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All correspondence regarding contributions, subscriptions, &c., should be addressed to—

The Hony. Editor,
The Ceylon Forester,
Forest Department,
9, Kew Road,
Colombo 2.

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Hony. Editor . . L. C. A. DE S. WIJESINGHE

Editorial Office . . FOREST DEPARTMENT

9, KEW ROAD

COLOMBO 2

"The forest is a peculiar organism of unlimited kindness and benevolence that makes no demands for its sustenance and extends generously the products of its life activity; it affords protection to all beings, offering shade even to the axeman who destroys it."—Gautama Buddha.

EDITORIAL

WE apologize to our readers once again for bringing out only one issue for 1966, and that too later than usual. Due to mounting pressure of work on the handful of senior forest officers of the Department, the journal has in the past few years become, in effect, an annual publication, and this is likely to remain so until the Departmental cadre increases.

IMPROVEMENT OF LOGGING TECHNIQUES IN CEYLON

A logging operation includes all the activities connected with the supply of timber from the forest to the mill site. These include felling, debranching (delimbing), cross-cutting (bucking), skidding from stump to wayside depot (extraction or minor transportation) and, finally, transport from the forest wayside depot to the mill.

It is unfortunate but true that logging techniques in Ceylon rank among the most primitive in the world. Felling is done by axes and hand saws, neither of which are of the best design to suit the job. Extraction is by elephants, but skidding distances are sometimes so long that not more than one or two logs can be hauled per day.

Transport is mostly by road, but forest roads are few in number and of rough construction; no proper grading and surfacing being carried out.

The lorries used for timber transport are generally unsuited to the job. Very often hooded lorries are used. In other cases the lorries are provided only with a loading platform devoid of side supports, and the logs are secured on to the platform by means of coir ropes. Generally the load which such a lorry can transport is less than 200 cu. ft.

Improvement of logging techniques can be effected in 2 ways :

- (1) by increasing the efficiency of the methods in current use and
- (2) by introducing new methods.

In the first category can be included the improvement of hand saws and axes. Time and work studies and experiments with hand saws, axes and other equipment of modern design will indicate how the efficiency of operations can be increased.

In regard to transport, greater attention must be paid to the planning and construction of forest roads. Present methods of logging in the wet zone where the forest is provided only with a single road and skidding distances are therefore excessive must give way to more intensive road net work planning.

Lorries, better suited to timber transport than those now in use are absolutely necessary if wood using industries are to be expanded. A load of 350 cu. ft. of round timber could easily be transported in a lorry specially designed for the purpose.

In the second category, namely, that of introducing new methods, might be included power saws for felling, debranching, and cross cutting, and tractors and cable cranes for haulage of timber within the forest.

Power saws are the rule in countries of Western Europe ; and, in Ceylon, unless hand tools are supplemented with power saws for felling and cross cutting we do not think that the outturn of timber can be substantially increased.

Tractors and cable cranes should be used to supplement extraction by elephants, as one of the impediments to increasing timber supplies at present is the shortage of elephants for forest work.

Outmoded techniques continue to be used in Ceylon because all logging operations are done by private contractors who take up only small areas of forest at a time, as a result of which they try to carry out the logging operations with a minimum of investment. Furthermore, logging is a field of forestry that has received hardly any attention from trained foresters in Ceylon ; this must be remedied without any delay.

It is in logging more than in any other field that we look forward to the recommendations of the United Nations Special Fund (Forest Industries) team that has, in collaboration with Ceylonese counterparts, studied the possibilities of mechanized logging in Ceylon.

DEPARTURES

In 1966 we bade farewell to Mr. Ganesan, Timber Utilization Research officer, who after over a decade of service in the Department left to join Paranthan Chemicals Corporation as Chief Executive Officer. As a contributor to this journal we will miss him, and, much as we regret that he has severed connections with forestry affairs, we wish him all success in his new post.

We also bade farewell to Mr. L. Abeynaike, Forest Engineer, who left to join the Port Commission. We wish him well in his new job.

Mr. W. G. Weeraratne, Senior Assistant Conservator of Forests, was seconded for service as Chairman, Plywoods Corporation. We congratulate him on his appointment and wish him well. We of the Department will miss his genial personality during his period of secondment.

UNITED NATIONS SPECIAL FUND PROJECT

This project entered on it's third and final year.

Two Ceylonese counterparts, Messrs. L. C. A. de S. Wijesinghe (Logging) and S. Sridas (Forest inventories) returned to the Island after Fellowship studies, and the Forest Industries counterpart, Mr. V. R. Nanayakkara, and the second Logging counterpart, Mr. J. A. M. de Silva* left the island for studies abroad.

* At the time of going to press we were deeply shocked by the news of the death of Mr. J. A. M. de Silva in the Philippines. An appreciation will be published in the next issue.

Report on a Seminar on Forest Seed and Tree Improvement held in Denmark from 24 July to 13 August, 1966

By S. MUTTIAH
(*Forest Department*)

INTRODUCTION

A Seminar on the basic and applied aspects of forest seed and tree improvement was held in Copenhagen, Denmark, from 24 July to 13 August, 1966, for selected English-speaking countries under the auspices of the Food and Agriculture Organization of the United Nations and the Danish Board of Technical Co-operation with Developing Countries. Twenty seven participants from twenty five countries were represented at the seminar. The countries were: Afghanistan, Ceylon, Cyprus, Ethiopia, India, Iraq, Jamaica, Jordan, Korea, Liberia, Malaysia, Malta, Nepal, Nigeria, Philippines, Sierra Leone, Somali Republic, Sudan, Syria, Taiwan, Thailand (3 members), Turkey, United Arab Republic, Yugoslavia and Zambia.

The centre of the seminar was a mansion called "Rolighed" (pronounced 'Roliket') usually reserved for international conferences and seminars, located at Skodsborg not far from Copenhagen and from where a bird's eye view of the Swedish shoreline could be obtained across a short stretch of sea—the Oresund. The Director of the centre was Mr. H. Barner of the Tree Seed and Improvement Station Humlebaek with Mr. Bent Soegaard of the Horsholm Arboretum as co-director, assisted by other members of the staff from the same arboretum.

The seminar consisted of lectures by leading geneticists and associates, discussions and groupwork followed by field excursions to various Danish forests, arboreta, seed orchards, 'Tree-Shows', seed testing and storage stations and nurseries. One of the interesting features of the tour was that participants were able to see the extensive work done on sand dune afforestation along the western coast of Jutland where, up to a hundred years ago, the problem of sand drift was a constant danger to the stability, and sometimes, even the very existence of agricultural communities closer to the coast. An opportunity was also taken by the writer to visit an integrated parquet flooring cum pulp factory which utilises slash and smallwood so that utilisation waste is almost reduced to nil in the sawmill and in the forest. This visit was kindly arranged by Mr. Bent Soegaard to the Junckers Savvaerk, one of Denmark's largest woodworking enterprises.

The following lectures were delivered at the centre :—

- (1) Variations in species, races and individuals by Dr. Syrach Larsen, Head of the Horsholm Arboretum.
- (2) Breeding on the basis of species, races and individuals by Dr. S. Larsen.
- (3) Introduction of species by R. H. Kemp, Forest Research Department, Nigeria.
- (4) Provenance research by V. A. Gohrn, Danish Experiment Station, Springforbi.

- (5) Economic evaluation of results from provenance trials by K. F. Anderson.
- (6) Classification and certification of seeds by H. Barner, Director, Tree Seed and Improvement Station, Humlebaek.
- (7) Methods in forest tree breeding by Bent Soegaard, Arboretum, Horsholm.
- (8) Seed orchards : purpose and principles by Bent Soegaard.
- (9) Seed orchards : techniques concerning establishment by H. Keiding, Arboretum, Horsholm.
- (10) Criterion for selection by H. Keiding.
- (11) Factors governing the choice of species by Prof. H. A. Henriksen, Faculty of Forestry, The Royal Veterinary and Agricultural College.
- (12) Other methods of generative mass production by Lars Feilberg, Arboretum, Horsholm.
- (13) Danish forestry : economy and policy by N. K. Hermansen, The Royal Veterinary and Agricultural College.

The theme of the seminar was divided into eight main topics :

- (1) Choice of species
- (2) Choice of races
- (3) Seed certification
- (4) Seed collection, extraction, cleaning, testing and storage
- (5) Breeding : criterion for selection
- (6) Breeding : methods
- (7) Breeding : mass production
- (8) Breeding : techniques.

The relative importance of these topics to each country was indicated in order of priority by each participant. Where some of the topics were of equal importance, they were given the same order of priority.

It was agreed that working groups representing similar interests should wherever possible be formed for exchange of information and ideas at a closer and more detailed level with a view to recommending suitable seed and tree improvement programmes for their respective countries in the light of the knowledge gained at the seminar as well as from their own experiences. It was apparent that the grouping should be on a geographical basis ; accordingly three working groups were appointed as follows : Group I—Afro-Jamaican, Group II—Near-Middle East and Group III—Asia. Quite understandably there were diverse problems in the countries within any one group and hence, separate study groups were appointed to discuss the economically important and most widely planted species namely—Teak, Eucalypts and Pines. Certain delegates were of the opinion that the seminar afforded a good opportunity for those interested in amenity values and the embellishment of towns, villages and parks to get together and this resulted in a study group on “Ornamental Trees and Shrubs”. Rapporteurs were appointed to cover individual topics within a working group and the essence of the views and discussions were embodied in group reports. In the opening stages of the seminar, each participant gave a general appraisal of the forest seed and tree improvement situation prevailing in his country. At the conclusion of the seminar, certain broad-based recommendations were made for the consideration of member governments and international organisations.

CHAPTER I—CHOICE OF SPECIES AND RACES (PROVENANCES)

The choice of species is governed by a number of factors ; the present trend is not only to grow species suited to particular site conditions but also to grow them to meet specific consumer demands. Economics play a critical and often deciding role. Several years ago the end-user had to utilise the timber grown by the forester, but now the forester has to grow what is required to suit particular needs within the limits of the site potential. The changing situation has been partly responsible for the spread of species far beyond natural geographic homes, to climatically similar habitats and even outside it where their performance may be superior. Familiar examples of better growth and vigour outside the natural range are certain species of Eucalypts and Pines. The choice of provenance goes hand in hand with the choice of species so that a great deal of experimentation is required to select the correct type of tree for a given site. For example, in Brazil 140 species of Eucalypts had been introduced for trial but only a very few were selected for large scale planting. In Nigeria, to quote another instance, 80 exotic species have been introduced but the number of likely species to be grown will probably not exceed ten. We have similar experiences in Ceylon with Eucalypts where a few species like *E. grandis*, *E. microcorys* and *E. robusta* have proved to be the most suitable out of the 30 odd species tried out in the up-country.

Size of trial plots and the number of replications in species trials were discussed. Primarily, this would depend on the amount of planting material available, the variety of sites to be tested and, most important of all, the funds available. The value of even single trees such as found in a botanical garden was pointed out by Dr. Larsen with the limitation that this would serve only as a guide. Small plots serve the purpose of elimination trials but are inadequate for growth and yield studies. In this context, it is considered more feasible to adopt bigger plots, say half to one acre plots combining different spacings and thinning regimes. The number of replications have to be determined locally depending on the factors involved.

The importance of species and provenance trials in plantation forestry cannot be overemphasised. In fact, out of the 25 countries represented at the seminar 16 rated choice of species as of first importance. Cyprus was the only exception which rated this subject at the bottom of the priority list, but it illustrates an important point of view. In this country, *Pinus brutia* which is a multi-purpose wood grows well in the natural forests so that the foresters there are more concerned with the choice and spread of 'plus' trees and superior stands than experimentation with species or provenances. To them seed certification and breeding work are most important.

From the proceedings of the seminar it was quite apparent that the timber of paramount importance to tropical countries were suitable species and races of Teak, Tropical Pines and Eucalypts. In Ceylon, Teak (*Tectona grandis*) has proved it's worth as a species to be planted out widely in the dry zone. It has also been found that certain species of Pines and Eucalypts can be established successfully in the montane zone. The critical question is the availability of land for planting, and this is getting more and more limited. The land which is available for future planting is mainly in the dry zone. This underlies the necessity to establish species

and provenance trials in this region. Species trials have already been initiated with *Pinus caribaea*, *P. patula*, *P. radiata*, and *P. insularis* in the Nuwaragama Reserve at Anuradhapura. *P. caribaea* of apparently unknown provenance, is found to be the most promising as regards the general growth and relative ability to withstand drought. *P. patula*, *P. radiata*, and *P. insularis* were almost total failures. An omission in this trial was that seeds of only one provenance each had been experimented with. The *P. brutia* seedlings at the Korakawewa nursery exhibit very slow early growth. *P. brutia*, *P. pinaea* and *P. halepensis* are commonly grown in the Near-East and Mediterranean countries where the climate is marked by low winter rainfall and a prolonged drought period extending up to seven months. All these species are said to grow fairly well on sandy to sandy loam sites. It therefore seems advisable to plant the *P. brutia* seedlings not only in the dry zone but also in the more arid areas in the ND and SD adopting suitable planting practices including the use of mulch.

The most widely spoken of among the tropical Pines was *P. caribaea* to which reference has already been made. It has been introduced from Central and South America into Malaya, Nigeria, Jamaica, Sierra Leone, Thailand and Zambia. Seeds had been imported from Mexico, Honduras, and Bahamas. Four growth forms had been identified in Malaya and Jamaica from these seeds origins, one which exhibits distinct 'foxtailing'. All the countries reported promise with most provenances of this species over a variety of soils and altitudes varying from 300'-5000' above sea-level. *It is well worth improving on the present P. caribaea trial by importing seeds from the three sources mentioned and to test them in a statistical lay-out over a variety of sites in the dry zone.* A rate of growth of up to 7' per annum has been observed in Malaya and Nigeria but under heavier rainfall.

Another important tropical Pine species is *P. merkusii*. It grows in the natural forests in Thailand, Phillipines, Cambodia, and Indonesia and found on a variety of soils, both at low and high elevations under rainfall ranging from 50"-100" per annum. Different provenances have been introduced in Malaya, Zambia and Jamaica. These countries reported two distinct types, one which has a 'grass-stage' associated with the Cambodian ecotype. *Extensive trials could be started in Ceylon using seeds of different provenances.*

Pinus oocarpa, another Tropical Pine, has been introduced from Mexico and Honduras in Nigeria, Zambia, and Malaya but the early growth is reported to be not as good as *P. caribaea* especially at lower elevations. The Honduras variety is said to exhibit early sinuous growth but this has not been observed with the Mexican variety. This species is also worth trying out locally.

Unlike with Pines, a study group could not be formed for Eucalypts partly due to lack of time and partly due to the members expressing a more avid interest in the growth of long-fibred species such as Pines. However, from the statements of the participants it appeared that two species could be tried out in the dry and 'arid' zones namely: *E. astringens* and *E. oleosa* from Australia. Both these species are being widely grown in parts of the Middle-East and Cyprus with apparently satisfactory early growth.

Mention was made of a fast growing hardwood, *Hibiscus elatus*, by the delegate from Jamaica. This timber grows on both acid and alkaline soils and under rainfall of 55" and over per annum. It is said to have an exceptional colour and grain and limited quantities have been exported

to the U. K. for choice panelling and decorative work. This species is being grown in certain African countries and is worth a trial in Ceylon. The tree seeds in December and Mr. Hall from Jamaica was quite willing to send seeds in exchange for those of the Broad-leaved Mahogany.

CHAPTER II—SEED CERTIFICATION

The purpose of seed certification is to identify the movement of seed lots as originating from certain selected stands or seed sources. This is of great importance in provenance research and in national and international seed trade. Among the countries represented at the seminar, seed certification is practised only in Yugoslavia where seed stands have been demarcated. In the Teak growing countries this is not done because as much Teak seed as possible is collected to keep pace with large scale planting programmes. Though this system is inevitable it has to be looked upon with disfavour especially when seeds are collected from very poor stands. To quote an example, if Teak seeds are collected from badly fluted trees where the furrows extend for a considerable part of the boles, then there is a strong possibility that the majority of trees in the subsequent generation would be badly formed with considerable loss of volume production. The rotational cycle would thus be spent, rather in vain, producing poor quality stands. An interesting example is the Palugama teak plantation which has a preponderance of fluted stems where the furrows extend upto about 15-20' or more from the base resulting in a loss of volume production in the best part of the stems. The number of good trees, apart from 'plus' trees, is so rare that they would not exceed 20 per acre.

In most countries where seed collection is done on a systematic and scientific basis, forest stands are classified as 'plus', 'normal', or 'minus'. Plus stands are those having more than 75 per cent plus trees, Normal—50-75 per cent plus trees and Minus—less than 50 per cent plus trees. Hence the Palugama plantation can be considered as an extreme example of a 'minus' stand. It is felt that the above percentages may be too rigorous for application to Teak in Ceylon but it is not so for the Eucalypts. The improvement of the quality of the future teak stands can be attempted as follows. Firstly the stands must be classified into plus, normal and minus, but as the requirements given above are too strict it is proposed that the percentages for the three groups be 60 per cent, 30 to 60 per cent and less than 30 per cent respectively. On this basis, the Mihintale Teak plantation could be classified as a 'normal' stand and the Tonigala Plantation as last seen by the writer before it was ravaged by the cyclone could be described as a 'plus' stand. The collection of seeds from 'minus' stands though usually deprecated is unavoidable where seed supply is inadequate to meet the planting programme. But *what could be done here is the preliminary selection and demarcation of 'normal' and 'plus' stands on the suggested basis and the raising of separate plantations from these certified seed sources so that they may serve as future seed stands.* Resort can be had to the induction of early and prolific seeding of 'plus' trees and seed stands by ploughing (root pruning), application of N. P. K. fertilisers and adoption of heavier thinnings where a stand is known to be a poor seeder. The amount of seeds collected from such selected sources and eventually from seed orchards could be expected to increase over a long term so that, seeds from 'minus' stands could be gradually avoided. There are a number of certification schemes for the

description of seeds of known origin and one such standard certificate is illustrated in 'Unasylyva' Vol. 18 (2-3) Nos. 73-74, 1964 or in the FAO publication 'Handling Forest Tree Seed' (1955), p. 98. These could be adopted for local use.

The formation of seed stands could be made an integral part of the research branch activity, to be done in co-ordination with the divisional range staff when it comes to seed collection and planting out under the reforestation scheme.

CHAPTER III—SEED COLLECTION, EXTRACTION, CLEANING, TESTING AND STORAGE

In most countries, collection is usually made from the forest floor or sometimes by climbing the trees. With Pines, collections are made by climbing the trees with the aid of special equipment such as pipe ladders, jointed ladders, or more rarely, tree bicycles. In the U. A. R. the aid of fire-brigade ladders is sought on occasions. The use of modern equipment for climbing trees was demonstrated on a field trip during the seminar. A particularly interesting demonstration was the use of an air-gun in shooting a weighted nylon string between the branches of tall trees, especially hardwoods. At the end of the nylon string is attached a guide rope followed by a rope-ladder. The rope-ladder is raised by lowering the guide rope which is then tethered to the tree trunk. It is compulsory that climbers should always use safety belts and this is a useful safeguard which could be introduced here. Leather safety belts of the type seen on the tour could be easily turned out locally.

Among the participant countries the method of collection varies from the use of special teams to collection by local villagers on a piece-rate basis.

Extraction

In the majority of tropical countries extraction of seeds from cones as in the case of Pines or from capsules as in the case of Eucalypts is done by exposure to the sun (sunshine method). Kiln drying is practised in Turkey and Yugoslavia. Kiln drying and other practices described below were demonstrated on a visit to the seed extraction, cleaning and testing station at Humlebaek, Denmark.

Cleaning

Cleaning involves the de-winging of winged seeds and the separation of impurities from clean seed. The practices, however, vary in the different countries from picking by hand and winnowing to the use of machines like revolving drums and mechanical sieves.

At the Humlebaek seed station cleaning, separation and grading are done by screening and gravitational methods using machines. Empty and infertile seeds are eliminated by these methods; hence, germination results are better assured.

Let us consider the necessity for cleaning in relation to Teak seeds in Ceylon. Random cutting tests have repeatedly shown that the percentage of empty seeds can be as high as 60 per cent even in fresh collections. It was postulated at the seminar that the rather high degree of infertility in Teak may be associated with the extremely short receptive period of the stigmas and consequent lack of fertilisation possibilities. The carrying over of useless seeds means that a corresponding amount of storage space (especially in cold storage) and effort can be conserved from the time of storage to pretreatment and final sowing if a method could be devised of eliminating at least, a substantial proportion of such idle stock at an early stage. Concomitantly, valuable nursery space can be utilised for the production of a higher density of plants per unit area by the judicious use of good, viable seeds resulting in a lowering of nursery costs. Briefly, there is an imperative need to introduce cleaning and some measure of grading of Teak seeds. Expensive machines will have to be ruled out for the present, but experiments could be initiated to try out simple separator devices, winnowing (may not be practicable on a large scale) and water floatation methods.

Testing

At the seed station visited, the cleaned seeds are dried in electrically heated kilns to certain values of moisture contents depending on the species. Thereafter samples are taken from seed bags with the aid of a sampling stick, intimately mixed, and the exact moisture content determined using an electronic device known as the 'Beha'. In the case of large seeds such as acorns, it is necessary to cut the seeds before the moisture content is determined. A sampling stick could be turned out locally but it is worth importing one as a prototype because this together with the 'Beha' are valuable aids in seed testing. The singular advantage of this instrument is that it gives an instant reading of moisture content, on a pre-determined calibrated scale, varying with the species. The prior calibration of the scale is done by comparison with the oven method as standard. The cost of the 'Beha' is around Rs. 2,000 in Denmark. Mr. Barner, the Director of the seed station, expressed his willingness to assist those interested in obtaining a machine and get scales calibrated with seeds sent there for the purpose. This instrument is a standard aid in seed testing stations in Denmark.

The necessity to reduce moisture content in the seeds is to prevent fungus growth and fermentation processes as well as to restrict metabolic activity. Until the adoption of refined methods, *the Teak seeds in Ceylon need to be thoroughly sun or air dried, after cleaning, at a storage station on receipt from the collection centres.*

After the determination of moisture content, further samples are tested for viability and germination percentages either by the tetrazolium staining method or by the more reliable Copenhagen tank test where the seeds are germinated under controlled conditions. The Copenhagen tank consists essentially of a rectangular metal tank with glass plates on top placed across it. The sample seed lots are wrapped in large filter papers and placed atop the glass slides with paper wicks extending down to the water in the tank. The temperature of the water is thermostatically controlled but this would not be an essential consideration in Ceylon where the variations within and between diurnal and nocturnal temperatures are slight.

Copenhagen tank and tetrazolium tests are carried out in Nigeria, Yugoslavia and Zambia. In most of the other countries, great reliance is placed on the 'cutting test' and on direct germination tests in the field though the former is not reliable and the latter somewhat time consuming. Germination tests in the laboratory give quicker results. In Iraq, gypsum blocks in water are used as the germinators. Both the Copenhagen tank and tetrazolium tests can be applied with facility to Teak in Ceylon so that when the seeds leave a central testing cum storage station they would be certified not only as regards their origin but also for their viability and germinative capacities.

Storage

Since most tree species do not produce seeds in the same abundance each year, the proper storage of seeds is of great importance in ensuring a steady and continuous seed supply. Many tree seeds can be stored successfully at air temperature for short periods *but cold storage is necessary over long periods*. The two main factors affecting viability are temperature and moisture. At the Humlebaek seed station, seeds brought down to low levels of moisture content are stored in air-tight tins or double plastic bags in cold rooms at 3-5°C. *In this manner the viability of the seeds is preserved up to 10 years.*

Cold storage is practised in certain countries, e.g., Nigeria, Jamaica and Zambia. Sometimes seeds are stored in underground cellars as in Malta and the Phillipines. The application of cold storage especially to Teak seeds in Ceylon is well worth consideration in view of the large scale reforestation programme and due to the existence of definite seed years. A recent experiment at Kankaniyamulla has shown a significant drop in viability beyond the 9th—11th month of storage but the germination percentage is highest from the 3rd-5th month of collection probably as a result of after-ripening or maturation. This is another vital reason for resort to cold storage. Immediate investigations could be started to test the reaction of Teak seeds to cold treatment over protracted periods.

CHAPTER IV—TREE BREEDING : GENERAL

From the majority of statements of the participants, it became clear that most countries had embarked upon tree-breeding just as much as breeding is used universally for effecting improvements in horticulture, crop and animal husbandry. However, the present status of breeding work differs in the various countries. The most organised type of work is being carried out in Korea, Yugoslavia and Zambia where there are separate institutes and specialised staff dealing exclusively with Tree genetics. Work on a smaller scale is being practised in the other countries.

In the host country, Denmark, tree breeding is highly developed. Active interest in this field in Europe and Scandinavia was generated about 30 years ago by Dr. Syrach Larsen with his famous contribution in bringing about controlled crosses between the European Larch (*Larix decidua*) × Japanese Larch (*L. Leptolepis*) = Hybrid Larch (*L. eurolepis*). The hybrid variety was found to be Canker-resistant and this led to the proliferation of this variety in preference to the canker-sensitive European Larch. Dr. Larsen also propagated the theory and practice of clonal seed orchards and tree-shows or clone trials. Since that time tree breeding work especially in Denmark, Sweden and Germany has been developed

greatly for the production of improved strains and mass production of seeds of improved, tested quality. Of late, a tremendous amount of work on similar lines has been done in the U. K. and U. S. A. The participants were very fortunate in having in their midst Dr. Larsen who is head of the Horsholm Arboreta where most of the tree breeding research is done in Denmark in conjunction with the Faculty of Forestry, Royal Veterinary and Agricultural College.

An interesting and elucidative review of selected topics on tree breeding can be found in *Unasylva* Vol. 18(2-3), Nos. 73-74, 1964 mainly embodying the papers delivered at the World Consultation on Forest Genetics and Tree Improvement held in Sweden in August, 1963, under the auspices of FAO and IUFRO.

CHAPTER V—BREEDING : CRITERIA FOR SELECTION

The first step in a breeding programme consists of an analytical study of the variations between races and individuals within the species in question. Then comes the selection of phenotypically superior trees or 'plus' trees for propagation and progeny testing. It has been proved that the genetic gain (G) is equal to the product of the selection differential (i) and the square of the heritability pattern (h).

$$G = ih^2$$

The selection differential represents the difference between selected and average parents in a stand. This factor is also a measure of the plasticity of the genes as reflected in the broad and narrow variations which exist say, in stem form, within members of a species. Thus it would be correct to say that local Teak has a higher value of i than broad-leaved Mahogany which does not exhibit marked differences in phenotypic characters within a parent population. The selection differential is always defined with reference to particular characters. It may be stem form or volume production with reference to Teak or the type and extent of grain with Eucalypts. *In Ceylon, breeding work should be directed to improving two main species viz : Teak and Eucalypts and possibly a third, Satin, which are of economic importance. It is still too early to attempt work on Pines since it is in an introductory stage in the dry zone.*

The following 'plus' tree characteristics seem to be of importance for most species : (1) vigour, (2) straight and persistent axis, (3) clear, cylindrical bole without bumps, epicormics and buttresses, (4) light and spreading branches with branch angles approaching 90° (5) a reasonable amount of seed production and (6) freedom from diseases. Other characteristics may be of more specific interest for the individual species such as fluting (Teak), the quality of the wood, mode of flowering, ability to grow under certain conditions etc. In practice, it will not be possible to find the ideal tree fulfilling all the above characters but the essential requirement is to select the superior trees as regards a definite number of selected characters. Mention must be made of the relationship between the crown diameter and Diameter at Breast Height (DBH). The smaller the crown width in relation to the DBH the better and more efficiently does the tree utilise the site factors.

The selection of plus tree is relatively easy in an artificial stand as compared with a Natural forest. In the latter, such as in the natural Teak forests of Thailand, this is done by a low percentage sampling. There is no

limit to the number of 'plus' trees that should be selected. This would be mainly determined by the genetic gain expected and expenditure that can be afforded. A number over 10 and up to 100 was advocated at the seminar.

An important aspect of selection is the maintenance of adequate data on 'plus' trees. Standard forms have been worked out for different countries depending on their needs. The 'plus' tree record form for Teak in Thailand appears to serve the purpose for local Teak.

A systematic study and differentiation of local Teak and Eucalypt stands into 'plus', 'normal' and 'minus' should be accompanied by a study of variations and selection of 'plus' trees. It is not unlikely that several strains growing under different climatic and edaphic conditions may be distinguishable. This kind of study could be also extended to cover Satin, especially the flowered variety. In certain countries selection of 'plus' trees is rendered easier by a system of scoring whereby marks are allotted for different characters, those obtaining more than 75 per cent are finally classified as the 'plus' trees. In other countries e.g. Yugoslavia and Thailand trees are classified as excellent, very good, good and poor. The latter method is of easier application in Ceylon. Under either system, it is advisable for the same team to select 'plus' trees in respect of a given species, so that the same standard would be used throughout.

CHAPTER VI—BREEDING : PRINCIPLES AND METHODS

There are three basic methods of tree breeding :—

1. Selection,
2. Hybridisation,
3. Polyploidy and Mutation.

1. Selection :

Mention has been made of 'plus' trees and 'plus' tree selection. 'Plus' trees could be utilised in three possible ways :—

- (a) for the establishment of clonal and/or seedling seed orchards ;
- (b) for immediate use in planting where clonal propagation is practical
e.g. *Populus nigra* cuttings in Nepal and *Cryptomeria* and *Cunninghamia* cuttings in Taiwan and
- (c) for the use in selective breeding and hybridisation.

Seed orchards will be dealt with more fully in the succeeding Chapter.

2. Hybridisation :

One of the most commonly used methods in tree breeding is hybridisation, especially the utilisation of F₁ heterosis or hybrid vigour. The first example of hybrid vigour was noted in the case of the canker-resistant

Hybrid Larch. Reference has been made in the Asia group report to the production of the cold-resistant hybrid *Pinus rigitaeda* in Korea. Hybridisation is usually brought about between races (intraspecific) or species (interspecific); few intergeneric hybrids are known. F1 hybrids have not always proven superior or intermediate to the parents; some products have been decidedly inferior. Hence the occurrence of hybrid vigour cannot be forecast beforehand but must be determined empirically by testing plants on a number of habitats. The reason for heterotic behaviour is little known. In addition to the F1, backcrossings either at an early or late stage also offer a way of incorporating certain desired characters such as growth rates, disease resistance etc. in the progenies. Among the hardwoods, breeding for improved disease resistance and growth has been done mainly on *Populus* and *Castanea* spp. especially as crosses and seed setting are easily effected in these two genera.

At the Horsholm Arboretum, Bent Soegaard has been successful in obtaining F1 hybrids from controlled crosses of the Red Cedar, *Thuja plicata* x *T. standishii* which combine the excellent growth and form of *T. plicata* with the resistance of *T. standishii* to attack by the leaf blight fungus, *Dadymascella thujina*. Both the juvenile and adult forms of the hybrid were seen on the tour and they were singularly free from fungus attack.

Work is also in progress at this arboretum on inbreeding lines of European and Japanese Larches and outbreeding at a later-stage but no additive effects have been noticed after six years. Obtaining hybrid vigour in late generation recombination is being attempted in Canada and Sweden.

Though hybridisation offers great promise for tree improvement, its application in Ceylon with regard to Teak is restricted for two basic reasons: 1. lack of data on the existence of strains or races and 2. lack of knowledge on flower biology. Further progress can be made only after these two aspects are studied. Possible lines of development are breeding for improved stem form and resistance to attack by the Teak leaf skeletoniser which seems to be getting more widespread. The writer was interested to learn from the participant from India that work has shown that repeated attack by this insect affects girth increment of *Tectona grandis*. It appears that another species, *Tectona hamiltonii* is quite unaffected by this insect so that possibilities exist for controlled crosses between the two species.

Keiding has studied the flower biology of Teak in Thailand for one flowering season and he has carried out controlled pollination but with very limited success. He has indicated the need for more work in this field.

Hybridisation can also be attempted for improving the grain and fibre lengths of Eucalypts which are noted for their ease of crossing even in nature. Due to the prevalence of spiral and interlocked grain in local Eucalypts, there is scope for attempting improvement through breeding.

Demonstrations were given at the Horsholm Arboretum on pollen collection, storage and pollination methods. Terylene bags imported from the U. K. are solely used now for isolating female flowers. The advantage with terylene unlike polythene is that it is unwettable and porous enough to permit exchange of gases and water vapour but sufficiently impervious to prevent pollen contamination.

3. Polyploids and Mutation

The alteration of the gene complex or of individual genes by mutagens or by exposure to irradiation has not been found to result in any appreciable benefits. At the Horsholm Arboretum control of *Dadymscella* attack on *Thuja plicata* has been attempted by exposure of the clones to Co 60 radiation but no positive result has been attained either in the vegetative or generative phase. Work on irradiation is also in progress in Sweden but no striking success has been reported.

Natural polyploids as a result of freak segregation of chromosomes or due to failure of cell wall formation during meiosis are not uncommon. Two specimens of polyploids resulting from controlled crosses were seen at the arboretum—one a tetraploid Larch (*L. decidua*) and the other a triploid Aspen (*Populus tremula*). In both cases, the growth and vigour are inferior to the common diploid forms. Due to the poor performance of polyploids and mutants, not much emphasis is placed on this aspect of tree breeding in Denmark.

From the foregoing it would appear that there is limited scope for tree improvement using mutation methods for the present. However, it would be interesting to study the effect of colchicine and irradiation treatments on Teak seeds. An irradiation unit is available in the Dept. of Agriculture and perhaps, this treatment could be easily arranged. A proper study of mutagenesis involves chromosome and gene mapping but these are really matters for fully equipped Research Institutes and may not be practical here.

CHAPTER VII—BREEDING : TECHNIQUES AND MASS PRODUCTION (SEED ORCHARDS)

Zobel et al have defined a seed orchard as a plantation of genetically superior trees, isolated to reduce pollination from genetically inferior outside sources and intensively managed to produce frequent, abundant easily harvested seed crops. It is established by setting out clones (as grafts or cuttings) or seedling progeny of trees selected for desired characteristics. Seed orchards can be established while genetic evaluation is still under way ; genetically undesirable trees, as shown by clone trials or better still by progeny trials, would be subsequently removed from the orchards. It is *very necessary to define the purpose and characteristics for which seed orchards are established.*

There are three different kinds of seed orchards :

- (1) Clonal orchards—started by Dr. Larsen and widely used the world over.
- (2) Seedling orchards—advocated in the U. S. A. by J. W. Wright and others.
- (3) Clonal cum Seedling orchards.

Clonal seed orchards

The clonal material may consist of buds or cuttings and are obtained from untested 'plus' trees or from 'elite' or tested clones. In the case of 'plus' trees, the clonal material should be gathered from the flowering branches which are usually located at the top third of the crown since it has been established that clones grafted in this manner flower earlier than when the clonal material is obtained from the lower part of the crown due

to a physiological effect termed topophysis. This phenomenon should be made use of in all future clonal orchards. The 'plus' trees for the establishment of an orchard may comprise trees of the same species drawn either from a number of stands or more rarely from the same stand within a geographical region or of trees from different geographical origins (Provenance crossing seed orchards). 'Plus' trees which are of different species and of good combining ability are brought together in clonal orchards for the production of inter-specific hybrids. Several hybrid orchards for the production of the hybrid Larch were visited on the field excursions. Open pollination is the rule in these orchards. In the case of the hybrid orchards of *P. taeda* X *P. rigida* in Korea hand pollination is done mainly by school children; this probably results in better seed production than open pollination.

A valuable and practical method of increasing clonal material without recourse to frequent climbing of 'plus' trees is the establishment of multiplication gardens. This is done by grafting clones as usual in areas set apart for the purpose and then pruning to encourage branching, and repeated collections of budwood or scions are made from them. Multiplication gardens have been established for Teak in Thailand. Sections of Research Nurseries, e.g., Korakawewa and Mudumpita can be similarly converted into these gardens for propagative work in Ceylon.

Local Teak seed orchards have been established by planting out budded stumps, while in Thailand grafting is done *in-situ*. It is generally believed that the nature of the rootstock does not influence the hereditary characters but experiments carried out at the Horsholm Arboretum by K. Bryndum on *Picea abies* grafts indicate that early height growth is affected by the origin of the rootstocks.

The frequent practice of topping the leader shoots in the local orchards is better dispensed with in future collections since one of the useful purposes of clonal orchards is also clone testing especially in the early stages of breeding work. It is necessary to make observations on growth, branching, flowering, etc., of each clone so that undesirable clones can be gradually eliminated. However, top pruning can be continued only if replicate orchards are established, or it is better left for a later stage in the 'elite' or tested orchards. The main advantage of top pruning is that it encourages branching and enables flowers to be studied or worked with at ease closer to the ground.

In certain private forests in Denmark, clone planting is done directly in the field in small blocks to achieve superior stands. K. Naess-Schimdt has found that direct planting on a forestry scale should be accompanied by high grafting about 3-4' from the ground instead of the usual height of 6"-1'. The grafts resulting from high grafting have been observed to grow more straight and besides, they are able to better withstand weed competition. This method of reforestation was seen in a private forest at Svennerup. It is suggested that this method of propagation be tried out as an experiment with 'flowered Satin'.

Seedling seed orchards

Seedling seed orchards are advocated by J. W. Wright and others in the U. S. A. who have shown by quantitative calculations that the relative genetic gain can be expected to be higher with seeds from seedling orchards.

than from clonal orchards. The reason attributed is that there is greater selection in the former than in the later parental generation. These orchards are raised from seeds derived from untested 'plus' trees (half-sibs) or from tested progenies (full-sibs). *Due to this reason they are easy and cheaper to raise than clonal orchards* but flowering and seeding would be delayed due to the existence of the juvenile stage. The juvenile stage is of very short duration in conifers, usually 4-5 years, but it appears to be much longer in hardwoods. However, this stage is probably of short duration in Teak since it is not uncommon to find early flowering and fruiting among very young plantations. But the average age when Teak produces viable, filled seeds remains to be investigated. This should not be difficult as there are many young plantations of different ages in Ceylon formed in the recent past.

In addition to clonal orchards, it is well worth raising seedling orchards in Ceylon in the future. The essential requisite is the separate collecting of seeds from 'plus' trees, germination in separate beds and planting out the the different stumps from a selected number of parent trees in orchards according to a statistical lay out. These orchards could be applied not only to Teak but more aptly to Eucalypts and Satin where grafting methods have yet to be tried out here.

Clonal cum seedling orchards

As the name implies these orchards have both clones and seedlings mixed together according to a set plan. These are, compared to the earlier mentioned types, of rare occurrence.

Factors concerning the Establishment of Seed Orchards

1. SITE

In the early stages of a breeding programme, some geneticists prefer the establishment of a number of small orchards, say of 2-10 acres, distributed over a variety of good sites and of different composition. This arrangement yields valuable data for reselection of parent material but involves management and isolation problems. Due to these reasons it seems better to form orchards in Ceylon in fairly large, compact blocks on suitable soils and isolated from contaminant trees. J. W. Wright has calculated that the isolation distance for conifers is about 1,000 yards and half this distance for hardwoods. Orchards should be always established on well drained fertile soils as infertile soils can cause slow growth and affect the abundance and nature of flowers and fruits. Orchards on poor soils are also more susceptible to attack by diseases and pests.

The Mudumpita and selected Nuwaragama sites are quite suitable for Teak orchards but *further establishment of more orchards in the N. D., E. D. and the drier parts of the S. D. is considered advisable*. It is a common observation that early and more profuse flowering occurs with trees of the same species growing under drier conditions and sometimes when they are grown outside their natural range. Practical application of this phenomenon is found in Sweden where clones of *Pinus sylvestris* have been moved to lower altitudes and latitudes for the sole purpose of seed production. Similarly Keiding has suggested the movement of Teak seed orchards in Thailand from the 18th to the 10th degree latitude.

2. LAY OUT OR DESIGN

The lay out or design of planting clones or seedlings is a very important consideration in the planning of orchards based on open pollination. Priority has to be given to maximum degree of cross pollination or diallel crossing combined with possibilities of clone testing and polycross tests. By maximum cross pollination is meant that all possible crossings among members of the seed orchard should occur an equal number of times. Polycross tests are meant for evaluation of parents by crossing each parent with a mixture of pollen from several known parents.

The most widely recommended is a randomised complete block design though incomplete block or lattice designs or latin squares are also used under certain circumstances. Examples of the first type of design were demonstrated in several orchards on the tour. In the majority, the ramets or members of the same clone are arranged in rows rather than in small blocks. Giertych has pointed out the importance for simplicity and suggests a systematic lay out where the clones are arranged in a consecutive manner and repeated likewise. The 5-clone collection at Mudumpita conforms to this arrangement. A drawback is that the mixing and test possibilities are restricted.

3. ESPACEMENT AND THINNING

Two factors which influence the lay out in orchards are espacement and thinning. These vary with the species depending on the rate of crown development and pollen dispersion. The normal espacements vary from $10' \times 10'$ to $20' \times 20'$. One or two, rarely three, thinnings is a generally accepted practice in orchards. Removals should aim at leaving behind a 'complete lay out' of the different clones at the end of the last thinning.

4. FLOWERING AND FRUITING

Geneticists as well as those concerned with planting are naturally anxious that they should be able to obtain good seeds from seed stands and orchards early and in abundant quantities. This has prompted research on the subject of early flowering and fruiting. It is generally believed that this characteristic is to a large extent determined genetically, but extra-genetic factors also play a definite role. Reference has been made already to the siting of orchards in Sweden at lower altitudes and latitudes and in drier habitats for achieving this result.

There are still other factors which have given encouraging responses. *Use of N. P. K. fertilisers singly and in combination, especially when accompanied by crown release or thinnings, has given good results.* This practice should be adopted with the 'plus' trees to be selected in local plantations especially as trees grown in plantations are reputed to be shy seeders and this would have a direct bearing on the formation of the proposed seedling seed orchards.

Partial strangulation of the stems have also given results but this is said to be more due to shock than a positive response. This method is not normally used since it invariably affects the health and vigour of the trees, sometimes ending in death.

Root pruning is another method, and is practised in several orchards in Denmark along with the application of N. P. K. fertilisers and thinnings.

Root pruning is effected by rotary tilling between the rows of trees. The Danish system could be adopted in our local orchards.

Yet another method of inducing flowering is the use of gibberellic acid as reported with conifers in Japan but this method is still in an experimental stage and has not been tried out extensively.

In spite of randomisation, it is seldom that the clones (or seedlings) produce flowers and seed evenly. This was clearly demonstrated on our visit to seed orchard No. 212 comprising Ash (*Fraxinus excelsior*). Four seed harvests since 1953/54 have shown that out of eight clones two—V 797 and V 710—contributed 70 per cent. of the total seed yield while the contribution from two other clones—V 796 and V 893—was nil. This illustrates the necessity to remove and exclude clones with poor combining abilities. This is a useful principle which ought to be followed in our orchards here.

ACKNOWLEDGEMENT

The writer wishes to thank the Government of Ceylon for nominating him to attend the seminar and the Food and Agricultural Organization and the Danish Board of Co-operation with Developing Countries for the well timed organisation of the seminar on this subject which plays a vital role of importance in present day plantation forestry.

Special thanks are due to Mr. Barner, the Director, Mr. Fent Soegaard the Co-Director, Dr. Larsen, other members of the staff and all those who assisted on the field excursions for their exemplary organisation of the seminar and for making it both instructive and memorable. Mention must be made of the active interest and keen participation by member delegates to make the seminar a successful and eventful one. One of the main purposes of seminars of this nature is the exchange of information and the establishment of a spirit of co-operation and this was amply demonstrated during the seminar. It was hoped that this entente would facilitate easier and better exchange of seeds.

Thanks are also due to Mr. Flemming Johansen of the Junckers Group for showing the writer round the complex of factories.

Last, but not least, a word must be said of the wonderful Danish hospitality, their sparkling beer and rich farm foods which was enjoyed by one and all.

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On Forest Inventories

By S. SRIDAS

(Survey Department)

INTRODUCTION

AS Ceylonese Counterpart in the United Nations Special Fund Forestry Project, the writer was awarded a fellowship to pursue studies in the field of forest inventory in foreign countries for a period of one year from September 1965.

The study programme included an initial period of seven months at the State University of New York where the studies were essentially theoretical. This was followed by visits to various forestry institutions in different countries to gather practical experience in the various aspects of forest inventory by observation of routine inventories and inventory projects. The latter included two weeks at the U. S. Forest Service, Washington; 6 weeks in Venezuela, attached to the U. N. S. F. Venezuelan Guiana forestry development project; seven weeks in the Philippines, attached to the Bureau of forestry, Manila.

In this presentation the writer discusses methods of sample 'selection' and other technical and practical aspects of forest inventory with emphasis on the underlying principles. A discussion of methods suitable for application to conditions in Ceylon, on the basis of those learnt and observed in other countries, is also incorporated.

INVENTORY DESIGN

Though the term 'Forest Inventory' could apply to the assessment of any attribute of a forest population (viz. gross volume, merchantable volume, number of trees, insect damage, mortality, cull, etc.), I shall here confine myself to its general meaning, which is, an assessment of the 'stock' and 'stand' of a given tract, completely or partially forested; stock, referring to merchantable volume by species and diameter classes and 'stand' referring to number of trees by species and diameter classes. The basic data required to provide this accurately are the total number of trees by species and diameter classes, their merchantable height and individual diameters of the tree boles. But tree boles are not perfect cylinders. Therefore, measurement of diameter at one point is not adequate. So, in addition to the diameter usually measured at breast height (D. B. H.) and height, a measure of 'tree form' should also be available to compute the actual volumes of the individual trees. (We shall disregard tree quality, sound and cull trees for the present). If the above measurements are obtained for every individual tree in the forest, accurate stand and stock figures, free of the so-called statistical error, could be computed readily for the entire tract. Though it may be feasible for very small forest areas, in practice it is not possible to do a 100 per cent enumeration, mainly due to considerations of time and money, not to speak of inaccessibility and other natural limitations. Hence, foresters attempted to enumerate a small, representative portion of the entire

forest and extend the results to the total forest. If actually this proportion sampled is *representative* and at the same time if this sampled area is known *accurately* as a proportion of the entire forest area, the results obtained by this procedure may be accurate. But, in practice, there is no method of ensuring the selection of a representative sample, even though it might be possible to ensure accuracy of the area sampled as a proportion of the total forest area. Therefore, this method is not reliable.

It is at this stage that statistics comes to the aid of foresters. Though foresters had not largely contributed to the development of 'statistics' and statistical analysis, it has since proved to be a very valuable tool not only for foresters but also for those delving in all the biological sciences. It came to be known, and empirically proved that if certain statistical principles are adhered to, in the so-called 'selection' of the sample, it is always possible to define the limits of the accuracy of the final result and in addition, provide a measure of its reliability in terms of 'percentage level of significance'. Depending on the nature of the population, so many basic systems of sample 'selection' are available and all sampling systems incorporating a statistically acceptable method of sample selection is normally designated 'sampling design'. Without the intention of a comprehensive treatment of the various sampling designs and the statistical principles underlying them, I shall give, in broad outline, some details about few of the sampling designs and selection most popular in forest inventory at the present time.

The four basic systems of selection, for forest inventories are :

- (1) Simple random lay-out of sampling units
- (2) Restricted random lay-out of sampling units
- (3) Lay-out of sampling units in clusters
- (4) Systematic lay-out of sampling units

In the first three cases, the condition that each unit must have an equal chance of selection is fulfilled, thereby rendering it possible to obtain an unbiased estimate of the population parameter sought (volume, for example), and also to calculate the sampling error. This is not so in the case of a systematic lay-out of sampling units.

- (1) *Simple random lay-out*.—In this case the sample plots will be laid, in the whole forest population in a completely random manner. If the forest area is small, the forest is fairly uniform in composition, and accessibility and transport is no problem, this may be the best method of selection. The required parameter may be estimated with a small unbiased sample. But, in practice, none of these conditions exist. As such this is very seldom resorted to.
- (2) *Restricted random lay-out of sample plots*.—In this case, the population is divided into strata or blocks of equal rank and the sample plots are distributed within these in a random fashion. This is a popular design as it greatly reduces the number of sample plots in comparison with a simple random lay-out while retaining the advantages of rendering for statistical treatment.
- (3) *Lay-out of sampling units in a cluster*.—This is a form of two stage sampling wherein the selection is done in independent stages. Primary units are selected first and within these secondary units are selected. The selection of the primary unit alone

or the selection of both the primary and secondary units could be done in a random manner. This system is then resorted to in large forest areas to increase the time spent on actual measurements in relation to that spent on transport.

- (4) *Systematic lay-out of sampling units.*—Here, the individual sampling units are selected according to a pre-determined scheme, the aim of which being mainly to cover the population as uniformly as possible. The disadvantage of surveying sample unit locations in a random lay-out is obviated in a systematic lay-out. The serious drawbacks in a systematic lay-out of sample plots, however, are :—

- (1) It is not possible to calculate accurately the statistical error. The estimate though useful is said to be biased.
- (2) The possibility of coincidence of the sampling interval with an un-noticed periodicity in the population.

In spite of these disadvantages, for many an inventory this is the preferred system of selection. In this case, the samples are usually laid out as :

- (1) Continuous strips or
- (2) plots on lines or
- (3) as plots at equal distance on a regular grid

In general, the choice among the four systems of selection depends on the size and structure of the population and also other practical considerations—accessibility, availability of labour etc.

AERIAL PHOTOGRAPHS IN FOREST INVENTORY

The role of aerial photographs in a forest inventory is important and varied. It may be said that at the present time no inventory of temperate forests is attempted without an aerial photographic coverage of the area, on some suitable scale, while in tropical forest inventories their use is becoming popular only now. Though aerial photographs cannot play the same role as it does and as it could, in the inventory of temperate forests, their absence is felt as a drawback in modern tropical forest inventory.

Aerial photographs are utilized for the mere photo-reconnaissance of the forest area in the one extreme to the procurement of volume data by its use in conjunction with aerial volume tables, in the other extreme. Between these, it may be usefully employed in a variety of ways, a few important ones of which are given below.

- (1) Complete delimitation of forest from non-forest by photo-interpretation, production of planimetrically controlled maps from these photographs by suitable photogrammetric methods and obtaining accurate information on the area of forest land.
- (2) Delineation of forest 'types' (by photo-interpretation) on an ecological or any other basis so as to divide the forest population into sub-populations or strata of equal rank, to render the application of the popular restricted random design, mentioned earlier.

- (3) Stratification of the forest into 'forest types' without delineation. In this method, the same information (i.e. the area of the respective sub-populations or strata) is obtained by a statistical procedure—viz : interpretation of only a small proportion of the forest (i.e. sample areas of a fixed minimum size), selected in a random fashion and obtaining the population parameter (area of individual strata) from the statistics of the sample. It may be seen that this is a process of photographic sampling to obtain area statistics and hence incorporates the so called statistical error.
- (4) Interpretation of a small proportion of the photographic detail, (i.e. only on sample areas of fixed minimum size) first on the basis of forest and non forest and then the forest into forest types (and/or/stand size) and also volume classes. A sub sample of the forest and non forest photo-plots, selected in a random fashion, are located on ground and the trees measured to obtain volume on a unit area basis. The volume information on the ground plots are expanded to the respective volume classes and thence to give total volume.

Yet another method is in vogue where a proportion of the photo-plots are measured to obtain crown density and mean tree height data. A further sub sample of this 'measured' photo plots is located on ground and trees measured. The correlation between the ground measurements of tree height and crown density with those of the photo is studied by regression analysis. The mean height and crown density of all photo-sample plots are entered as variables in the regression equation to obtain mean volume of unit forest area. This is expanded to the whole forest area, the proportion of forest having been determined by a first phase of photo sampling for forest and non forest.

STAND AERIAL VOLUME TABLES

The more ambitious use of aerial photographs is in the construction of aerial volume tables. Independent variables for which methods are available for measurement on photographs, are measured on photo-sample plots which are distributed to cover the whole range of volume classes. The same plots are located on ground, and volume of standing timber in these plots is determined by conventional methods. The usual photo variables are height (often the mean height of the 3 tallest trees in the stand), crown density and crown closure. A multiple-regression analysis is done to determine the correlation of these variables with 'ground volume'. Multiple regression equations with various combinations of the photo-variables are tested for best 'fit' or to select the one with the highest multiple correlation co-efficient. Even though crown diameter is also found to be correlated to volume, the common methods disregard crown diameter as a variable and multiple regression equations with only height and crown closure are developed. To give an example, $V = bC + cHC$ (where V is volume in cu. ft./0.2 acre plots, C is crown cover per cent and H is stand height in feet and b and c estimates of the multiple regression co-efficient) is the equation used by S. F. GINGRICH and H. A. MEYER in the preparation of stand aerial volume table for upland oak.

It will be apparent that useful results may be obtained when the stands are pure. Composite aerial volume tables may also be prepared for mixtures, but in their application, supplementary field data on the composition

will be required for volume adjustments. The main limitation of the stand aerial volume table is that it could only furnish information on gross volume and absolutely no information on size class distribution, timber quality, etc. However, aerial volume tables are widely used currently in the U. S. A. and Canada to obtain quick volume estimates.

In so far as the tropical forests are concerned not much work has been done on these lines mainly due to the highly complex nature of the forests. In view of the difficulties in tropical forest inventory a lower precision may be acceptable. Some inventory specialists like Prof. Loetsch who have experience in tropical inventory are of view that a study of the regression 'total timber volume' on the independent variables 'no of trees', 'crown closure of upper canopy' and 'stand height classes' could be a promising line of research. Even though the usually required information on the specific composition and size classes could never be furnished, the advantage of a rapid estimate could be availed of.

From above, it will be seen that aerial photographs may either be used to obtain area statistics on the different forest formations or types, either by delineation of them on the photographs or by photo sampling procedures. In this case, it is only an aid in the inventory and forms an independent phase in the sampling procedure. In other cases, such as is currently popular in the United States Forest Service, photographic sampling phase is one of the dependent phases in a multi-phase sampling design.

SAMPLE PLOTS

Whatever the method employed, none of them obviates a phase of ground measurements. The accuracy of the final result is guaranteed on the assumption that the ground measurements on standing trees (and sometimes felled trees also) were made accurately. In the construction of volume tables as a preliminary to an inventory and also in the construction of aerial volume tables the sample plots are systematically distributed so as to cover the whole range of volume, size, age and site classes. In this case an optimum size and a convenient shape of ground plots is arbitrarily chosen. But in a lay-out of plots for an inventory so many factors are taken into consideration in deciding on the size and shape of the sample plots. In general, larger the plot size, lesser will be the variation between the sample plots, thereby reducing the sampling error. On the other hand, large number of observations (i.e. the no. of sample plots) also has the same effect of reducing the sampling error. Thus, in the general formula $S_y = \frac{S}{\sqrt{n}}$ (' S_y ' is the sampling error; ' S ' is the standard deviation or the square root of the variance; ' n ' the sample size), if the sample plots are large in size, the value S^2 (variance) will be small in magnitude, and hence S_y , the sampling error will also be small. Similarly if the sample size (n) is large S_y will be small. It is neither feasible to have too large a plot size nor to have too large a sample size (i.e. the number of observations). Therefore, usually a plot size small enough to be practical and large enough to 'capture' the variation is chosen. Therefore, in choosing the plot size, certain preliminary studies are conducted which may take the following form:

Suppose it is decided to have circular sample plots, concentric plots representing 1/10th, 1/5th and 1 acre (or any similar dimension) are established. Measurements are taken first within the 1/10 acre plots and the variance between plots is calculated. Thereafter, it is repeated with

measurements within the $1/5$ th and 1 acre plots. If there is a substantial increase in the variance between plots when the size was increased, it would be preferable to decide on a larger plot size. On the other hand, if the increase in size of the plot does not have an appreciable effect on the variance between plot volumes, it implies a fairly uniform population and hence it might be quite adequate to measure plots of smaller size. The same approach is adopted even in considering plots of any other shape. In a systematic inventory design where the plots are laid out on a fixed grid or on lines, the plot size is decided upon after similar studies, generally referred to as 'influence of proximity'. This is a very important consideration in a cluster sampling design. Here, fairly large sized plots are chosen as primary units (usually circular) and within these primary units, secondary units of a certain size are chosen—representing units of different order. If the size of the primary unit or the cluster is too large, there will not be an appreciable variation between clusters. On the other hand, if the size of a cluster is too small it might not be feasible to select secondary units within the cluster, showing sufficient variation to justify a cluster design. This question is usually studied as 'inter and intra cluster correlation' choosing primary and secondary units of various sizes within the forest population. The size of the units of both orders are decided upon after insuring a low inter and intra cluster correlation.

Yet another method of obtaining the ground measurements is on plots of variable sizes, the size depending on the particular tree dimension (tree diameter). Trees around the sample point are sampled on an area proportional to their sizes. The respective radii of the concentric circular plots can be calculated assuming a fixed basal area factor. But, in practice, the selection of trees over a fixed minimum size is accomplished by the use of a wedge prism or any other contrivance (even a coin held at a certain fixed distance from the eye) subtending a fixed angle corresponding to the assumed Basal Area Factor.

From the above, it will be understood that choosing the sample plot shape and size is one of the major tasks in an inventory procedure as it involves practical, statistical and economic considerations.

DENDROMETRY

The measurements on the trees within sample plots are taken with the purpose of obtaining data on merchantable or gross volume of all or some species above a minimum size, on a unit area basis. This figure is later expanded to give an estimate of gross or merchantable volume of timber in the whole area.

The measurements usually taken are diameter at breast height (outside bark) and height of merchantable bole (we shall disregard the exceptional cases where total tree height is measured either to obtain gross volume including those of branches, etc. or in the preparation or checking of aerial volume tables). In the temperate zone, D. B. H. is sometimes the only measurement taken. In such cases, the volume is obtained by the use of the so-called local volume table which is developed from the single variable, diameter (BH). The accuracy of such a method is controlled by the method of construction and accuracy of the local volume table. Perhaps, the results obtained by applying such methods to pure stands may be acceptable. But most often, both DBH and height of merchantable bole are measured and converted to volume by reference to respective volume tables developed with both variables, D. B. H. and height.

If the tree boles are perfect cylinders, volume tables may be prepared without any measurements in the field as volume would just be represented by $\pi D^2/4 \times H$ where D is the diameter and H is the height (both in the same units). Not only are the tree boles non cylindrical, but this departure of form from that of a true cylinder varies with species, with size classes of the same species and also with site or locality. Many measures of tree form such as, form factor, form quotient, form class, are available, but form factor which is the ratio of the actual volume of the tree bole to the volume of a corresponding mathematical cylinder with D.B.H. as diameter is the most popular measure. So, if the form factor F is known, the true volume of the bole may be arrived at by use of the formula.

$$V = \pi D^2/4 \cdot H \cdot F.$$

However, the problems involved in obtaining this factor F may be appreciated in noting that even trees of the same species but of different size class may have a different form factor. But, in practice two or three form factors are developed for application to all size classes and groups of species whenever the inventory involves large areas and large numbers of species.

For the development of form factors adequate special measurements on standing or felled trees are taken by the routine inventory crews or special crews. It may be understood that all size classes, species and site classes must be adequately represented. The total number of trees to be measured in each species, size class and site class may be fixed beforehand by a preliminary study of the variations in form so as to insure a fixed statistical accuracy. Or, the number of trees to be measured may be fixed arbitrarily. The special measurements are taken to calculate the individual tree bole volume. The type of measurements taken depend on the method of calculation proposed, and the instrument available or proposed to be used. For instance, with the BARR and STROUD dendrometer it is possible to measure the end diameters of sections and their lengths on standing trees. The average diameter of each section together with its length can give the volume of the section (Smalian method). The volume of all the sections thus calculated, together, gives the true volume of the bole.

Sometimes, lengths of sections with a uniform reduction in diameter are measured and the various sections from the top to the bottom are treated as paraboloid (only when total tree height is being considered), cone, frustrums of paraboloid, cylinders, frustrums of neiloids etc. and their volumes calculated.

Whatever the method, if the forest concerned is large and complex in character, so many form factors will result. However, finally, only a few are chosen, by grouping, with statistical justification.

Yet another method very often applied now in tropical forest inventory involves regression analysis of true volume (obtained by methods similar to those outlined above) on the tree bole measurements D , B , H , and height. Regression equations of the type.

$$V = X \text{ or } V = a + bx$$

Where V is true volume of bole, X is the combined variable D^2H (or some tree—dimension in other forms), 'a' a constant and 'b' the regression co-efficient.

It will be seen that the same type of measurements are required for the regression method too and the same considerations apply in the selection of suitable samples for measurement. Here too, treating every

species size class and site class separately, so many coefficients (and constants) may result but by a process of pooling with due statistical analysis and justification, just a few coefficients (and constants) can be chosen.

The advantage of this regression method is in that it renders for calculation of volume directly either by hand-calculators or electronic computers without reference to volume tables, the preparation of which is completely obviated.

CHOICE OF AN INVENTORY METHOD SUITABLE FOR CEYLON

As long as the population under consideration is one of trees, an inventory method applicable to a forest tree population in America should be equally applicable to such population in any other part of the world. This statement would hold true if the information usually required to be gathered, either from photographs or on ground or both, to compile the inventory, is as readily available in one forest as in another. In practice, it is known not to be so. The required information on sample areas or on the whole forest area, is more easily obtained in a temperate Forest than in a tropical Forest. This is due to the inherent complex nature of the tropical forest with its innumerable species of diverse size and forms as against the temperate forest with a much simpler composition. Therefore, it has become customary to distinguish tropical forest inventory from temperate forest inventory. If the information sought is a basic one such as the total number of trees in the forest, this distinction need not exist. But, the inventory objectives, be it with regard to temperate or tropical forest, remain generally the same viz. stand and stock by species and size classes and various other breakdowns. Therefore, different methods are applied in the tropical forests to reduce the usually high cost of inventory. But, when cost is one of the factors, compromises such as the acceptance of less detailed information, a less accurate estimate or one of less reliability, become common. For instance, if the accuracy aimed is ± 2 per cent in a temperate forest inventory, it may become necessary to settle for a ± 5 or 10 per cent accuracy, at the same level of significance, in a tropical forest inventory. However, the size of the inventory unit is, of course, a main consideration in the definitions of objectives and accuracy limits. If for a small tract of forest 50,000 acres in extent, the accuracy limit is defined at 1 or 2 per cent the same limits are never prescribed for a national forest inventory.

Ceylon is a tropical country of only about 24,000 sq. miles in extent of which about 40 per cent is described as forest land. However, only 17 per cent are in Reserves or proposed Reserves administered by the Forest Department, though another 10 to 15 per cent may be added to this figure, in describing the current extent of the country's forest resources. Based mainly on rainfall, topography and humidity, the Island is divisible into two main climatic regions described as the 'wet' zone (confined to the Central mountainous area), and the 'dry' zone confined mainly to the plain land with a third intermediate zone representing the transition between the two. This climatic zonation is reflected in the character and specific composition of the forests. The wet zone forests are richer in stock and species compared with that of the dry zone. The wet zone species number around 300 of which only about 50 are known to be of economic importance, whilst the corresponding figures for the dry zone are less than 100 and 15 respectively.

In evolving an inventory design, no specific problems, uncommon to tropical forests in general, are encountered in Ceylon. On the other hand, the following are enviable aspects from the point of view of pre-requisites for a forest inventory.

(1) The availability of topographic and planimetric maps at practically any desirable scale, covering the whole Island.

(2) The availability of complete air photographic coverage at 1:40,000 and also restricted areas in larger scales.

(3) The possibility of procuring fresh coverage of any area of interest, at short notice, in view of the monopoly of air photography with the local survey department. Weather conditions, intermittent repairs to the air plane and the need to cater to the requirements of all government and private agencies using aerial photographs, have proved to be controlling factors. Nevertheless, the potential advantage cannot be discounted.

(4) Well surveyed forest boundaries depicted on suitable maps, reducing specific fresh air photo coverage, for inventory, to the minimum.

The aerial photographs provide for stratification of the forest population either on the basis of ecological or semi-ecological forest types or volume classes or both. The stratification may be by complete delineation on photographs or by interpretation of points only. If the forest area to be inventoried is small in extent delineation of strata may be advisable so as to obtain stratum area free of statistical error. On the other hand, if the area is extensive, as in the case of an Island wide inventory, stratification by photo-sampling may be more desirable in view of cost. In the Island-wide survey undertaken a few years ago, three volume classes (high, medium and low) in the wet zone forest and two volume classes (medium and low) in the dry zone forests were recognized in the photo-delineation in addition to a few ecological types. Though the net volume figures justified this volume class distinction, a closer study of volumes within plots in the different volume classes recognized will be fruitful. This study should be aimed at establishing whether the difference is only in their mean volumes (represented by total merchantable volume per acre) or also in the variance within the different volume strata. The existence of a statistically significant difference of the latter, if established, would justify an optimum allocation of ground sample plots with cost also as a factor. A lower variation figure in the high volume strata would mean a considerable reduction in cost of ground sampling as the high volume stratum is generally the most inaccessible though not the largest.

The ground samples, in the earlier survey were variable radii plots on selected lines, within the strata, the selection of the lines within strata mainly determined by the indentifiability of photo and corresponding ground tie points. At the present time, experienced inventory specialists are using cluster lay-out of sample plots in the tropical forests whenever the sampling design is anything other than a systematic one. The main advantage of this lay-out is in that there is a considerable reduction in the time spent in transport of working crews, in relation to the actual time spent on tallying. The variable radii plot can very well be the most desirable one and the selection of the trees for measurement may be controlled by a tape with the radii calibration corresponding to different diameters of trees above a minimum size or by a suitable wedge prism. The number of points in the cluster and their distance apart may be chosen after suitable studies on experimental plots within the various strata. Whichever the method of sample plot allocation proposed, the plots within each stratum may be selected on the photographs in a random manner. The main problem in such a selection is the difficulty in the ground location of the photo-selected points and the time required for the location. From observations in the Philippines, the writer is convinced that the actual ground location of photo selected points is by no means a problem with an

experienced and enthusiastic field crew, but considerable time is required to be spent in the field location. This time loss is more than offset by the advantages of the randomness of the ground samples and those inherent to a cluster lay-out of plots.

Dendrometry

It has been found that the regression method of establishing the quantitative relationship between the actual bole volume and its usual measures of D. B. H. and height has advantages. It may be possible to develop 3 regression coefficients for application separately in the 3 climatic zones and additional independent ones for the plantations, such as Eucalyptus, Teak and Conifers.

Volume Computations and Analysis

Unless the inventory is on an all island level, it may not be necessary to use electronic computers. Hand calculators of the type already available would be quite sufficient to handle all the computations. If the inventory involves the whole island, the I. B. M., a branch of which exists in Ceylon, may be entrusted the job of developing programmes performing the required analyses and compilations.

The Planning of Transportation Networks and Extraction Schemes in the Forest

By

L. C. A. de S. Wijesinghe

(*Forest Department*)

Extraction and transportation are the two most important phases in a logging operation. By extraction is meant the haulage of timber from the stump to the forest way side depot. This is called 'minor transportation' by Cermak & Lloyd (1962), Extraction, so defined, would include all forms of skidding such as by horse, tractor, elephant etc. Under the same heading would also be included timber chutes, cable cranes—especially those of short range (up to 300 yards), and even trailers drawn by tractors, provided haulage by this means takes place from stump to wayside depot.

"Transport" as defined in this paper is the haulage of timber from the forest wayside depot to the wood-using centre (e.g. a saw mill). A transportation network is the means by which a forest is made accessible for the removal of timber and for carrying out silvicultural and management operations. Although extraction and transport are interconnected—the planning of one depending on the means adopted in the other—it is necessary to maintain the distinction when logging operations are planned. It should, however, be borne in mind that in some cases a clear cut distinction is not possible as for example when a cable crane of long range (about 1 mile) takes the timber from the stump right to the saw mill or when a tractor-trailer combination carries out both extraction and transportation in one operation.

In this paper the main factors of terrain and stand, which have a bearing on extraction and transportation will be outlined and this will be followed by a consideration of the different transportation and extraction means commonly used in forestry.

TERRAIN

The terrain factors to be considered are :

- (1) gradient
- (2) surface and sub surface conditions
- (3) obstacles on the ground.

Gradient

Gradient is a factor of major importance in determining the means of extraction and transportation that could be employed and in the overall cost of logging operations. For example, in very mountainous terrain the cost of road building might be prohibitive and cable cranes may, for this reason, be preferred to roads as a means of transport.

As a preliminary step in the planning of transport and extraction therefore it will be useful to divide up the forest on the basis of gradient. In order to do this one must decide on the scope of the different gradient classes which are to be used. The limits of gradient for the use of different means of extraction will be an useful guide. To illustrate this, when one considers extraction by tractors and by cable cranes it would be convenient to divide the area into 2 classes, up to 25 percent and over 25 percent. Extraction by tractors is possible in the former and by cable cranes in the latter. A problem that will arise in such a classification is the minimum distance over which the gradient is to be measured. 200 ft. or 300 ft. as decided may be taken as the minimum distance.

Surface and Sub-surface conditions

This factor includes the type of soil and sub-soil; the presence or absence of organic matter, and, if present, its thickness; the presence of water, and seasonal changes in water level; presence or absence of a snow cover; ground temperature; and microtopography.

All these factors have a bearing on the technical possibilities of using different means of extraction and transport. In Germany, for example, the presence of thick layers of peat in some forest areas creates problems in road construction. The nature of the soil will also affect the road construction possibilities, and the presence or absence of suitable surfacing material in proximity to the road building site can profoundly affect the cost of road construction. Taking a further example, the presence of a snow cover and sub-zero temperatures where the soil is frozen are two conditions which are generally favourable for the skidding of timber.

Obstacles on the ground

The nature, size and frequency of the obstacles will affect skidding operations and also, to some extent, road construction. Obstacles may occur in the form of stones or boulders, and the material of which they are composed may have various degrees of hardness. Some sort of classification which will give an indication of the degree of obstruction caused by these objects is necessary. In the first instance the nature of the obstacles should be noted, e.g. Gneissic rock. The objects may then be classified into the diameter and height classes, and the frequency within each class per unit area noted. For this purpose suitable diameter and height classes should be formed.

STAND

Quality

A factor of great importance in planning transportation networks is site quality which will decide the type of forest in the area, both now and in the future. Where classification strictly on the basis of site quality is not practicable, a classification based on the existing stands is acceptable. As a first step, particularly in tropical forests, it would be well to demarcate

the productive forest from the non productive scrubland which is often the result of shifting cultivation. A further classification into low, medium and high yield will be useful. In planning the opening up of the forest by, say, a road net work, special attention should be paid to high yield forests. This is of special importance in tropical countries where generally the funds available for investment on forest roads is limited and naturally the maximum benefits from such investments can be obtained by opening up the highly productive areas first.

Silvicultural Systems

This factor is of special importance in extraction. For example in a clear felling operation extraction is generally easier and less costly than in selection felling. The frequency of cutting and the location of cutting areas should also be taken into account in preparing an extraction plan.

Yield

The yield per acre will influence the cost of operations. Generally with a high yield extraction costs are reduced whatever the method of extraction used. This is specially so with cable cranes which have to be set up afresh once extraction on either side of the line up to a lateral distance of about 150 ft. is completed. Since installation and dismantling costs contribute to the cost of extraction, the higher the yield from the strip of forest covered by the cable crane at a setting the more economical the operation.

Size and weight of logs

For extraction work the method that will be employed will depend, among other things, on the size and weight of logs. For all logging means, be they mechanised or otherwise, there are load limits beyond which extraction by the equipment in question become uneconomical if not impossible. The weight of the logs should therefore be carefully considered when selecting a method of extraction. For light and small sized timbers it would be uneconomical to use high powered machines. The types of tractors, winches, cable cranes etc. which are selected for logging will therefore depend on the loads that have to be hauled. One should also take into account the gradient in relation to the direction of haulage since this will greatly influence the effective load.

TRANSPORT

The following means of transport are commonly used in forestry : roads, railways, rivers, cable ways and cable cranes.

The points to be kept in mind in relation to each of these means of transport (except railways) when planning a communication network are mentioned below :

Roads

This is by far the commonest means of opening up the forest. The following points should be kept in mind when planning a road network :

Technical Factors

1. Availability of personnel trained to carry out road planning and construction.
2. Availability of instruments such as clinometers and prismatic compasses.
3. Availability of maps of suitable scale giving contours.
4. Machines and other equipment for road making such as bulldozers, excavators, tipping trucks, rock drills, explosives, road rollers.
5. Standardization of construction methods for bridges and culverts. Type plans for bridges and culverts of different spans should be prepared.
6. Standardization of road width, camber, gradient, surfacing and side drains.

Economic Factors

1. Spacing of roads. This has to be decided on taking into account the relative costs of extraction and transport, the overall cost of road construction and the yield from the forest.
2. Costs of road construction and maintenance.
3. Volume and value of timber to be extracted and quality of forest served.
4. Other uses for the road besides forestry.

Rivers

Rivers are a relatively cheap mode of transport provided the distances are long. Transport by floatation is used in many temperate and tropical countries.

Technical Factors

1. General suitability of waterways for floating.
2. Seasonal fluctuations in water level.
3. Obstructions to floating.
4. Floatability of the timber.

Economic Factors

1. Distance over which floatation is possible as compared with the distance over which other means of transport have to be employed for taking the timber from wayside depot to mill.
2. Cost of making waterways suitable for floating.
3. Cost per cubic foot of timber transported.
4. Time taken for transport of timber from forest to mill and volume of timber that can be transported.

Cable Ways

Timber may be transported by cable ways for varying distances ranging from a few hundred yards to several miles.

Technical Factors

1. Possibilities of using gravity or machine operated cable ways—dependent on gradient.
2. Weight of logs.
3. Selection of suitable machines and cables.
4. Availability of personnel who are capable of planning, installing and working the cable way.
5. Facilities for repairs and maintenance.

Economic Factors

1. Cost of installation in relation to alternative means of transport like roads.
2. Restricted use for cable ways as compared with roads.
3. Cost of transport per cub. ft.
4. Time taken for planning and installing in comparison with time taken for alternative means of transport.

Cable Cranes

A clear distinction should be drawn between cableways and cable cranes. A cableway is a means of transport. The logs are suspended on the cable at certain predetermined points called loading stations which are in fact way side depots in the forest. One of the usual means of extraction—e.g. tractor has to be used to haul the timber from stump to the loading stations.

Cable cranes, unlike cableways, are used to pick up logs right from the stump, so that a cable crane is essentially a means of extraction. However, cable cranes of long range* can carry out both extraction and transport as stated before, and for this reason, they are considered under both headings transport and extraction. Cable cranes are generally installed in areas with a gradient of over 25 per cent. Cable cranes which work on level ground are also available but they are generally confined to the short range class.

Technical Factors

1. Suitability of gradient for cable crane installation.
2. Weight of logs.
3. Selection of equipment including type of crane (horse power of engine etc.), type and diameter of cables etc.
4. Silvicultural system (clear felling, selection felling etc.)
5. Availability of personnel and instruments for planning cable crane projects.
6. Availability of personnel skilled in the installation and operation of cable cranes.
7. Repairs and maintenance.

* Cable cranes may be divided into short range (up to 300 yards), medium range (300 to 700 yards) and long range (over 700 yards). Cable cranes generally do not exceed a length of 1 mile.

Economic Factors

1. Spacing of cable crane lines. There are two distinct phases in haulage by cable cranes. In the first phase the logs are skidded from the stump to a point below the main cable. In the second stage the logs are hauled up to the main cable and then transported along the cable. The spacing will affect the initial skidding phase, and the most economic spacing can be worked out for a given set of conditions
2. Size of loads.
3. Cost of transport per cu. ft. compared with transport by other means.

EXTRACTION

Elephants

Elephants are used for timber extraction in many S. E. Asian countries.

Technical factors

1. Limitations of gradient and other terrain factors for skidding by elephants.
2. Maximum load under different conditions, for example, up-hill and down-hill haulage.
3. Possibilities of improving on the methods of skidding and so increasing the output per elephant.

Economic Factors

1. Speed of extraction controlled largely by the availability of elephants.
2. Cost per cubic foot.
3. Maximum hauling distance based on economic considerations.

Winches

Winches by themselves are not commonly used for haulage, but because of the low capital involved they could be economically employed for extraction of small sized timber over short distances. Winches are also useful as supplementary skidding means in logging operations.

Technical factors

1. Weight of logs.
2. Distance of haulage.
3. Type of terrain.
4. Type of cutting operation.
5. Capacity of machine.
6. Repairs and maintenance.

Economic Factors

1. Cost per cubic foot.

Cable Cranes

Cable cranes of short and medium range may be considered as a means of extraction. The technical and economic factors are the same as for long range cable cranes discussed under the heading of transport.

Conclusion

The need for careful planning of logging operations cannot be overemphasised. Such planning is meticulously carried out in some European countries where forestry plays an important part in the national economy, eg. Finland and Sweden. In many tropical countries, on the other hand, logging is entrusted to private contractors and little or no attention is paid to the proper planning of logging operations. The first phase in a logging operation which is the opening up of the forest is important not only for the removal of timber but for all other aspects of forestry too. Yet, strange though it may seem, in many countries the planning of communication networks is a subject which receives little or no attention from trained foresters, and unless more attention is paid to this aspect of forestry it would be difficult to reap the full benefits of progress in other branches such as Silviculture.

The writer has in this paper made certain proposals for the planning of transport and extraction. The article is not meant to be comprehensive but it gives in broad outline the main factors to be taken into account in the planning of communication networks and extraction projects. It is based on experience gained by the writer in Western Europe in the course of studies on a fellowship awarded by the F. A. O.

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Fertilization of Teak Nurseries

By

S. N. U. FERNANDO
(Forest Department)

SUMMARY

Teak plants raised in the nurseries of the Ceylon Forest College, Monkey Bridge, showed the following signs of nutritional deficiency : short internodes, small leaves, stunted growth and yellowing of the leaves.

Experiments with inorganic and organic fertilisers where Nitrogen, Phosphorus or Potassium was supplied showed that the nutritional deficiency was caused by Nitrogen shortage. Better response was obtained by supplying Nitrogen in the inorganic form than as an organic fertiliser.

INTRODUCTION

Teak seedlings raised in the nurseries of the Ceylon Forest College, Monkey Bridge, appear to grow in a very poor state of health. The plants are usually stunted in appearance compared with those grown in the open. The internodes are correspondingly short and there was also a diminution in size of the leaves. One common feature in all these plants was that there was a distinct yellowing of the leaves, whereas they should be dark green normally. It was at first thought that this "diseased" condition was a result of an inadequate supply of water because they were watered mechanically. To test whether this was so an experiment was conducted where 20 "diseased" beds with 100 plants in each of them were permanently irrigated for 6 months, but the plants showed no improvement.

Since the plants showed no external evidence of any pathological disease, it was then thought that the poor health of the seedlings was due to a physiological condition brought about by an imbalance of some major nutritional element in the soil of this nursery. Usually such major nutritional disorders were a result of the deficiency of one of the elements, Nitrogen (N), Phosphorus (P) or Potassium (K) or a combination of them. In order to determine whether the "diseased" condition was due to a shortage of any one of these elements, N, P or K, fertilisers containing one or the other of these nutrient elements were used separately on samples of plants in standard nursery beds (40 ft. by 4 ft.), and their effect was studied.

EXPERIMENTS AND RESULTS

Preparation of sample beds and plants

Firstly, samples of 100 plants per standard bed were made ready in a nursery where all the plants were "diseased". They were approximately 2 ft. in height and 6 months of age. It was also seen that the plants in a sample bed were quite far apart in order to mitigate the effects of mutual suppression.

(a) *Inorganic fertilizers :*

Into one such sample bed containing 100 plants 3 lbs. of Ammonium sulphate (a source of Nitrogen) was spread uniformly and covered with loose soil. This procedure was repeated with 3 lbs. each of Rock phosphate (P) and Muriate of potash (K) in two other sample beds. Besides these, one sample bed was left untreated as a control. The whole experiment was in triplicate. Therefore, altogether there were 12 beds, of which 3 were left untreated as controls, while the other 9 had groups of 3 each treated with either N, P or K fertilizer.

All these experimental beds were watered daily and weeded regularly. The plants in them were sprayed periodically with insecticide to ward off insect attacks. After 2 months had lapsed measurements were made on the sample plants in order to observe whether the fertilizers had any effect on them.

Table I—Effect of Inorganic fertilizers on growth

<i>Fertilisers used per 3 sample beds each with 100 plants (i.e. 300 plants in all).</i>	<i>% of active agent in fertiliser</i>	<i>Average height of plants originally</i>	<i>Average height of plants after 2 months</i>	<i>Difference in height</i>
Ammonium sulphate	.. 21% of N.	.. 2 ft.	.. 6 ft.	.. 4 ft.
Rock phosphate ..	.. 27.5% of P.	.. 2 ft.	.. 2½ ft.	.. ½ ft.
Muriate of Potash ..	.. 60% of K	.. 2 ft.	.. 2½ ft.	.. ½ ft.
Control (Untreated)	.. None	.. 2 ft.	.. 2½ ft.	.. ½ ft.

From the results shown in table 1, it is seen that where N fertilizer was used the plants trebled their heights in 2 months, the increase in height during this period being 4 ft. In the case of the plants treated with P and K fertilisers they increased in height by only 6 inches during the same period of time ; as was also the case with the untreated control plants. Similar results to the above were obtained when comparisons were made of internode lengths and leaf sizes—the plants treated with N fertiliser only showing a significant response. The leaves too in the plants treated with N fertilisers showed a rich bluish green colour, while all the other plants treated with P or K or were left untreated, continued to show the pronounced yellowing of their leaves. Further, the plants treated with N fertilizer were all looking healthy and robust, and they seemed to have recovered fully.

Table II—Effect of fertilizers on Vegetative parts

<i>Dimensions of leaves & Internodes (after treatment)</i>	<i>Plants treated with P or K or untreated</i>	<i>Plants treated with N or Complex contain- ing N</i>
Average breadth of 5 largest leaves per plant	.. 8"	.. 12"
Average length of the same leaves ..	.. 23"	.. 35"
Average length of penultimate internodes	.. 3.3"	.. 6.7"
Average length of roots ..	.. 15"	.. 21"

(b) *Organic fertilisers :*

The experiment conducted with inorganic fertilisers was repeated in an identical manner with organic fertilisers containing as before either N, P or K as the main active agents, but in these cases 50 lbs. of fertilisers (instead of 3 lbs.) was used in each sample bed containing the 100 diseased plants. Here too, as in the case of the inorganic fertilisers, wherever N fertilisers were used, the plants showed a remarkable increase in height, internode length and leaf size, but the results were not so pronounced as when inorganic fertilisers were used. For instance, when dried blood meal (N fertiliser) was applied to the sample plants they only doubled their heights in two months (a height increase of 2 ft.) Therefore, it can be said that inorganic sources of N are more effective than organic sources. Besides this, organic fertilisers have added disadvantage that larger quantities have to be used to produce equivalent results to those produced by inorganic sources of any one fertiliser.

Table III—Effect of Organic fertilizers on growth

<i>Fertiliser used per:</i>	<i>sample beds with 100 plants each</i>	<i>% of active agent</i>	<i>Difference in height after 2 months</i>
Dried blood meal		.. 5 to 10% N.	2 ft.
Ground bones		.. 50% of $\text{Ca}_3(\text{PO})_2$ & 4% N.	$\frac{1}{2}$ ft.
Wood ash from Ficus tree ..		.. 3% of K together with Ca & Mg.	1 ft.
Untreated		.. None	$\frac{1}{2}$ ft.

In the case where wood ash was used, the plants showed an increase of height by one foot and the leaves too turned dark green in colour. This is because ash is really a complex fertiliser containing N in addition to its main constituent K, and it is probably this N that causes the increased height growth and change in the colour of the leaves.

(c) *Complex Fertilisers :*

As in the two previous experiments 3 sample beds each with the usual 100 "diseased" plants were treated with an inorganic complex fertiliser containing N, P and K in the ratio of 8: 8: 8. Similar results to those obtained with inorganic fertilisers were obtained, but the increase in plant sizes were still more pronounced than with pure inorganic N fertilisers such as Ammonium sulphate—the plants more than trebled their heights.

Table IV—Effect of Complex Fertilisers on growth

<i>Fertiliser used per 3 sample beds with 300 plants in all</i>	<i>% of active agents</i>	<i>Increase in height after 2 months</i>
Complex	.. 8:8:8 of N, P & K	5 ft.
Control	.. None	.. $\frac{1}{2}$ ft.

Here too the agent that caused the pronounced increase in the size of the plants was no doubt Nitrogen ; it is also possible that the presence of Phosphorus could have induced increased assimilation of N giving the enhanced height increase.

The cause of the unhealthy state of most plants in the nursery of the Ceylon Forest College, Monkey Bridge, is because of a deficiency of Nitrogenous nutrients in the soils. This can be rectified by a judicious application of organic or inorganic N fertilisers, but inorganic sources of N give much better results, and with relatively smaller quantities, than organic sources.

A chemical analysis carried out of apparently healthy leaves and diseased leaves of Teak also reflects the general nutritional deficiencies in the soil of the nursery.

CHEMICAL ANALYSIS OF LEAVES

Preparation of materials for analysis

Leaves, diseased and healthy, were wiped clean with a moist cloth, cut into small pieces and dried in an oven overnight at 100° separately. Samples from each were next powdered in a Wiley mill.

3g. of samples (diseased and healthy separately) were weighed into two Erlenmeyer flasks, and then 20 ml. of 1: 1 perchloric acid and 10 ml. of Nitric acid were added to each. The contents of each flask was digested on a hot plate and then filtered to volume (100 ml).

Determinations were carried out in duplicate.

Nitrogen determination was carried out on separate samples of materials.

Methods

Nitrogen—Kjeldahl determinations.

Phosphorus—Colorimetric using Ammonium Vanado-molybdate.

Potassium—Flame Photometric determination.

Calcium—Oxalate— KMnO_4 volumetric determination.

Calcium and Magnesium—EDTA determinations—Volumetric—Magnesium obtained by difference.

Copper—Using Sodium diethyl dithiocarbonate—colorimetric.

All colorimetric determinations were carried out using a Beckman DU Spectrophotometer.

Results

<i>Elements</i>		<i>Healthy leaves</i>	<i>Diseased leaves</i>
Nitrogen	..	.. 4.54%	.. 3.84%
Phosphorus	..	.. 0.38%	.. 0.36%
Potassium	..	.. 1.03%	.. 0.88%
Calcium	..	.. 2.73%	.. 3.34%
Magnesium	..	.. 0.36%	.. 0.33%
Copper	..	.. 2.19 mg/100g.	.. 1.81 mg/100g.

It is thus seen that the diseased leaves reflect a deficiency in the soils of most elements tested for, except Calcium.

Determination of Basic Densities of some Ceylon Timbers

By K. VIVEKANANDAN
(Forest Department)

INTRODUCTION

INFORMATION on the physical properties of most of the lesser known species of Ceylon timbers is not available or is scanty. Some of these species although available in plenty are not utilized for lack of information as to their suitability. The United Nations Special Fund Project which is carrying out a "Pre-investment Survey of forest industries development" in Ceylon is exploring the possibility of utilizing the lesser known species which are available in plenty for making paper pulp, fibre board, particle board, etc.

A number of physical properties such as the basic density, fibre length, thickness of fibre wall, amount of parenchyma and vessel elements are taken into consideration when the suitability of a particular species is assessed for these uses. This investigation was carried out to determine the basic densities (R) of thirty-seven species of common Ceylon timbers with a view to selecting the suitable ones for these purposes.

MATERIALS AND METHODS

Test samples were cut from top and butt ends of each sample log. The samples consisted of rectangular pieces of cross section 18 mm. wide and 15 mm. in thickness (i.e., along the grain) and of sufficient length to cover the heartwood and sapwood. Samples from logs of larger diameter were cut into smaller pieces (maximum length about 40 mm.) to facilitate easy determination of volume.

The test samples were soaked in water under reduced pressure for about a week and their volume determined by the displacement method using a measuring cylinder. The volume was measured to the nearest cm^3 . Each test sample was oven dried at a temperature of 105°C to constant weight and the weight determined to the nearest 0.05g.

Basic density (R) was calculated as follows :

$$\text{Basic density (R)} = \frac{\text{Dry weight in grams}}{\text{Wet volume in cm}^3}$$

RESULTS

Results are shown in the table.

TABLE

Showing the Basic densities of top and butt ends of logs and their average basic densities

Local Name	Botanical Name	Basic Density (R)				Average
		(in g/cc)		in (lbs./cu. ft.*		Basic
		Top	Bottom	Top	Bottom	Density in (g/cc)
1. Alubo	.. <i>Syzygium makul</i> Gaertn.	.. 0.75..	0.73..	46.9..	45.6..	0.74
2. Aridda	.. <i>Campnosperma zeylanica</i> Thw.	0.38..	0.42..	23.7..	26.3..	0.40
3. Badulla	.. <i>Semecarpus coriacea</i> Thw.	.. 0.40..	0.40..	25.0..	25.0..	0.40
4. Bu-seru	.. <i>Premna tomentosa</i>	.. 0.62..	0.65..	38.7..	40.6..	0.64
5. Daulkurundu	.. <i>Neolitsea involucrata</i> (Lamk.) Alston	0.62..	0.73..	38.7..	45.6..	0.68
6. Diyapara	.. <i>Wormia triquetra</i> Rottb.	.. 0.59..	0.61..	36.9..	38.1..	0.60
7. Diyataliya	.. <i>Mastixia tetrandra</i> Clarke	.. 0.36..	0.39..	22.5..	24.4..	0.38
8. Dorana	.. <i>Dipterocarpus glundulosus</i> Thw.	0.62..	0.64..	38.7..	40.0..	0.63
9. Etamba	.. <i>Mangifera zeylanica</i> Hk. f.	.. 0.50..	0.51..	31.3..	31.9..	0.51
10. Gal-seru	.. <i>Tricalysia dalzellii</i> (Thw.) Alston	0.62..	0.64..	38.7..	40.0..	0.63
11. Hedawaka	.. <i>Chaetocarpus castanocarpus</i> Thw.	0.69..	—	43.1..	—	0.69
12. Hora	.. <i>Dipterocarpus zeylanicus</i> Thw.	0.60..	0.63..	37.5..	39.4..	0.62
13. Kataboda	.. <i>Cullenia ceylanica</i> (Gardn.) ex. Shum.	0.49..	0.52..	30.7..	32.5..	0.51
14. Katukenda	.. <i>Scolopia acuminata</i> Clos.	.. 0.68..	0.65..	42.5..	40.6..	0.67
Do.	.. do.	.. 0.74..	0.76..	46.2..	47.5..	0.75
15. Kekuna	.. <i>Canarium zeylanicum</i> Bl.	.. 0.42..	0.39..	26.3..	24.4..	0.41
16. Kenda	.. <i>Macaranga peltata</i> Muell. Arg.	0.26..	0.27..	16.3..	16.9..	0.27
17. Kirihembiliya	.. <i>Palaquium petiolare</i> Engl.	.. 0.35..	0.43..	21.9..	26.9..	0.39
18. Kumumella	.. <i>Diospyros ovalifolia</i> Wight	.. 0.68..	0.68..	42.5..	42.5..	0.68
19. Liyan	.. <i>Homalium zeylanicum</i> Benth	.. 0.73..	—	45.6..	—	0.73
20. Madan	.. <i>Syzygium cumini</i> Skeels.	.. 0.62..	0.69..	38.9..	43.1..	0.66
21. Madol	.. <i>Garcinia echinocarpa</i> Thw.	.. 0.66..	0.69..	41.3..	43.1..	0.68
Do.	.. do.	.. 0.73..	0.76..	45.6..	47.5..	0.75
22. Malaboda	.. <i>Myristica dactyloides</i> Gaertn.	.. 0.46..	0.51..	28.7..	31.9..	0.49
23. Mugunu	.. <i>Tetrameles nudiflora</i> R. Br.	.. 0.30..	0.30..	18.8..	18.8..	0.30
24. Na	.. <i>Mesua ferrea</i> L.	.. 0.78..	0.86..	48.7..	53.7..	0.82
25. Panudan	.. <i>Syzygium neesianum</i> Arn.	.. 0.77..	0.86..	48.1..	53.7..	0.82
26. Pelen	.. <i>Kurrimia zeylanica</i> Arn.	.. 0.79..	0.78..	49.4..	48.7..	0.78
27. Ratatiya	.. <i>Palaquium thwaitesii</i> Trim.	.. 0.60..	0.61..	37.5..	38.1..	0.61
28. Talan	.. <i>Litsea gardneri</i> Thw.	.. 0.35..	—	21.9..	—	0.35
29. Tiniya Dun	.. <i>Doona congestrifolia</i> Thw.	.. 0.33..	0.29..	20.6..	18.1..	0.31
30. Ubbériya	.. <i>Carallia calycina</i> Benth.	.. 0.67..	0.69..	41.9..	43.1..	0.68
31. Wal-del	.. <i>Artocarpus nobilis</i> Thw.	.. 0.23..	0.40..	14.4..	25.0..	0.32
32. Wal-divul	.. <i>Hydnocarpus octandra</i> Thw.	.. 0.60..	0.62..	37.5..	38.7..	0.61
Do.	.. do.	.. 0.63..	0.63..	39.4..	39.4..	0.63
33. Wal-Jambu	.. <i>Syzygium aqueum</i> (Burm. f.) Alston	0.65..	0.68..	40.6..	42.5..	0.67
Do.	.. do.	.. 0.66..	0.64..	41.3..	40.0..	0.65
34. Walukina	.. <i>Calophyllum bracteatum</i> Thw.	.. 0.55..	0.44..	34.4..	27.5..	0.50
35. Welang	.. <i>Pterospermum canescens</i> Roxb.	0.49..	0.45..	30.7..	28.1..	0.47
36. Welipenna	.. <i>Anisophyllea cinnamomoides</i> , Alston	0.62..	0.62..	38.7..	38.7..	0.62
37. Weliwenna	.. <i>Dimorphocalyx glabellus</i> Thw.	.. 0.66..	0.70..	41.3..	43.7..	0.68

* Obtained by multiplying R in g/cc. by 62.428.

Seminar of the Utilization of Forest Produce

(held on 13 & 15th December, 1966)

A Seminar on the utilization of forest produce organized by the Forest Department was held in the auditorium of the Irrigation Department on 13th and 15th December, 1966. The chief guest at the Seminar was the Honourable C. P. de Silva, Minister of Land, Irrigation and Power. The participants included the forest officers attached to the U.N. Special Fund Project (Forest Industries), representatives of Government Departments and Ministries, representatives of Corporations, and private firms interested in timber utilization and timber export.

The introductory talk and the papers presented at the Seminar are reproduced here.
Editor.

INTRODUCTORY TALK BY M. NAMASIVAYAM, CONSERVATOR OF FORESTS

Hon'ble Minister and Gentlemen,

I have very great pleasure in extending a cordial welcome to you and of thanking you for your presence at this seminar on "UTILIZATION OF FOREST PRODUCE". The idea of convening this Seminar was mooted by the Hon'ble Minister. It was felt that the timber users both in the private and public sectors should meet together with officers of the Forest Department not only to exchange information but also to discuss the possibilities of making better use of the existing timber resources of the country.

Timber is one of the most important natural resources of this country. In a developing economy such as ours it is essential that an evaluation of this important resource be made very early and mistakes avoided not only for the benefit of the present generation but also the generations to come. Forests are a gift of nature and a visible asset. They are not unseen wealth like oil, minerals or fish but a living and visible asset which can be improved and utilized to maximum benefit in perpetuity.

The contrast between Forests and a wasting asset like minerals does not end there. Forests provide cover to precious soil, prevent erosion and safeguard the country against floods, earthslips and similar calamities which beset a country with periods of high rainfall alternating with periods of drought.

The fundamental principle of Forest Management is that the forest estate is treated as a capital asset which must not only be conserved but improved. The removal of the annual growth or 'the annual cut' as it is termed in Forestry, does in no way reduce the capital value. Therefore, in theory, the return in terms of timber or money cannot diminish. Sustained yield management, as this is called, is universally recognised and adopted in the most advanced countries of Western Europe where forestry has been practised as a science for several centuries.

The danger in a developing country like ours where the impact of industrialization is now being felt is that forests are treated with scant respect. Forest land is subject to heavy inroads for the settlement of an exploding population, the production of food and the cultivation of crops like tea, coconut and rubber. In this race for land the utilization and cultivation of timber tends to take second or third place. Forests are looked upon as a nuisance. Little thought is given to systematic harvesting of this natural resource which forms the basis for several wood based industries like plywood and paper.

The most urgent aspect of industrial planning is to use wisely the natural resources of a country. It is with this in mind that this seminar has been organized. The subjects which have been selected for discussion are those industries which have been initiated over the last few years. If these industries are properly developed with regard to availability and supply of timber not only will they save the country valuable foreign exchange but also give employment to an expanding population.

It was with this in view that the Government sought the aid of the United Nations Special Fund to send a team to make a pre-investment survey of forest industries. The team has been in Ceylon for over two years and is present here today to take part in this seminar. Their studies are as yet incomplete but you will, I am sure, be interested in listening to their views.

We of the Forest Department are mainly concerned with the propagation of trees and harvesting of timber and its better utilization. But, trees do not grow overnight and take many years to reach maturity. Hence a long term project such as forestry takes many years of trial and error. The right species which are for example suitable for the manufacture of paper cannot be selected and grown to yield raw material in the space of a few years. Factories can be installed with expensive machinery in a few months to produce plywood but if the supply of available timber is not planned beforehand it would be putting the cart before the horse. Denuding the few accessible forests and then looking around for fresh supplies means that the expensive machinery bought with the slender resources of the country can only become a white-elephant.

I would like to conclude these comments with a brief survey of what we have achieved over the period of the existence of the Forest Department from about the end of the last century. About 12,000 acres of Jak and Mahogany plantations have been planted in very accessible areas, particularly in the North-Western province and 20,000 acres of Mahogany in degraded forests in the Wet Zone. These will come into full maturity in the next decade or so. It can be confidently predicted that Mahogany which is widely used in Western Europe and the United States may well become one of the chief export commodities of Ceylon and earn much foreign exchange. These plantations are within a radius of 60 miles of Colombo and extraction and transport of this timber can be done at a little more than a third of the world market price for Mahogany.

Teak has been propagated in the Eastern Province from the end of the last century. The plantations of 40 years of age can yield volumes and cash returns that can be quite staggering. I was in a Teak plantation last week with a forester of international repute who computed the present value as Rs. 12,000 for an extent of 11 acres of Teak. Both Teak and

Mahogany are being propagated over the last few years at a feverish pace. Last year's target was 8,000 acres and this year's target is 15,000 acres. I trust, therefore, that those who forecast doom for this country with the falling prices of tea will sit up and take notice of the achievements and possibilities of systematic reafforestation and intelligent land use.

I have much pleasure in calling upon the Hon'ble C. P. de Silva to inaugurate the seminar.

INAUGURAL ADDRESS—THE HON'BLE C. P. DE SILVA, MINISTER OF LAND, IRRIGATION AND POWER

I have great pleasure in inaugurating this Seminar on forest produce.

I got the idea of holding a seminar when I visited the paper factory about 2 months ago along with the Chairman of the Paper Mills Corporation. I got a lot of ideas during my visit on the use of timber and forest produce.

We have burnt a lot of timber of our forests in the development of the land for agriculture, but we have not made sufficient attempts to make up for the destruction of forests. I was told by the Conservator that roughly speaking one acre of planted Teak is equal to about 40 acres of natural forest. I have, therefore, set my mind on working out a plan to see whether we can compensate for the rapid inroads made into our forests by the requirements of agriculture by planting Teak and such useful timbers on a big scale. Targets must be fixed for raising plantations of Teak, Mahogany, Eucalyptus, and other useful species on land to be cleared for this purpose. The Forest Department has in fact, fixed targets and achieved fair success in realising them. I am glad to hear that Mahogany can be exported and that it is widely used in Western Europe and the United States, and that this can be exported at very favourable prices. I was told that you can use the produce of Eucalyptus for the manufacture of paper and hardboard for tea chests.

For many years, I have been thinking of a method of hauling logs by tractor and other mechanized methods to increase output. We must try to find ways of using more modern methods of logging and of improving on the available methods. This is where the Special Fund Project can help us.

I would like you to express freely what you have in mind, your ideas that you have on timber utilization. I am sure gentlemen, you have brought with you many useful ideas and suggestions that would help us in this seminar.

I thank you.

Appropriate Technology Services
121, POINT-PELLEO ROAD
NALLUR, A.A.F.N.A
No.

Raw Material for the Manufacture of Paper

By K. C. THANGARAJAH

(Chairman, Eastern Paper Mills Corporation)

The total paper and paper board production for the entire world in 1965 reached about 108 million tons. The total world output of pulp—namely chemical pulp, ground wood and pulps made from sugar cane, bagasse, reeds, grasses, cotton fibres, straw and bamboo had reached a record of nearly 91 million tons. The average consumption of paper per person throughout the world in 1965 was 66.5 pounds, compared with 42.3 pounds ten years earlier. It is now being generally accepted by the F. A. O. and other international forecasters that the world demand of paper and paper board will at least double every 15 years. The world demand for pulp and paper is expected to reach about 225 million tons by 1980. Somehow the world has to get the fibre to make all this paper and paper board as well as rayon, acetate, cellophane, tyre cord and other products.

The per capita consumption in Ceylon rose from 5 pounds in 1956 to 7.8 pounds in 1965. The demand for newsprint, printing and packaging papers even now is high, but we cannot make enough for ourselves. The imports are limited by the lack of foreign exchange. At a very conservative figure it has been estimated that the demand by 1975 would at least be about 87,000 tons. As against this, our current production is 9,000 tons. Additional mill capacity has to be created, therefore, for about 78,000 tons by 1975. The likely pulp requirements for the additional mill capacity is estimated at about 26,000 tons of mechanical pulp, 24,000 tons of chemical long fibre pulp, 23,000 tons of chemical short fibre pulp, supported by about 10,000 tons of waste paper.

The problem before us is to create locally or to find unexploited and wasted cellulose containing material for manufacturing within the next decade, about 80,000 tons of pulp for the production of paper and paper board for the country and thus save valuable foreign exchange to the extent of 80 million rupees, which would otherwise be needed to import paper for our requirements.

The orthodox material for making paper is long fibre soft wood from the temperate zones. Scandinavia, Canada and U. S. S. R. are well endowed by nature. Even in these countries supplies are running out and the industry is looking out for fresh fibre resources. Perhaps the most important future development will be higher yields of pulp per unit area of forest. The whole tree—branches, roots, bark, will be used and high yielding species will be grown. In these countries extensive use is being made of saw mill chips and a number of new mills are sustained without cutting down any additional trees.

If we leave out these fortunate countries and look around the world and examine what is being done in some of the other countries which do not have adequate indigenous supplies of soft wood suitable for paper making, we will come to the conclusion that with proper planning and research, the natural resources in this country can very well be used to produce all the pulp requirements.

The Netherlands has a population of 12.2 million with a per-capita consumption of 231 pounds. The home production of pulp is about 592,000 tons of which mechanical pulp is 157,000 tons and straw pulp 435,000 tons. The balance pulp required for the production of 1.4 million tons of paper and paper board is imported from Scandinavia, U. S. A., France and Canada. They have established a very good export market of certain types of paper and paper board and in fact Ceylon is one of the biggest buyers of straw board from this country.

Rumania has a population of 19.5 million with a per-capita consumption of 31.8 pounds. Their home production of pulp is 353,000 tons of which 105,000 tons comes from reeds and straw. They have specialised in using river delta reeds or rushes, and straw. In fact the biggest straw pulp mill in the world is in Rumania.

China with a population of 715 million has a per-capita consumption of 9.8 pounds and produces 3.3 million tons of paper and paper board. It is reported that production of wood pulp is 450,000 tons and pulp made from bagasse, bamboo, rags and straw amounts to 1.75 million tons.

In Taiwan, for instance, with a population of 12.7 millions the per capita consumption is 41.3 pounds. The pulp production is reported to be about 227,000 tons—17,000 tons of chemical wood pulp, 16,000 tons of mechanical pulp and 194,000 tons of straw, bagasse and other vegetable fibre pulp.

The per-capita consumption in the U. A. R. is 13 pounds and the current production is 122,000 tons. The U. A. R. produces about 33,000 tons of straw reed and other pulp and imports from Finland, U. S. A. and U. S. S. R., her long fibre pulp requirements.

Right across in India the per-capita consumption is 3.3 pounds. The home production of paper and paper board is 704,000 tons, for which the chemical pulp produced from wood and bamboo amounts to 580,000 tons, mechanical pulp 27,000 tons, and pulp produced from straw, grasses and bagasse is 105,000 tons. The Indian paper industry is moving to use pulp from fast growing hardwoods, especially Eucalyptus hybrid in blend with bamboo pulp for paper production. A government committee on natural resources has recommended that new forestry plantations of 400,000 hectares—100,000 for Bamboo and 300,000 for fast growing trees such as Eucalyptus be a target for the fourth plan.

These and many more such countries are making pulp for paper with their existing resources and they propose not only to be self-sufficient to meet the home consumption, but also to export such grades of pulp and paper as could be made with the available local resources in exchange for other types which the country needs and which the other countries are in a more fortunate position to manufacture.

In Ceylon we have to use the existing resources which remain unexploited and wasted, such as wood from the Dry Zone and Wet Zone forests, agricultural wastes like paddy straw and, when available, bagasse. We have to create new man-made plantation forests of bamboo, conifers and eucalyptus. With these main fibrous raw material the needs of the paper industry can be met.

A mission organised by the International Bank for Reconstruction and Development at the request of the Government of Ceylon reported in 1952 that the construction of the paper mill at Valaichchenai should be abandoned at that stage at a small loss rather than later at a larger one. This was

so upto 1958 when operations at Valaichchenai had almost come to a stand still and talks of abandoning the project were seriously considered. Today the mill which was intended to produce $12\frac{1}{2}$ tons per day, but which it never did, is manufacturing, with one hundred per cent Ceylonese personnel, 30 tons per day, giving a return of 10 per cent on the capital outlay and saving considerable foreign exchange. It is now realised that the Valaichchenai plant could be expanded to a 100 tons-per-day plant without much difficulty. It is gratifying to note that the recent World Bank Reconnaissance Mission to Ceylon in connection with State Industrial Corporations has found the paper industry in Ceylon in good health. With the administrative and technical experience gained at Valaichchenai, it is possible to produce the paper and paper board requirements of the country by not only expanding at Valaichchenai, but also by constructing two new mills in the central and southwestern areas of Ceylon. Our immediate need therefore is to find or create the necessary fibrous resources.

With regard to the processes for pulping, those in the industry do not any longer talk of processes confined to one type of raw material in a particular mill. It is now possible to adopt new processes for pulping of raw material like straw, grass, bagasse, bamboo and hard wood in one single line pulp mill. It is felt that this development is of great importance for such countries where there is a shortage of fibrous raw materials. Each mill may have to use a large number of raw materials for its production and it will mean too much capital investment and perhaps uneconomic working, if there are different pulp mills for different raw materials. A new mill in India uses four distinctly different raw materials namely grasses, bagasse, hardwood of various types and bamboo. All these are processed in a single pulp mill built to produce a well-bleached pulp of nearly 75 GE brightness and the final pulp has about 50 per cent. bamboo and 25 per cent. hardwoods and balance grass and bagasse in it. We are fortunate that in Ceylon with the new mill construction or even at Valaichchenai the pulping process can be installed or modified to use all the possible raw materials available.

The estimates made of the likely pulp requirements for the needs of the industry in Ceylon during the next 10 years are based on the assumptions that paper and board consumption in the Island will be satisfied from the indigenous products; and that a gradual shift towards the maximum substitution of long fibered pulp will take place.

These estimates are not intended as a prediction of how fibre needs will actually be met, but rather as an indication of the possibilities of satisfying the growing demand for paper making fibrous material from indigenous resources.

It is not anticipated within the next decade that any long fibre pulp will be produced in Ceylon because of the lack of suitable coniferous plantations. However, the knowledge that 24,000 tons at an estimated foreign exchange expenditure of Rs. 20 million will be required should spur efforts to start the necessary plantations in up-country areas where there are large tracts of land presently available.

It is presumed that mechanical pulp will be produced from Eucalyptus plantations already in existence in and around the Nuwara Eliya District and which must be rapidly expanded to meet the growing demand.

Chemical short fibre pulp can be produced from paddy straw as at present, from bagasse, eucalyptus, bamboo and from some of the 300 species of trees indigenous to Ceylon.

In this context it should therefore be only necessary to solve the silvicultural problems involved and plant extensive tracts of bamboo and Eucalyptus in and around Valaichchenai; conifers and Eucalyptus in and around the Nuwara Eliya district; bamboo in suitable locations in south-western Ceylon where a third mill is likely to be established.

I would add just one more word in regard to the re-forestation of the up-country areas. During the latter part of the 19th Century the Bio-Bio River Basin in Central Chile was covered with grain fields and wheat was exported to all parts of the world by way of the Bio-Bio River which then was a navigable stream. However, by the turn of the century erosion of the top soil turned the grain fields into a dust bowl and resultant sand banks in the Bio-Bio river closed it to navigation. Encouraged by the government, the central Chilean farmers eventually embarked upon a soil conservation programme, including the planting of trees. *Pinus radiata* or *Pinus insignis* was first planted in Chile in 1885. However, large scale plantings did not really begin until 1935 but were increased rapidly to 40,000 acres per year in 1947, 1948 and 1949. Today more than 700,000 acres of man made pine forests exist in Chile. These plantations now support four pulp and paper mills producing annually approximately 280,000 tons of bleached and unbleached kraft pulp and paper and paper board and 120,000 tons of newsprint. In addition, there is ample wood for two particle board plants and a considerable number of small to medium sized saw mills. Recently a new newsprint mill has been established where the equity capital of the company was raised by monthly subscriptions from many thousands of very small shareholders. I mention this in passing as the forestry experts might not only find a way of meeting the pulp requirements for the paper industry but also, in the process, find a solution to the soil erosion and other allied problems in the up-country areas.

I have merely made a case for the development of the raw materials which are required and it is for the forestry experts to plan without more delay, ways and means of meeting the raw material needs of the paper industry. I look forward with great interest to the papers which will be read and discussed here today by two experts on the possibilities of using local timber for pulp and the silvicultural problems connected with the growing of bamboo, pine and Eucalyptus.

Possibilities of using Local Timber for Pulp

By J. HUUHTANEN

(F.A.O. Forestry Officer—Forest Industries)

DESPITE the short time I have been given for this talk, I should like to widen my theme slightly.

First, I will tell you very shortly what the FAO-team, of which I am a member, is doing here in Ceylon. Secondly, I will touch on possibilities which the local market offers for pulp and paper making. Thereafter, I will come to the main topic of my talk: the possibilities of using local timber for pulp and paper manufacture in the future.

I am working here in a project sponsored by the United Nations Special Fund and executed by the F.A.O. called "Pre-investment Study on Forest Industries Development". The purpose of this project is to assist the Government of Ceylon in the rational development of its forest industries sector by evaluating the immediate possibilities of establishing selected industries and by providing the necessary planning for the long-term development of forest industries based on sustained forest resources.

In order to achieve this objective, our team is conducting forest inventories in the most promising forest areas, demonstrating the modern logging and extraction methods and training the local personnel in the use of mechanical logging and extraction equipment, giving instructions on proper methods of timber utilization, mainly timber seasoning and preservation, carrying out preliminary feasibility studies for specific forest industries in selected locations, and advising in the preparation of suitable management plans to ensure the long term development of forestry and forest products industries. We have also conducted surveys of the existing forest industries and markets for forest products in Ceylon, and provided for five one-year fellowships abroad for the local counterparts. We have used the services of six short-term consultants in different aspects of our work and several wood research institutes for the testing of selected Ceylon timbers. The work of the project started in April 1964 at which time our Project Manager arrived in Colombo. The strength of the project was then gradually increased and for most of the time, has included six foreign experts. In the beginning, there were some difficulties in recruiting certain foreign personnel. The most harmful, in my opinion, was the late arrival of the inventory expert resulting in the late start of forest inventories. Up to date, we have not yet received the inventory results, which naturally has delayed planning work.

The main criterion for industrial planning is market. Actually, the sole purpose of a new factory is to satisfy a demand for its products. Even with plentiful domestic resources, there is no reason for local production unless the products can be sold. This is the reason, why I want to treat the question of demand for pulp products in Ceylon. For this purpose, I am presenting a table which shown the development of the per head consumption of paper in Ceylon and other parts of the world. These figures include also products of paper.

TABLE 1

Consumption of paper and paperboard

(kg. per head)

Region	1950-52		1960-62		1963		Rate of annual increase 1951-61
	..	..	..	..	..	..	
World	..	18	..	25	..	27	3.4%
Asia	..	1.5	..	5.4	..	6.2	13.7%
Africa	..	1.8	..	3.1	..	3.9	5.6%
Latin America	..	7.8	..	12.1	..	12.2	4.5%
Continental S. E. Asia	..	1.2	..	1.9	..	2.5	4.7%
Insular S. E. Asia	..	1.2	..	1.8	..	2.1	4.1%
South Asia	..	0.6	..	1.2	..	1.4	7.2%
East Asia, excl. China and Japan	..	1.6	..	7.8	..	9.3	17.2%
Ceylon	..	2.5	..	4.3	..	2.9	5.6%

Source : FAO Yearbook of Forest Products Statistics, 1965 ;

" Wood : World Trends and Prospects ", Unasylva 20, Nos. 80-81, 1966 ;

Pulp and Paper Prospects in Asia and the Far East, Vol. I, UN/FAO, 1962.

This table shows that Ceylon's consumption is below world average, but that 15 years ago it was well above the average for Asia. During the decade, 1951-1961, Ceylon's paper consumption increased faster than the world average, but could not keep pace with that of the whole of Asia. In 1961, Asia's average consumption was already 25 per cent. above that of Ceylon's and in 1963 more than double. Africa's consumption, which in the same decade had increased at the same rate as Ceylon's but starting from lower level, has also surpassed Ceylon's. Compared with the neighbouring regions in Asia, Ceylon is still ahead of most of them, but the gap is closing fairly fast.

We all know the reasons for the sudden slump in Ceylon's paper consumption after 1962. (This was due to severe import restrictions imposed by the government with a view to conserving foreign exchange.) This slump does not mean that the people would not use paper, but simply that paper was not available or prices were too high because of import restrictions. In such conditions, it is very difficult to estimate the future consumption. Usually, paper consumption is compared with the increase in Gross National Product (GNP) per capita. For the last six years, Ceylon's GNP per head has increased annually by only about 0.5 per cent. On the other hand, increase in GNP does not always mean increase in foreign exchange earnings, which have the most profound effect on Ceylon's paper consumption as long as most of the paper is imported.

If we however assume that the economic situation will improve and that the same growth rate which took place in 1951-1961 is again achieved, then, starting from 1966-level of about 3 kg per head, we arrive at about 3.9 kg in 5 years time and at 5.1 kg in 10 years time. These figures correspond to a total consumption of about 50,000 tons in 1971 and 75,000 tons in 1976, provided that paper is available and that the prices are not significantly higher than they were in 1951-1961. I personally have the feeling that these figures are absolutely maxima.

Today, roughly 1/3 of the paper consumption in Ceylon is newsprint, another 1/3 other printing and writing papers, and the rest so-called industrial papers, i.e., packing and wrapping papers and paperboard. If these same ratios are maintained, the consumption of each of these groups would be about 17,000 tons in 1971 and 25,000 tons in 1976. There are, however, some indications that the use of industrial papers will increase faster than that of printing and writing papers. This is especially so with the development of local manufacturing industries which need paper and paperboard for packing the products. From the pulp production point of view, these capacities are still too low to be considered for competition in the world market. They may also be too low for the domestic market. A good example is India, which has a central development plan for her pulp and paper industry. In the past, the plan relied heavily on small production units, producing only 1,500 to 3,000 tons a year. These were, however, found to be very uneconomical, and in the latest 5-year plan the smallest units to be built are for 50,000 to 75,000 tons a year. (Pulp and Paper International 7, No. 9: 113, 1965 Review Number). Similar cases could be cited from other countries. One example is also the pulp mill at Valaichchenai where the production cost for straw pulp is about Rs. 1,000 a ton against a CIF-price of less than Rs. 800 for imported pulp. Strictly, from the point of view of mill economy, it would be more profitable to shut down the pulp mill and use only imported pulp in the paper mill. There are, however, other factors to be considered. We technicians can only show the economics of a mill compared with competing materials. It is for the economists and governments' policy makers to decide if the resulting increase in the cost of living due to higher product prices is more than compensated for by foreign exchange savings, creation of new jobs, etc.

The question of the price of paper is very important in Ceylon, where the people seem to be very price conscious. During the last six years, the duty on newsprint was increased from 5 per cent. to 50 per cent. and the duty on printing and writing papers from 5 per cent. to more than 60 per cent. For other kinds of paper and paperboard the increases have been less. It looks very certain that these increases are there to stay, if local production is expanded as planned. The newsprint mill study, based on the use of up-country eucalypts, is calculated on newsprint prices with 60 per cent. duty on them. Even with this high product price, the profitability of the mill is very low. The study for the paperboard mill to be built at Valaichchenai advocates a duty of 55 per cent. on paperboard, which is nearly the double of present duty. All these price increases must have an effect on the growth rate of paper consumption, and it may be very difficult to achieve the previous rates anymore.

Finally, I am coming to my main subject, the use of timber for pulp and paper. Necessarily, I have also to treat other raw materials in order to compare the advantages or disadvantages of timber.

First, I have to stress that purely technically it is possible to make nearly any kind of paper from nearly any kind of timber or other fibrous raw material, as laboratory experiments indicate. It is only when economics, i.e., the price of the final product, is taken into consideration that the picture changes. This is an important point, and it has to be always remembered that the economic suitability of a raw material is more often more important than the technical suitability. This is one reason why I have spoken fairly lengthily on the demand and prices of paper. The question of costs

of paper should never be forgotten. Local production cannot be an end in itself, but a means for a better standard of living.

Conifer timbers have been the main raw material of the traditional pulp industry since its start about 100 years ago. Later on, hardwoods have also been used when it was found that their shorter fibres, either mixed with conifer pulp or alone, produced certain qualities of paper cheaper than conifer fibres. Other fibrous raw materials like bagasse, bamboo, reeds and straw are also used in areas which are poor in timber resources. More than 90 per cent. of all pulp is still made from timber and most probably this will continue until such time as synthetics take over.

At the moment in Ceylon, there are three types of timbers which could be considered as raw materials for pulping. These are :

1. Mixed hardwoods from natural forest
2. Rubberwood
3. Eucalypts

As all these woods have short fibres, there is a lack of long fibre material. Some conifer plantations exist in the up-country, but these are too small to support any pulping operations. Their existence however shows that it will be possible to plant more conifer species for the future. No local timber is used for pulping in Ceylon, therefore, all the experience has to be taken from experiments conducted abroad or from industrial uses outside Ceylon.

In table 2, I have selected fibre characteristics of some tropical timbers including the three groups available in Ceylon. The approximate suitability for paper is also indicated. Some other fibrous materials are included for comparison. This table is basically taken from the proceedings of the FAO conference on "Pulp and Paper Development in Africa and the Near East" held in Cairo in 1965.

TABLE 2

Fibre characteristics and suitability for paper

Species	Fibre characteristics				Approximate indication of suitability
	Length mm.	Diam. micr.	Flex.* coeff.	Basic density	
<i>Tropical pines</i>	3.2-4.8..	40-54..	0.7-0.8..	0.43-0.58	.. All kinds of papers High burst, tear and tensile
<i>Plantation eucalypts</i>	0.9-1.1..	15-20..	0.3-0.6..	0.43-0.60	.. Printing and writing papers Low strength, good opacity
<i>Tropical hardwoods :</i>					
Light woods (West Africa)	0.9-1.6..	20-40..	0.7-0.85	0.22-0.5	.. Printing, writing and second grade wrapping papers High tensile and burst, low tear and opacity
Heavy woods (West Africa)	1.1-2 ..	15-25..	0.2-0.6..	0.5-0.85	.. Printing and writing papers Medium tensile and tear, high opacity
<i>Gmelina arborea</i> (Malaya)	1.3..	32..	0.7..	0.4	.. Printing, writing and second grade wrapping papers High tensile, medium burst and tear

Species	Fibre characteristics				Approximate indication of suitability
	Length mm.	Diam. micr.	Flex*. coeff.	Basic density	
<i>Rubberwood</i>	.. 1.4..	19..	0.6..	0.5 ..	.. Printing and writing papers Good tensile and burst, low tear
<i>Bamboos</i>	.. 2-2.5..	18-25..	0.4..	—	.. Printing, writing and second grade wrapping papers. Low burst and tensile, good tear
<i>Rice straw</i>	.. 1.2..	7-9..	0.2-0.3..	—	.. Printing and writing papers with addition of other fibre. Very low tensile and tear, good opacity
<i>Bagasse</i>	.. 1.7-2..	20..	0.5..	—	.. Printing, writing and second grade wrapping papers. Medium tensile and tear good opacity

* Flexibility coefficient — lumen diameter/fibre diameter.

All the natural forests in Ceylon are tropical hardwoods. When considering their use for pulping, the only solution would be to use them in mixture since there are no dominant species, unless may be Wira (*Drypetes sepiaria* (W. & A.) Pax. & Hoffm.) in the dry zone.

Most of these forests are in the dry zone, where the stocking per acre is only about 1/3 of that in the wet zone. This means that an area 3 times as large should be worked every year. In addition, dry zone species are very slow growing, hard and dense woods which make their usage uneconomical nearly in every stage of processing. It is my firm belief that the dry zone natural timbers have no significance as pulping raw material.

The wet zone offers much better possibilities. The trees grow much faster, the timber is softer and yields per acre are higher. This was the basis we used for selecting species for our pulping test. 24 species were selected, of which 20 were from the wet zone and comprised 50 per cent. of the total volume of Wet Zone timber. The rest were intermediate zone species which occur also in the dry zone. All these species were pulped by the sulphate process. The results were very similar to those presented in Table 2 for light tropical hardwoods from Africa. Our tests were on a somewhat narrower basis and therefore a complete comparison is difficult. Ceylon species had a slightly higher density (0.4-0.6) but longer fibre length (1.0-2.5), and the paper properties were as good as for African species, tear-strength even somewhat higher. This test indicates clearly that technically these species are fully suitable for the manufacture of printing, writing and second grade wrapping papers.

Rubberwood is the next largest quantity available after mixed hardwoods. It has been estimated that nearly 1 million tons of rubberwood (air-dry basis) are available every year. As pulp, this quantity corresponds to about 400,000 tons which is 10 times the present paper consumption. Therefore, rubberwood has to be considered very seriously as a potential raw material for pulp. Rubberwood has been lately the object of much research and its pulping properties have been studied in Malaysia, the United States, Japan, Germany and Finland. As the Table 2 shows, its

fibre properties make it fully suitable for printing and writing papers. About 50,000 tons of rubberwood have been used by a Japanese pulp and paper mill in commercial scale trials. (The amount is 10 times Valaichchenai's annual pulping capacity). The wood was shipped from Malaya. These mill trials indicated that the main and practically the only problem is the existence of latex in pulp which causes spots on the paper. After these mill trials, the research has centered on two points: how to prevent latex entering the wood during and after debarking, and how to remove the latex from pulp before paper making. I am fully confident that with present techniques these obstacles will be soon removed. Economically, there should be no objections. If it pays for the Japanese to transport the timber all the way from Malaysia, the outlook must be much better for a factory located in the midst of rubber estates.

Eucalypts are the only plantation species which exists in large enough quantities to be considered as raw material for pulping. Unfortunately, these plantations were put up for the production of firewood and consequently they are all scattered, in fairly small patches and mainly of mixed species. Luckily, the most common species, *Eucalyptus grandis* (Hill) Maiden, is the species which has been found so far the most suitable for pulping of all the exotic eucalyptus and is already widely used in the pulping industry in many tropical and sub-tropical countries. Its main uses are as bleached sulphate pulp for printing and writing papers and for the manufacture of rayon. It is technically possible to manufacture newsprint type paper from *E. grandis*, with a chemical pre-treatment before pulping, but the economics of the process are still so poor that this is not done commercially anywhere. As far as I know, there is only one mill in South America which grinds *E. grandis* or *E. saligna* Sm. in conventional grinders after chemical pre-treatment but uses this pulp only up to 40 per cent. in the newsprint furnish, the rest being conifer groundwood and chemical pulp. In Australia, some eucalypt species are used for mechanical groundwood successfully but the trees are very old, more than 100 years, which is too long a rotation for plantations. *Eucalyptus grandis*, has hardly any use as pulpwood in Australia. Generally, Australian experience cannot be applied to plantation grown eucalypts. The difference lies in the fact that Australian eucalypts are all from natural stands resulting in very different fibre properties. Looking at Table 2, we see that the fibre characteristics of eucalypts are not very outstanding, tropical light hardwoods and rubberwood being fully comparable, if not better.

Regarding other potential timber raw materials for the future, development work should be concentrated on conifers, since long fibre materials are practically lacking in Ceylon. As Table 2 shows, tropical pines have the longest fibres, their flexibility coefficients are among the highest, they produce the strongest papers and are suitable for all kinds of paper and paperboard. According to experiments, araucarias and cypresses can be included in the same category. Several tropical pines and at least one species of Araucaria are already used in industrial pulp and paper making. As the up-country plantations indicate, several conifer species can be grown there. It has also been suggested by our silvicultural consultant that it should be possible to grow some conifers on lower elevations in the wet zone and even in the dry zone. This is indicated by the araucarias which can be seen in some parks in Colombo and in estate gardens in the wet zone. It can be concluded from the above that if development work is started early and on a large enough scale, the supply of long fibre material can be secured in Ceylon. This is however a long term programme and its economics cannot be estimated quickly.

As to the short fibred timber, we have seen from Table 2 that eucalypts are not the only acceptable timber. As soon as the latex troubles with rubberwood are overcome, rubberwood will be a more important raw material since its fibre properties are not worse than those of eucalypts, and it is available in much larger quantities and practically all of it at the roadside. Another interesting hardwood is *Gmelina arborea*, Roxb. (local name Et-demata), which already grows in Ceylon. It has been experimentally tested for pulping and found to be at least as good as eucalypts. It is also fairly quick growing and in Africa it is considered to be a better choice in some localities than eucalypts. It could be a sort of over-all utility species, since it may be possible to use it also for plywood and matches. According to Forest Department experience here, it is an easy species to grow anywhere.

For comparison, I have also included in Table 2 some fibre characteristics of bamboos, bagasse and rice straw which are the competing raw materials for timbers. Bamboos have a long fibre but since their flexibility coefficient is fairly low, most of the strength properties are not at the same level as conifers, and consequently highest quality packing papers cannot be made without an addition of conifer pulp. There are no natural stands of bamboo in Ceylon which could be used for pulping, and plantations should be created first. This should however be considered together with the starting of conifer plantations, since bamboo cannot replace conifer fibre entirely as was shown before. Bamboo has one definite advantage over conifers, and that is the shorter period of rotation. The results can be seen earlier, about after 4 to 5 years. The best solution may be a combination of bamboo and conifer plantations. Bamboo would be used first, and if the economics after the first rotation of conifers, which may take 10 to 15 years, show that conifers are more profitable, bamboo could be abandoned in favour of conifers, or the other way around. There are some problems with the utilization of bamboo as the experience in Pakistan shows. They have large natural bamboo stands, but the tendency is to change over to plantation conifers.

Bagasse has a longer fibre than most hardwoods and can be used for many types of papers, even for newsprint. It is not available at the moment and cannot be considered until such time as there is a cheap fuel to replace it at the sugar mills or until the mills work at so high a capacity as to supply sufficient quantities of bagasse for paper making.

Rice straw is the only material used for pulping in Ceylon. It has short and weak fibres which are however well suitable for printing and writing papers with the addition of longer fibre to give the required strength. Straw is a very bulky material making its collection difficult and resulting in a fairly high delivered price. This is felt in the manufacturing cost in Vaiaichchenai, which is higher than for any kind of imported pulp.

Before finishing, Table 3 shows some cost comparisons between the raw materials discussed. The costs are estimated per ton of bleached chemical pulp, and the figures are not claimed to be exact giving only the order of magnitude. Eucalypts and rubberwood seem to be the cheapest raw materials, mixed hardwoods and conifers are at about the same level, bagasse and rice straw being the most expensive. For bamboos, the information varies greatly and it is difficult to say what the costs would be in Ceylon. The highest figures are from India. Bagasse is valued according to the present cost of fuel oil in the Kantalai and Gal Oya Sugar Mills. For timbers, an average transport distance of about 20 miles to the mills is assumed.

In the same table, I have included a comparison of areas to be worked annually for a production of 10,000 tons of chemical pulp. These areas are smallest for plantation timbers which makes their collection the easiest. For bamboos, the information is very variable. For mixed hardwoods, this depends on how much of the timber volume can be used for pulping. It is assumed that 50 per cent. of the species in the wet zone could be used. The lower figure is for the case when all these species above 4' girth are used for pulping the higher figure when larger logs are taken for plywood or sawmilling and only tops and branches are pulped. The figure for bagasse makes it quite clear that the growing of sugar cane has to be intensified considerably before bagasse is available in large enough quantities. In addition, this table assumes that all the bagasse is used for pulping and is replaced by an alternative fuel. For rice straw, the collection area is naturally large, which is one indication of the costs involved in its collection.

TABLE 3
COST COMPARISON OF DIFFERENT RAW MATERIALS

		<i>Plantation</i>		<i>Mixed Rubber</i>	<i>Bamboos</i>	<i>Rice Bagasse</i>
		<i>Coni- fers</i>	<i>Euca- lypts</i>	<i>hard - woods</i>		<i>straw</i>
Cost per ton bl, chemical pulp						
Rs.	..	230 ..	155 ..	225 ..	135 ..	115 325 ..
						300 .. 255
Area to be worked annually for						
10,000 ton pulp production				2100-	1600-	
acres	..	670 ..	570 ..	6300 ..	560 .. 3100	.. 82,000 .. 12,800

Note. 1 Ceylon Rupee = 0.21 US\$

Silvicultural problems connected with the Growing of Bamboo, Pines and Eucalyptus

By M. S. RANATUNGA

(Forest Department)

One of the fundamental requirements concerning industrial raw material is that such raw material should be found in abundance, in concentrated locations, and within easy access of consuming centres. In trying to achieve this end, of supplying wood products as raw materials, often artificially grown species are found to be more attractive than the naturally available species which are sparsely distributed over a wide area.

Forecasts made by the Eastern Paper Mills Corporation in a report to the World Bank, highlighted the importance of pulp for paper in future Ceylon. The pulp requirement forecast for 1975 is in the region of 78,000 tons. In order to accommodate this increase in demand, proposals have been made to increase the capacity of the already established paper factory at Valaichchenai, install a new chemi-mechanical pulp factory at Ambawela and explore possibilities of installing other factories elsewhere.

The existing factory at Valaichchenai, uses short fibred straw purchased locally along with imported long fibred pulp, on an approximate ratio of 60 of straw to 40 of imported pulp. Taking into account that over 8,300 tons of locally collected straw was used in 1965, the imported annual pulp requirement may be in the region of 5,500 tons. In the planned programme to meet all future requirements of paper in 1975, the amount of long fibred pulp required is in the region of 24,000 tons. Apart from this long fibred pulp requirement, 49,000 tons of other fibre are also needed.

A survey carried out by a firm of consultants at the instance of the Eastern Paper Mills Corporation demonstrated the feasibility of using *Eucalyptus grandis* for the proposed newsprint mill at Ambawela. In addition, planting of *Eucalyptus camaldulensis* in the Dry Zone with a view to feeding the factory at Valaichchenai has also been undertaken. Another F. A. O. report recommends trial plantations of coniferous species outside the up-country. This has been adopted with a view to meet the requirements of long fibred pulp.

These future programmes had not taken into account the possibilities of using Bamboo for obtaining long fibred pulp. This has now been considered on a suggestion from the Hon'ble Minister of Lands himself. The Eastern Paper Mills Corporation authorities are also very enthusiastic about the possibilities of Bamboo.

My talk today concerns the problems connected with producing these three sources of fibre namely, Bamboo, Pines and Eucalyptus. As the problems connected with growing these vary from one to another, and also due to the fact that attempts made so far were carried out at different times and at different locations, I intend taking the three groups separately.

BAMBOO

Bamboo belongs to the grass family Graminae with a worldwide distribution. In Ceylon there are fourteen species of bamboo, while in the neighbouring Indian sub-continent over 136 species have been recorded. In Ceylon none of the bamboo species have been used on an industrial scale. This is not so in India. Species of bamboo have been used for pulp for as long as thirty years or more. Of the species used there, the most common and the most economical is the male bamboo, botanically known as *Dendrocalamus strictus*. This species has a very wide distribution in India, ranging from 3,000 ft. altitude on the foothills of the Himalayas in Uttar Pradesh extending southwards to Madras State which is practically at sea level. A single species with such a wide range of distribution growing on different conditions of soil, aspect, drainage, rainfall and seasonal changes, is bound to produce recognisable growth forms. These may possibly be inherited through the seed. A study of this aspect in India has revealed a common type, a large type and a dwarf type, with variations within each type. This fact which I will refer to later on may be one of the biggest problems we are faced with in introducing this species to Ceylon.

The temperature tolerance of this species is between 42 degrees to 110 degrees F. In areas of natural distribution in India the annual rainfall varies between 30 inches to 200 inches. It is believed that with such variations in the rainfall, the atmospheric humidity is one of the determining factors in the distribution of this species.

With regard to soils, this species is found on a wide range, but known to avoid moisture retaining soils, recent alluvial deposits, savanna type grasslands, steep precipitous slopes and water logged areas with heavy soils.

The male bamboo differs from most other bamboos by being almost solid with little or no central chamber. It is also smaller than the normal bamboos we are accustomed to in Ceylon, the average girth being $3\frac{1}{2}$ to $6\frac{1}{2}$ inches. The height varies from 15 to 60 feet. The solidity is reported to be related to poor and dry soil conditions. In very rich sites the tendency is for the development of a thinner wall and larger chambers. The average life span of a single stem is about seven years. In natural forests the density of clumps vary from 25 to 90 clumps per acre, with 10-60 culms or stems per clump. With this variation it is rather difficult to make an accurate assessment of production on a per ton per acre, per annum basis. The best natural forests in Uttar Pradesh, produce only 0.2 tons per acre per annum. It is believed that in artificially raised plantations, production would be as high as 3 tons to an acre per annum.

With the background information given earlier, one has to almost rule out the West Zone or even the Mountain Zone as suitable planting areas for this species. Apart from the climatic unsuitability, these zones are far removed from the existing paper factory at Valaichchenai. The first departmentally recorded introduction of this species was at Palugama near Anuradhapura and at Vakaneri in the Eastern Province. At both these locations only a few clumps were grown. When the department attempted to plant these species on a large scale in 1964 there was little or no information to go by.

The foremost difficulty has been, and still is, the problem of obtaining planting material ideally suited to our local conditions. The planting

material for artificial propagation are seeds, plants and rhizomes. The seeds have relatively short lives and must be sown within a few weeks of collection. Plants cannot be transported without risk of desiccation. The first batch of seeds obtained from Madras in 1962 proved to be a total failure at the Nursery level itself. In the absence of any response from Southern seed sources in India in the year 1964, 10 kilograms of seed and 2,000 rhizomes were airlifted from well known seed and plant merchants in Dehra Dun in North India. The rhizomes were planted in weeded patches under Teak at Vakeneri. The result was a total failure. The seed from Dehra Dun was germinated successfully in four nurseries at China Bay, Anuradhapura, Kurunegala and Kamburupitiya. Some of the seedlings were transplanted in polythene bags. The only hazards at the Nursery stage were the rodents which were kept off using small gauge wire mesh. At China Bay wild elephants repeatedly browsed on the young plants in the nursery. In the course of browsing the plants in the beds were uprooted and destroyed, while the plants growing in polythene bags suffered little damage; the reason being that when the wild elephants browsed on the tender shoots, the polythene bags got lifted up with the soil and prevented the shoots being uprooted. The fondness of this species to the elephant will undoubtedly be a major hazard in propagating it in the vicinity of Valachchenai where elephants are frequently found.

In the 1965 North-East planting season, the original planting area was once again planted with locally raised plants in polythene bags. In addition five acres of open type scrub forest and five acres of clear felled and burnt high forest were also planted. Except in the clear felled and burnt high forest where a few healthy plants were found, results elsewhere were not at all encouraging. One acre each in Selankandal in Puttalam District and Mudunpita near Kurunegala were also failures.

In attempting to evaluate the reasons for these initial failures one cannot fail to think of two possibilities. Firstly, the planting material obtained from North India may not be quite suited to local conditions. Even a more widely distributed species such as Teak, similarly introduced to Ceylon many years ago has shown that the strains from Nilambur and Anamalai in South India are better suited to local conditions than the strains from Burma.

Another factor which may have been responsible for the poor results was the location of nurseries away from the planting centres.

Future planting of this species will be undertaken after making further efforts to obtain viable seeds from South Indian seed sources and by locating nurseries in the vicinity of the planting areas. We also expect to try out the effects of deep ploughing and application of small doses of artificial fertilizer.

Before passing to the next group namely the Pines, I thought it appropriate that I should make mention of the presence of the local bamboo which grows in large patches in the Naula-Elehera area. It has been identified as *Bambusa orientalis* and locally referred to as Katu Una. It inhabits poor sites which the villagers have left out. The culms measure 7-12 inches in girth reaching 40-50 feet in height. What is of interest is that in some culms the central chamber is very small occupying only about $\frac{1}{4}$ of the cross-section rather resembling *Dendrocalamus strictus*.

One drawback in harvesting this species on a large scale is the profuse thorny buds which comes off the branchlets and cascade down all around the clump.

PINES

PINES, or to use the correct name 'Pinus' is a large group of species, most of which are found in temperate habitats. A few of these pines are found naturally in the tropical belt but at high elevations. Still fewer numbers are found in tropical plains.

The first introduction of this group of species to the country is represented by single trees at Peradeniya and Hakgala gardens. Some small scale planting by the Forest Department was undertaken in 1930 at Ohiya and at Kandapola in the up-country using *Pinus insularis* a native of Burma and the Philippines and *Pinus patula* from Mexico. In the year 1951 larger areas were taken up for planting at Etalapitiya near Bandarawela and Erabedde near Welimada using *Pinus caribaea*.

At this stage I think mention should be made of the fact that unlike most other groups of plants the roots of pine seedlings should be in close association with a group of fungi which form a mantle around the roots. The exact relationship between the fungi and the root system is a controversial subject, but it has been well established that for the successful raising of pine seedlings in the nursery, the soil should be well infected with the required fungal group. When early plantations were raised, the new nursery sites were infected using soil, pine needles and duff from the sites of the older pine plantations. When these nurseries failed, repeated infections were done. The *Pinus caribaea* grown in this manner has reached a height of 40 feet in fourteen years.

Another pine successfully introduced about the same time was *Pinus khasya*. At Pattipola on a small plot some trees have reached a height of sixty feet in fifteen years. Besides the four pine species mentioned, ten others have been grown in the up-country areas but results are not encouraging. However, large scale planting of the successful species was not undertaken for a number of reasons; the main ones being the unusual difficulties in obtaining seed, the absence of an established market for the timber and the ready markets for Eucalyptus as fuel in up-country areas. Now with the demand for long fibred pulp a ready market for pines is assured. In planting out on a large scale, the species already proven to be successful can be grown in the up-country areas with an eye on the proposed Ambawela Paper Factory. But for long fibred pulp requirements elsewhere, we must come down to the Dry Zone. Here we are on new ground as regards pines.

The F. A. O. study mentioned earlier recommends three species of pines for the Dry Zone. But what are the problems we have to face? The foremost is the difficulty in obtaining the correct provenance or seed suited to our particular planting location. In this connection it should be mentioned that some *Pinus* seeds have relatively short viability and the seed sources are located in the West Indies and Central America. The other major problem is that the nomenclature of *Pinus* species is a little in the melting pot at the moment. For example *Pinus caribaea* one of the species required by us for planting is identified as *Pinus elliottii* in the U. S. mainland and as *Pinus caribaea* in the West Indies and Central America. Due to the wide distribution of this species in its natural surroundings, as recently as 1962 three separate varieties of this species have been recognised, namely *Pinus caribaea*, variety *caribaea* in Cuba, *Pinus caribaea*, variety *bahamensis* in the Bahamas and *Pinus caribaea*, variety *hondurensis* in Central America. However, other taxonomists consider the Honduras variety of *Pinus caribaea* as a separate species called *Pinus hondurensis*.

The original planting of *Pinus caribaea* at Erabedde is now believed to be a mixture of *Pinus elliottii* and *Pinus hondurensis*. Another species found suitable to Ceylon conditions namely *Pinus khasya* is also believed to be a mixture of two other species but not *Pinus khasya* at all. *Pinus insularis* a successfully established species in Ohiya is now believed to be *Pinus khasya*.

These were brought in to illustrate difficulties with which we are faced when attempting to expand into large plantations from seed sources abroad. What now appears to be necessary is to correctly identify all the successful local species and obtain identical strains from overseas seed sources. Till such time local seed trees could produce our requirements. For the reasons already described, getting the identical strain from overseas is well nigh impossible. Hence we will be compelled to carry out further extensive trials, using seeds from foreign sources marketed under names fancied by seed suppliers abroad. These trials may take many years.

Another problem so far not met with, but which could not be disregarded for the future, is whether large scale pine nurseries could be successfully established in the Dry Zone. Most of the Pine planting material raised so far even for Dry Zone trials have been raised in the up-country. Experimentation has to be done to find out whether the same mycorrhizal fungus could successfully infect Dry Zone nurseries.

Very recently trials of *Pinus caribaea* from British Honduras were tried out at Nuwaragama reserve in Anuradhapura, Vakeneri in the Eastern Province, Hunnasgiriya, Kottawa near Galle, Erabedde and Madawelagama. Judging from the results so far, this strain of *Pinus caribaea* appears to be better suited to places other than the Dry Zone. However, unless trials are repeated for a number of years the results will not be conclusive.

Another major hazard pine species would face in the Dry Zone is fire. Teak plantations especially in the Eastern Province are subjected to repeated fires due to the presence of Illuk. These are ground fires sweep through fast, doing relatively little damage except in very young stands. Pine with a resinous thick bark and a carpet of needles covering the floor will be more inflammable than teak, and fire damage will be greater. In order to overcome this, usual method of fire lines and other known measures will have to be adopted at extra cost.

EUCALYPTUS

EUCALYPTUS is a native of Australia with a very large number of species. In Australia it extends from extreme temperate climate of Tasmania in the South to Northern Australia which is almost tropical. Eucalyptus had caught the fascination of travellers due to the aromatic quality of the leaf and its fast growth and had been introduced to a wide range of countries the world over. The country to have done this most successfully is Brazil, where there are 110 species of Eucalyptus covering 2 million acres. The Brazilians, after careful study of the properties of the various species have adopted different species to suit different needs.

The first introduction of Eucalyptus to Ceylon was in 1888. At present there are 28 species on record almost all of which are confined to the up-country. Of these the most successful are *Eucalyptus grandis*,

Eucalyptus microcorys and *Eucalyptus robusta*. Growth rates of these are higher than any other species growing in Ceylon. The annual production of *Eucalyptus grandis* is in the order of 300 cu. feet per acre per annum.

The area under Eucalypts in the up-country is over 12,000 acres. To this, five hundred acres are added each year. The nursery methods, planting methods and other allied operations are sufficiently known to the Department, that planting of extra areas to feed the proposed Ambawela Newsprint Mill is not going to be a major problem.

As in the case of pines mentioned earlier in this talk, *Eucalyptus* species have not been planted on a large scale in the low-country. However, the recent attempts in this direction are quite successful. *Eucalyptus camaldulensis* has been successfully grown in Pallai in the Jaffna peninsula under extremely dry conditions. Unlike in the case of pines, nursery material in this case was raised in Pallai itself. Planting was done in polythene tubes. In a five acre block, the average height at five years is about fifty feet.

The same species and another, *Eucalyptus citriodora*, have been successfully grown without artificial watering in the vicinity of Vakeneri in the Eastern Province. Hence there is no doubt about the suitability of this species to the Dry Zone. With a view to selecting better strains with faster growth, thirty different provenances of the same species have been planted out this year. In addition to the above, further trials will be undertaken using other species recommended by a visiting F. A. O. Forestry Officer.

Hence, I would conclude by mentioning that the *Eucalyptus* presents a far rosier picture than Bamboos and Pines.

The Present and Future Demand for Plywood in Ceylon

By W. G. WEERARATNE

(Chairman, Ceylon Plywoods Corporation)

Advantages of Plywood

PLYWOOD in its simplest form consists of layers of thin wood or veneer firmly glued together with an adhesive. These layers of wood may be rotary cut, i.e. peeled, or they may be sliced. Plywood generally consists of an odd number of layers, 3 ply being the most common.

A characteristic feature of wood is that it has a grain and it absorbs moisture on exposure. When moisture enters wood, it swells, but only across the grain. When the wood dries it shrinks. This is known as "movement" in timber, and different timbers have different degrees of movement. When plywood is manufactured, the thin layers of wood are glued together in such a manner that the grain in one layer is kept at right angles to the grain in the adjacent layer.

This arrangement in plywood neutralises any tendency to shrink and swell in the timber. Hence plywood has a dimensional stability not found in the original wood.

Solid wood has its predominant strength in one direction i.e. along the grain. Wood is intrinsically weak across the grain, and tends to split easily in this direction. In plywood, since the veneers are glued together in alternate grain directions, there is reinforcement of any crosswise weakness rendering plywood stronger than solid wood of the same thickness.

One of the major advantages of plywood over solid wood in commerce is its availability in relatively large sizes. Whilst sawn timber is rarely available in large widths, plywood sheets could be made to unlimited widths depending on the length of the peelers. Hence in the case of plywood the number of joints used in construction are negligible, compared with sawn timber, minimising the attendant dangers in joints such as "opening out" due to poor seasoning.

Thus for a partition, a single length of ply-board 8' x 4' could be conveniently prepared whilst with sawn timber, several pieces will have to be joined together making the operation more costly as well. In the case of wood intended to cover surfaces such as walls, roofs, floors, partitions, crates, etc., plywood is more advantageous than solid timber.

Some of the other advantages of plywood over solid wood are its non-splitting qualities and the favourable strength-weight factor.

In view of the above advantages of plywood, the cheapest and most inferior timbers are used in plywood manufacture, particularly for crates and tea chests. For expensive plywood connected with decorative work, a face veneer of superior quality timber can be given.

The use of wood veneer for artistic work and designs dates back to very ancient times. Classical Greek architecture shows evidence of the skilful use of veneers. Pliny states that the proudest possession of Ceasear was a table beautifully veneered. In the 18th Century, in France a plywood masterpiece was constructed for Louis XV—"Bureau du Roi". Walnut and Mahogany veneer were also used in England and Europe in the early 18th Century.

Plywood, however, came into industrial use during World War I for aircraft manufacture. During World War II, plywood was an acceptable alternative for thin metal. Since then, with advanced techniques in slicing, gluing and drying, plywood has forged ahead replacing solid wood and metal in several industrial fields.

It is today extensively used in aircraft construction, boat and ship building, barrels, cooperage, constructional work (e.g. flooring, boards, doors, partitioning, decorative, panelling) furniture, crates and containers, coachwork, sports goods, musical instruments, surgical splints and a variety of other items.

Until recently, plywood in Ceylon has been utilised solely for the manufacture of tea chests. Today it is, however, used in several other industries, e.g., furniture, sewing machine cabinets, doors, boats, constructional work, etc., and should play a more important role in the future of our wood-working industry.

The Gintota Plywood Factory

The Government Plywood Factory at Gintota was established in 1941 under the Department of Industries. Under the State Industrial Corporations Act of 1957, it was made a Corporation. The primary function of the Plywood Factory is the manufacture of tea chests.

Very limited quantities of multiply boards, flush doors, block boards, table tennis tables, office trays, etc., are also manufactured. The total labour strength of the Factory is 659 with an Executive Staff of 7 and Clerical and Supervisory Staff of 69.

The Island's requirement of tea chests has been estimated at about 4 million. On the basis of 3 per cent annual increase in our tea crop, the projected demand for tea chests in 1970 would be about 4.5 million. Over the last 25 years there has been a slow but steady progress in the manufacture of tea chests at the Plywood Factory, and last year the factory produced about 20 per cent of the total requirements of tea chests of the Island. The balance 80 per cent of the Island's requirements has been imported mainly from Japan, Russia and Sweden. The import figures over the last 5 years and the foreign exchange involved in this importation are given below :—

Year				<i>Value of Imports of plywood veneer and battens for Tea chests Rs.</i>
1960	..	..	..	13,300,000
1961	..	..	..	13,700,000
1962	..	..	..	10,400,000
1963	..	..	..	13,000,000
1964	..	..	..	14,900,000

In view of the large imports of tea chests, an attempt was made recently to launch out on a scheme of expansion to increase production of plywood tea chests. The limiting factors for increasing production hitherto have been insufficiency of equipment for drying veneers, insufficiency of machinery for splicing waste veneer and a certain amount of doubt as to whether the raw material, i.e. timber, was available in adequate quantities.

In about 1955-56 a comprehensive aerial survey of forest resources was undertaken by a team of Canadian forest officers, and it was found that about 30 million cu. ft. of timber of all species are available for annual cut on the basis of sustained yield, from all forests of the Island. 5.7 million cu. ft. of plywood species has been found to be available annually from the Wet Zone forests of Ceylon, situated in the south-western sector of the country.

Hence with a vast timber potential available in the country, any doubt as to the availability of raw material has been eliminated. Suitable drying and splicing machinery have recently been imported and erected at the factory under the first stage of expansion.

The Forest Department has been the chief source of supply of raw material, and in 1962-63, about half a million cu. ft. of timber was supplied to the plywood factory. 1.2 million cu. ft. will be required annually to meet the needs of expansion at Gintota. With the machinery that has already been installed, and the increase in supply of log timber, it is hoped to double the present output at the factory and produce about 40 per cent of the Island's requirements of tea chests at Gintota.

The 2nd Plywood Factory

With the completion of stage I of expansion when it is proposed to meet about 40 per cent of the Island's requirements, saturation point would be reached in respect of expansion at Gintota. Further expansion is not advisable due to limited space for effective machinery installation and the high cost of timber delivered at the factory from distant forests in Sabaragamuwa.

Since further expansion in local tea chest production is imperative to save the large amount of foreign exchange that goes out annually, it is proposed to set up a Second Plywood Factory closer to the point of availability of the raw material, i.e. in Sabaragamuwa or thereabouts, to produce the balance 60 per cent of the Island's requirements and aim at self-sufficiency.

When the plywood factory at Gintota first commenced operations, only about 5 species of timber were used in plywood manufacture. Since then, various species from the tropical wet zone forests have been subjected to tests and today about 25 species of timber have been found to be suitable for plywood manufacture. Unlike the temperate forests, tropical forests have a variety of timbers. The forests of the wet ever-green-type have over a 100 varieties of timber, most of which would be suitable for peeling.

In the last few months, a careful investigation was also made of the use of rubberwood for peeling. The tests carried out so far indicate that rubberwood is eminently suitable for the manufacture of plywood tea chests and

plyboards. With the large quantities of rubberwood that would be annually available under the rubber-replanting scheme, rubberwood has a bright future in plywood production.

Plywood Research

A Quality Control and Research Officer has been appointed recently to the Plywood Factory, and investigations as the one carried out in the case of rubberwood would be a specific function of this officer.

An alarming feature that has received the attention of the Corporation has been the high loss in conversion of logs. It has been found that only about 32 per cent of timber peeled actually goes into utilisable plywood, and the rest is burnt or disposed of locally for fuel. With the recent installation of splicers and a new dryer (and the anticipated use of new peelers to peel logs up to smaller dimensions) a larger percentage outturn of plywood is expected.

At present tea chests are manufactured out of 3 ply, each ply having a thickness of $1/16''$. Certain investigations were carried out recently on the possibility of reducing the size of the individual ply. Plies of $1/32''$ thickness on the outside and inside with the core of $1/16''$ glued together in a particular arrangement has given this 3 ply a very satisfactory strength.

With investigations such as these it should be possible to reduce the total quantity of wood in a tea chest, whilst retaining optimum strength, with a consequent over-all reduction of the annual requirements of timber.

Investigations are also presently being carried out on different types of glues, hardeners, glue spread, etc., with a view to reducing the cost on this item. Research of the type set out above, will receive the highest importance in all future programs of the plywood factory.

Plywood Waste for Chipboard

Since large quantities of waste are available at the factory, a programme has been drawn up to utilise this waste in a more efficient manner. Hitherto, the waste has been used as fuel. In the re-organisation scheme, a proposal has already been approved for the setting up of a chipboard plant. With the installation of this plant, all waste would be converted into "chipboard" which is eminently suitable for the manufacture of furniture. The Chipboard industry, although of recent origin, is one of the bigger wood based industries in the world today.

Almost every country today makes use of wood waste for the manufacture of chipboard which is fast replacing solid wood. With the use of quality veneer over the chipboard or with artificial printing on the chipboard, very superior furniture could be turned out. Today in Europe, hardly any furniture is manufactured out of solid wood. It is proposed to set up a chipboard plant as an adjunct to the plywood factory, turning out about 1,000 cu. ft. of chipboard per day.

The National Small Industries Corporation which uses several millions of rupees worth of sawn timber annually for furniture manufacture could be one of the many consumers of chipboard for furniture manufacture.

World Demand for Plywood

Several countries in the world today are turning out plywood in larger quantities annually. Japan has 236 plywood factories and is one of the biggest manufacturers and exporters of plywood, although the entire plywood industry in Japan is dependent on timber imported from the Philippines.

Taiwan too has recently come into the limelight in the manufacture of plywood. Taiwan is also an importer of timber. Both Japan and Taiwan earn large quantities of foreign exchange from the export of plywood, particularly to the United States. In 1965, Japan exported approximately 3,000 million cu. ft. of plywood, which is about 300 times the total requirement of all varieties of timber in Ceylon. Russia and the Scandinavian countries are also large producers of plywood.

With the increase in world demand for plywood, several requests have been made from the United States and Pakistan for our plywood.

Timbers which have no intrinsic strength cannot be used as solid timber for constructional work. If these timbers could be suitably peeled they could be converted into plywood. Most of the timbers used in Ceylon for plywood manufacture have a very poor durability and strength, e.g., Malaboda. If these timbers do not find their way into plywood manufacture or for chipboard, they would not have any value as sawn timber, or even as firewood.

Synthetic glues for Plywood and Chipboard

The plywood factory at present consumes about a million rupees worth of glue. With the anticipated new factory and the chipboard plants, about 3-4 million rupees worth of glue would be required annually. With the introduction of chipboard for other industrial uses, the private sector too will need large quantities of glue in the future. Whilst there are several types of glue for bonding wood the best glue is the synthetic Urea Formaldehyde.

Several countries today manufacture Urea Formaldehyde to keep their respective wood-working industries going. With the installation of the petroleum refinery and the fertiliser plant in Ceylon, some of the basic raw materials for glues would be available. However, until such time as these projects reach fruition, it would be possible even to import Urea and Formaldehyde and synthesise glues locally. Action is being taken in this direction.

The total anticipated expenditure for the second plywood factory is about Rs. 10 million. This factory together with the expanded existing factory will meet the Island's requirements of tea chests. This will result in a net saving of about Rs. 16 million foreign exchange annually, which is now used in the importation of tea chests.

Timber for House Construction and Furniture

By A. C. CANAGARAJAH

(Walker Sons & Co. Ltd., Colombo)

IT is a paradoxical to commence this paper by saying that we are quite ignorant of the properties of timber available in our forests, hence I cannot present a true picture of timber for house construction and furniture in Ceylon. In most countries of the world, where wood forms part of the natural resources, volumes of literature are available on design, data and the properties of timber so much so that every effort has been made by these countries to use wood as a nucleus in varied industries. All possible attempts have been made by these countries to use every inch of timber that is sawn including saw-dust and chips for various finished products. We, in our country, are still in the primitive stage in that specifications are traditional and are far from being helpful in reducing the costs. Conditions, particularly in respect of foreign exchange, are becoming so difficult that it is time we increased our research facilities and explored our timber resources, both in quality and quantity, with a view to using products particularly in respect of timber in combination with other indigenous materials and changing specifications accordingly. I refer to a change in specification from Burma Teak to Ceylon Teak or Ceylon Plywood, Pineboard shuttering to shuttering with local planks etc.

The research referred to does not necessarily mean finding the properties of all our species of timber but also finding out ways and means of improving the qualities of timber. Here, I pose the following questions to our Forest Department: Why can't Ceylon Teak be relied upon to the same degree as Burma Teak and, if not, how can this be improved and so on. It is known that properties of timber vary with the change of locality and I venture to think that improvements of our timber properties are not impossible in a country like ours where we are fortunate to have all types of climates and soils. Incidence of inherent defects like knots, sloping grain, etc. do considerably influence the strength of wood but it is not economically justifiable to use only defect-free or clean timber for structural purposes particularly as most defects have little effect on stiffness which is frequently the design criterion. Only a small portion of timber is entirely clear and it is desirable to conserve this for purposes of furniture, sporting goods and joinery etc. Instead of specifying that the structural timber should be free of all defects, it is more practicable to accept these defects but to place definite limits as to size and number that will be permitted, to base working stresses on the strength of the piece of minimum acceptable quality. The usual standard specification in Ceylon is as follows: "Timbers to the best of their respective kind; all timbers used to be thoroughly dry, free from sap shake etc." These specifications are incapable of fulfilment and therefore meaningless. Even in this regard, these specifications have to be changed. In order to change same, we have to establish standards of our own and specifications drawn based on standards which permit certain amount of defects. This has been adopted in other countries.

Selection of Timber species for House Construction

Selection of species to be used is not simply a matter of specifying the strongest and most durable timber, as such practice would be both expensive and detrimental to the national economy. On the contrary, it is desirable to strike a balance between relative merits of various species judged from the mechanical and physical properties, durability, availability and price. Availability should be a determining factor in the choice. If suitable timber can be obtained locally, it is obviously undesirable to specify timbers that require transport from distant places. In this regard as an example, I recommend the use of coconut and palmyrah rafters for roof construction as against the Class I or Class II roof timber rafters. It is a well known fact that if Palmyrah or coconut rafters are permitted in the specification, the cost of the roof framework will be brought down by about 40 per cent—50 per cent in places where palmyrah or coconut are in plenty when compared with the modern type of roof with hardwood Class I and Class II rafters. Possibly some sort of treatment has to be carried out for coconut rafters to make it more durable but as the cost of this treatment is of the order of 10 per cent such treated material will still compare favourably with the price of hardwood Class I and Class II timber rafters. I would like to digress here to the treatment of timbers and although this is not my subject, I would like to mention that the cost of preservative treatment of such timbers could be largely compensated for by the ready availability of timber and the relative cheapness of the timber compared with the naturally more durable species. The only snag in this regard is that very few stations are available for such treatment and some action must be taken by the Government or private firms to open up more facilities for preservative treatment of timber all over the country so as to keep down the cost of transport to a minimum. As an alternative, if Government departments and Corporations could specify preservation of timber for the non-durable species, the private sector would be encouraged to open up more and more places and facilities for this type of treatment.

Design of Timber

It is not my intention here to touch on the design of timber as books are available in plenty giving indications of the design formulae etc., but accurate designs are not possible without the knowledge of the properties of all available timber in Ceylon.

Standardisation

The most important factor that could bring down the cost of timber in house construction and furniture is standardisation. I am glad that the Government is taking steps for standardisation but this has to be carried out in two respects; one standardisation in respect of the type of timber to be used which I have already dealt with earlier and the other dimensional standardisation. I do not wish to elaborate on how dimensional standardisation should be carried out as experts, I understand, are going into this question but I would recommend that in deciding the sections of timber to be produced, consideration be given to the sawing of $1\frac{1}{2}'' \times 1\frac{1}{2}''$, $2'' \times 1\frac{1}{2}''$, $2\frac{1}{2}'' \times 1\frac{1}{2}''$ and $3'' \times 1\frac{1}{2}''$ sections in preference to the $2'' \times 2''$ and $3'' \times 2''$ as I feel these sections are more economical for use in the building industry as structural timbers. Along with the standardisation of sections, we should also standardise the sizes of doors and windows so that the barest minimum wood is used in the manufacture of same and also that the number of standard sizes of doors and windows are kept to a minimum. In this instance, I would recommend to the Committee the adoption of the sizes of doors and

windows on the same lines as that being adopted by the metal door and window manufacturers. The interesting point to note in this regard is that various sizes of doors and windows can be made up at the site using the basic sizes of metal doors and windows produced by the factory.

Further, if even the room sizes can be standardised to some extent so that the whole house is designed on basic unit dimension, it would be possible even to standardise on the lengths of rafters and reapers which could automatically bring down the cost of timber used on roof and ceiling. It may sound silly that the Government should step in and standardise even the houses but the ordinary man who just cannot afford, under normal circumstances, to build a house would be prepared to build his house to some basic unit dimensions if he is made aware that the cost of the house to be built would be reduced considerably.

Standardisation has many advantages and the following are some of them :

- (1) Reduction in the cost of production of the initial timber.
- (2) Reduction in wastage of timber.
- (3) Reduction in the cost of labour in the manufacture of doors and windows in that the private sector or the village carpenter could open up shops where they could manufacture standard doors and windows using jogs to save on labour and be sure that there is a ready market for same. Today one is unable to obtain a carpenter in the village and be certain that the work would be completed within a certain period of time purely because the carpenter is not prepared to satisfy himself with the work given him by one individual and he goes round asking for work from every possible individual so that he is sure of his employment. In this process he tends to neglect the works he has undertaken and thereby the work on house construction is delayed. This is a human problem and the only way it can be solved is by standardisation of doors and windows. Then the carpenter can be at his work bench instead of wasting half his time in search of employment, and produce standard doors and windows and be sure of the sale of same.
- (4) It helps pre-fabrication and the private sector would be encouraged to manufacture pre-fabricated houses and the requirements of the normal house owner would automatically get confined to certain basic dimensions based on standardisation.
- (5) It helps the ordinary layman to erect his house without much skill i.e. it provides "Do It Yourself" service. This indirectly or otherwise brings down the cost of the entire house.

Time does not permit me to give you a basic analysis how cost could be reduced but, in passing, I would mention one incident when I had to pay at the rate of Rs. 2.25 per sq. ft. for $1\frac{1}{4}$ " plank in a certain village for our contract whilst 1" plank was being sold at the same village at Re. 1 per sq. ft. This was because 1" plank was a standardised commodity whilst $1\frac{1}{4}$ " was not.

Cost Analysis

The cost of an average house of about 1000 sq. ft. with ceiling for bed rooms is about Rs. 25 per sq. ft. excluding drainage, water service and electricity, of which Rs. 6.50 per sq. ft. forms carpentry and joinery works which includes roof, ceiling framework and doors and windows. Should standardisation be adopted on the lines suggested above, it is the writer's opinion that this Rs. 6.50 per sq. ft. could be brought down to about Rs. 4.50 per sq. ft. thus bringing down the cost of timber work by 33 per cent.

Pre-fabrication

Prefabrication is resorted to mainly because of the urgency of the requirement and also for better control of the construction. Timber, to some extent can be exploited for prefabrication methods in house construction. In this regard, I think in terms of plywood, hardboard and chipboard industries, and it is my humble opinion that to start with plywood if dimensional standardisation is adopted in respect of houses, it will be possible for the above industrial concerns to manufacture panels incorporating doors and windows which need not necessarily be load bearing and this would definitely help in expediting the construction and also improving the aesthetic quality of the building. Based on the present prices of plywood doors manufactured by the Plywood Corporation and giving due consideration for mass production, I think the above panels should not cost more than Rs. 4 to Rs. 4.50 per sq. ft. in its fixed position. This should definitely compare favourably with panels in brick and cement incorporating doors and windows.

Roofing

Our age old system of roof material is the tile, and with the advent of asbestos sheets, tiles are becoming more and more out of the date and asbestos sheets are becoming more and more popular. The main reasons for this are as follows :—

- (1) The timber used on the roof with asbestos covering is less than the timber used on tile covering, and hence the cost of roofing as a whole is cheaper in the case of asbestos sheet roofing.
- (2) Asbestos is thought to be better material for protection against rain compared with tiles.
- (3) Asbestos permits shallower roofs than the tiles thereby making the house aesthetically more modern and more pleasing to architects.

Although it is not relevant to this subject, I begin to wonder why Government should encourage the expansion of the asbestos sheet manufacturing industries particularly in the light of the country's present position in regard to foreign exchange, when tiles for roofing and timber for ceiling which are indigenous materials, could be comfortably used in our houses and other buildings. The only thing that the Government should do is to explore the possibility of manufacturing tiles so as to overcome as far as possible the so-called defects mentioned above.

The saving in cost of timber framework covering in asbestos as compared with that for tile covering is sometimes as much as 55 per cent. It is possible to reduce the timber framework for tiles by about 8 per cent if the rafters could be spaced at 4'—0" centres with 2" × 1' reepers (presently not standard). The rafter-reeper system of timber framework for asbestos roofing is about 15 per cent more than the purlin system of timber framework. This is based on the use of 2" × 1½" 'reeper' spanning 4' 0". I am using the word 'reeper' for sections which span across the rafters. The rafter-reeper system for asbestos roofing still makes the timber work more expensive than the usual purlin system. I am inclined to advocate this system for stability and as it permits ceiling boards to be fixed to the underside of the rafters yet allowing the free passage of air making the house cooler.

If ceiling boards are to be fixed to the underside of the purlins the free passage of air between the roofing and ceiling sheets is impaired thus making the house warmer than in the earlier case.

Roofing framework still follows the age old traditional system but could be reduced considerably if some thought is given to the design feature of the frame.

Timber Roof Trusses

In the past timber roof trusses have been clumsy in design because of the lack of accurate structural analysis and also because of the difficulty of producing efficient joints between members. Now with the introduction of laminated roof trusses, it has become possible to reduce on the timber used in the trusses making the truss lighter and easy for erection by non craftsmen. The connections used for trusses in Europe and America are bolts and split ring connectors since the timber available is generally softwood and has little shrinkage. In our country, hardwood which has higher shrinkage, necessitates the use of smaller fixing units to allow the timber to shrink without splitting. Nails or steel rivets would satisfy the requirement. It is essential for economy that buildings to be roofed with trusses should be basically rectangular in plan with gable. The cost of timber laminated trusses using known species of timber, not necessarily the cheap quality, and assuming that modular *standardisation* would soon be achieved, the timber laminated trusses would cost about 40 per cent. less than the corresponding steel trusses.

Ceiling

It is my view that sloping ceiling is not only economical but it makes it possible for timber planks to be used as ceiling boards as against the asbestos sheets which is completely a foreign component to Ceylon. Even here, the use of timber boards or plywood must be encouraged as ceiling material as against the asbestos sheets so as to conserve foreign exchange. Ordinary local $\frac{1}{2}$ " thick treated planks with architectural grooving makes the ceiling aesthetically more pleasant than asbestos. In regard to cost, the sloping ceiling with $\frac{1}{2}$ " thick treated or grooved planks compare favourably with flat asbestos ceiling.

Doors and Windows

The cost of glazed doors and windows can be reduced by 40 per cent. as stated earlier by standardisation alone. Further reduction of timber of about 10 per cent. can be brought about by the economic use of timber in sashes. For example instead of using $3" \times 1"$ stiles and rails in the window sashes one could use with added advantage of strength $1\frac{1}{2}" \times 1\frac{1}{2}"$ stiles and rails. A further reduction in cost of the timber could be achieved by reducing the sizes of the frames to the barest minimum and if necessary to nil. The hinges could be fixed by rawl plug etc. to the wall itself. A beading say $1" \times 1"$ may have to be fixed round the opening to cover up the space if any between the door sash and opening in wall and also to give a better look to the door. If this method can be adopted in other countries like U. K. why not in Ceylon. If non glazed window sashes are required the only suggestion I could make other than the reduction of timber frame size to minimum or nil is to adopt standard

sashes in plywood. One can readily see the saving in cost in the use of sashes of plywood for doors as manufactured by the Plywood Corporation. Door sash in plywood without furniture costs Rs. 3 to Rs. 4 per sq. ft. as compared with Rs. 8 to Rs. 10 for flush panelled door sashes.

Form-work

To compensate for the high cost of land in cities and for other various reasons multi-storeyed flats are becoming more and more popular. In these, construction form work play a vital role. Some comparative costs of form work and concrete of various structure units that form the multi-storeyed flats are given below but the percentage will of course vary with the complexity of the design and the number of uses obtainable.

Columns or stanchion casings	..	Concrete 40 per cent. Formwork 60 per cent.
Columns or stanchion (circular)	..	Concrete 30 per cent. Formwork 70 per cent.
Beams or Beam casings	..	Concrete 40 per cent. Formwork 60 per cent.
Suspended roof slabs 4½ in. thick with strutting 10 ft. high	..	Concrete 50 per cent. Formwork 50 per cent.
Staircase	..	Concrete 45 per cent. Formwork 55 per cent.
3 in. shell roof	..	Concrete 33 per cent. Formwork 67 per cent.

It is reasonable to conclude that for most structures any economies in production and use of formwork are clearly just as important if not more important than economies in structure itself. In this respect it has been found that in some cases it is more economical for all the columns throughout the building to be of similar dimensions. In a similar way, it may be cheaper to construct a building with flat slab floors of constant thickness throughout although more concrete may be used in the ordinary beam and slab floor.

In regard to timber for such framework we still find that Government departments specify the use of pineboard and are insisting on the use of same whilst there are several species of timber available in Ceylon unexplored which can be used economically for shutterings. It may be argued that this timber cannot give the finish that the pineboard could give or that this timber cannot be put to the same number of uses as pineboard but yet cost wise I can say from experience that local timber, if properly used, could be made more economical than the pineboard. Recently, the foreign contractors who had built some of the largest buildings in Ceylon and who could have used pineboard with ease particularly as this is manufactured in their own country, used as far as possible, local timber for shuttering. This was done by them not because they were anxious to reduce foreign exchange but because they were quite sure that this was more economical.

I am glad to say that we in Walkers have already begun to use local timber as much as possible and most of our tenders are based on the use of local timber. In this instance, I refer to the shuttering used by the ancient house builder for the production of concrete roofs and it is interesting to note that they used Palmyrah or coconut stumps cut into two to serve both as shuttering timbers and bearers with the curved surface

facing downwards and the flat surface facing upwards. Using clayish sand they formed the shape of the underside of the roof or ffoot and provided a rendering of a very weak mix to prevent concrete mixing with clay when being poured. In fact, they took an added precaution of laying the requisite plaster for the underside of the roof over this weak rendering before the concrete was laid so that once the shuttering was knocked down, there was hardly any work required for the underside of the roof or the floor. The average man who bought this timber then used it as firewood for his house work, so much so that he did not spend any money on the cost of the shuttering used on the works except the labour involved. Even in regard to labour he saved considerably as he did not require specialists to knock his shuttering or form work.

Finally on the shuttering too standardisation in terms of beam sizes etc. makes it possible for shuttering cost to be brought down to reasonable levels. It would also be possible for the shop owner to keep a certain size of shuttering ready-made for hire, to hire out along with other materials for house building etc.

As a matter of fact, the sizes of the rooms are generally dictated by the astrologers of the village who fortunately or otherwise have in general one plan but shift the doors and windows and location to be constructed in accordance with the findings of astrology. Fortunately, this gives rise to standardisation and a villager is able to obtain the shuttering at a very cheap cost and the ordinary carpenter is able to have planks ready-made of a certain size and is able to fix and remove same at a very much reduced cost e.g. the labour cost for a villager for laying 4in. concrete with B. R. C. fabric and supplying, fixing and removing the shuttering is roughly between 50 to 60 cents, per sq. ft. whilst the labour cost alone for non standard structures is of the same magnitude.

Furniture

Although I am not an authority on furniture making, it is appropriate that the subject should be included and I would make the following suggestions as I feel that the present customs and traditions are luxuries which this country cannot afford.

Getting down to furniture, it is well known that the bulk of it is custom built to suit fancy furniture or the particular fad of the individual, and in this regard, I would say that the ladies are the biggest offenders who have to be acquainted with the shortage and quality of timber in this country, and that the balance must be held between utility and individual taste. In the present trade, it is customary to use timber sawn off logs. But the time has come or may be shortly reached, when it would not be possible to do so due to the shortage of traditionally known good furniture making timber. The answer would be to use plywood. Also, in my opinion, it will be necessary with the purpose of achieving economic use of timber for furniture construction and reducing cost that the Government should promote the scheme both in the public and private sector for standardised utility furniture. This would eliminate the requirements of kiln drying wood for furniture as all panel top boards etc. would be in plywood. I would also suggest and recommend very strongly the design in production of "Do It Yourself" kits as done in other countries. This would be a boon to the lower income groups, to the manufacturing trade and would at the same time reduce the very exorbitant cost of production of furniture.

Manufacture of chipboard and floor board should considerably relieve the requirements of timber in furniture making and these materials with the use of elementary tools will enable the ordinary layman to knock up any standard furniture that perhaps would be required in any household.

Conclusion

In conclusion, I might say that the purpose of this paper will not be served if I have not made you realise the importance of the Plywood, chipboard and other similar timber industries in relation to house and furniture construction and the necessity of establishing or encouraging more wood treatment centres in the Island including kiln drying. In addition, I would once again stress the urgency of the implementation of methods for standardisation.

The role of Seasoning and Preservation in the Utilization of Timber

By A. E. K. TISSEVERASINGHE

(Forest Department)

Some of the things that exasperate a normal user of timber are its warping and shrinkage during seasoning, its movement after seasoning, its wide variation in durability and generally its unpredictability in service. This is in sharp contrast to other building materials which generally have uniform, well defined and predictable properties. Thus the use of timber is often a source of annoyance to the Engineer's orderly mind and there is, therefore a tendency to replace timber with steel and concrete instead. Fortunately perhaps, for Ceylon, our economic situation does not permit us to discard timber as a building material and Engineers thus have to make do with a perverse material which, if they had their way, would be entirely done away with.

In this country we have two problems to contend with. We have not only the inherent variability of properties within a particular species of timber but also the great variation between species. In temperate countries the species of timber available are comparatively few and a measure of standardisation is possible to guide the user. In Ceylon, there are hundreds of species and our problems are proportionately much greater.

In the past, users of timber did not face up to this problem; instead, they restricted themselves to a few known varieties such as Jak, Teak or Halmilla, left ample margin of safety and thus insured themselves against any failure in the timber. Today the position is very different. These select varieties of timber are either not available in sufficient quantities or a high price puts them out of reach of the average buyer. We are thus forced to use species which would have been rejected out of hand twenty years ago.

The qualities which are required in a building timber are firstly, that the timber should have certain minimum strength properties, secondly, that it should be reasonably durable in service and thirdly that it should not warp or shrink more than the permissible amount for the particular class of work. The specifications are thus not very strict and quite a large number of timbers will satisfy these conditions. Different qualities are required of timber for different purposes and a variety of timbers suitable for any one purpose can always be found. However, it is the duty of the user to treat timber in such a way that he can get the best out of it. It is illogical to say the least, to use unseasoned Ceylon Teak for cabinet work and then complain that it shrinks more than Burma Teak which reaches us in a seasoned condition. Burma Teak will also shrink if used unseasoned.

It is not generally appreciated that the user of timber has a certain amount of control over its behaviour. What is required is to learn something about the behaviour of timber and apply this knowledge when using it. Other building materials are more uniform and hence much more is known about their behaviour. Every builder for instance knows that concrete must be poured as soon as it is mixed, but few know that damage can be caused to timber by dumping it in ill-assorted heaps on a building site while building goes on.

The first aspect of timber handling I will deal with is seasoning. Basically, this is a very simple business. Seasoning only means a slow and even drying of the timber until it reaches a moisture content which will be in equilibrium with the atmosphere. To achieve this result certain steps have to be taken. Before I go on to this it will be necessary to say something about moisture content. Moisture content is of course the quantity of water in wood but it is expressed in per cent. weight of water per unit weight of oven dry wood. Thus moisture content can be much in excess of 100 per cent. Freshly felled logs in the Wet Zone often have moisture contents of more than 100 per cent. Now this water is found in the wood in two forms, one form is the free water contained within the wood cells and the other is the water bound in the walls of the wood cells. Before I proceed any further I would ask you to picture a log of wood as a bundle of tubes with absorbent walls glued together. A scantling sawn from a log of wood would have the same structure. No shrinkage (and thus no warping) will take place when the free water i.e. the water within the tubes dries out. It is only when water bound in the walls begins to evaporate that shrinkage commences. The point at which all the free water has dried out and only bound water remains is called the fibre saturation point, and is generally about 30 per cent. It is from this point onwards that shrinkage begins. Thus drying timber down to fibre saturation point only, except as a prelude to subsequent drying, serves no purpose at all. Timber before use must be evenly dried down to a point when it neither absorbs moisture from the atmosphere in which it is placed nor gives up moisture. Once this is done the timber is relatively stable.

I must stress here the word *evenly*. If drying were all that is required it would be very easy to season timber by subjecting it to high temperature or low humidity. But if this is done the timber will dry unevenly. Even-drying results only in shrinkage, but uneven drying will result in warping and cracking. Timber will also warp if uneven stresses are imposed on it during the drying period. This happens when green timber is used for roof work.

It is therefore essential to control the drying process.

Besides reducing the tendency to shrink and warp the drying of timber increases its strength and reduces its propensity to attack by destructive agencies, such as insects and fungi. Most living organisms need moisture to sustain life and hence cannot survive on dry wood although there are a few exceptions to this rule.

Thus it will be seen that by proper seasoning, shrinkage and warping in service are reduced, strength properties are improved and durability is prolonged. These are the three qualities which are required for building timber. Not everybody is aware that so much control can be exercised over the qualities of timber.

There are two main methods of seasoning timber, air seasoning and kiln seasoning. In air seasoning, the timber to be seasoned is stacked on a raised platform; the individual rows of scantlings or planks being separated by transverse lengths of timber of small cross sections known as stickers. The thickness of these stickers and their distance apart vary with the initial moisture of the timber, the species to be seasoned and the thickness of the timber to be seasoned. The aim is to allow free circulation of air within the stack. The stack is of course, kept under cover and is usually weighted down at the top.

Control cannot be exercised in air seasoning because neither temperature nor atmospheric humidity can be changed. Only the rate of movement of air through the stack can be controlled to some extent by varying the thickness of the stickers. Accordingly air seasoning is a slow process and may take several months.

In kiln seasoning on the other hand all the factors leading to drying of timber are under control i.e. temperature, humidity and the rate of movement of air. Accordingly the seasoning process can be considerably hastened. Timber that might take six months to air season may be kiln-seasoned in two weeks. A further advantage is that with kiln seasoning, the moisture content of the timber can be brought down below the point at which it is in equilibrium with the atmosphere. The timber will thus swell slightly in service instead of shrinking, thus making for tighter joints. There are other advantages in seasoning to a low moisture content which it is not necessary to go into now.

The advantage of being able to control the seasoning process in a Kiln carries with it certain risks. Too high a temperature or too low a humidity or a combination of the two can produce conditions within the kiln that lead to excessive and uneven drying and serious warping and splitting or collapse can occur. Experimental kiln runs, therefore, have to be done with each species so to determine the optimum conditions i.e. the quickest possible rate of seasoning without adversely affecting the timber. The process of seasoning has to be continuously watched and test pieces removed from the kiln and examined at intervals.

One thing that should be remembered with all seasoned timber, and this particularly applies to kiln-seasoned timber, is that the timber should be stored under conditions resembling the final service conditions i.e. the timber should not be allowed to re-absorb moisture to an extent greater than the equilibrium moisture content which it is likely to have in service. Generally it means that all seasoned timber should be closed-stacked (i.e. without stickers) under cover.

Two points about the behaviour of timber during drying will be of special interest to furniture makers. One is that timber does not shrink equally on the radial and tangential planes. Most of you will be aware that timber can be sawn in two different ways—one is where the width of most of the planks is more or less along the radius, this is called quarter sawing, while the other is where the width of most of the planks is at right angles to the radius (flat or slash sawing). Shrinkage along the tangential plane is higher than shrinkage along the radial plane (the value is usually about double). Thus in a quarter sawn plank the shrinkage is least along its width and greatest along its thickness. In a slash sawn plank the shrinkage is greatest along its width and thus if such planks are joined together in a piece of furniture, the extent of opening of the joints will be double that of joints made with quarter sawn planks. Often quarter sawn planks have a much more beautiful figure than slash sawn planks.

I would like to mention here an example where seasoning alone helped to solve a major problem. Some years ago the Forest Department was requested by the Commissioner of Cottage Industries, the Marketing Commissioner and curio manufacturers to investigate a problem which they were facing i.e. the splitting of ebony and satin elephants when they were exported to Europe and America. The Department carried out an experiment in collaboration with a leading curio manufacturer. Ebony and

Satin logs were quarter sawn into 2in. planks and seasoned in a kiln to the moisture content which was likely to be the equilibrium moisture content in temperate countries. The curio manufacturer sent craftsman to carve elephants from this material and some 300 elephants were sent to embassies in Tokyo, Rome, London and Washington with a request that they be returned after one year for observation. After one or two years the elephants were returned to the Forest Department and not a single elephant was found to be cracked. Unfortunately one Ambassador returned only some of the elephants stating that he had given the rest as gifts to important people, but it was safe to conclude that seasoning alone to a low moisture content was sufficient to insure against cracking.

The other aspect of timber drying which is important is what is called 'movement'. So far, I have been treating the relative humidity of the atmosphere as if it were constant figure in any one situation. Everybody knows, however, that this is not true. There are some days when the air is moister or dryer than other days and the moisture content of seasoned wood will reflect these changes. The changes in moisture content leading to shrinkage or swelling in response to changes in atmospheric humidity, may be very small or may be large depending on the species of timber. This is what is referred to as 'movement'. There is only one quality in which Teak surpasses all other timbers—its capacity for movement is less than that of any other species of timber. There are timbers which are harder than Teak, others which are more durable and and so on but no other timber is as stable as Teak.

I think enough has been said about seasoning to show its importance in building construction and furniture manufacture.

Wood preservation is a much more facinating subject. Historically it was known a very long time ago. Probably the first means of wood preservation used was charring. This had two effects—firstly, a thick shell of material would have been formed over the timber, which, being only charcoal, was immune to attack by insects or fungi and secondly, charring would release a certain amount of creosote and wood tar which would serve to protect the uncharred wood from decay. The ancient Egyptians used bitumen to preserve their coffins and wood tar was used to paint the boat used by Erik the Red on his voyage to America in the 11th century. Much later, inorganic chemicals such as mercuric chloride, copper sulphate and so on began to be used.

Prior to the middle of the last century treatment of timber was only by brushing with, or dipping in, preservatives. Treatment of timber received a great impetus from the building of railways which needed sleepers and the development of telegraphy and electricity which needed large numbers of wooden poles. It is interesting to note that in Ceylon, the Forest Department preservation plant was, and is, almost exclusively occupied with treating sleepers and poles. However, in the future, the use of treated timber for building purposes is likely to become more and more important with the growing shortage of naturally durable timber. Since I have been so far dealing with the difficulties in using timber, some might wonder why we should go to all the trouble of treating non-durable timber instead of using a substitute. For the record let me enumerate the advantages of timber.

Firstly, it is readily available. Before those of you who have had experience of buying timber at Forest Department depots begin to laugh, let me say that I am speaking generally of all timber, not of any particular

species or size which may be required by a consumer. Timber is strong, it is a non-conductor of electricity, it has sound absorption properties, it is resilient, it is comparatively cheap and can be salvaged and re-used, it has low weight, low thermal conductivity, it is easily worked and last but not least it is aesthetically pleasing. Despite its undesirable qualities, therefore, timber will continue to be used for building and furniture and it is up to us to devise ways and means of countering its natural disadvantages and making the best use of its natural advantages. Among species of timber there are great variations in durability and those at the perishable end of the scale cannot be used without some kind of treatment to render them more durable. Also in conditions of high decay hazard, all timber should be treated.

It should be stated at the outset that properly treated timber is more durable than the most naturally durable timber. I am drawing the particular attention of builders to this because of their extreme conservatism in using timber. For door frames for instance, nothing but Milla will do, and for roof work, only a small number of select species are preferred. In the case of roof timber, this conservatism is naturally because roof timbers are usually not visible thus preventing a person from counteracting incipient decay, and because the consequences of roof failing are disastrous. For door and window frames however. I have not yet been able to find a satisfactory reason for the almost exclusive use of Milla. One outstanding quality of Milla is its durability in the ground, and hence the preference for Milla for fence posts. But door frames or window frames are not buried in the ground and in any case a treated fence post will last longer than a Milla fence post. Milla has other undesirable qualities which should militate against its use as a door or window frame, for instance it tends to crack and has poor dimensional stability. Yet, it is always in demand for door and window frames. One hopes that when treated building timber from the Forest Department plant comes into the market this craze for Milla will disappear.

The only really effective methods of treatment of wood are the diffusion process (which is confined to green wood), the hot and cold bath process and pressure impregnation. I will not say anything more about the diffusion process because it is not used in Ceylon as yet, although provision for diffusion plants has been made in the Forest Department's 5-Year Development Plan. The hot and cold bath treatment is quite effective. It is rather wasteful of preservative but capital costs are low. Essentially it amounts to heating timber in a bath of preservative and then either allowing it to cool in the preservative or transferring it to a bath of cold preservative. The bath can be heated over an open fire if adequate precautions are taken. Commercially, the Forest Department uses only the pressure impregnation process.

The different types of preservatives used can be broadly classified into three types:

1. The oily type such as creosote.
2. The solvent soluble type such as pentachlorophenol and,
3. The water soluble type.

I will not deal with the creosote type because it is mainly used for railway sleepers and poles. Creosote has an unpleasant smell and it tends to creep, hence it is not an ideal preservative for use in buildings.

The solvent type has not generally been used in Ceylon although it has some advantages over creosote.

The water-soluble type can be divided into two groups—those which remain soluble in the treated wood and those which fix themselves in the wood by forming insoluble salts.

The first type has not been used in Ceylon except experimentally. They are suitable for building timber or furniture but because the preservative can be leached out of the wood such timber cannot be used in the open. The fixed type has been used in Ceylon many years ago by the Electrical Department for the treatment of poles, more recently by Setrac (Ceylon) Ltd., for the treatment of poles, fence posts and building timber and this year by the Forest Department which has established a plant at Ratmalana for the treatment of building timber.

The treatment at Setrac (Ceylon) Ltd., with Tanalith 'C' is carried out under the close technical supervision of a firm in England which supplies the preservative. In the plant run by the Forest Department the treatment will be in accordance with internationally acceptable standards. I cannot speak of Setrac's treatment any more but builders who use treated timber from the Forest Department can be quite confident that the roof will not fall on the heads of the occupants of the house.

A word of caution is however necessary here. As with every other commodity, treated timber also has a small list of do's and don'ts. Even with pressure impregnation it is not often that the preservative penetrates right through the timber. This is also not necessary, because if there is a well treated shell, this will be adequate protection for the core which has escaped penetration by preservatives. This of course means that the untreated core should not be subsequently exposed by fashioning process. As far as possible all fashioning should be done before treatment. This is however not always possible and then certain precautions will have to be taken. A fashioning process that exposes the end grain of the untreated core is not very serious because a preservative can be brushed over and this readily penetrates a reasonable distance along the end grain. If the sides of the core are exposed however, it is not easy to ensure penetration into the core and there would be some risk in using it. All exposed surfaces should be brushed over, preferably with an oily type preservative, because these have a tendency to creep and thus achieve a little more penetration than a soluble type. Usually, however, the side grain is exposed for purposes of jointing and if an oily type preservative is liberally brushed over on both sides of the joint, protection should be adequate.

In the case of furniture timber, protection by preservative treatment is generally not necessary because the timber will be used in conditions that are not favourable to decay. I must mention here that at a certain meeting which I attended, it was intended to persuade the Education Department to use a wider range of species for school furniture, rather than the 5 or 6 species which they were confining themselves to up to that time, and the Education Department representative insisted that they should use only very durable timber because the roofs of school buildings were generally leaky!

I am afraid I have concentrated more on the background to, and the technical details of, seasoning and preservative treatment, rather than on their direct impact on the building trade and furniture industry. My only excuse is that it is difficult to discuss the role of seasoning and preservation without this background knowledge. Perhaps, several of you already have this knowledge and have been bored by this paper but I hope it will stimulate discussion.

Export of Timber

(Talk by M. Namasivayam, Conservator of Forests)

Export of timber from Ceylon started very early during the period of the Portuguese regime in Ceylon. At that time spices such as Cinnamon and timber (mainly Satin and Ebony) were exported to European markets. Ceylon became quite famous for these two items of export.

Recently, however, the urgency to find an export market for Ceylon timber has become more aggravated—the reason is that the agricultural products on which the economy is based like tea, rubber and coconut have fallen in prices in the world market. Two thirds of our foreign exchange is derived from export of tea. Recent trends in the tea industry have caused the country much concern. It is, therefore, vital that other indigenous commodities should be offered for sale and markets found in order to obtain the scarce foreign exchange which in its turn buys both the food and machinery required by the people of this country.

Record of sales of Satin through the Forest Department exists only from 1888. In that year, 4359 logs of Satin, 1475 logs of Na (iron wood) 349 logs of Halmilla and 12,000 cwts. of Ebony were exported from Ceylon. This goes to show that a flourishing market existed for this timber at the time and this should have been actively developed over the last so many years. However, in respect of Satin there have been severe fluctuations both in demand and price. Satin timber is generally in high demand because of its flowered and streaky texture. It is probably one of the most unique timbers which can be used for internal and other decorative purposes. Severe fluctuations in prices had indicated that there is a very specialized market for this timber. It is obvious that the trends in the manufacture of furniture, panelling and other indoor decorative work are subject to the dictates of fashion in as much as, I would say, the designs of clothes. In 1954 the total of 11,000 cu.ft. of Satin and Ebony valued at approximately Rs. 203,000 were auctioned by the Forest Department for export. We then experienced a gradual decline till sales came to a complete halt in 1962. One of the serious drawbacks in the export of a specialized commodity is that it should always be of the highest quality. It is very likely that the lowering in quality of Satin which had been exported from 1954-1962 was mainly responsible for the decline in the market. However, sales were renewed in 1964 and it is heartening to note that there has been a steady improvement in the demand for flowered and streaked Satin and Ebony from U. K., Japan, U. S. A., Germany and France.

I am not aware of other reasons which may be existing for these fluctuations in the world prices of Satin and I hope that in the discussion that will follow the representatives of export firms who are here today will give us some indication of the reasons for such fluctuations. The export of timber is in my opinion a matter which should be to a large extent sponsored by the private sector. The Government, in its turn can only seek out ways and means of popularizing Ceylon products through Embassies, Trade Fairs and similar institutions. However, it is the private sector that must seek out and contact buyers from abroad who may be interested in the import of timber from Ceylon. Satin is not used in its solid form. Thin veneers are sliced out from a log and these veneers are glued on to inferior timber in order to give a decorative effect on the finished product for either furniture or panelling. For this reason logs which are purchased for export must always be straight, sound and and free of defects such as knots and decay.

Although Ebony is a timber which has a world market the Forest Department has recently found great difficulty in supplying this timber to the local curio trade for the manufacture of elephants and other ornaments for which this country is famous. The Department has tried to propagate the use of timbers like Palu which are equally good for manufacture of curios. There are several other hard woods such as even Satin which can be easily used for this purpose. Diversification of the species used in the curio trade is also very essential particularly if the tourist industry becomes a reality in the near future.

I believe that severe competition from African hardwoods is one of the reasons why Ceylon timber sometimes drop in price. The proximity of African territories to the U K. and continental markets is another factor which affects the export of timber from Ceylon.

What of the future? Are we going to be content with exporting Satin only and allow ourselves to be subject to the vagaries of the world market for this specialized timber? I think that the export of quality timber such as Mahogany has a tremendous future. I have already referred to this aspect earlier in my introductory talk. Honduras Mahogany which is commonly referred to as the Broad Leaf Mahogany grows in profusion once it is propagated particularly in the Wet and Intermediate Zones of Ceylon. We have very fortunately introduced this species as a ground cover to support Jak plantations which had been planted from 1920 onwards. The original purpose of planting Mahogany was to give soil cover to the Jak which is an extreme light demander. During the last 30 years it has been conclusively proved to us that Jak does not thrive to the extent that it normally does in a village garden. The reason is that it wants plenty of room for crown development and therefore it was a failure as a plantation crop. The Mahogany which had started to regenerate itself naturally solved the problem of replanting. 12,000 acres of Jak-Mahogany and 20,000 acres of natural forest plantations are now found in the North Western Division and these will ultimately become pure Mahogany plantations. These plantations are in very close proximity to Colombo and a beginning should be made immediately to export small quantities of this timber to foreign markets. A member of the furniture trade of the U. K. met me in Office about 2 months ago and he informed me he will be prepared to purchase Mahogany sawn into graded lin. boards at Rs. 2.50 a board foot loaded into ships in Colombo. On the basis of an approximate calculation I made for supplies from a plantation which is approximately 60 miles from Colombo and is more or less along the main road it appears that the CIF value could be kept down to a third of the price which was quoted to me. It is obvious that importers of timber to U. K. and European countries will be extremely interested in this timber. Mahogany in this plantation can be made available continuously for the reason given earlier and I would invite the exporters who are here today to consider this matter very seriously and make early contact with their principals.

Similarly, I would say that the Dry Zone hard woods like Hulanhik and even Wet Zone timber like Kiriembiliya have a very pleasing texture and figure for internal decorative work and export markets can also be found for these as in the case of Satin and Mahogany. Kiriembiliya is used as a veneer for flush panel doors which are now being manufactured by the Plywood Corporation and very few people even now realise the possibility of using this timber as veneer.

Export of constructional timber from Ceylon in large quantities does not appear to be possible in the near future. Seasoning and preservation which has been dealt with by a previous speaker have not been developed to the extent required for exporting these products from Ceylon. The reason is that research has been lagging far behind and I offer no excuse for this Department not having pursued this matter with vigour. I believe that a highly expanded programme for utilisation research should be undertaken here with increased staff. The return from this investment will I am sure, pay for itself many times over.

Neighbouring countries, particularly India, have given high priority to forest products research. The Research Institution at Dehra Dun is one of the best in the world. If the common timbers which do not find a market in Ceylon itself can be treated with preservatives and seasoned then we can certainly look forward to not only bridging the gulf between the present supply and demand, but also even thinking in terms of exporting, perhaps to countries in the Middle East where timber is a scarce commodity.

