site. Several species are represented by multiple subspecies and/or seed sources. Each plot received 49 (when available) containerized seedlings.

After 26 years some long-favored species have performed poorly at the site, while other relatively new introductions show great promise.

Reforestation and Forestry Practices in the LEF - J. Zambrana (CNF) and L. Rivera (CNF) conducted a field trip that focused on nursery practices and reforestation programs in progress in the Caribbean National Forest. Visits were made to several reforestation sites and to the Catalina Nursery where subjects such as mahogany hybrid (Swietenia macrophylla x mahagoni) seed collection, processing and sowing techniques; lifting and packaging of seedlings; outplanting techniques; and, insects and diseases were discussed.

Mahogany Line Plantation Management and Research - J. Bauer (CNF) led a fieldtrip that focused on mahogany hybrid (Swietenia macrophylla x mahagoni) line plantation research and management in the Luquillo Experimental Forest.

Since 1931, mahogany has been planted in understocked secondary forest lands in order to improve stand structure and composition, protect watershed conditions and improve wildlife habitats. Several sites were visited to observe stand conditions of various ages. Discussions covered current research activities, management techniques and guidelines, insect problems and stand development characteristics.

Ecosystem Dynamics: The El Verde Radiation Study Site - A. Lugo (ITF) led a field trip to the El Verde Research Area, site of the now famous research project where H.T. Odum and collaborators conducted numerous studies on the effects of radiation on tropical vegetation in the 1960's. While at the site, participants were able to see facilities used in follow-up studies currently underway and interact with scientists from the University of Puerto Rico Center for Energy and Environment Research who maintain a field station at the site.

Discussions were oriented towards long-term efforts in Puerto Rico to understand tropical forests as ecosystems. They covered currently active Institute of Tropical Forestry studies into ecosystem dynamics, including: nutrient and water use efficiency in plantations, changes in carbon and nutrient content in decomposing wood in decomposing wood in tabonuco and palm forests, carbon and nutrient dynamics of palm forests, successional dynamics of dry forests, and watershed manipulation study (in early phases of planning).

Plantations of the Limestone Region - B. Cabarle (Puerto Rico - DNR) led a field trip to forest plantations in the Rio Abajo State Forest in the limestone region of northwestern Puerto Rico. The trip passed through the heart of the rice, pineapple, dairy and recent sugarcane production areas of the island. A stop was made at the scenic overlook of the Dos Bocas Reservoir where the group was given a short introduction to the area's geologic formation and karst topography.

The group traveled on to Camp Radley, site of the former Peace Corps training center for Latin America. A short hike was made to top of a "haystack hill" (mogote) passing by plantations of Tectona grandis (1940's, 1960's), Hibiscus elatus (1960's, 1970's), Pinus caribaea (1960's) and Anthocephalus chinensis (1960's).

Hikes were also made through the haystack hills and bottoms through stands of Swietenia macrophylla (planted in the 1940's) and native timber species (Petitia, Guarea and assorted legumes). Visit was also made to Los Sotos, (a sawmill and wood processing site).

Caribbean Pine Growth and Yield - L. Liegel led a field trip on the performance (growth and yield) of Caribbean Pine (Pinus caribaea) in Puerto Rico. The field focused on tree major studies at four sites. The Provenance Study-East site visited is located within the Caribbean National Forest. Elevation is 350 m, mean annual precipitation is 2500 mm, and life zone is Subtropical Wet. In July 1973, an Oxford International pine trial was established, using sixteen provenances, representing the three P. caribaea varieties. An adjacent pine spacing study planted in 1962, was also visited. Spacing is triangular; treatments are 1.5, 2.1, 3.0, and 4.2 m.

The Seed Orchard/Progeny Trial site located near Humacao was another stop on the trip. Elevation is 50 m, mean annual rainfall is 2000 mm, and life zone is Subtropical Moist. Seedlings of 16 plus trees (families) from Mt. Pine Ridge, Belize, were outplanted in 1971 at 3 x 3 m spacing. Thinnings were made in 1978 and 1980; the last eliminated the eight worst-performing families. Final assessment at 11 years showed overall poor form and low cone production.

The Provenance Study-West site in Anasco has a mean annual rainfall Anasco site is 2100 mm, elevation is 150-200 m, and life zone is Subtropical Wet. The site was planted in 1973, with two P. caribaea and two P. oocarpa Oxford pine trials, having 16 provenances in each. At 10 years, the five top performers for each site had mean annual increments greater than 1.6 m in height and 2.0 cm in diameter. For P. oocarpa, trees with best height growth in 1979 also had highest diameter and height growth in 1983; for P. caribaea rankings changed between assessments. P. caribaea proved less susceptible to wind damage than P. oocarpa.

## B. Workshops

Productive Potential of Tropical Secondary Forests - F. Wadsworth (ITF) conducted a workshop on the role of secondary forests in Tropical America as an increasingly important supplement to primary forests and forest plantations. The decline in the area of primary forests and the less than compensating yields of prospective plantations leaves a critical future role for secondary forests. They may become the chief refugia for native fauna and flora, and the only prospect for restoring abandoned clearings. Secondary forests already cover 30% of the productive forest land of the region and are increasing 1% per year. Many, as did 50% of those in Puerto Rico, may contain adequate immature trees that will be marketable in the future.

The workshop focused on the discussion of alternatives to the transformation of secondary forests into plantations. Inventories were suggested to identify adequately stocked stands, and discussion centered on the possibilities of promoting research into the ecological stability of secondary forests under treatment, the potential of secondary forests as germplasm refugia, new markets for secondary species, identification of trees of last potential growth, quantification of growth response, and cost/benefit relationships.

Incentives for Private Investment in Forestry - L. Ford directed a workshop on incentives for private investment in forestry that allowed participants to relate experiences with both successful and unsuccessful tactics in tropical countries. Through small group discussions consensus were reached as to strategies to promote private sector investment in forestry.

Most tropical countries have attempted to counteract deforestation, through public tree-planting projects and the adoption of various forestry incentive programs. Technology currently exists for successful establishment of forests, at least in tropical countries with abundant rainfall. However, regeneration of forests will not occur at a sufficient pace until successful strategies are found and implemented that overcome the socio-economic barriers to the widespread establishment and maintenance of forests on private lands unsuitable for sustained agriculture.