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TECHNOLOGICAL OPPORTUNITIES FOR TROPICAL FORESTRY DEVELOPMENT

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PREFACE

This paper is intended to identify the highest pay-off opportunities for the application of U. S. technology to the needs of developing countries for sound management and utilization of forest resources.

It is a follow-up to the AID Office of Science and Technology's publication TA/OST 72-12 entitled Forestry in Developing Countries: Potentials, Constraints, and Opportunities of October, 1972. That first publication included general information such as worldwide data on current regional consumption and production of forest products, projections to 1985, and estimated investment needs. The second paper is primarily a more detailed presentation of the situation by countries and does not repeat material covered in the first publication. Specifically, this paper includes the following:

- -- development of criteria for determining whether the political-socio-economic and institutional framework in a lesser developed country is sufficiently favorable so that technological inputs can have a meaningful impact on improving development and use of wood products and on improving forest management;
- -- identification of those developing countries where the criteria appear to be adequate for such aid;
- -- examination of a limited number of those countries to illustrate how specific technological inputs can be matched with priority needs, and assessment of likely pay-offs.

The analyses are based on data published by the United Nations Food and Agriculture Organization. A composite ranking of institutional capabilities was made by foresters with many years experience with developing countries.

A Substantial assistance to the paper was made by professional employees of the U. S. Department of Agriculture's Forest Service, who helped in selecting and evaluating potentially applicable technological innovations. This paper was prepared by Gordon D. Fox, forestry consultant, in collaboration with the Office of Science and Technology. The assistance of the many individuals who contributed to this study is gratefully acknowledged.

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INTRODUCTION

The ability of developing countries to absorb technological innovations in forestry vary considerably. In general, those countries which are the farthest advanced within FAO's Economic Class II (Developing Countries) are the ones having the best opportunities for pay-offs. For forestry applications, the developing countries need to be further limited to those having substantial areas of reasonably accessible forests that could be managed on a sustained yield basis, and having established forest products industries with opportunities for expansion.

There will always be some exceptions, such as countries lacking large areas of native forests and wood industries but having large afforestation programs. In such cases the opportunities for technology transfers will be more limited but are still important. In these cases forestry assistance is needed in addition to technology innovations. While such additional assistance is outside the scope of this paper, it needs to be considered in overall programs. Assistance in institution-building is especially important. Relatively recent decisions by international assistance agencies to give priority to the least developed countries gives emphasis to this point.

Almost without exception developing countries have improved their forestry capabilities since the inception of technical and financial assistance programs after World War II. Increased harvest of industrial wood, expanded local manufacture, and strengthened institutional structures, such as forest services, have resulted.

There have been substantial differences in the extent of economic, social, and technical gains, in different countries. At times, forestry development has retrogressed.

There has been a tendency for industrial use of wood products to expand faster than the technical and administrative capabilities of the forestry institutions. Since the majority of the forests are in public ownership, this results in inadequacies in the protection, development, and management of the national timber lands. Destructive and wasteful practices, including migratory agriculture, have decreased the productive capacity of millions of hectares of forest lands.

In many situations, logs are shipped from developing countries for manufacture elsewhere. While attempts have been made to justify log exports because they provide a quick source of needed foreign exchange, this "export of jobs" has contributed to forest destruction. Where local manufacturing industries are not using the raw material base, its economic importance has been minimized and opportunities for technological innovations consequently have been neglected. Log exportations also have been difficult to change since manufacturers with alternate sources of log supplies have had a semi-monopoly on markets. It is only recently, with increased demand and prices, that there has been a swing toward a seller's market. This same trend is also occurring with minerals. The situation with regard to the petroleum supply is familiar. The timber supply trend is corroborated by the increasing number of countries prohibiting log exports. This in turn increases the importance of forests to the producing nations because of the value added in their industrial development.

It has been noted that developing countries with the strongest and most capable forest services also have the highest percentage of assistance projects for overall improvement of public administration. The best developed forest services also have the highest percentage of FAO projects for improvement of forest service administration. This indicates that such countries have reached a stage in which they recognize the need for strengthening their overall administrative capacity and are doing something about it.

Forestry assistance projects from various sources which developing countries have received, that are under way, or have been requested in their United Nations Development Programme's five-year country plans, are an indication of interest in forestry.

It can be assumed that countries selected for priority attention should be those which are presently at a stage in the development process where the "pay-off" from technological innovations is likely to yield the highest return. It is quite likely that the five to ten years there will be changes in the categories. Developing countries will move ahead generally but at different rates. Their development will be hastened by the current world emphasis on environment in relation

to forest utilization and on the protection of recreation values of the forests. Reduced timber harvest potentials in developed countries are resulting from this environmental emphasis at a time when their demands for forest products are increasing. This trend and the resultant relationships accelerate harvests in developing countries.

Forestry development in countries now largely outside the export economy will also be hastened by current practices of harvesting lower-cost accessible timber first. In Southwest Asia, where tropical timber exploitation is presently centered, the added costs for exploitation of the more inaccessible timber will make the resources of other forested countries more competitive and accelerate their production. For example, Latin America, with nearly one-fourth of the world's forest areas, presently accounts for only about four percent of industrial wood production.

In summary, the countries selected for application of technological innovations in this report are those where present opportunities appear most favorable, recognizing that the economic forces of supply and demand will change the relationships within a relatively short time.

A principal criterion in selecting countries to which preference should be given in technological inputs is the technical and administrative capabilities of a country's forest service. This is based on the assumption that the most important element in forestry development is the effectiveness of the forest service in controlling exploitation and in developing sound management of the forests. Technological advancements that result in increasing timber exploitation in countries not yet ready for them may often hasten the process of wasteful cutting and forest destruction. The "pay-off" over a period of time in such cases is largely negative. This is an important limitation on the countries selected for technological innovation.

Selection of the countries which have expressed an interest in technical and/or financial assistance programs for forestry is the first step in the screening process. The second step is to classify those

countries which have strong forest service capabilities. The next step is to include those countries with larger forest areas and current industrial production to provide the basis for a promising return from technology transfers. These criteria and their application are described in more detail under the heading CRITERIA that follows.

I. CRITERIA

The establishment of criteria for determining the highest pay-off opportunities for U.S. technological assistance in improving forest management and use of wood products in developing countries is based on the following assumptions.

Results from the application of technological innovations will vary with different countries. Priority countries should be those which on the average would profit most in the shortest period of time from such applications. There will be variations in applicability depending on the degree of sophistication of specific applications. Since the statistical and other data used are not precise indices, there will always be some exceptions.

A discussion of criteria follows.

The interest of a country in its forests is an important consideration. If a country has not recognized the significance of its forest resources and taken measures to do something about them, it would be doubtful if anything that could be done in the technological field would have a meaningful impact. The measure used as an index of interest is the forestry technical assistance programs of the United Nations, for which the Food and Agricultural Organization (FAO) is the executing agency. A check of the UNDP country programs for 1972-1976 with the data on recent forestry programs and those currently under way with FAO as the executing agency indicates that almost without exception the countries which have been receiving technical forestry assistance are requesting additional help in their UNDP country programs.

Application of the interest criterion resulted in the selection of eighty-five developing countries. (See list in Appendix A for details on applying this and other criteria which follow.)

The technical and administrative capabilities of the countries are a very important factor in technology transfers. Many countries have not yet reached the stage of development of their public forest services and private forestry sector to utilize the more advanced technology. One measure of technical and professional readiness would be the number of professional foresters and forestry technicians working in a developing country. This measure overlooks the quality aspect and the administrative capability of a forest service.

After testing alternative methods, the composite judgment of several experienced foresters of different nationalities who had been working with the developing countries for many years was taken as the best criterion. The countries were rated in accordance with standards which were established for each of three capability categories. They were rated independently by the raters and the results combined for a composite rating for each country.

This capability factor is also highly important from the standpoint of assuring that a country's forest service will have the administrative and technical strength required to protect, manage, and develop the country's forest resources for permanent production. Otherwise, technology transfers in the utilization field could lead to an accelerated destruction of the developing countries' forests. The countries chosen by the interest criterion were placed in the three capability categories as the second step in the rating process.

The relationship of forest land area to total land area of a country gives an index of relative potential importance of forests in economic development-- particularly in rural areas. Ratios of forest land acreage per inhabitant were considered as indicative of population pressures on the forest resource, but these ratios were not used directly.

Industrial wood production per country, measured in volume or value, is taken as a relative index of opportunities for current application of technological innovations in harvesting operations. It is a measure of the present economic importance of the timber resource. The larger the production the greater the opportunities and benefits.

Production of sawnwood and wood-based panels per country is an index of potential application of innovations for those products. Production of pulp and paper per country are indices of potential applications in a more sophisticated industrial area. Import and export values of these products are secondary indices with reference to foreign exchange considerations and to transport innovations. Industrial innovations are important in "industry-to-industry" transfers of technology.

The acreage of forest land in a country is a measure of potential development possibilities. It indicates the raw material base on which the forest products industry depends. It is therefore an indicator of the extent to which technological innovations may result in benefits over a long period of time. Lands classified for forestry but presently deforested are included in the forest land category since they represent an index of reforestation potential--an increasingly important factor in tropical forestry. Non-commercial forests, so classed because of low productivity, topography, or inaccessibility, were not excluded from overall forest totals, for reasons such as difficulties in classification and the fact that they embrace large areas of forests which require protection measures and present opportunities for applying certain technological innovations. Rates of timber growth were considered but not used as factors in the country selections, except as reflected indirectly in the size of their reforestation programs.

While the presence of a resident U.S. AID Mission will facilitate forestry technology transfers regardless of the source of the U.S. assistance, it is not used as a criterion in the priority selection of countries for receiving forestry innovations. Whether or not there is an AID Mission in a country with a forestry program, there is need for someone, such as a U.S. embassy official, who is generally knowledgeable of and has access to information sources in the forestry development field.

II. COUNTRY SELECTIONS

Data on 132 countries with United Nations Development Programmes were reviewed. Including all assistance activities, there were 74 of these countries presently having forestry projects. This list was increased to 85 by including additional countries which had been recipients of a considerable amount of forestry assistance. Countries in FAO's Economic Class I, "Developed Market Economies," were omitted on the basis that the focus should be on countries in FAO's Economic Class II, "Developing Market Economies."

The 85 countries were grouped into three categories by experienced foresters who had been in the international field for many years and were best qualified to make the capability judgments. The definitions for ranking the country capabilities in the three categories are as follows:

A. Definitions

1. Category 1 contains those countries with a forest service that, with a minimum of training, is capable of putting into practice most of the U.S. innovations in forestry that the country considers desirable. (innovations, broadly defined, include operations from growing the tree through processing to marketing).

2. Category 2 includes those countries with forest services that have capability for putting selected desirable forestry technological innovations into practice. Generally, the innovations would not be the most sophisticated ones, and considerable training would be needed.

3. Category 3 contains countries with forest services having at present limited capability for application of desirable technological innovations, except when these are simple and/or do not involve significant demands for local technological know-how in the short term. Technology innovations which are non-recurrent and can be effectively carried out by consultant contracts and do not involve technology transfers may also be considered.

As a result of this rating, 15 countries were placed in the Number 1 category, 33 in the Number 2 category, and 37 in the Number 3 category.

The listing by categories was reviewed from the standpoint of eliminating countries in which the forest resource is not considered important enough relatively for technological innovations to produce a significant pay-off in the nations's economy. A guideline for this review was a minimum of 10,000,000 acres, or at least ten percent of the area of the country, as forest land. Application of this guideline to the first category reduced it to 14 countries, and reduced the second category to 25 countries. The 39 countries in these two categories are the ones considered to have the best pay-off opportunities for matching U.S. technological capabilities with forestry development needs.

B. Country Listing by Categories

Category 1

Argentina
Brazil
Chile
Colombia
India
Iran
Korea, Rep.
Malaysia
Mexico
Morocco
Nigeria
Trinidad & Tobago
Turkey
Venezuela

Category 2

Burma
Cameroon
Ghana
Congo, Pop. Rep.
Cuba
Ecuador
Gabon
Honduras
Indonesia
Ivory Coast
Jamaica
Liberia
Madagascar
Malawi
Peru
Philippines
Senegal
Sierra Leone
South Vietnam
Surinam
Sudan
Tanzania
Thailand
Uganda
Zambia

Category 3

See Appendix A

In decisions on the application of specific technological innovations, consideration should be given to the status of a country's forestry development program and how the innovation fits priority needs within that program. These programs are prepared with varying degrees of detail and coordination. The UNDP Country Programme is one source of information on forestry development planning. Consideration should also be given to whether introducing a particular innovation will produce the desired benefits or whether there needs to be complementary assistance in other activities. The socio-economic impacts of proposed technological transfers should also be weighed by the governments of developing countries in their decisions on adopting innovations. The effect on employment is generally one of the major considerations. The examples that follow will have minimal repercussions in labor displacement. Such innovations as the large combines that fell, delimb, and buck trees into pulpwood-length sticks have not been included partly because of the undesirable employment reduction that would result substitution of machines.

III. EXAMPLES OF SPECIFIC TECHNOLOGICAL INPUTS MATCHED WITH COUNTRY NEEDS

For illustrative purposes, a dozen examples are given of specific technological innovations matched with countries that have substantial programs or activities in the fields in which these applications should produce pay-offs. For example, industrial innovations are directed to countries with higher industrial production of particular wood products; reforestation applications to countries with the larger reforestation programs; forest fire protection developments to those countries with detection and suppression programs that need intensification; etc.

A. Cadastral Surveys

There are many countries, such as Honduras, Philippines, and Iran, that have problems in locating the boundaries between private and public lands for determining ownership. This is a serious obstacle to management, protection, and development of forest lands. A system known as the Air Borne Control, or ABC system, was developed for use in Alaska. In this system, field control is established by standard methods, such as triangulation, electronic traverse, doppler positioning, or stellar photography. The cadastral plan or layout is developed mathematically on a map of the area in the office, and positions are derived for the property corners. Direction and distance between the ground control points and the property corners are then calculated. A helicopter equipped with electronic distance measuring equipment is used to establish the land corners.

For tracing outland lines on the ground, a laser beam application has been developed which can accurately locate the lines. The portable laser apparatus is placed on one known property corner with the beam directed vertically. A sensor on the other known corner can pick up this beam and maintain the line as it is marked between them. The system is applicable in rough terrain.

Thailand has written the Forest Service for permission to send two men to the United States for a short period to review cadastral survey systems and discuss their application to Thailand conditions. If satisfactory, this will be followed by assignment of a Forest Service technician to Thailand to train counterpart personnel in an applicable system.

Variations in survey techniques are necessary under different situations, as when, for example, the cadastral project plans to use a standard grid system or a metes and bounds survey.

B. Aerial Spraying

The Forest Service Missoula Equipment Development Center (MEDC) has developed a spraying system for use in C-47 aircraft. Its purpose is aerial spraying for forest insect control. The system is activated by pressurized nitrogen gas. One of the features of this method is that the spray drops are of uniform size, which greatly facilitates control of drift and obtaining uniform coverage. These are highly important needs in a spraying project.

During their recent floods, Pakistan had an insect pest attacking a large area of its rice crop. The disaster Relief Coordination Office of AID requested assistance from the Department of Defense, which referred AID to the Forest Service. In response to the AID request, made through the Secretary of Agriculture, the Forest Service provided personnel and equipment for a spray project. A four-man Equipment Development team from MEDC and a Forest Service pilot flew to Pakistan on this cooperative project. This example is mentioned to illustrate the desirability of closer contacts between the USDA's Forest Service and AID to facilitate technological applications in developing countries. Insect epidemics in forest and agricultural areas develop on short notice and prompt control action is needed. Countries with heterogeneous tropical hardwood forests have less susceptibility to forest insects and diseases.

C. Evaluation of Southern Pine Beetle Infestations

The Southern Pine Beetle (*Dendroctonous frontalis*) is one of the most destructive forest pests found in the southeastern United States, and in the related pine timber types of Mexico through Central America to northeastern Nicaragua.

Techniques for determining beetle populations and the amount of parasitism or predation involve primarily the use of color infra-red serial photography of infestation areas and x-rays of bark samples. The insect is normally present in endemic numbers, but may increase to epidemic populations under certain conditions. Insect population levels by areas, as derived from insect counts in bark samples, determine control decisions and the magnitude of projects to effectively suppress epidemic populations and control population trends in outbreak areas. Radiographic sampling of brood density provides the best means of predicting population trends and future beetle damage. Comparable data from several surveys of the same area establish trends. Supplemental ground checks are made to identify causal agents.

The importance of technological development is in reducing the judgment element in control decisions by substitutiing scientific methods. Control is costly, and delay in starting control measures may seriously affect control costs as well as effectiveness. (It has been estimated that timber loss from the 1963-64 Southern Pine Beetle epidemic in Honduras was about $100,000,000).

D. Press-Lam System

Press-Lam is an innovative system for producing lumber-type products from sawtimber. It would be applicable in developing countries such as Indonesia, Malaysia, Brazil, Mexico, Nigeria, and the Republic of Korea where the more technically advanced timber companies have manufacturing interests. It would involve industry-to-industry technological transfer.

The first step in the system is to knife-cut the log by a rotary process into a sheet about 1/2 inch think. Knife-cutting eliminates sawdust and insures that most of the high-quality outer part of the log is used effectively.

Cut-to-size sheets are dried by an extremely rapid new process. This drying, done in a hot press, produces flatter and more stable products than does conventional drying.

The dried sheets, unplaned and still hot, are coated with adhesive and assembled into the desired product, taking advantage of latent heat to cure resin adhesives. The entire processing time from log to finished product is about fifteen minutes, and the yield is about 65 per cent. This contrasts with a processing time of five days or more and a yield of 40 percent for conventional softwood lumber. Presence of lathe checks allows the product to be readily treated in any size with preservatives and fire retardants. The Press-Lam system is technically feasible and economically promising. Further research and development efforts will tie the various steps into efficient systems for specific structural products without limitation as to size and shape. Engineering design data will be provided for the necessary production equipment. This new innovation is not yet being used in the United States.

E. Computerized System for Sawing Logs (Best Open Face - BOF)

This system is feasible in countries such as Indonesia, Brazil, Malaysia, and Mexico where more technically advanced forest industries have large permanent sawmills in locations with a dependable electric power source. It would be an industry-to-industry technology transfer.

Sawing logs into lumber involves the fitting of rectangles into a circle. The key is the width of the face of wood exposed after removal of the first slab. A mini-computer analyzes all possible combinations of face-opening widths for logs of any diameter and shows the one resulting in maximum lumber yield. The use of this computerized system increases yields by at least ten per cent in small logs. This makes possible an automated mill system. The new development so far has had only limited use in the United States.

Research is being carried on to develop an ultrasonic sensing device to find defects in logs. The speed and character of the sound waves passing through wood are altered by defects in the logs.

F. Economics of Kraft Pulping of Unbarked Wood

The practice of pulp mills has been to use only relatively bark-free wood. Bark tolerances have been held at unrealistically low levels and have not been based on technological and economic necessity. In a recent study by the Forest Products Laboratory bleached kraft pulps from all species tested, were produced at competitive levels of dirt, brightness, and strength regardless of whether or not the wood chips contained bark. There were, of course, differences in processing conditions and procedures to obtain uniform results.

Estimated capital outlay is $91.66 million for a 750-ton-per-day bleach kraft pulp mill not using the bark, and $88.42 million for a bark-using mill. The saving is due to eliminating the need for debarking equipment. Net costs for bleached southern pine kraft pulp are $105.92 per ton for the mill not using bark and $101.24 for the bark-using mill. Therefore it is concluded that rough wood pulping by the kraft process has economic advantages, in addition to being the most viable procedure for extending wood resources. Losses of white-wood during debarking are eliminated and more small tops, branches and young trees can be used if debarking is not necessary. Rough wood pulping is particularly applicable to short-rotation tree crops.

This innovation would be applicable in Honduras, where the construction of a large pulp and paper complex based on pine species with similar characteristics to U. S. southern pines has been under consideration. Its application in Chile would help overcome anticipated shortages in supply of plantation wood. The Republic of Korea is another country anticipating local pulp wood shortages.

G. The STX (Three-P) Timber Cruising Method for Timber Sale Volume Determination and for Forest Inventories

One of the first requisites of forest industry development and scientific forest management is a determination of the sources of supply and of how the timber stands should be managed for continual production. This requires a considerable amount of data, the major part of which is obtained on a sampling basis.

The recently developed STX tree measurement procedure, using Three-P sampling techniques, can be used in making forest inventories of tree species, measurements of sizes, and volume determinations over large areas for overall management purposes. It can also be used for similar determinations on smaller areas for individual timber sales. The procedure is more accurate, less costly, and more flexible in its uses and applications than previous methods. A much smaller sampling intensity is needed to obtain the desired accuracy.

The new system requires utilization of large computers and expensive dendrometers. A list of random numbers is obtained from the computer for intensive sampling. The selection of sample trees is drawn from the random number list in proportion to their size and volume. The system favors the sampling selection of large or valuable trees. The STX estimates are expressed by a trio of measurements (cubic foot volume, square feet of log surface area, and linear feet of log length). This trio of measurements can be converted directly to estimates of potential for producing primary products such as lumber and secondary products such as chips. Conversion to dollar values of products can be made.

In Iran a forest inventory is under way using the new Three-P system. It is not being used for timber sales. The forest inventories are being conducted by a different bureau from the one that makes the sales of timber and the timber cruises preparatory to selling the timber. Under the present sales procedures, the trees felled by the timber sales operator are required to be left until such time as Forest Service employees remeasure them on the ground. They are subject to insect and disease hazards, and they damage the young growth bent over under them. By intensifying the Three-P forest inventory sampling system through STX timber estimating procedures, the sales can be consummated on the predetermined volumes and values. The marked trees can immediately be cut and removed from the sale area.

Many countries currently making inventories and timber sales could profitably use the above described system. Argentina, Peru, and Colombia are examples.

H. Tree Improvement Programs

Tree improvement programs include breeding for improved strains, use of exotic species or hybrids, and selection of the best individuals from native species. Tree improvement programs are applicable in developing countries committed to large-scale reforestation programs. With the exception of a few hardwoods such as *Eucalyptus sp.* and *Gmelina arborea*, most afforestation is with exotic coniferous species which have long wood fibers and which are valued for their greater strength and utility. Seed has been obtained from several provenances with varying results. Many of the conifers are North and Central American species. In many countries forest plantations are of sufficient quality to permit mass selections of desirable trees from them; to permit the establishment of seed orchards using the selected trees as parents or as source of grafts the progeny testing of the seed orchards, and weeding out inferior trees. The rate of growth in many of these countries is exceptional and rotations of from ten to twenty years, with interim improvement cuttings and thinnings, are common. Genetic gains based on information from the southern United States give about 20 percent to 30 percent increase in volume production. The genetic gains are realized in quantity, quality, and reduction in losses.

The Forest Service Tree Seed Laboratory, Macon, Georgia (one of the few such centers in the world) is an intermediary in tree seed procurement for developing countries. Technological developments in the establishment and management of seed orchards, including selection, genetic gain, and evaluation methods, can probably best be transferred by including working visits of foresters from developing countries to the United States. A few countries which should gain from the techniques are Brazil, Chile, Colombia, Jamaica, and Indonesia.

I. Radio Communication Systems

The use of fixed radio communication systems, with mobile equipment and small lightweight portable, multi-channel two-way radio sets to extend communication to isolated forest areas, has been highly developed under U. S. Forest Service specifications. The systems operate in the Very High Frequency (VHF) range. The fixed equipment is located at headquarters and stations where forest fire suppression crews are dispatched, and relay or repeater stations

are placed on high points as needed in mountainous terrain. Isolated sets are battery powered and there are several adaptations in types of batteries and recharging systems. Use of the solar panel power source is being tested but is presently limited because of high costs.

A communication system for forest fire control and administrative traffic, including aerial communication for detection and fire fighting purposes, can readily be adapted for any of the developing countries where there are forest fire control organizations. It would be applicable in the coniferous forest types of Mexico and Central American countries and in certain forest types in Chile, Argentina, and Brazil which have regular dry seasons with high fire hazards and risks.

Savings in reduced costs for fire suppression and in reduction of timber and other resource losses result from more prompt and coordinated initial attack and suppression actions on fires.

J. Forest Fire Simulator

One of the more important jobs in a forest fire control organization is training firefighters, and particularly supervisory personnel, in fire behavior and in suppression techniques. For that purpose a 'fire simulator' has been developed by the U.S. Forest Service. It has been found to be more effective than other training procedures.

A forest landscape is projected on a screen as background. The rear screen projection technique is employed in which the operators are on one side of the screen and the trainees on the other. Adjustable and reversible discs are used to simulate smoke and fire motion. Directional changes to simulate wind shifts are easily made during an exercise. Hose lays, fire lines, roads, heliports, etc. are clearly projected through an overlay on the background scene. Fire can be gradually replaced on the screen with burned-over area and smoke composition can be changed. The trainees are required to make prompt attack and control decisions as the simulations are changed. The results are reflected on the screen. Trainees are checked on the accuracy of those decisions by the trainers. This simulator can be used for other training purposes.

Training is an essential part of technology transfers to developing countries. One of these fire simulators has been purchased by the Canadian International Development Agency (CIDA) for British Honduras. The simulators will have similar application in such countries as Mexico, the Central American countries, Chile, Argentina and Brazil.

K. Uniform Fire Danger Rating System

For those countries having forest fire control problems there is always a need for gearing control organizations and their readiness to the risks and hazards of fire occurrence and rates of spread. These depend on fuel types and burning conditions, and vary with weather conditions at any given time.

A rating system measures such factors as number of days since rain, temperatures, humidity, wind velocity, condition of the vegetation, and fuel moisture relationships. It relates these factors to the organizational readiness of man-power and equipment needed for effective fire control under the computed fire danger reading.

The fire danger rating system can be easily adapted to the developing countries which have forest fire losses that justify control operations and which have national meteorological forecasting systems. Particularly, Mexico through Central American countries to Nicaragua, and Chile, Argentina, and Brazil in South America could benefit from adoption of a fire danger rating system.

Savings result from eliminating overmanning in periods of low danger rating and undermanning in times of high fire danger. Savings are thus realized in man-power and equipment during low danger periods, and much larger savings in reduced timber losses result from adequate presuppression and suppression manning in high danger periods.

L. Determination of Secondary Wood Properties

The identification of species not being used commercially and the determination of their physical, chemical, and other wood properties is needed in several countries. Much research has been done on these species by various agencies in forested countries. There are about 40 research laboratories engaged in investigations on the properties of tropical woods. Prior to selection of countries for additional studies, presently available data in the

research laboratories should be brought together and analyzed. This is needed to avoid duplication and to answer questions on uniformity and reliability of testing methods and on variations in wood characteristics of the same species in different environments.

The USDA Forest Service has the world's largest collection of tropical wood samples and data on wood properties of tropical tree species. Financed by AID, a preliminary study by the Forest Service is presently reviewing data on the status of knowledge on tropical woods and markets in different parts of the world. The end result needed is a determination of the countries in which additional research in wood properties will result in increased timber harvests, employment, income, and forest management opportunities.

IV. RELATED RECOMMENDATIONS

The studies made in the preparation of this paper highlight a need for field surveys on a selecting country-by-country basis in order to do a better and more complete job in delecting applicable U.S. technology innovations. The Canadian International Development Administration (CIDA) started a procedure in late 1970 in which a team visited several countries in Latin America to identify possibilities for Canadian technical assistance. These trips were followed with visits by experts for the identified projects to consider them further and work up project plans where applicable. A similar procedure is suggested for consideration by other donor agencies. The visits would, of course, be preceded by staff discussions with representatives of the higher priority countries to insure that they were desirous of obtaining such assistance.

The technological innovations listed in this paper do not duplicate those in the paper on Forestry in Developing Countries, TA/OST 72-12 of October, 1972. The innovations described in the two papers were selected to illustrate applications to forest management, protection, and utilization activities in developing countries. Other innovations could be added, and those now in the research and development stage will provide additional opportunities. It is suggested that a procedure be established to review, modify, and update the listed proposals, and that this information be furnished to appropriate organizations and individuals who direct, assist, or plan forestry programs in developing countries.

V. SUMMARY

In the selection of highest pay-off opportunities for application of U.S. technological innovations to the forestry needs of developing countries, the following favtors were considered:

1. The first step was selection of those developing countries which had forestry technical assistance programs either ongoing or recently completed. This selection was made on the basis that an assistance program is evidence that a country has recognized the importance of its forest resources and has taken measures to improve them. Conversely, the benefits from technology were assumed to be less if the country has not shown sufficient interest in its forest resources to request technical assistance in managing, protecting, and developing them for utilization.

2. The stage of forestry development of a country was measured by the capability of its forestry institutions and their relationship to the overall administrative capability of the country. This was selected as one of the most important criteria, on the basis that within the developing countries the opportunities for pay-offs are greater in those countries with higher technical and administrative capabilities. A strong correlation was found between the higher rated countries and those which had assistance programs for strengthening both their forestry institutions and their overall governmental administrations. The classification of the countries into three capability classes was made independently by several foresters of different nationalities who had years of experience in working with developing countries. There was a surprisingly high degree of consistency in the ratings by these raters.

3. The acreage of forest land and its relationship to the total area of a country were selected as measures of importance of the resource to the country's economic development. A minimum of 10,000,000 acres of forest land or at least 10 percent of the total land area of the country that should be under forest management were the criteria selected.

4. Data by countries were obtained for annual industrial production of (a) round wood, (b) sawn wood and ties, (c) wood panels, (d) wood pulp, and (e) wood-based paper and paperboard products. Exports, imports, and trade balances in wood products were likewise rated by countries. These data were helpful in selection of industrial technology applications.

5. FAO data on afforestation and reforestation rates and on country summaries of forestry needs; UNDP, 1972-1977, Country Program statements on forestry priorities established by the countries; and World Bank (IBRD) country background statements on forest resources in relation to pulp and paper production and consumption were useful in considering particular technological developments related to country needs.

A total of 85 countries with forestry programs were rated by the different criteria. Of these, 14 were placed in the first category and 25 in the second category as having the highest pay-off potentials for application of U.S. technological innovations.

For illustrative purposes, brief descriptions were given for 12 technological innovations, with suggested countries for their application.

It is recommended that a procedure be initiated for teams of experts to visit developing countries to explore applications of specific technological innovations. This might be patterned after the practice being used by the Canadians in developing CIDA projects.

It should be emphasized that there will be exceptions to the selection of countries most likely to give the highest pay-offs from forest technology transfers. The priority list, which is a relative ranking, will likewise change within a few years. Since the selected technology applications are for illustrative purposes and there are additional innovations available or in the development stage, it is recommended that the listing be reviewed, expanded, and updated periodically, and brought to the attention of interested parties, particularly those contemplating the promotion of forestry programs in developing countries, or where such programs are already in existence.

APPENDIX A

COUNTRY DATA TABLES

Explanatory Notes

1. The 85 countries listed in the following tables are selected from FAO's "Economies Class II, Developing Market Economies," using the "Country Interest Criterion" based on international assistance in forestry.

2. The countries marked with an asterisk (*) are those with more than 10,000,000 acres of forest land or more than 10 percent of the total area classified as forest land. This is a criterion used in selection of countries with relatively greater opportunities for, and importance of, forestry in country development.

3. Refer to the text, page 8, for Category 1, 2, and 3 definitions.

4. The average industrial round-wood production in Category 1 countries (6.0 million m^3) is about triple the production in Category 2 countries (2.0 million m^3); the average industrial wood production in Category 2 countries is about three and one-half times greater than average production in Category 3 countries (.57 million m^3).

5. The nine countries with the highest wood pulp production are in Category 1, and indicate a trend of increasing forestry institutional capabilities coincident with more sophisticated pulp and paper industry development. Per capita use of paper and paper products increases rapidly with development and is reflected in the import percentages.

6. Blanks in data result largely from nothing to report, occasional reporting failures, or negligible quantities.

Countries in Category 1 1/

Countries	Production Industrial Round-Wood 1000 m^3	Production Sawn-Wood & Ties 1000 m^3 (s)	Production Wood Panels 1000 m^3	Production Wood Pulp 1000 m.t.	Wood Pulp Rating	Exports Wood Products 1000 $	Imports Wood Products 1000 $	Paper Products % of Imports
*Argentina	2,913	767	186	138	4	2,004	171,328	37
*Brazil	21,765	8,935	1,087	741	1	117,234	62,415	77
*Chile	3,971	1,085	56	400	2	36,464	6,300	63
*Colombia	4,775	1,876	115	55	8	12,112	26,812	60
*India	9,865	2,825	161	78	6	18,261	49,805	65
*Iran	5,506	192	77	-		1,620	53,565	65
*Korea, Rep.	2,986	1,773	879	75	7	103,270	170,600	5
*Malaysia	18,389	3,026	183	-		306,201	43,451	86
*Mexico	5,302	1,572	174	319	3	11,579	92,605	54
*Morocco	280	41	17	44	9	12,317	36,920	20
*Nigeria	1,920	500	28	-		11,320	33,003	92
*Trinidad & Tobago	71	45	-	-		1,911	12,582	65
Tunisia	60	16	7	-		5	17,345	50
*Turkey	5,311	2,344	156	109	5	3,781	31,627	80
*Venezuela	585	328	81	-		1,045	62,535	55

1/ Selection by experienced foresters, before screening against criteria developed by this study.
* Countries with more than 10,000,000 acres of forest land, or more than 10 percent of the total classified as forest land.

Countries in Category 2

Countries	Production Industrial Round-Wood 1000 m^3	Production Sawn-Wood & Ties 1000 m^3 (s)	Production Wood Panels 1000 m^3	Production Wood Pulp 1000 m.t.	Wood Pulp Rating	Exports Wood Products 1000 $	Imports Wood Products 1000 $	Paper Products % of Imports
Algeria	52	23	4	-		-	37,446	37
*Burma	2,567	637	10	-		23,989	7,059	100
*Cameroon	1,075	130	37	-		21,030	6,148	88
*Ghana	1,920	359	32	-		39,257	7,303	99
*Congo, Pop. Rep.	950	40	75	-		19,400	3,097	97
*Cuba	380	96	70	-		-	46,000	22
*Ecuador	1,205	603	19	-		3,750	10,241	100
*Gabon	1,835	49	80	-		49,368	1,568	85
Guinea	305	23	1	-		3,684	22,638	-
*Honduras	800	457	6	-		13,628	17,891	96
*Indonesia	8,045	1,701	7	1	17	86,118	25,223	91
*Ivory Coast	3,888	309	70	-		107,291	22,638	97
*Jamaica	6	1	8	-		493	28,391	62
Kenya	601	100	2	-		11,509	17,124	80
Lebanon	15	12	46	-		4,393	33,863	61
*Liberia	450	191	-	-		6,945	1,759	73
*Madagascar	1,436	90	1	2	16	884	4,353	65
*Malawi	222	23	-	-		302	4,613	65
Pakistan) Bangladesh)	1,960	701	19	38	11	426	27,203	40

Countries in Category 2 - Continued

Countries	Production Industrial Round-Wood 1000 m^3	Production Sawn-Wood & Ties 1000 m^3 (s)	Production Wood Panels 1000 m^3	Production Wood Pulp 1000 m.t.	Wood Pulp Rating	Exports Wood Products 1000 $	Imports Wood Products 1000 $	Paper Products % of Imports
*Peru	635	245	42	-		3,078	20,224	65
*Philippines	14,400	1,341	661	39	10	275,100	80,195	93
*Senegal	330	15	-	-		-	5,970	68
*Sierra Leone	141	13	-	-		-	1,093	41
*Vietnam, Rep.	500	250	-	8	12	-	9,420	62
*Surinam	193	53	35	-		4,211	1,517	86
*Sudan	1,115	26	4	-		-	10,714	42
Syria	62	9	10	-		810	19,324	34
*Tanzania	1,095	161	4	-		2,647	10,632	82
*Thailand	4,670	1,626	58	-		12,154	33,885	75
*Uganda	894	65	13	-		2,629	7,272	74
Uruguay	148	73	18	6	13	147	13,985	38
*Zambia	308	47	-	-		763	16,050	65

Countries in Category 3

Countries	Production Industrial Round-Wood 1000 m^3	Production Sawn-Wood & Ties 1000 m^3 (s)	Production Wood Panels 1000 m^3	Production Wood Pulp 1000 m.t.	Wood Pulp Rating	Exports Wood Products 1000 $	Imports Wood Products 1000 $	Paper Products % of Imports
Afghanistan	2,630	999	1	-		-	709	50
Egypt	60	-	22	-		814	54,455	31
*Khmer, Rep.	960	240	3	5	14	2,248	1,389	62
*Laos	71	35	-	-		1,715	2,807	73
*Equa. Guinea	550	-	-	-		-	-	-
*Mongolia	900	420	4	-		-	-	-
*Nepal	408	220	-	-		4,073	-	-
*Solomon Is.	235	4	-	-		3,118	95	14
*Sri Lanka	753	165	11	-		193	7,357	70
*W. Samoa	9	3	-	-		10	1,706	18
Yemen Arab Rep.	-	-	-	-		-	-	-
Yemen Dem. Rep.	-	-	-	-		224	1,858	43
*Bolivia	275	115	2	-		930	1,400	100
*Costa Rica	685	387	25	-		3,676	21,301	93
*Dominican Rep.	412	100	-	-		60	11,600	68
*El Salvador	79	201	-	-		3,831	12,514	78
*Guatemala	850	73	12	4	15	4,189	13,233	91
*Guyana	236	87	-	-		1,558	2,715	70
*Haiti	225	14	-	-		730	1,364	83
*Nicaragua	453	197	13	-		4,336	8,434	77

Countries in Category 3 - Continued

Countries	Production Industrial Round-Wood 1000 m^3	Production Sawn-Wood & Ties 1000 m^3	Production Wood Panels 1000 m^3	Production Wood Pulp 1000 m.t.	Wood Pulp Rating	Exports Wood Products 1000 $	Imports Wood Products 1000 $	Paper Products % of Imports
*Panama	180	50	24	-		472	17,559	85
*Paraguay	1,031	224	9	-		12,641	2,333	81
Botswana	45	-	-	-		-	639	50
Burundi	2	1	-	-		-	-	-
*Cen. African Rep.	466	55	-	-		1,863	737	63
*Chad	380	-	-	-		-	1,422	50
*Dahomey	130	10	-	-		27	782	85
*Ethiopia	1,105	63	4	-		37	3,924	78
*Libya	53	20	-	-		9	5,981	100
*Mali	205	10	-	-		-	1,145	65
*Rwanda	6	6	-	-		-	246	20
*Somalia	3	3	-	-		5	3,923	68
*Swaziland	796	86	-	-		17,283	1,738	70
*Togo	102	4	-	-		5	1,490	60
Upper Volta	894	1	-	-		-	980	61
*Zaire	1,600	150	67	-		3,887	5,705	97

APPENDIX B

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