

The CEYLON FORESTER

Vol. IV, No. 3 (New Series)

January—June, 1960



Published by the Forest Department, Ceylon

PRINTED AT THE GOVERNMENT PRESS, CEYLON

Price Rs. 3

OUR CONTRIBUTORS

M. Namasivayam, Senior Assistant Conservator of Forests, Forest Management.

J. R. T. Andrews, Forester and Chief, Forestry Section, Photographic Survey Corporation of Toronto, Canada.

W. G. Weeraratna, Junior Assistant Conservator of Forests, Principal, Forest School.

L. C. A. Wijesinghe, Junior Assistant Conservator of Forests, Divisional Forest Officer, Nuwara Eliya.

R. A. de Rosayro, Senior Assistant Conservator of Forests, Research, Education and Working Plans.

A. E. K. Tisseverasinghe, Junior Assistant Conservator of Forests, Divisional Forest Officer, Working Plans and Aerial Survey.

S. D. E. Vincent, Forest Guard, Forest Field Training School.

THE CEYLON FORESTER

The Ceylon Forester is published biannually by the Forest Department, Ceylon.

The Department does not hold itself responsible for opinions expressed in articles published. Criticism of Government policy or other Government departments will not be published without the prior approval of the Permanent Secretary, Ministry of Lands and Land Development.

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

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

Contributors will be supplied with 12 extra copies of their contributions together with illustrations free of charge if 2 pages or more in length.

Important Notice

Due to the increased costs of production, the rates of sale of The Ceylon Forester have been increased as follows:—

Subscriptions—

				Rs. c.
Annual	..	..	..	5 00
Single copies	..	..	..	3 00

(Special concession rates applicable to Ceylon Forest Department staff will be notified through D. F. OO.).

CONTENTS

Appropriate Technology Services

121, POINT-PEDRO ROAD

NALLUR, JAFFNA

No. 1062

PAGE

FRONTISPIECE

EDITORIAL—A PLAN OF DEVELOPMENT FOR FORESTRY IN CEYLON 233

WATERSHED MANAGEMENT IN THE U. S. A. .. N. Namasivayam 237

THE CANADIAN COLOMBO PLAN SURVEY OF NATURAL RESOURCES J. R. T. Andrews 260

THE ECOLOGY AND BIOLOGY OF PARASITISM OF THE LORANTHACEAE OF CEYLON
W. G. Weeraratna 264

THE DIFFERENTIAL SHRINKAGE OF WOOD L. C. A. Wijesinghe 281

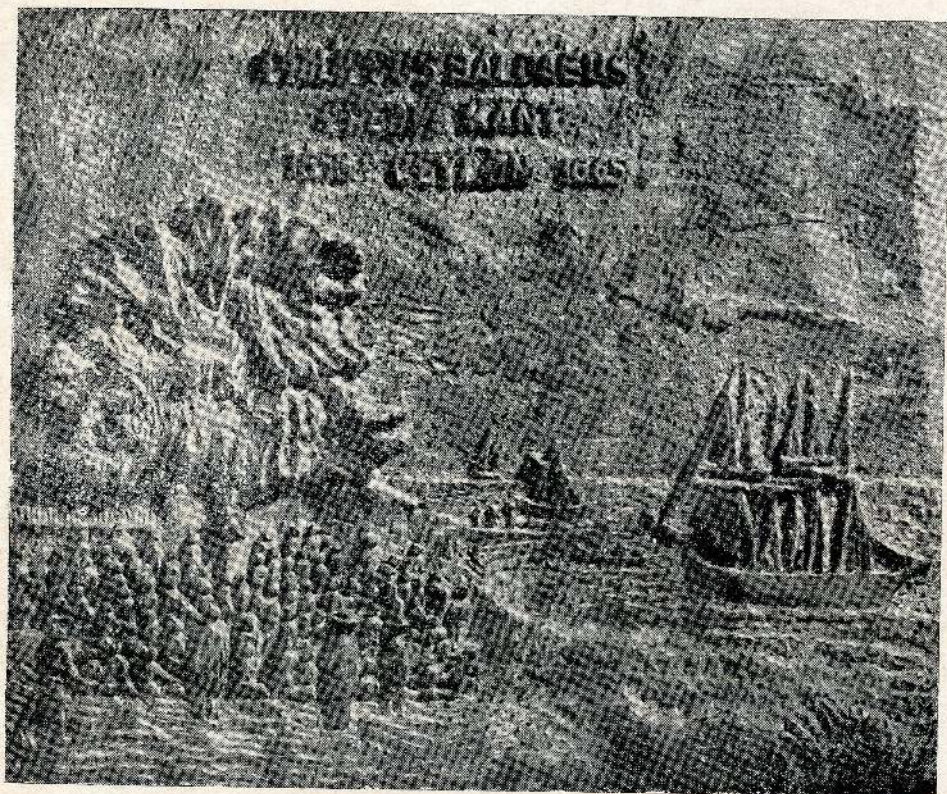
FIELD KEY TO THE IDENTIFICATION OF WET EVERGREEN (RAIN FOREST) TREE SPECIES
R. A. de Rosayro 287

Reviews : THE AGING OF APICAL MERISTEMS .. A. E. K. Tisseverasinghe 295

TROPICAL SILVICULTURE, VOL. I, F. A. O. FORESTRY AND FOREST PRODUCT STUDIES,
No. 13, F. A. O., ROME 1958 .. A. E. K. Tisseverasinghe 297

CEYLON TREES—BY T. B. WORTHINGTON .. R. A. de Rosayro 298

අප ලැබූ මන විද්‍යා පුහුණුව
(TRAINING IN FORESTRY) .. (S. D. E. Vincent) 301



FRONTISPIECE

This photograph is published as a tribute to Mr. A. W. Wilson, Range Assistant of the Forest Department, who died on the 23rd December, 1959. Among the numerous wood-carvings made by Mr. Wilson who showed exceptional talent in this respect, is this reproduction of a wood-carving made by him when attached to the Research Division. It is an exact reproduction of an original etching kindly lent by the late Dr. John Blaze to Dr. C. H. Holmes, the then Head of Research. It is made on a piece of tamarind wood (*Tamarindus indica* L.) taken from the remnants of the original tamarind tree depicted in the wood-carving under which Phillipus Baldaeus the famous Dutch historian and missionary (1656 to 1665) landed and preached in Point Pedro in the Jaffna Peninsula. The tree which was preserved as a national monument and known as the "Baldaeus tree" was blown down by a gale in 1952 and the remnants, mostly of branchwood, were collected and preserved by the Forest Department. The bole was found to be a mere shell of sapwood with little or no heartwood remaining.

The Ceylon Forester

January-June, 1960

Vol. IV, No. 3 (New Series)

Hony. Editor .. R. A. DE ROSAYRO
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

A PLAN OF DEVELOPMENT FOR FORESTRY IN CEYLON

IN the last two issues of "the Ceylon Forester", Volume IV, Nos. 1 and 2, 1959, we have discussed the general background to forestry in the Dry and Wet Zones of Ceylon and indicated the lines on which progressive development in forestry is being planned in these two Zones.

It is now appropriate to deal more generally with the overall development plans of the Forest Department. The *Ten-Year Plan* of the Government published last year has now become generally accepted as the basis of all future planning of the Island's resources. It is unfortunate that this Plan contains no reference to the future development of forestry. This is understandable, however, as the interests of the Forest Department have not been represented either in the National Planning Council or the Planning Secretariat. The accent in the Ten-Year Plan has been primarily on the development of agriculture, including the major commercial crops of tea, rubber and coconuts, and, secondly, on the industrial development of Ceylon, viz., minerals, fisheries, agricultural by-products and hydro-electric power.

The fundamental concepts of land-use policy, as such, have been relegated to a position of secondary importance and the emphasis has been on the expansion of agriculture without any positive land-use policy being defined and accepted. The place of forestry in the Dry and Wet Zones has been stressed in the two editorials which have been referred to. It has been generally accepted that the physical basis of land planning must be individual river basins, in order of their importance. Unless this fundamental principle for all land use is properly appreciated and made effective, the country will be committed to a series of patchwork schemes, based largely on political expediency.

In this issue of "The Ceylon Forester", we publish a comprehensive report by Mr. M. Namasivayam, Senior Assistant Conservator of Forests (Forest Management), consequent on a Study Tour and Seminar in the U. S. A., organised by the F.A.O. The value of this report lies not merely in its appraisal of the various schemes and organizations in the U. S. which control the very life-blood of a nation, but draws from his own personal observations, study and analysis of the various aspects of watershed (catchment) management, sound and practical recommendations for planning similar schemes and organizations in this country. In Chapter V of his report, Mr. Namasivayam has outlined the logical approach to the development of river basins in Ceylon. The conservation of water, the best use of water resources and balanced land use are so closely inter-related that no planning for agricultural development or other forms of development affecting the use of land can be made without a careful study, analysis and evaluation of all the factors affecting the catchment.

There need not be a conflict between agricultural and forestry interests as is likely to ensue if the "Ten-Year Plan" is to be accepted for agricultural development without reference to parallel development in forestry. Apart from the contribution of forests towards the Island's economy, it has been emphasized time and time again by numerous authorities that there is a certain minimum extent of land which must be preserved in forest. A safe margin has generally been accepted as about one third of the total land area, but this may have to be increased for any particular catchment (or river basin) depending on the nature, special conditions and requirements of each individual catchment.

Towards the appraisal of the forest resources of the Island, especially in relation to the major river basin projects, the Forest Department is presently engaged in the first island wide survey of *all* forests, that is, practically fifty-five per cent of the total land area of Ceylon. The latest developments in aerial photography are being employed with the technical assistance of Canadian personnel under the Colombo Plan. An outline of this survey is contained in an article by Mr. John Andrews, Chief of the Forestry Section of the Photographic Survey Corporation, in this issue. The field sampling of forests, which is a necessary adjunct of this work for the preparation of complete forest inventories, is being done by Forest Department field staff controlled by Canadian and Ceylonese technical officers. The first stage of reconnaissance mapping will be completed shortly and the second stage of the preparation of forest inventories will be completed by 1961. These inventories will contain full information on the composition, growth, yield and drain of our forests based on the essential recognition of ecological types from aerial photographs and their correlation with field sampling. With the exact and detailed information which will be available, the final re-selection of forests (1) to be intensively managed as economic units and/or (2) to be retained as protective cover for the individual catchment, can be done on a firm and lasting basis.

In 1958, the most important step towards the development of forestry in Ceylon on a sound basis was the formulation of a Development Plan originally prepared by a former Conservator of Forests, Dr. C. H. Holmes. This Plan, on a somewhat modified basis, has been accepted by Government and has been embodied in a Cabinet Paper by the Hon'ble Minister for Agriculture and Lands. The Plan has been prepared to cover a period of 20 years; estimates have, however, been framed for the next five years, giving details of the areas that are to be taken up for improvement by natural regeneration and by forestation.

The accent in this new Development Plan is primarily on forestation as a means of stepping up the production of timber and fuel in the Island with the objective of making the country self-sufficient in its requirements of these essential commodities within a period of approximately 20 years. This objective can only be realized by increasing the rate of forestation projects to several times the past rate of forestation. The main plantation schemes are the raising of teak plantations in the Dry Zone which have been increased to a minimum of 2,000 acres annually and the improvement of natural forests in the Wet and Intermediate Zones by line planting with Honduras mahogany. The latter has been only sporadically done in the past, but it is now planned to cover a minimum of 2,500 acres annually. It is also planned to accelerate the progress of reforestation of degraded forests in the Montane Zone up to a minimum of 200 acres annually and finally to take up a minimum of 1,000 acres of Montane Grasslands especially in the Dry Patana region annually.

Towards this end, large scale nurseries for raising teak and mahogany, as stump plants and "striplings" respectively, have been opened in the most accessible and suitable centres to make each Division self-sufficient in this respect. The teak nurseries are now producing a total of over half a million stumps. The Department has now organized full scale collection of teak seed from the Dry Zone Divisions from selected sources. For 1959, over 37,000 lbs. of teak-seed were collected, an all time record, thus making the Department independent of seed supplies from foreign sources, chiefly India, which had become increasingly difficult to obtain. In 1959, working on a somewhat limited budget, it was possible to raise a total of 1,100 acres of teak plantations of which 770 acres had been planted by 'taungya' and the balance Departmentally. It has been found, however, that in the latter method, inter-planting with a cover crop of *Tephrosia candida* provided ideal conditions for the growth of teak and generally resulted in plantations of better stocking, growth and form. The programme of 2,000 acres of line planting with mahogany (and some nedun) in the Wet and Intermediate Zones was accomplished. 312 acres of montane patana grasslands were planted with Eucalypts and *Acacia mollissima*.

In order to make certain that our efforts in implementing the 10-Year programme of the Department will be successful, a *sine-qua-non* for all phases of forest development is a stable and well-conceived land policy. Within the last three years, on the score of pressing need of land for agricultural expansion to meet the demands of a rapidly increasing population (now estimated at over 9 millions), not only have large extents of forests been cleared indiscriminately, but direct encouragement by political forces has been given to undeserving and lawless elements to exploit the situation. As Mr. Tom Gill, the eminent U. S. authority on tropical forestry, commenting on the alarming rate of destruction of forests in the Phillipines (in an official report to the Phillipine Government), so aptly puts it, the cry of "land for the landless" has become "land for the lawless". The situation in Ceylon is perilously approaching a similar crisis. The hands of the field staff of the Department have often been tied in their endeavour to take summary action against encroachers by the interference, if not definite incitement, by politicians. Until and unless this tendency towards lawlessness can be effectively curbed by a firm land policy and rigid enforcement of the provisions of the law, little purpose will be served in trying to implement plans for the improvement of forests, especially those subjected to continuous pressure of encroachments.

Another not entirely satisfactory aspect from the point of view of technical forestry, is that, since the last World War, the Forest Department has been saddled with the entire production, distribution and retail sale of timber and forest produce from forest land. As the proportion of private forests is negligible, the private trade has largely to depend upon sporadic supplies of timber found in isolated patches of private forest, small-holdings of tea, rubber and coconuts and village gardens. These inadequate supplies are largely augmented by the illicit feller and transport agent, thus directly creating and stimulating an organized illicit trade in timber.

This unsatisfactory situation can to some extent be alleviated by giving more scope for the legitimate expansion of the private trade, making supplies of saw-logs readily available to private timber dealers. Many officers of the technical staff of the Department are *primarily* engaged in business which should be more properly in the hands of the private sector or corporations. The multiplicity of saw-mills, seasoning and retail depots for timber and firewood controlled and staffed by Forest Department officers calls for special organization, careful supervision and the application of business methods which the technical staff cannot adequately cope with. The practice of sawing timber to sizes to meet the orders of Government Departments and in some instances, even of private individuals, is not only time-consuming and troublesome but must ultimately be reflected in poor utilization and financial loss to the Department. The economy of such a scheme is, therefore, open to question.

This phase of activity requires careful examination and re-organization, strictly limiting the contribution of the Department to the technical side of forest utilization, without frittering away its energies on the intricacies of production and sale of sawn timber and firewood (especially where special requirements in sizes or species are being catered for). The grading of logs and sawn timber is another aspect of utilization which has unfortunately been neglected by pre-occupation with the business of supplying and retailing these commodities. It is imperative that Ceylon should be brought in line with the other countries of south-east Asia who are more advanced in this respect and will do well to adopt the standard grading rules drawn up by the F. A. O. as a basis for the grading of teak, other hardwood logs and sawn timber.

WATERSHED MANAGEMENT IN THE U.S.A.

*Text of an official report on the F. A. O. Watershed Management Seminar and Study
Tour in the U. S. A., 1959**

M. Namasivayam

CONTENTS

CHAPTER I	PAGES
GENERAL	239
POLITICAL BACKGROUND	240
HISTORICAL BACKGROUND	242
CHAPTER II	
WATERSHED MANAGEMENT	242
SCOPE OF STUDY TOUR	243
NEED FOR WATERSHED MANAGEMENT	243
CHAPTER III	
TECHNICAL OPERATIONS—	
(1) LAND USE PLANNING	244
(2) LAND TREATMENT—	
(i) FORESTS—	
(a) REDUCTION OF FIRE HAZARDS	246
(b) CONTROLLED BURNING	246
(c) PREVENTION OF EROSION	247
(ii) RANGE (PASTURE)	248
(iii) AGRICULTURAL LANDS—	
(a) CONSERVATION OF SOIL	250
(b) IMPROVEMENT OF SOILS	250
(c) EFFICIENT USE OF WATER	250
(iv) RECREATIONAL USE	251
(3) STRUCTURES—	
(i) SMALL STRUCTURES	251
(ii) MEDIUM STRUCTURES	251
(iii) LARGE STRUCTURES	251

*The introductory section and Appendices have been omitted (Editor)

CHAPTER IV

PAGES

THE T. V. A. STORY	252
ROLE OF FORESTRY IN THE TENNESSEE VALLEY	253

CHAPTER V

PLANNING	254
RESEARCH	257
(i) THE SOIL AND CONSERVATION RESEARCH STATION AT COSHOCTON (OHIO) ..	257
(ii) THE COWEETA HYDROLOGIC EXPERIMENTAL STATION (NORTH-CAROLINA) ..	257
EDUCATION AND PROPAGANDA	258
ECONOMIC CONSIDERATIONS	258
APPRECIATION	259

CHAPTER I

General

IN recent years a cry has arisen that the United States is in dire need of a National Water Policy—a uniform and coherent plan for the development and use of its water resources. Several critical studies have been made by competent persons but action based on their findings has been very slow. Instead, piece-meal attempts have been made but no overall and integrated policy has been laid down for the development and conservation of water resources at the national level.

The United States is a country which has a very wide distribution of rainfall ranging from 5 inches to 200 inches. The areas of heavier rainfall are on the eastern sea-boards of the United States where an annual rainfall of between 30 to 50 inches is recorded. The Pacific North-West comprising the States of Washington, Oregon and North-California have a rainfall of between 50 to 80 inches. The Mid-Western States and the South-Western portions, e.g., Wyoming, Nebraska, Colorado, Arizona, Texas, Utah and South-California have very scanty rainfall, sometimes as low as 4 inches per year and never reaching above 20 inches per year. It would thus be seen that the problems of water conservation in these areas are crucial and every effort has to be made to conserve the water resulting both from precipitation and from the melting snow in the mountainous areas. An additional problem which has to be faced is the large increase in population which is anticipated and also the migration of population particularly to California which has after the last war become a centre of industrial activity. Therefore, the planning which is now under consideration has to provide not only for the immediate needs of the people but also for a vastly increased population in about 20 to 30 years time.

In spite of the rigorous measures now being adopted to conserve water, it is estimated that only $\frac{1}{6}$ th of the total supply is consumed for national purposes excluding that used for hydro-electric power and that the balance $\frac{5}{6}$ th is unused and flows into the sea. It is anticipated, however, that in about 1975 about one-quarter of the total precipitation will be impounded and utilized, after the present and future programmes of water conservation are finally executed.

The large increase in the consumption of water is also due to the raising of the standards of life throughout the United States. The more important uses of water are :—

- (i) Domestic consumption. Increase due to the use of washing machines, modern plumbing, &c. It is estimated that a family uses an average of 250 gallons of water per day ;
- (ii) sprinkler type of irrigation in farming and market gardening is used extensively in periods of drought ;
- (iii) industrial uses of water for processing and the manufacture of plastics, cellophane, &c. ;
- (iv) inland navigation canals like the St. Lawrence Sea-way, recently opened to give sea access to the Great Lakes and to the large cities like Chicago ;
- (v) improved recreational facilities in water sports, wild life and fishing.

About 56 per cent of the total area of the United States is arable land. Concentrated agriculture in the production of wheat and other grains both for human consumption and animal fodder is undertaken throughout the entire States particularly in the Mid-West. The production of beef is one of the main industries of the farms as the consumption of beef is very high in the United States. The result is that there is tremendous pressure for grazing land (Range Land) and disputes about proper land use are inevitable under these circumstances. However, the production of other food such as wheat, eggs and dairy produce is well above the national consumption. In spite of this the Federal Government is unable to ensure proper land use. The prices of farm produce are being artificially kept at a high level by the price support scheme and there is a monetary incentive to cultivate more land and use more intensive methods of agriculture. The Federal Government is helpless to prevent over-production because the price support which has been given cannot be withdrawn. No administration will dare antagonize the farm vote which is probably the largest single block vote outside organized labour.

An exception, should however, be mentioned in this connection. The Tennessee Valley Project which was initiated during the 1930's has developed into a vast planned organization of which the United States can be justly proud. The area covered by this project is about 80,000 square miles of the Tennessee River basin covering the States of Kentucky, Tennessee, Alabama, Mississippi, Georgia and North-Carolina. It is somewhat significant that no attempts have been made for planned development on this scale in any other part of the United States. Since the initiation of the Tennessee Valley Authority (T.V.A.), one is compelled to the conclusion that the large corporations which control electricity and power are not anxious for development to take place on these lines as it might affect their individual interests. The prosperity which has been brought to the Tennessee Valley by this planned development is phenomenal and it is a pity that this cannot be emulated elsewhere in the United States.

Political Background

In order to understand fully the relationship of Federal to State Agencies, it is necessary to review briefly the set up of the United States Government itself.

The United States Government is composed of three distinct units :—

- (1) Federal.
- (2) State.
- (3) County.

There are now 50 States in the Union—Hawaii and Alaska have come in only recently to the Union. The States have delegated certain powers to the Federal Government. The Federal Government has certain overall functions to perform, like defence and foreign affairs but has no direct control within a State. The Federal Government only acts on delegated power. This type of Government appears to have developed as a result of large distances to be traversed in the United States.

Apart from the State Government, the County Government has also assumed great importance recently. Each State is made up of a large number of Counties and these Counties are the creatures of the State and are governed by State Regulations. However, the seat of political power is actually the County itself and this is an aspect which has to be kept

in mind when discussing the development and growth of the United States. As far as plans for Watershed Management are concerned, this has resulted in communities deciding on programmes of water development without much regard to the overall national welfare. The same development is witnessed in Labour, Public Health and Education. This has resulted in bad national planning dependent purely on local politics. However, the Federal Government over the course of the last 70 years has increased its powers over State Governments and a gradual evolution of suitable central planning appears to be taking shape. The individual American, however, is entirely opposed to Federal control in matters which come within the purview of his own community and he defends this attitude as a "Democratic Right" which is guaranteed to him under the United States Constitution. It is, however, somewhat difficult to reconcile this rather narrow attitude with the national interest and several clashes of State and Federal control have been witnessed in the recent past where disputes have arisen in matters arising chiefly out of Education, Labour, Health and also Watershed Management.

The pattern of Government which has developed in the United States has been such that the people living within a community are encouraged to take a fair share in the planning and execution of matters which affect them. The Federal Government induces State Governments to undertake projects which serve a wider national interest by giving monetary grants. This has compelled small communities to plan projects in connection with Watershed Management with the advice and consent of the Federal Government.

A well informed public opinion is the best means of ensuring a democratic system of Government and the large number of people from varying professions and walks of life who participate in local matters affecting Watershed Management is a matter which was brought home forcibly to one's notice. There is no doubt that public consciousness is the best stimulus for the welfare of a community. A scheme springing from the community itself is therefore more likely to meet with success rather than one foisted on the people by an authoritarian government, however well intentioned. This is the basis of Public Law 566. This law has been promulgated with a view to encouraging participation by the local community on the basis that if the local interest requires a water plan for a watershed and is prepared to contribute towards the total cost, then the Federal Government undertakes to offer monetary aid and technical assistance in both the planning and execution of the project.

The States themselves jealously guard their rights and privileges and do not tolerate unnecessary Federal control. This is natural when one considers that the Federal Government was originally an instrument created by the States to protect common interests in the field of foreign affairs and defence. The incursion of Federal interference is however inevitable in modern development. The balance is maintained by the United States Supreme Court which adjudicates on any dispute between State and Federal Governments and in the interpretation of the United States Constitution.

A further factor which has affected the evolution of Government in the United States is the multi-racial composition of its peoples. The largest number have emigrated from European countries and have diverse backgrounds of culture, language and customs. In addition, there are the people of Negro extraction originally brought over as slaves from Africa and the rather small and inarticulate minority of the original indigenous inhabitants known as the North American Indian.

It is indeed creditable that this large conglomeration of peoples have progressed so far in such a short time as to be welded into one society and they now take pride in being called citizens of the United States.

Historical Background

Water resources have played an important part in the development of the United States since its founding in the mid-seventeenth century. The natural resources of the country appeared to be an unlimited storehouse and hence forest, soil and water were greatly exploited to provide subsistence. The three main uses were :—

- (1) Navigation.
- (2) Water Power.
- (3) Domestic Supply.

Navigation up and down the rivers and streams was the easiest means of communication, and canals were subsequently developed.

Water-power exerted a tremendous influence on national development as it was the primary source of energy for industrial development. The industries and the cities which arose out of them were established at the fall lines of the larger rivers. The cities of New York, Baltimore, Philadelphia, Boston, &c., have arisen out of such development.

Domestic Supply was naturally an important development and several private companies appeared on the scene to augment domestic supplies for the cities which grew out of the villages and towns.

As development progressed westwards, water for irrigation became increasingly difficult to obtain particularly in the arid South-West and the rich valleys of Southern California which needed only irrigation to yield an abundance of crops.

The *riparian doctrine* of water rights prevalent up to this time and was spreading westward was unsuited because the problem of water was more crucial. As a result water users adopted a code of law known as the *appropriation doctrine* which came into use in the eighteen Western States while the rest of the country used the common law "doctrine of riparian rights".

Further problems arose on the water resource horizon. The rivers and harbours of the country needed improvement. Disastrous floods compelled the authorities to take suitable flood control measures. The rapid growth of industry brought in its wake the pollution of rivers and canals by the waste products of processing and cooling. Concentrations of population compelled domestic sewage problems to be tackled without delay.

CHAPTER II

Watershed Management

WATERSHED Management means the management of water resources in an area of land that is drained by a stream or river. The area of land may be as small as fifty acres or as large as the Tennessee Valley which drains an area of 26 million acres. The objective of watershed management is to meet the problems of land and water use, not in terms of any one resource, but on the basis that all resources are interdependent and should be considered together. Therefore, good watershed management can only

be achieved by a thorough understanding of the natural processes which govern the behaviour of soil, plants and water. The detailed study includes the processes of infiltration, evaporation, transpiration, percolation, plant cover, geology and soil depth, to mention a few of the more important aspects. It is the blending of these processes which go towards the understanding and application of the principles and practices of watershed management. In any given watershed unit, the total precipitation by rain or snow cannot be increased. Hence the availability of water is limited. The terrific pace of industrial expansion and population pressure which affects a country like the United States, therefore, compels accurate study of these phenomena for the sustenance of the nation itself.

These natural phenomena are modified by land use practices which have evolved for the production of food and other resources like timber. Some of these practices may tend to conserve water and soil, while other practices would cause deterioration and ultimate destruction of a region by impoverishment of the soil, as took place by production of cotton in the loessal deposits of the Southern States. Foresters, Farmers and Engineers have each developed good techniques for impounding and controlling water. Sound management would, therefore, depend on co-ordination of all techniques and not on one particular profession. The goal of water resource policy should be maximum conservation, development and utilisation of all the water resources of the nation for the greatest good of the greatest number of people over the longest period of time. This poses the question of what policy is to be followed in order to achieve this goal. Herein arise the differences of opinions on matters of finance, priority, nature of improvements, timing, &c. This leads to the conflict of interests which is today witnessed in the United States where overall planning is so difficult to achieve in the light of the earlier discussion on the historical and political background of the country.

Scope of Study Tour

The participants of the Study Tour and Seminar were afforded an excellent opportunity to study the growth and development of the watershed management practices which have grown in the United States. The object of the Tour as explained by the Director Mr. Warren T. Murphy was not only to demonstrate to the participants these beneficial practices which have yielded lasting results but also those which are of doubtful value. This provided an opportunity for discussion both with officials of the United States Agencies and among the participants themselves in the seminars held throughout the Tour.

The Study Tour covered 21 States from coast to coast both in the Northern and Southern sections of the country and afforded a comprehensive study of practices in varying climatic regions, from the humid Eastern States of Pennsylvania, Georgia and Tennessee to the more arid States of Arizona and Southern California.

Need for Watershed Management

The problems arising out of watershed management vary from scarcity of water to flood damage and include competition for existing water and plans for additional requirements. In all areas the basic problem is to make existing supplies serve more uses, do more work and satisfy more needs.

CHAPTER III

Technical Operations

THE Study Tour can be reviewed briefly under this heading. The practices varied considerably according to the different problems that arose regarding the use and conservation of water in different parts of the country. It was decided to consider the problems under the following heads :—

- (1) Land Use Planning.
- (2) Land Treatment.
- (3) Structures.

(1) LAND USE PLANNING

AS stated earlier in the course of this Report, Land Use Planning on a national scale for the purpose of watershed management is somewhat deficient in the United States. As against this, planning for smaller units has been carried out in several places with notable success. The best example of this is the Brandywine Valley which is in the States of Delaware and Pennsylvania. The watershed of this river is comparatively a small one and the area is about 300 square miles. The planning of this watershed has been done purely by private citizens from the very beginning with technical assistance given by the State. This valley is typical of the industrial development which has taken place in the United States. In the beginning, the entire valley was inhabited and various industries started along the river. Accelerated industrial growth resulted in the denudation of forests along the catchment and bad farm practices contributed to the impoverishment of the soil and the resultant erosion which took place during the 18th and 19th centuries.

The communities which sprang up on its banks also diverted their sewage into the river. The mouth of the river at Wilmington became choked and the Government was compelled to spend about \$ 300,000 annually on dredging operations alone. The polluted water became unfit for domestic use and the fish-life became scarce. In 1947, the people of the area were compelled to take action on this serious situation. A Citizens Committee headed by one Mr. Clayton Hoff began a series of propaganda meetings to demonstrate the ill-effects of this indiscriminate waste of natural assets and showed that long term benefits could be derived from careful management of the watershed. Mr. Hoff was instrumental in forming the Brandywine Valley Association which was a private body dedicated to the improvement and management of the watershed. The Association enrolled membership of farmers, industrial organisations, civic groups and clubs interested in wild life, fishing and water sports. Membership fees were levied according to the use of the valley and the river waters. Several improved methods of farm practices like strip-cropping, contour ploughing, were introduced. Research centres were set up and stream gauges and silt sampling stations were established. Eroded marginal field land was converted into pasture and one million trees were planted. This improvement has added wealth to the area and dairy farming and raising cattle for beef has become a thriving industry. Soil erosion has been cut by half and sports and recreational facilities have attracted tourist traffic from adjoining States. Marshy areas have been drained and more land made available for housing and communications.

The lesson from this project is that public consciousness regarding the watershed is of paramount importance in carrying out a project of this nature. This Association has inculcated into its members the importance of planning in a small watershed without much State or Federal aid.

Similarly the Washita Watershed at Clinton in Oklahoma, the citizens have banded themselves into a group which has demonstrated that Voluntary Associations can organise improved farm practices and range management in privately owned lands which could improve the value of lands and maintain its fertility for future generations.

As against this, many difficulties arise when planning larger watersheds under Federal or public ownership. The reason is that there are several pressures, sometimes influenced by politics, whose demands are opposed to each other. One such instance is the Coconino National Forest in Arizona. The conflict of interests here are :—

- (i) The demand for more Range land for cattle ranches ;
- (ii) The demand of the Down Stream Water Users' Association for an increased supply of water for domestic consumption and industrial use ;
- (iii) An increased demand for water for recreational purposes.

These three demands have caused difficulties to be faced by the Federal and State Agencies in co-ordinating their programme. While the multiple use of water and the land is important from the point of view of conservation and economics, it is difficult to reconcile these demands with the interests of the National Forest. The first to suffer by this increased demand for water is the interests of timber production. All water uses require increased supplies and there has been an unfortunate tendency to manipulate the forest cover by practices which are unsound. This struggle for water and correct land use poses several important and urgent questions which must be answered before action is taken on a management scale :—

- (i) Does the elimination of forest cover and replacement by pasture reduce loss by evapo-transpiration ?
- (ii) Is range land more suitable for the conservation and storage of water rather than forest cover ?
- (iii) Is the increased yield of water obtained by removal of forest and replacement by pasture of permanent benefit or is it only temporary ?
- (iv) Is the increased yield of water so obtained distributed equally throughout the year or does the water increase so obtained come only during peak flows ?

The correct analysis of these questions can only be obtained by careful investigation of the watershed itself. Results obtained elsewhere may not be applicable to another watershed. There is no doubt that whilst increased run-off by elimination of forest cover can be had temporarily, the consequences of such drastic action may result in siltation of reservoirs and ultimate destruction of the watershed itself. This tendency to clear large extents of forests has brought untold suffering and damage in other parts of the United States. Whole communities have suffered grievous flood damage to their homes and their farms by indiscriminate clearing of forests and piece-meal attempts are now being made in several places at enormous costs to rectify the errors of the past.

Afforestation has been relegated to a minor role in most watersheds with the exception of the South-Eastern Region of the United States as in the Yazoo-Talahatchie Watershed which comes within the Tennessee Valley basin. In this connection it is pertinent to point out that experimental stations which were also visited during the Tour, e.g., the Frazer Experimental Forest Station near Denver, Colorado, and the Fernow Forest Experimental Station are carrying out investigations in practices which would aim at increasing water supplies and at the same time conforming to good management practices.

(2) LAND TREATMENT

The various practices seen under this category can be conveniently divided into 4 sub-heads :—

- (i) Forests ;
- (ii) Range (Pasture) ;
- (iii) Agricultural Lands ;
- (iv) Recreational Use.

(i) FORESTS

The main operations seen in the use of Forests in the protection of watersheds are as follows :—

(a) *Reduction of Fire Hazards*

Reduction of fire hazards was particularly stressed in the San Gabriel Valley in California and in the Apache Indian Reservation in Arizona. In the former, remarkably well organized fire prevention and fire-fighting measures had been adopted to ensure that the catchment will not be destroyed by fire. The fire-fighting unit had at its disposal much modern equipment including trucks and a helicopter used in the detection and prevention of fires. The erosion rate in this area is 9,000 cubic yards per square mile per year. This will increase to 60,000 cubic yards per square mile per year in a burnt watershed. It would thus be seen that prevention of fires is an urgent necessity.

(b) *Controlled Burning*

In the case of the Coconino Forest, large extents are annually burnt by fires with much destruction of the forest. The Federal Government together with the United States Bureau of Indian Affairs have organized a system of controlled burning of the leaf-litter in order to reduce the risks of fire hazards. The authorities concerned appear to be convinced that controlled burning is sound Silvicultural practice and in fact enables the Ponderosa pine to regenerate itself in correct proportion of girth classes during its early stages. Controlled burning is a practice which is widely used in other parts of the world to reduce fire-hazards. There appears to be no alternative under these circumstances. In the same forest, thinnings of the Ponderosa pine have been introduced with a view to increasing the water supply. Here again the question of increasing water supplies appears to be the main objective and not the conservation of the forest itself from the point of view of water storage and timber production. Similar practices of eliminating vegetation in order to increase water supplies were observed in California. Here "Chapparal" (low scrub) was being cleared in order to induce

more run-off and Juniper was being up-rooted and destroyed in Arizona to make way for Range Land. The beneficial results of these practices were explained to us at great length but these practices appear to be adopted mainly by the pressure of public opinion rather than the considered results of research. The actual figures furnished show that the increased yield of water did not exceed 10 per cent to 20 per cent of the existing supply. These figures do not justify those operations on a management scale. It is conceded that the silvicultural practice of thinnings may yield more water but the carrying out of these thinnings in order to increase water yield is a retrograde step.

The work done at Frazer Experimental Station under the leadership of Dr. Dudley Love includes experimental work in connection with Management, Silvicultural Research and Utilization in the Rocky Mountain National Forest. The forest is a mixture of lodgepole pine, spruce and fir and alpine grasslands. In silvicultural practice the experiments conducted have shown the influence of cutting on water yield. Quite naturally the availability of water increased proportionately from uncut stands to cut stands. The figures furnished showed an increase from 10.34 to 13.52 acre inches or 31 per cent. The effects on stream flow have also been investigated. At Fernow Experimental Station an area of 600 acres has been divided into three small watersheds and the effect on stream flow and turbidity is being measured on three different intensities of cutting. At the same time the costs of felling and extraction are computed to determine whether the return from the sale of timber felled on this basis compensates for the cost of special fellings prescribed in different watersheds.

(c) *Prevention of Erosion*

The most efficient measures taken in good management regarding this aspect was seen in the Brandywine Valley, West Virginia. This has already been described earlier and the advice given by the Association to private owners in good silvicultural and farm practice has resulted in planting of marginal lands of the watershed with extensive areas of forest.

The other example which was observed during the Tour was seen in the Cadar River basin near Saginaw (Michigan). This was carried out under the leadership of the Michigan State Department of Conservation. The smaller tributaries of this river go through farm land and by continuous grazing of these lands, extensive gully erosion has taken place. The Soil Conservation Service has initiated a scheme to take over derelict farm lands along the stream reservations which run through private property. These units are about 15 acres in extent and the area is fenced off to prevent cattle from damaging the banks of the streams. The area is reforested and considerable success has been achieved by stabilising the channel banks by encouraging the regrowth of vegetation in addition to the planting of trees. Photographs were shown of the various sections before and after the stabilisation measures had been adopted. Remarkable success was observed in the Nowellogg Farm. The streams are now full of fish and the banks are completely stabilised with minimum loss by gully erosion.

The Wind River Watershed which was seen in Wyoming had a different problem. One of the tributaries of the Wind River which is known as the Five Mile Creek has suffered extensive damage by gully erosion along its banks. A further problem was the transport of large quantities of debris from flash floods which occurred when there were thunderstorms. The waters of the Wind River are impounded by the Boysen Reservoir and heavy sedimentation has occurred by the uncontrolled flow of turbid water. The measures adopted along the banks of the Five Mile Creek include

mechanical measures to stabilize the banks in addition to the planting of Salt Cedar. The mechanical measures entailed the construction of 'Tetrahedrons'. These consist of poles tied up lengthwise and placed at an oblique angle with the flow of the river. After a certain period, sediment and debris collected along the tetrahedrons and this sediment which stabilized itself along the banks was seeded with Salt Cedar. In due course, the Salt Cedar flourished and the banks thus became completely strengthened preventing further erosion.

The most remarkable example in which forests have been used for the prevention of erosion was seen in the State of Mississippi. The Mississippi River drains into the Gulf of Mexico and most of the land area along the lower end of this river is composed of sandy deposits. These deposits have accumulated in these parts of the United States over several thousands of years as a result of the transport of sand and sediment from the upper reaches of the river. Uncontrolled cultivation of cotton in these areas has resulted in very heavy erosion of these deposits with the consequent loss of top soil. The impoverishment of the soil has led to widespread distress as a result of poor agriculture in this area. Apart from the degradation of the soil, very heavy floods have taken their toll and the Federal Government stepped in to introduce not only flood control measures but also the prevention of further soil erosion. The waters flowing along the Yazoo-Talahatchie river have been impounded by a series of dams to prevent floods. Apart from this, extensive areas of eroded agricultural and cotton lands have been converted into forest by the planting of several millions of trees. The extensive nature of this afforestation can be gauged by the fact that in 1959 alone over 50 million trees were planted in this area.

Forestry has advanced considerably in the South-Eastern region of the United States and it is very heartening to note the importance given to forests in the conservation of soil and water as opposed to other places in the United States where forests are being cut to increase water supplies. There is no doubt that this bitter lesson has been learnt in the South-Eastern parts of the United States after several years of devastation by improper land use. It is hoped that those responsible for watershed management in other parts of the United States will take a lesson from this devastation and the heavy costs incurred in bringing the lands back to profitable use.

The use of forests as Wind-breaks was seen near Lincoln, Nebraska. Nebraska is one of several Mid-Western States which has thriving farm lands used both for Range and the production of wheat. These originally formed the 'Prairies' of the United States where there was little or no forest since grassland was the climax vegetation. The whole area experiences a very strong desiccating southerly wind which blows across the State throughout the year. This causes considerable wind erosion and the farms round about Lincoln have been planted up with very effective wind-breaks consisting of indigenous timber and pines. The wheat-lands of this area are highly productive and there is no doubt that the wind-breaks afford extremely good shelter against the ill effects of the wind. Wind-breaks do not appear to have a universal appeal in other parts of the United States. The example of Nebraska can be profitably used elsewhere where wind is an adverse factor.

(ii) RANGE (PASTURE)

Several good practices were seen in connection with the rehabilitation of degraded range lands. Very impressive work in connection with rehabilitation of degraded range lands has been carried out in the upper reaches of the Mt. Pleasant Watershed in Utah. Mount Pleasant is a small

town at the foot of a range of steep mountains. The mountainous country is affected by precipitation of snow during winter and thunderstorms during the summer. The average annual precipitation is only 14 inches. The Mt. Pleasant Creek which flows into the valley has been the cause of very disastrous floods. It has been recorded that this river has flooded the town of Mt. Pleasant over 20 times from 1892 to 1947. One of the reasons for the very heavy erosion and the serious flood damage is the deleterious effect of excessive grazing in the watershed by live-stock. It would appear that during the very serious floods of 1947, large boulders which were seen strewn around the vicinity of the town had been brought down by the flood waters during that year. This repeated damage to homesteads and property has prompted the local population to band themselves together and initiate activities to control the waters which come down the river. The participants of the Study Tour had the advantage of examining the watershed both on the down-stream and the up-stream areas. In the down-stream area a large 'debris basin' has been constructed by damming the creek. This would control not only the water but the debris which would come down during a peak flood. On the following day an extensive tour was undertaken on the upper reaches of the watershed which is on the West side of Colorado Plateau Province. It is here that the worst damage has been caused by excessive grazing. Earlier on, grazing permittees had resisted, through political agitation, the work planned by technicians. However, after repeated flood damage had been experienced, the local population in co-operation with several agencies—Municipal and Federal—had taken up the task of stemming the dangerous trend of over-grazing. Two programmes were started in Utah under Public Law 566 and one of these was in the Mt. Pleasant Creek. Under the project the catchment was terraced by use of caterpillar tractors and re-seeded with grass. Alternative grazing grounds were allotted to the permittees while the land was being rehabilitated. The upper watershed has now been completely terraced and re-seeded with grass and grazing has been brought under control. This has automatically put an end to disastrous flood damage which had been experienced by this township earlier. Apart from the extremely good Range practice which had been carried out here an equally important point is that the leadership for rehabilitation of land and the control of grazing sprang from the people themselves.

In the case of Washita Watershed (Oklahoma) similar methods were adopted by a local Citizens Committee to control over-grazing and to re-seed the areas where grazing has been carried out intensively. The results are remarkable and several farm lands in the vicinity of the watershed were visited by the Party to demonstrate the willing co-operation offered by the farmers to the local Soil Conservation Committee. Here again, we were given several talks by the Office-Bearers of the Committee whose Chairman was a Bank Manager. The most remarkable fact to be observed was that the ordinary layman, other than the actual farmer, was equally interested in the conservation of soil and water within his own community.

A point brought to the attention of the participants was that in Public Lands under the charge of the Bureau of Land Management, grazing is considered a *Right* whereas in the Public Lands under the control of the Forest Service, grazing is only considered as a *Privilege*. This difference is responsible for extensive damage to lands under the control of the Bureau of Land Management which is helpless to control over-grazing.

A few interesting practices in connection with Range Management were observed in Riverton (Wyoming) and Safford (Arizona). In both places

the danger of flash-floods has been to a certain extent eliminated by the construction of water detention dams which are dry for most parts of the year. These structures are meant merely to hold up flood waters and prevent damage to homes and property. Both areas have very limited rainfall and although large extents of land here are used for pasture, the cattle eke out a very precarious existence. The waters impounded by these dams are sent out through sluices after the rains to 'spreaders'. These 'spreaders' are in fact terraced fields which are in some instances fenced. Seeding of grass is done within the 'spreaders' and the water which irrigates these gives sufficient grass for pasture. This is an instance where water has been profitably used instead of being sent out to waste.

Steps had also been taken both in Wyoming and Arizona to eliminate undesirable brush or weeds by chemical and mechanical means.

An interesting practice observed in Ohio was the rehabilitation of land after strip-mining for coal. The coal is not mined in the orthodox manner but the earth is dug up and scooped out by large mechanical excavators until the coal seams are reached. The earth so excavated is piled up in large 'spoil banks'. After sections of these areas have been stripped of coal the 'spoil banks' are levelled out and a forage crop called *Crownvetch* (*Cornelia varia*) is sown on the levelled ground. Extremely good results have been obtained and the Hawa Coal Co., which operates this strip-mining concession is contemplating the use of these areas for the raising of beef cattle. The speed of excavation of these large machines can be gauged by the fact that an excavator removes 475,000 lbs. per lift and excavation averages $1\frac{1}{2}$ million cubic yards per month, working night and day.

Another very interesting feature which was observed on all lands used for pasture is that farm ponds or water points have been created for cattle. These ponds apart from providing water are also a means of holding up excess water which would otherwise be wasted.

(iii) AGRICULTURAL LANDS

Numerous agricultural practices of land treatment were carried out by private owners in order to retain soil and conserve water.

- (a) *Conservation of soil* :—Strip-cropping, contour ploughing, terracing, stubble mulching and wind-breaks ;
- (b) *Improvement of soils* :—Crop rotation, various methods of ploughing and chiselling, use of green manure and fertilizer ;
- (c) *Efficient use of water* :—Irrigation in Arizona, Wyoming and California. The irrigation canals were lined with concrete to eliminate waste by seepage. In some instances, canals had been replaced by pipes and water was re-utilized instead of being allowed to run to waste. Plastic siphon tubes were used in many places to divert the water into smaller irrigation channels, e.g., Good Year farm in Arizona. In this farm water is obtained from wells. The wells are 900 ft. in depth and the actual depth of water is 200 ft. Powerful electric pumps are used to lift the water and the output per pump is 2,276 gallons per minute. Each pump costs 25,000 dollars to 30,000 dollars. A disturbing feature here is that the water table is reducing at 8 feet to 10 feet per year. There is no immediate prospect of recharging the ground water and unless stricter control is exercised the area will have to be abandoned in 20 years' time.

(iv) RECREATIONAL USE

Recreational use of forests and water is one of the major factors influencing the use of water throughout the United States. The interests of fishing, shooting, swimming, water-skiing and boating appear to play a dominant role in the life of the average American family. It is estimated that there are nearly 7 million boats owned and used as pleasure craft during vacation. A very common sight in the highways is the trailer used to carry these boats when a family goes on vacation. Almost in every instance where water has been impounded for flood control or irrigation, the recreational use of water has followed. This is a very bright feature of water use as it creates a public interest in the conservation of water. This urge to use the outdoors for pleasure and recreation creates a healthy nation. Many centres for Summer camping were visited during the Tour as in Muskingum (Ohio) and Yosemite National Park (California). Thousands were making their way during the weekends and on public holidays with trailers, camping equipment and fishing tackle to get away from the crowded urban areas even for a brief day or two. It is estimated that about one million visitors come annually to the Yosemite National Park where the giant sequoias (*Sequoia gigantea*) are an added tourist attraction.

(3) STRUCTURES

The various structures seen throughout the Tour for the conservation of water, flood control and hydro-electric power were both efficient and well-planned. These ranged from the small structures built as anti-soil erosion measures to the large reservoirs in Tennessee constructed by the United States Corps of Army Engineers.

(i) SMALL STRUCTURES

Gully-plugging to stop erosion at Saginaw (Michigan) and the tetrahedrons at Five Mile Creek (Wyoming) to stabilize the stream banks and to prevent gully erosion were two of the efficient small structures observed. We would have liked to see more anti-soil erosion measures particularly in the up-stream areas as these contribute towards better control rather than the large dams which impound the water and sediment after they have actually created most of the damage. Small structures are moreover cheaper to construct and are efficient if located correctly.

(ii) MEDIUM STRUCTURES

The dams constructed at Muskingum (Ohio), Washita (Oklahoma) and Safford (Arizona) were flood detention dams to retain sediment and prevent floods. These are well built but it would appear that their duration may be short-lived as they may in due course be filled with sediment. These structures must be accompanied by land treatment measures to reduce erosion.

(iii) LARGE STRUCTURES

The large structures are those which the United States is justly proud of being some of the most remarkable engineering feats of modern times. The largest dams which were seen were the Coolidge Dam—largest multiple arch dam in the world. It has a capacity of 1,200,000 acre feet of water; the

Dover Dam and the Sardis Reservoir Dam in Tennessee. It was unfortunate that the Party had no opportunity to visit the Hoover Dam or the Boulder Dam owing to a very crowded itinerary. These dams are used mainly for flood control, irrigation and hydro-electric power. In California the Party had the opportunity of seeing the Santa Anita Dam and debris basin which traps about 374,000 cubic yards of debris. Further upstream smaller crib structures or channel stabilization barriers were under construction to hold up debris. The greatest danger in this area is the large amount of debris which is carried down the San Gabriel River.

CHAPTER IV

The T. V. A. Story

THE participants of the Study Tour and Seminar had the unique opportunity to be introduced to General Vogel, Chairman of the Tennessee Valley Authority. General Vogel unfolded the dramatic development of the Tennessee Valley from a rural and backward community to an industrial area by harnessing the Tennessee River to obtain hydro-electric power. The Watershed of the Tennessee Valley is 26 million acres and covers seven States. The area was earlier subject to disastrous floods and the land was impoverished by soil erosion. In 1930, the United States Corps of Engineers planned to control the Tennessee River which was carrying these flood waters. There were two plans :—

- (i) To construct a series of small dams for flood control and navigation without power production ;
- (ii) To construct large dams not only to control floods but also to produce power.

In 1933 under the guidance of the late Franklin D. Roosevelt the United States Congress passed the T. V. A. Act vesting power in a Board of 3 members. No direction was given to use any Government Agencies and the Board decided to build its own organisation, construct its own dams and produce the maximum benefit by use of power. Two large dams, the Norris Dam and the Wilson Dam were already existing. People living within the area of 80,000 square miles were requested to express their desire for T.V.A. power. There were hardly any industrial works at this stage except the American Aluminium Co., at Knoxville (Tennessee). The outbreak of the Second World War however gave the area the impetus it needed to initiate industries by the use of cheap power. During World War II the demand for aluminium and power grew at a tremendous pace. More dams were needed and a total of 31 dams were constructed up to 1954. These produced 6,000,000 Kilowatts. In addition to this, Atomic Energy Plants were also built to increase the power potential. Ultimately Congress felt that no further appropriation could be made to develop more power in the area and today the T. V. A. is planning to float loans and borrow public money by sale of bonds to build steam plants. Today the production of electricity by T. V. A. is over 11 million Kilowatts.

There is no doubt that this planned development of the Valley is one of the most successful human enterprises ever undertaken. Unlike in other parts of the United States, the well integrated and co-ordinated effort of all resources in the area has been responsible for this phenomenal growth. The cost of electricity is half as much as anywhere in the United States. The result is increased production. Industries are increasing at the rate of 100 million dollars per year.

Although the T. V. A. is an outstanding success, the desire to emulate it is absent elsewhere in the United States. Two reasons were adduced for this absence of planning by the Chairman of the T. V. A. :—

- (i) There are no other large river basins like the Tennessee which could be integrated and planned on the basis of T. V. A. ;
- (ii) The American being a pragmatic personality was not prepared to accept large scale Federal planning which would infringe on his liberties.

It is difficult to deny that even if large projects such as T. V. A. cannot be contemplated, smaller river basins do exist which can be modelled on T. V. A. As for the argument that the American is inherently opposed to State directions, the fact, that T. V. A. has produced such tremendous industrial potential in a hitherto impoverished region is in itself proof that planning on a national scale must eventually produce the greatest good for the greatest number in the long run.

Role of Forestry in the Tennessee Valley

The Forestry Relations Division of T. V. A. at Norris (Tennessee) was visited and the problems of Forestry were discussed with the very capable and experienced staff engaged to promote the welfare of Forestry in the Valley. Of the 26 million acres in the Valley, 12 million is non-forest land. Of the 14 million acres of forest, 12 million are privately owned. The T. V. A. controls only 200,000 acres of the State-owned forests and 2 million acres are under Federal control. The Forestry Division, therefore, acts only in an advisory capacity. The privately owned Forest Estate of 12 million acres is owned by 245,000 persons. The difficulties of this large ownership are manifold. The owners have to be educated not only in the value of forests to the Valley but also that lands under forest can pay sufficient return if maintained under good management. There are no laws which compel owners to conform to good management practices. All propaganda and education are carried out in 300 demonstration centres. These demonstration centres are scattered throughout the area and farmers and owners are given practical instruction in all aspects of Forestry like fire-protection, reforestation, and efficient saw-milling. There are about 4,000 portable saw-mills owned by private individuals throughout the Valley. It has been proved that even a small owner can get a return of 25 dollars per year per acre with good management practice.

One of the main problems of the forests was damage by fire. This has been reduced to 100,000 acres annually. All results produced are by joint co-operative efforts. The Forestry Division is proud of these results although it has experienced many failures. But it is the general opinion that persuasion rather than compulsion is the key to success.

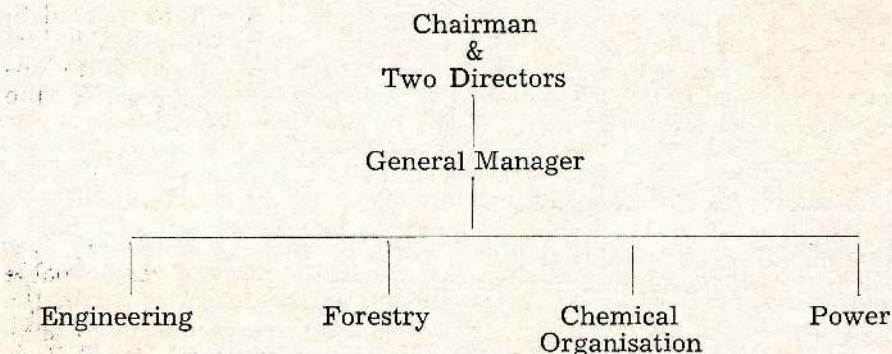
As opposed to other parts of the United States the duty of the Forest Service is to moderate peak flows in the rivers and streams rather than to increase the water. This is understandable as there is a well distributed average annual rainfall of about 60 inches. The Tennessee Valley is divided into 10 large watersheds and 26 small watersheds. Each watershed whether large or small is an interdependent unit which is managed in a well integrated pattern for the entire Valley. It was here that the complete organised watershed was seen from every point of view. The up-stream work in the small watersheds to prevent soil erosion by good farm practices and the down-stream work in the rivers to impound water for electrical energy

and flood control. Range land, Agricultural land and Forest land find their place in a well integrated plan in the smaller watersheds and demonstration centres.

The Forestry Division of T. V. A. has a Chief with three Assistants :—

- (1) Economics ;
- (2) Forest Development ; and
- (3) Water Control Planning.

This general set-up of the T. V. A. itself is as given in the Chart below :—



This set-up has been adopted in the Gal Oya Board in Ceylon. There is, however, a difference. The T. V. A. ensures that there is co-ordination of the State and Federal Agencies within the Valley. The position in Gal Oya is that separate organizations within the frame work of the Board act independently of the State Agencies who have no voice either in the planning or execution of the projects within the Board area.

CHAPTER V

Planning

The most important conclusion reached during the course of the entire tour was the necessity of plan in Watershed Management. We have seen several instances where planning has yielded extremely valuable results which have been used for the ultimate benefit of the watershed. In other instances, we have seen lack of planning leading to lop-sided development, and the very serious problems that arise in due course when there is conflict of interests. In the United States there are several Agencies which have interests in watershed management planning and it appeared to the participants that insufficient co-ordination existed between the Agencies responsible for planning watersheds. It was pointed out that there is a Committee which attempts to co-ordinate the work of all Agencies towards a final goal but although the need for such co-ordination was repeatedly stressed in all aspects of work it is difficult to achieve without overall control vested in one body.

In a country like Ceylon where the Government set-up is still based on Central Government planning, it is very necessary that the various Departments which control irrigation, land development, forests and agriculture should be co-ordinated in their activities when thinking in terms of

watershed management. A step has been made in the right direction by the present Government in this connection. The Hon. Minister for Agriculture and Lands has tentatively drawn up a Scheme of Development for the river basins of the entire Island. A Water Resources Board has also been set-up but its functions have not yet been clearly defined. The idea of initiating such a plan is a very laudable achievement and whatever the consequences, it is very necessary to think in terms of central planning in an under-developed country.

The whole of Ceylon has been divided up into 103 watersheds showing the areas which will come under irrigation. One of the advantages that we possess is that earlier systems of irrigation had existed and watershed planning occupied a prominent place in the history of the country. Ceylon is dependent on an agricultural economy and it is very necessary that the development which had hitherto existed under a Colonial regime should be rectified for the future welfare of the people. The people themselves have already been accustomed to direction from a Governmental level. There is hardly any citizen participation in projects as we have witnessed in the United States. This is understandable in view of the fact that the standard of living and education is not comparable with the United States. There is no doubt, however, that the public consciousness must be stimulated to enable people to take an active interest in affairs directly concerned with their material benefit. For this purpose, development of local government itself is one of the methods by which such public interest can be aroused. The present set-up whereby District Agricultural Committees act in an advisory capacity to State Agencies like the Irrigation Department is an important development which must be fostered and encouraged. There is no doubt that the proposed Regional Councils will be responsible bodies who will be in a position to correspond on the national level with the Central Government and carry out works of improvement and benefit as is happening in the United States. However, a moderate amount of central planning backed by financial assistance will always influence local politics.

The proposed Water Resources Board in Ceylon should not only act in an advisory capacity but should be backed up by funds allocated from the Central Government. The model of the T. V. A. appears suitable to be followed even when setting up a National Agency. Two Directors and a Chairman could be appointed to constitute the Board. These men will be highly skilled professionals who have a deep understanding of the requirements and needs of the people. The Land Departments such as Irrigation, Forests, Agriculture, Wild Life and Land Development should function under this Board. All river basin planning as envisaged by the Hon. Minister of Agriculture and Lands in his tentative plan should be first undertaken by the Board and a Scheme of Development in all phases and activities of these various departments should be undertaken by the Departments themselves with the approval of the Board. There will be a plan of priorities drawn up for each Department and the Board should have complete authority in allocating funds for each department separately in this proposed set-up. At the present moment each department sets up its own schemes and there is no co-ordination between various departments although they work under the same Ministry. This lack of co-ordination can easily be eliminated at this stage before these departments become too unwieldy to follow a pattern of overall development. This is the defect which has been witnessed in the United States and which can be easily rectified by smaller under-developed countries like Ceylon.

The foremost need in Ceylon is increased food production. With this end in view the Government has over the last 25 years aimed at the colonization of the Dry Zone. With the eradication of malaria and the renovation of some of the earlier irrigation systems, the development of the Dry Zone has proceeded apace. The total extent of land under paddy cultivation in Ceylon is one million acres. The bulk of this area is only cultivated once annually and only 39 per cent is double-cropped annually. The reason for this is that in the areas which are only cultivated once a year the water is obtained only from the annual monsoons, and water is not obtained by irrigation. In the 39 per cent of land which is double-cropped the water is partly obtained from irrigation. It would thus appear that the urgent necessity in Ceylon is not to increase extent under cultivation but to plan a more efficient system of irrigation for the land already under cultivation. It is estimated that a further 250,000 acres of land can be double-cropped if the present system of irrigation can be improved by renovating old and unused irrigation systems. It is further estimated that an extent of 8 per cent. of the total area under cultivation is unsown throughout the year due to failure of monsoon weather in certain parts of the Island. The urgent necessity in Ceylon is to utilise already available water in order that the existing areas under cultivation may be in a position to increase their yield. Although actual irrigation has been given top priority, the other uses of water like flood control and hydro-electric power have also been given consideration in planning. Disastrous floods and succeeding droughts which occur in a regular cycle are two factors which have to be taken into consideration when planning in watershed management. The industrial use of water, the need for which would soon be felt as the wealth of the country increases, will also have to be taken into consideration in due course. The example of California where there is a dearth of water, illustrates this particular point. California is the third largest State of the United States and has an area of 100 million acres. The annual rainfall in the North-Western section of the mountainous region is about 100 inches whereas the rainfall in the populated valley is about 2 inches. Over 90 per cent of the population live in the metropolitan areas of Los Angeles and San Francisco. The population has increased after World War II to 15 million because of the discovery and development of minerals and petroleum and also the extremely equable climate which attracts a large number of immigrants from abroad. The present supply of water is totally inadequate to meet this increasing demand. In addition to industrial development, the area produces 40 per cent of the United States supply of fruits, 24 per cent of the vegetables and even field crops and dairy produce. This production is concentrated only in 13 per cent to 14 per cent of the irrigated area of the entire State. Both the Federal Government and the State Government of California are now compelled to think in terms of very large projects in order to increase the water supply for industrial use, domestic use and irrigation. Already 70 million to 90 million dollars have been spent by the Federal Government, and local Agencies spend 150 million dollars each year in the quest for water. The Federal and State Governments have drawn up the Feather River Project which is going to cost 2 million dollars in order to transport water through the mountain range into the Valley. This is no doubt an extreme example of accelerated development which has taken place due to reasons beyond the control of planners, but it serves to illustrate that in unpopulated areas industrialisation can always take place within a very short time, particularly, if cheap power is made available and mineral deposits are discovered in sufficient quantity.

Research

Several important research centres were visited during the Tour. These centres are doing extremely useful work in collecting basic information required for the planning of watersheds. Two of these research stations require special mention :—

- (i) The Soil and Conservation Research Station at Coshocton (Ohio).
In this research station work is being done to determine the benefits of improved farm practices. Valuable information and data have been amassed and analysed in the practical work that has been carried out here, e.g., it has been shown that old practices caused as much as 25 tons of soil loss per acre per year whereas new methods only caused 5 tons of soil loss. Experiments had been carried out to indicate that normal tillage gives higher crop out-turn than heavy tillage. It has also been established that heavier weed growth is experienced in heavily tilled soils rather than in normally tilled soils. Comparisons of run-off, percolation, infiltration, etc., have been made between land under grass and wheat. Research is being carried out in evapo-transpiration by the use of Lysimeters.
- (ii) The Coweeta Hydrologic Experimental Station in North-Carolina.
This Experimental Station is maintained by the United States Forest Service and several studies have been undertaken here to determine the relations between forest and stream flow. Basic and applied research has been carried out here and several interesting results have already been obtained, for example :—
 - (a) Felling of trees leaving the rest of the forest undisturbed causes no difference in stream flow ;
 - (b) Orthodox mountain agricultural practice shows a heavy run-off and also heavy erosion ;
 - (c) In woodland pasture where grazing has been uncontrolled there has been a serious loss of timber and forage accompanied by serious erosion ;
 - (d) Mountain logging practised indiscriminately without precautions shows a heavy run-off accompanied by erosion and deterioration in quality of water.

These examples serve to show that it is very necessary to establish Experimental Stations to collect and correlate data in all phases of the hydrologic cycle.

In Ceylon the problem is one of excess water which has to be impounded and diverted for productive use after the heavy monsoonal rains. The amount of precipitation in this country is no problem and even in the Arid Zone the rainfall is not much less than 50 inches which is more or less equivalent to the rainfall in the more humid areas of the United States. The difference, however, is that distribution of rainfall is unsatisfactory in Ceylon as it occurs during a very short period of the year. The research stations which were seen in the United States had very expensive and elaborate equipment to collect data. It is not considered necessary to establish stations here on such an elaborate scale and with expensive apparatus as was seen both at Coshocton and San Dimas. Both these stations were equipped with series of Lysimeters. These Lysimeters are used to measure evapo-transpiration and their cost is approximately

\$ 25,000 each. The Ceylon Agricultural Department has established several experimental stations throughout the country both in the Wet and the Dry Zones to collect information on crops and soils and the behaviour of water. Basic data in connection with run-off, percolation and infiltration are very necessary in assessing the qualities of a watershed. The set-up proposed in the planning stage discussed earlier can also have a Branch for Research which would collect and disseminate information on the hydrologic cycle.

Education and Propaganda

It had been repeatedly stressed during the course of the Tour that citizen participation is an essential factor in the development of watersheds. Mention has already been made of Public Law 566—(Flood Prevention Act), where cost-sharing is a preliminary requisite if the Federal Government is called in to give either technical or financial assistance. In a country like Ceylon where the standard of living is low compared to that of the United States, and where public opinion has not been yet sufficiently advanced, the ordinary citizen looks to the Central Government not only to plan the projects but also to foot the bill. This early stage in development cannot be avoided but it is most essential that we take into consideration the existing organisations such as Rural Development Societies which have been formed recently to promote the welfare of rural communities and create a public interest in matters which affect the community.

The up-stream phase of watershed management which is usually on the headwaters of smaller tributaries could be looked after by local organisations and farmers who make immediate use of the land. These organisations should be given intensive instruction in ordinary agricultural practice which would be beneficial not only to them but also in the conservation of water and soil. Propaganda is one of the chief branches by which watershed management is publicized throughout the United States. Instructions and lectures, practical demonstrations aided by films were a feature of the programme which was arranged for the participants of the Tour. Even if people themselves are educated the actual demonstrations by means of pictures, etc., go a very long way in bringing home the beneficial results of good practices as opposed to bad methods.

The present Governmental set-up in Ceylon necessarily involves a Central Government in work where there is any type of large scale planning or irrigation structures to be built. It would be quite some time before a local authority could afford the money to even contribute small amounts towards the expenditure involved in large scale irrigation planning. It is, however, necessary that a beginning should be made and the citizens of any particular area who benefit from a scheme of irrigation or water storage should be made to realize that they should bear at least a part of the cost of such expenditure.

Economic Considerations

Every Government has to face the cost of large scale planning and execution of works which are designed to give long range benefits to the people. The main difficulty which faces a country like Ceylon is lack of capital. This is not one of the handicaps which has been encountered by the United States. The wealth of that country and the skill of its technicians over the last half a century have provided the means to undertake gigantic operations in the field of watershed management and all associated activities.

The resources of a smaller country like Ceylon are very slender and the basic plantation industries which support the economy cannot rapidly increase in productivity. The income derived from these sources is insufficient to meet the expenditure of the big programmes of work to be executed even over the next ten years. A Government, therefore has the very onerous task of not only improving the present standards of life but also making sufficient provision for future benefits. In all such undertakings the Government has to consider carefully the total amount of money a country can afford to spend for any type of material improvement. All expenditure should be considered as an investment which would give sufficient return in due course. The best example of such investment has been seen and discussed in the T. V. A. Story in Chapter IV of this Report. All projects when drawn up must also make a critical analysis of the benefits which can be derived over a reasonable period of time and should be measured in terms of money. This aspect is known as the Benefit-Cost-Ratio which must be analysed before making provision for funds. There are direct benefits to be derived like the immediate irrigation of a large tract of land but there are also several other benefits which must also be taken into consideration like flood control, recreational use of water, hydro-electric power, etc. The benefit-cost-ratio as evaluated by various people when putting forward a scheme is always open to debate and criticism. However, unless proposals for large schemes are examined very critically to justify the expenditure, the Government with very meagre resources will find it extremely difficult to allocate funds particularly when other requirements such as Public Health and Education make equally important demands on the State.

National Schemes have always to face this criticism but smaller schemes involving small watersheds need not necessarily think in terms of national undertakings, e.g., the immediate benefits accruing from small operations like water detention structures, improved methods of agricultural practice, reforestation to prevent erosion, stream banks stabilisation of small streams, etc., which always give immediate results within a very short time.

Appreciation

The Food and Agriculture Organization has to be congratulated in organising this Seminar and Study Tour for the benefit of the participants from different countries. Extremely valuable illustrations of works which have been attempted in this review was possible due to the careful planning of the itinerary and the seminars and discussions which took place during the course of the Tour.

Mr. Warren T. Murphy of the United States Forest Service was primarily responsible not only for the schedule of the tour but also for taking a leading part in the seminars and discussions which were of immense benefit to the participants.

Dr. John Blackmore and M. Francois of the F. A. O., Rome, gave very valuable assistance in the group discussions, the results of which are incorporated in this Report.

The participants themselves came from varying and diverse climatic regions and the experience shared by the entire party in discussing the problems of their own countries amongst each other has gone a long way in not only increasing the knowledge gained on the Tour but also fostering better relations between technicians of different countries which is the primary aim of the United Nations Organization.

THE CANADIAN COLOMBO PLAN SURVEY OF NATURAL RESOURCES

J. R. T. Andrews

IN Ceylon as in the other so-called "under-developed countries" of the world, Government officials and others concerned with national and regional planning have been hindered in their work by the lack of basic information about the nature, extent and distribution of natural resources. These planners are well aware that information about these resources must be quickly acquired for the country as a whole, and also for its component regions, before any sound development plan can be drawn up.

These considerations led the Government of Ceylon to request the Government of Canada, through the Colombo Plan Administration, to provide assistance in carrying out a program of air photography and the mapping and evaluation of land and water resources. In 1955, a contract for this project was awarded to the Photographic Survey Corporation, Limited of Toronto, Canada. In accordance with the terms of this original contract and subsequent amendments, the following are the main projects undertaken :

(1) Air Photography

Air photographs having a scale of 1 : 40,000 were taken for the whole island and, from these, semi-controlled mosaics having a scale of 1 : 31,680 were prepared. Air photographs having scales larger than 1 : 40,000 were taken of areas of special interest, including the Sinharaja Forest. A photograph-processing laboratory was established in Colombo for the Air Survey Branch of the Survey Department.

(2) Survey of the Sinharaja Forest

During 1957, a forest inventory and management study of the Sinharaja Forest was carried out by foresters of the Ceylon Forest Department and the Photographic Survey Corporation, Limited. Some results of this survey are presented in an article in the "Ceylon Forester", Vol. IV, No. 20.

(3) Map Showing the Structural Geology of Ceylon

(4) Geophysical Surveys

(5) Reconnaissance Land-Use and Forest-Cover Surveys of Ceylon

The land use and forest cover of the entire island are now being mapped on mosaics having a scale of 1 : 31,680. Details of the reconnaissance forest-cover survey are given in the second part of this article.

(6) Forest Inventories

Detailed forest surveys are now being carried out for the valuable and potentially valuable forests of the island, i.e., those shown to be promising as a result of the reconnaissance forest-cover survey mentioned above. The procedures and uses of these inventories are described in the second part of this article.

(7) River Basin Surveys

Surveys of natural resources have been completed for the Kirindi Oya, Walawe Ganga and Mahaweli Ganga basins and similar surveys are now under way for a number of river basins in the west part of Ceylon. Together, these comprise roughly 60 per cent of the area of the island. The aim of these surveys is to provide an inventory of geology, landforms, soils, land use, forest cover and hydrology and to make suggestions and recommendations about the future use of the land and water resources of each basin. For each basin, geological, landform, land use and forest cover, and drainage maps have been compiled, or are being compiled, on mosaics having a scale of 1 : 31,680 and this detail is being reduced to provide final maps having a scale of 1 : 126,720. Reports are being written on the natural resources of each basin.

The survey team consists of specialists in geology, hydrology, landforms, soils, land use and forestry. The whole operation was planned so as to integrate Canadian and Ceylonese personnel in each phase of the work. Close co-operation was set up with various Government departments, with the Surveyor-General as the Ceylon Government Administrator. Apart from personnel seconded to the survey team by Government departments, a number of Ceylonese technicians and office workers were hired by the Company to assist in carrying out the work.

The mapping of resources was done using a combination of air photograph interpretation and ground survey. The greater part of the mapping was done by means of stereoscopic study of the air photographs; field traverses were made in sufficient density to establish the main elements in the patterns of resources, confirm the mapping done on air photographs and check any doubtful cases.

The resources survey comprises the following fields : geology, geophysics, hydrology, soils, land use and forestry. Specialists in each of these fields study the photographs and mosaics and then go out on the ground and check their interpretation, after which they prepare maps. When all the maps have been prepared, they are studied together in order to provide a basis for resources development planning. For example, let us assume that one basin, such as that of the Walawe Ganga, is to be developed for settlement. The first step is to study the geological and geophysical maps to see if there are any promising areas of mineralization. If there are, they are located on the planning map. Next the hydrology reports are studied and possible dam-sites are evaluated in terms of the irrigation water which will be available, the hydro-electric power that would be generated and the area which would be inundated by a reservoir. The land use and forest cover map, which shows each area of paddy, rubber, chena, forest and other land uses presently found in the basin, is then examined. A transparent overlay of the landform map is then superimposed on the land use map in order to show the relationship between crops and landforms. The last step is to decide which is the best possible distribution of forest and agricultural lands. Dam-sites are chosen, the flooded area is delineated, the area to be irrigated is outlined and future areas of dry farming and forest are demarcated. In this way, the use of each area of land is planned in such a way that it will yield the maximum economic return.

Survey of Forest Resources

Forests are among the most important resources of Ceylon. They cover about 50 per cent of the island and provide a host of products necessary to everyday life and also valuable timbers for export. The forest surveys have been designed and conducted with the co-operation of the Forest Department so that the information most needed to meet the immediate requirements of the country will be provided. Two types of forest survey have been undertaken, a reconnaissance survey of the whole island and management surveys for selected areas of good timber. Merchantable volume data obtained from the management surveys are used in combination with the reconnaissance forest mapping in order to produce an inventory for the whole island. It will also be separately used in the preparation of management reports on the selected areas of good timber.

The reconnaissance survey involves the production of forest-type maps and the acquisition of suitable volumetric data for the selection of the most productive forest areas in Ceylon. These maps are necessary for the re-delineation of Forest Reserves and will facilitate their grouping into units of manageable size. At present no volumetric data exist for the forests of Ceylon. After the survey is completed it will be possible for the first time to calculate the allowable cut for each forest on the basis of sustained-yield management.

The forest surveys also serve as an integral part of the whole resources survey program, since forests are one of the main land uses of the island. Maps are being prepared showing both forest and agricultural uses of land and these will be used determining the best possible use of land.

The reconnaissance survey of forest consists of three phases, photo interpretation, ground checking, and mapping. Photo interpretation involves the examination of adjacent overlapping air photographs by means of a stereoscope. This gives a three-dimensional view of the landscape. Species composition, size, density and other features of the forest are all elements that effect the appearance of the forest on the photographs and the experienced photo-interpreter can evaluate all of these features.

This study permits the drawing up of a classification of forest types. The interpreter draws a line around each type on the photograph and marks each area with a symbol. This information is then transferred to a mosaic. Mosaics are made by cutting out the central part of each of a series of aerial photographs and pasting them together to form a composite map. In the Ceylon survey, photographs having a scale of 1 : 40,000 were made into mosaics and then enlarged to a scale of 1 : 31,680 or 2 inches to 1 mile. After all the information for both forestry and land use has been mapped on mosaics, a tracing is made and a final map is prepared. The accompanying report describes each land use and forest type and presents statistical summaries of their areas. The volumes per acre for each forest type, which will have been provided by field sampling, are applied to the areas of each type. These volumes are then added together in order to obtain the volume of merchantable timber in Ceylon.

The management surveys are being carried out only in the areas of most-productive forest, especially virgin or well-managed rain forest. Photographs having a scale of 1 : 15,840 are used. This is a much larger scale than that used for the forest reconnaissance and many more details of the forest may be seen under the stereoscope, thus allowing a more detailed and comprehensive classification to be used. The photographs are interpreted in the same manner as

are those used for the reconnaissance survey. However, the mapping is more accurate. A base map is prepared, using such specialized methods as a slotted template laydown. The transfer of topographical detail is done using a Watts Radial-Line Plotter. Later the forest type boundaries and symbols are transferred from the photographs to the base map. The field work is being carried out by four field parties consisting of three Canadian foresters and three Ceylonese foresters, in charge of rangers and forest guards supplied by the Forest Department. The survey is carried out from camps in the forest, often under rugged and difficult conditions. It is impracticable to measure all trees in order to determine the volume and species composition of the forest. Therefore, a sampling system which involves the measurement of representative parts of the forest is used; the results of this sampling are then extended to provide information about the forest as a whole. The field crews take samples at fixed intervals along lines established in the various forest types. The diameter and merchantable height of each tree are recorded and, from tables, the volume of wood per tree can be calculated. These data are then recorded on cards for later sorting and tabulation by electronic calculating machines. The volume per acre calculated for the sample plots are then used to obtain the total volume of trees of each forest type in the management area. From this information the allowable cut can be calculated and this incorporated in a management plan so that the forest will continue to produce timber for all time.

The two surveys together thus provide a basis for calculating growth and drain (i.e., the periodic loss due to cutting, fire or natural causes) for Ceylon and give a firm foundation for decisions on forest policy. They also provide enough detailed information on selected high-yield areas for planning intensive, sustained-yield management.

THE ECOLOGY AND BIOLOGY OF PARASITISM OF THE LORANTHACEAE OF CEYLON*

W. G. Weeraratna

INTRODUCTION

THE LORANTHACEAE is a family of Angiosperm parasites. It is predominantly tropical and is represented in Ceylon by 11 genera and 27 species. Most of the Ceylon species were described by Trimen (1895), but his account is now, at least partly, out-of-date. Since then Danser (1929) working on the Malaysian Loranthaceae divided the larger genera of previous workers into many smaller genera. An attempt has been made by the present writer to classify the Ceylon Loranthaceae according to the concepts of Danser and the modern terminology is used here.

126 host species are now known from Ceylon, those of economic importance being *Tectona grandis* (Teak), *Artocarpus integrifolia* (Jak), *Hevea brasiliensis* (Rubber) and many species of *Citrus*. Teak and Jak are cabinet timbers. Jak also bears edible fruits. Severe infection by *Dendrophthoe falcata* has been observed in these two species. In *Citrus* plantations, extensive damage is caused by *Dendrophthoe falcata* and *Taxillus cuneatus*.

Notwithstanding the considerable economic importance of this family, the ecology and biology of parasitism has previously not been much studied. The only contribution to its biology is by Keeble (1896) who studied the structure of the flower and germination of the seed of a few species.

During the last 4 years the present writer has made extensive observations in this field, and they are summarised below together with the findings of other workers.

DISTRIBUTION AND SPECIFICITY

Climate as a factor in distribution

A review of the information available on the climate of Ceylon is given by Koelmeyer (1957). He has also discussed the merits and demerits of Koppen's, Thornwaite's and Swain's climatic classifications as applicable to Ceylon. A simpler classification in provided by Lewis (1934) who recognises five broad climatic zones :—

- | | |
|-------------------|--------------------------|
| (i) Wet zone ; | (iv) Intermediate zone ; |
| (ii) Dry zone ; | (v) Montane zone. |
| (iii) Arid zone ; | |

The Tropical Wet Evergreen Forest is characteristic of the Wet zone, and the Dry Evergreen Forest is characteristic of the Dry zone. The composition of the former is described by de Rosayro (1943) and that of the latter by Holmes (1951).

The Arid Zone is composed of low open thorny scrub forest.

* Condensed from a thesis accepted for the Diploma of Forestry, University of Oxford, 1959

In the Intermediate Zone, species of both the Dry and the Wet zones occur, the drier facies containing more of the dry types and the wetter facies more of the wet types.

The Montane zone occupies the central parts of Ceylon at altitudes over 5000 ft.

It has been found that most species and certain life forms of Loranthaceae are characteristic of these climatic zones and they are listed below :—

- A. WET ZONE. *Barathranthus nodiflorus*, *Dendrophthoe lonchophylla*, *Elytranthae capitellata*, *Ginalloa spathulifolia*, *Helixanthera ensifolia*, *Notothixos floccosus*, *Tolypanthus gardneri*, *Viscum* sp.
- B. DRY ZONE. *Helixanthera hookeriana*, *Scurrula cordifolia*, *Taxillus cuneatus*, *Viscum orientale*, *Viscum hyneanum*, *Viscum articulatum*, *Viscum nepalense*.
- C. ARID ZONE. *Dendrophthoe ligulata*, *Viscum* sp.
- D. MONTANE ZONE. *Barathranthus mabaeoides*, *Dendrophthoe suborbicularis*, *Elytranthae parasitica*, *Taxillus sclerophyllus*, *Taxillus tomentosus*, *Korthalsella opuntia*, *Viscum ramosissimum*.

Employing Raunkiaer's (1934) leaf size class as the basis of measurement it was found that 50 per cent. of the leaves of the Loranthaceae of the Wet zone are mesophylls, in contrast to those of the Dry, Arid and Montane zones which are mostly microphylls with a high percentage of leptophylls. The leaves of the Wet zone are characterised by leaf tips tending to be acuminate. Those in the Dry and Montane zones show rounded, broadly oval or rotundate tips.

These findings are in agreement with the observations of Holterman (1910) and Richards (1957) for various ecological types. An increase in the percentage of microphyll leaves with increase in altitude has been observed by Brown (1919) for the vegetation of the Philippine mountains.

Illumination as a condition for the spread of the parasite

STRONG overhead light appears to be essential for the development and spread of the parasite. Maximum infestation is seen on isolated trees, opened out scrub jungle and the periphery of plantations adjacent to cleared lands. Heavily thinned plantations of *Tectona grandis*, *Artocarpus integrifolia* and *Casuarina equisetifolia* are more susceptible to attack than those thinned less. Plantations of *Hevea brasiliensis* on unfavourable sites which open due to poor crown development suffer severe damage. In thick natural forest, particularly the Wet Evergreen forest, there are hardly any traces of the parasite, and when they do occur they are located on the uppermost branches. Richards (1936) has made similar observations on the vertical distribution of the Loranthaceae. Plagnat (1950) has observed that heavily thinned plantations of *Abies alba* in France were more susceptible to mistletoe infestation than dense stands.

In the Teak plantations of Vakaneri in the Eastern Province of Ceylon, where heavy openings have been made due to excessive fellings in the last War period, subsequent over-thinnings and fires, heavy parasitic invasion is noticeable. It is noteworthy that in one of the Research Experimental Plots where no thinnings have been carried out as a "control", there are no traces of Loranthaceae.

Host selection and specificity

THE Loranthaceae grow on numerous hosts. Although they infest many families of the Dicotyledons they have not been found on Monocotyledons. Attempts made by the writer to germinate *Dendrophthoe falcata* on *Bambusa* sp. and *Imperata cylindrica* failed. Amongst the Gymnosperms in Ceylon, Loranthaceae have been observed growing on *Pinus patula* and *Widdringtonia whytei*.

Trimen's (1895) Flora which is the only taxonomic work on this family does not give the host plants on which the parasites grow except for a casual mention of a few host species which had probably attracted the author's attention. The present writer has recorded 126 host species.

Of the 26 species of Loranthaceae, *Dendrophthoe falcata* has the widest distribution and parasitizes a large number of hosts throughout the Island. The aggressiveness with which it can attack different hosts however varies and it exhibits variations in degree of specific pathogenicity. Whilst it attacks species such as *Bombax malabaricum*, *Mangifera indica* and *Tectona grandis* with ease, its capacity to attack species such as *Mimusops hexandra* and *Pithecolobium* sp. is limited.

Most other species have a narrow host spectrum of varying degree, the extreme case being *Viscum capitellatum*.

Some outstanding examples of specificity as observed by the writer are enumerated below :—

1. *Viscum hyneanum* severely attacks *Chloroxylon swietenia*. Enumerations indicate that over 50 per cent. of the avenue trees are attacked. However, none of the species which occur in intimate mixture with *Chloroxylon swietenia* are attacked by this species of *Viscum*.
2. *Viscum articulatum* has been found mostly on *Cassia fistula* and *Cassia marginata*.
3. *Viscum capitellatum* has been recorded mostly on *Dendrophthoe falcata* as a hyperparasite.
4. *Notothixos floccosus* has been recorded chiefly on *Palaquium* sp.
5. *Dendrophthoe ligulata* has been found only on *Tamarix gallica* and *Salvadora persica*.
6. *Dendrophthoe suborbicularis* and *Taxillus sclerophyllus* have been found mostly on *Rhododendron arboreum*.
7. *Taxillus tomentosus* shows a preference for *Phyllanthus embilica* and *Neolitsea* sp.
8. A species of *Dendrophthoe* attacks *Eucalyptus globulus* severely at Haputale arboretum, whilst several other Eucalypts growing in intimate mixture are unattacked.

Several theories have been adduced to explain the specificity of the Loranthaceae. Scot (1871) says the habit of the host and the physical and chemical qualities of its bark determine its relation with the Loranthaceae. Bidie (1874) attributes immunity to parasitism to the deciduous bark of the host dislodging the seed before it can germinate, and cites *Eucalyptus globulus* as an example. Fischer (1926) found that many species cited by Scot as immune to parasitism on his observations, were actually heavily attacked. Scot's observations appear to be of limited extent. Fischer

also found *Eucalyptus globulus* referred to by Bidie as immune, heavily attacked by *Dendrophthoe falcata* in the Nilgiris. My observation too agree with those of Fischer—*Eucalyptus globulus* being one of the most heavily attacked species.

Immunity to infection is fundamentally based on protective barriers and bark can function as an effective barrier. Hence basically, both Scot and Bidie may be correct but they have failed to realise that whilst the main stem of a tree or an old branch may have sufficient bark for protection against the penetrating haustorium, the tender parts of a growing branch would not have the same degree of protection. Further, a main stem is hardly a place where a bird would perch to disperse the seed, the most likely place being a growing branch. Hence what Fischer observed may have been the established *Loranthus* tufts from seeds deposited on tender branches of trees with thick or exfoliating bark referred to by Bidie and Scot.

Harley (1863) advanced the view "other conditions being equally favourable, the size and number of medullary rays is the chief cause which determines in any given case the attachment of the mistletoe and this is probably true of all other cases of parasitism". The number of host species observed by the writer where medullary rays of diverse types are found disproves this view. Harley's observations appear to be based on a few temperate mistletoes.

Somerville (1914) attributes the absence of the mistletoe in certain places in England to soil variation. This is not in agreement with Fischer's findings for *Loranthaceae* in India and my observations in Ceylon where *Loranthaceae* occur on hosts growing on every kind of soil.

McLuckie (1923) says "certain hosts possess a substance that may be injurious to the advancing parasitic haustorium". Angell (1930) showed that brown skinned onions are less liable to "rot" than white skinned ones due to the presence of fungicidal phenols. Further investigation on cell contents of plants that refuse to act as host, after artificial inoculation with *Loranthaceous* seed, may throw more light on this question. McLuckie also suggests that where a haustorium cannot penetrate a cuticle it may be due to the absence of an enzyme.

Fischer (1926) remarked that the failure of the parasite to attach itself to a host is due "to definite repulsion or inhibition of some kind..... the inhibition whatever its nature may be is on the penetrative power of the haustorium". To corroborate this hypothesis he says that parasites of this family do not grow on plants of their own species. The writer however has observed *Taxillus cuneatus* growing on its own species. Singh (1954) and Stevenson (1934) have made similar observations with *Dendrophthoe falcata* and *Korthalsella lyndsayi*. The writer has also observed that suckers arising from *Dendrophthoe falcata* at times enter one of its own branches or adventitious roots. Skene (1924) and Singh (1954) have also observed this phenomenon. Hence Fischer's theory of repulsion is questionable.

Bergdolt (1927) has found that the suction pressure in the cells of *Orobanche crenata* was higher than that in *Vicia faba* on which it grew parasitically. He found a suction pressure gradient at the site of infection. Hence if a plant has a suction pressure in its cell contents higher than that the *Loranthus* can exert, it is osmotically protected against the parasite.

Apart from the pre-existent defence barriers referred to above i.e., bark, presence of antibiotic substances in cells, and high osmotic pressure, resistance to infection could also be ensured by dynamic defence reactions released in the host after infection.

Heinricher (1929) found that due to special defence reactions in the pear tree it is rarely parasitised by mistletoe as compared with apple. If susceptible varieties of pear are inoculated with mistletoe seedlings, they show a hypersensitivity with cork and bark formation, insulating the healthy tissue from the effect of the parasite, which ultimately falls off along with the host bark. Gaumann (1950) refers to this as "an eliminative and necrogenous defence reaction". It has also been pointed out that no immediate re-infection occurs on such a pear tree due to "a heightened readiness for cellular defence". It has been referred to as a "localised disease which gives rise to a general humoral sensitization". A plant could thus potentially immunise itself against a parasitic Lorantheaceae.

Tubeuf (1923) demonstrated that in Central Europe there are three distinct races of *Viscum album* which are indistinguishable by any botanical features and differentiated only by their hosts. These could be termed biological species or *formae specialis* (f.sp.). The three biological species are :—

- (a) The hardwood mistletoe (*Viscum album* f. sp. *mali*).
- (b) The fir mistletoe (*V. album* f. sp. *abietis*).
- (c) The pine mistletoe (*V. album* f. sp. *pini*).

The possibility of further sub-division into biological races has been suggested as the hardwood mistletoe on lime shows a specific capacity for infecting lime and the poplar mistletoe a similar capacity for poplar.

In the light of these observations the possibility of the existence of genetic forms in species such as *Dendrophthoe falcata* need further investigation.

BIOLOGY OF INFECTION

Dispersal

THE dispersal of the seed is effected by *Dicaeum erythrorhynchus ceylonensis* (Dicaeidae). It is the smallest bird in Ceylon and is distributed throughout the Island, feeding chiefly on loranthaceous berries. It is also known as the "parasite bird" and its existence is closely bound up with that of the Lorantheaceae. Keeble (1896) has observed *Pachyglossus vinceus* and *Chloropsis jerdoni* also aiding dispersal.

The ripe one-seeded berry contains a sweet viscid pulp surrounding the seed. In the act of feeding, the bird squeezes the seed out of the fruit coat. The fruit coat is rejected, probably due to its high tannin content.

Two views have been put forward as to the exact mode of dispersal. According to Ryan (1899) the bird swallows the entire seed and passes it out within 8-12 minutes. He found the seed to be more sticky on emergence than entrance, thus enabling its attachment to any object. Ashworth (1895) also records *Dicaeum hirudinaceum* swallowing *Loranthus* seeds in Australia.

According to Keeble (1896) the bird does not swallow the seed except by accident. He says "at the hill gardens Hakgalla, Loranthi grow luxuriantly. On the single telegraph wire there are every year hundreds of seedlings of *Loranthus loniceroides* all in early stages of germination. It can hardly be supposed that the seeds arrive at this anomalous position as a consequence of being voided, but rather that the birds free their beaks of them by striking or rubbing against the wire".

The writer made several observations and found, that when feeding, if the seed directly slips into the mouth in the act of removing the fruit coat the bird swallows the seed entire, otherwise it feeds only on the pulp and wipes its beak immediately against a branch to clear off the seed stuck to the beak. The latter appears to be the more general method. Dissections were also carried out of the alimentary canal of two birds killed whilst feeding on *Taxillus cuneatus*, and 12 seeds were found in the guts. Eight of these were in a state of disintegration and one out of the other four which looked sound, germinated.

More observations are required for a final explanation. However, Ryan's observations on the rapid passing out of the seed, and the writer's observation on the immediate wiping of the beak to clear the seed, would suggest a slow migration of the plant.

Host-parasite connection

MECHANISM OF INVASION

Loranthaceous seeds are dispersed in such a manner that many are left attached to the bark of a suitable host. There is sufficient material provision in the germinating seed to maintain the seedling until it assumes a stable parasitic relationship with its host, which it does within a few weeks.

Details of germination of many of the Loranthaceae of Ceylon are given by Keeble (1896). McLuckie (1923) gives the germination of *Loranthus celastroides* and Singh (1954) that of *Dendrophthoe falcata*. The germination of the European mistletoe *Viscum album* has been studied by several workers including Tubeuf (1925) and Thoday (1951).

According to Keeble (1896) "the hypocotyle of some species worked on, show it is negatively heliotropic and ageotropic. Besides this, nutation affects curvature of the hypocotyl. By this nutation the suckorial disc if it fails to reach the host by the direction which negative heliotropism imposes upon it, is brought into a series of positions whereby its chances of obtaining some hold on a suitable object are enhanced."

The end of the hypocotyl which comes into contact with the host is flattened out in the form of an irregular pad or holdfast, from the centre of which arises a haustorium which is able to penetrate the host tissue. No injury or wound is necessary for penetration. McLuckie (1925) says that penetration of the haustorium is due to pressure and chemical action. According to Thoday (1951) "a pectic enzyme is also probably secreted having a solvent action on the pectic middle lamella of the cork".

Further infection proceeds on lines similar to attack by parasitic fungi, exhibiting an active mechanism of host invasion. The growing haustorium is selective in its path of spread and grows towards the xylem tissue of the host, aided by host cell disorganisation.

THE HAUSTORIAL SYSTEM

THE haustorial system of the two major groups of the Loranthaceae, the Viscoideae and the Loranthoideae, differ significantly. In the Viscoideae it is of an endophytic nature, colonisation being restricted entirely to the interior of the host. From the primary haustorium, a system of lateral outgrowths arise, which elongate to form the "cortical strands". These lie in the cortex of the host and are capable of extending both lengthwise and round the circumference of the host branch, and send down secondary suckers into the host xylem. This arrangement permits a tapping of the host sapwood round the entire circumference. Thus externally there is only one point of attachment of the parasite with the host.

In the Loranthoideae, however, secondary roots arise from the haustorial tissue and these "adventitious roots" grow on the outside of the host. They are insensitive to gravitational stimulation and extend both upwards and downwards and round the circumference of the host from the original point of infection, sending in secondary haustoria at intervals, capable of tapping the host sapwood round its circumference at different heights. Thus the Loranthoideae are attached to the host externally at several points and this is generally a useful morphological feature for identification of the two groups. (See Plates III and IV.)

Occasionally the Loranthoideae remain attached to the host at one point like the Viscoideae. This occurs when the parasite is lodged on a host where penetration could proceed rapidly, assuring a quick stable relationship. The tendency for attachment at one point is common in "softwood" host species such as *Mangifera indica*, *Bombax malabaricum*, *Moringa pterygosperma* and *Broussonetia papyrifera*.

In the Viscoideae too, aberrant types are occasionally found. In a specimen of *Viscum articulatum* growing on *Dendrophthoe falcata* itself parasitic on *Hevea brasiliensis*, Thoday (1956) found no cortical strands, the parasite being attached by only the "primary graft".

The external adventitious roots of the Loranthoideae can grow to several feet, their extent of growth varying in different species. They are best developed in *Dendrophthoe* where lengths up to 18 feet have been observed. When the adventitious root reaches ground level of the host, further extension stops, the tip becoming shrivelled. It was also found to exhibit nutation when growing on the apex of a young shoot of *Pericopsis mooniana*. Microtome sections of these "adventitious roots" showed clear exarch vascular bundles. Young shoots arise at most points where the adventitious roots send in haustoria. It was observed that when the apex of the adventitious root was removed, a lateral adventitious root developed from a point close to the amputation. When the adventitious root was severed on either side of an established sucker with a shoot, it functioned as an independent plant. Hence the adventitious root besides functioning as an organ for production of suckers to enhance nutrient absorption, also functions as an organ of vegetative propagation. In the Viscoideae the internal cortical strands behave likewise, occasionally producing adventitious buds which emerge as aerial shoots.

Thoday (1956) has found structural differences in the haustorial system even amongst different genera in the Viscoideae. He found the pattern of the haustorium in certain species of *Korthalsella* different from that of *Viscum* sp., lending strong support to Van Tieghen's separation of *Korthalsella* from *Viscum*. Thoday (1956) says "the comparison of the various ways in which the hosts are attached and the structural relations

that are established between parasite and host would yield clues to the course of evolution from relatively primitive to more advanced or more specialised forms and methods, and also perhaps make it possible to distinguish those basic features on which the initial adoption of parasitism depended”.

WATER RELATIONS OF HOST-PARASITE

Histology of point of attachment

TO investigate the structure of cells at the point of infection, microtome sections were prepared of several host-parasite connections with *Dendrophthoe falcata* as parasite. (See Plate V.)

Infection was found to activate the cambium and lead to an excessive development of host wood surrounding the advancing haustorium. In the formation of extra wood by the host, there appears to be an increase in the cambial surface and an abundant proliferation of tissue. It was observed that generally the xylem cells at the point of contact with the haustorium differentiate into isodiametric parenchyma cells whilst those further away from the haustorium differentiate into fibres and vessels. More work is however required to throw light on the exact behaviour of the cambium in response to the infection to produce this hypertrophy.

It was found that in both young and mature haustoria, the peripheral layer of cells immediately in contact with the hypertrophied host xylem was parenchymatous. Prominent scattered groups of stone cells having characteristic sclerides occur in the haustorium. Differentiation into tracheids and vessels takes place in isolated patches inside the periphery, towards the centre of the haustorium, but these do not extend up to the periphery. They join up with the fairly well developed central conducting strand of the parasite. McLuckie (1923) working on *Loranthus celastroides* and Thoday (1956) on *Viscum album* report on the existence of a few direct connections between the xylem elements of host and parasite. Singh (1954) working with *Dendrophthoe falcata* has made observations approximating those of the writer. He says “The part of the haustorial cone, which is in intimate contact with the wood of the host is formed of parenchymatous cells In a few cases only, a vascular strand from the haustorium was found to have entered a few millimetres into the wood of the host.”

Water absorption

A few xylem elements in direct association with the host conducting strand cannot account for the entire process of water absorption by the parasite, and one is led to the conclusion that the peripheral parenchymatous layer of the haustorium plays a dominant role in water absorption and transfer.

Of the several theoretical possibilities in the passage of water from the xylem elements of the host to those of the parasite through the peripheral parenchymatous zone of the haustorium, some evidence is available on possible absorption due to osmotic suction and transpiration pull.

Harris and Lawrence (1916) determined by cryoscopic methods that the sap in photosynthetic tissues of some Jamaican Loranthaceae had generally a higher osmotic pressure than that in the mature leaves of their hosts,

and it has been shown by Dixon and Atkins (1915) that generally the osmotic pressure of the sap in the leaves of many species is higher than that in the xylem vessels. Further, Bergdolt (1927) found a suction pressure gradient at the site of infection of *Orobanche crenata* on *Vicia faba*.

Hence if an osmotic pressure gradient was the factor determining the polarity of water removal, one would expect a transfer of water from the host to the parasite and thence to the leaves of the parasite for subsequent transpiration. But in view of the present limited knowledge of the physiology of water absorption and transpiration, this must remain a hypothetical answer. For example, although generally the osmotic pressure of the xylem sap is lower than that of the cortex, water moves from the cortex to the xylem against an osmotic pressure gradient.

Kamerling (1914) showed that the transpiration of the parasitic Lorantheae is more rapid than that of their hosts. Excessive transpiration from the parasite would lead to a high diffusion pressure deficit in the parenchyma of the haustorium, providing the necessary force for uptake. Hence it may be that this is responsible for movement of water from host to parasite. Whatever the cause, it is apparent that with the absence of a continuous conducting system, water transfer from host to parasite still takes place.

Effect of parasite on host

As a result of infection, drastic organisational and functional disturbances occur in the host with obvious visible pathological symptoms.

Hypertrophy of host cells in varying degree is associated with the parasite entrance, the extent being determined both by the parasite and the host. Whilst it is pronounced in the Loranthoidae it is less marked in the Viscoideae. A hypertrophy 2 feet in girth due to infection by *Dendrophthoe falcata* has been observed. Thoday (1956) attributes hypertrophy to a hormone secreted by the parasite, the extent of hypertrophy being related to a quantitative or qualitative hormone production. Microtome sections of *Thespesia populnea* as host to *Dendrophthoe falcata* showed that the xylem elements contiguous to the haustorium of the parasite are plugged with gum and tyloses, whilst those more remote were open. This is an apparent host reaction to the parasite. Struckmeyer (1954) observed this same phenomenon of extensive gummosis and tyloses in *Quercus ellipsoides* when attacked by the wilt causing fungus *Chalara quercina*. He suggests that the metabolite of a fungal pathogen could act as a toxic agent producing this reaction.

Parasitic infection by Lorantheae eventually leads to the death of the host above the point of infection. A vigorously growing branch of *Broussonetia papyrifera* 6 inches in girth was killed within five months by artificial inoculation with *Dendrophthoe falcata*. Although the actual cause of death has still not been ascertained, a plausible explanation is death due to deprivation of water and nutrients, aggravated by plugging of xylem vessels. Struckmeyer (1954) found that in *Quercus ellipsoides* attacked by *Chalara quercina* the additive effect of plugging of xylem elements in different parts was sufficient to reduce sap flow in the wood to a level capable of causing host leaf wilt. Beckmann (1953) has confirmed this reduction in sap flow preceding wilt using radio-active rubidium. A similar situation is possible in the Lorantheae—an interrupted ring of plugging at different levels in the sapwood being possible with the type of haustorial development seen in the Lorantheae.

That the plugging of the xylem elements of the host does not interfere with sap movement to the parasite is evident from the continued active growth of the parasite even after the death of the host branch distal to the infection. Hence it may be that the plugged xylem elements are not functional with respect to the parasite and that it obtains its water and nutrients from the hypertrophied tissue surrounding the haustorium. It is significant that vessels in the hypertrophied portion show no signs of plugging. However the precise significance of plugging to the host itself remains to be established by experiment.

Death of branches due to infection reduces crown size. A heavy attack can considerably lower the vitality of the tree and kill it. Nicoloff (1923) showed that in mistletoe-parasitised apple there is a selective accumulation of nitrogen, phosphorous and potassium in the mistletoe to the detriment of the host.

Heavy tree mortality has been observed in plantations of *Tectona grandis*, *Artocarpus integrifolia* and *Casuarina equisetifolia* as a result of infection. Increment measurements of infected and non-infected *Tectona grandis* are being compared at present. Klepac (1955) found a reduction of 19 per cent. in total volume in mistletoe-affected Silver Fir stands in France as compared with unattacked stands. Gill (1957) found a loss of 33 per cent. in merchantable timber in Lodgepole Pine subjected to dwarf mistletoe in Colorado. In the *Citrus* plantations of Ceylon, heavy infection results in production of fruits of poor quality. Keily (1957) says "failure to control *Loranthus* could lead to a decline in citrus cultivation".

Hyperparasitism

Viscum capitellatum is a common hyperparasitic member of the Loranthaceae with a wide distribution in Ceylon. It has been recorded in abundance on *Dendrophthoe falcata* when the latter assumes damage in epidemic form, and tends to keep *Dendrophthoe falcata* in balance.

Viscum capitellatum shows extreme modification in its morphology. The leaf is reduced and often shed, the stem assuming the photosynthetic function. The conducting elements have also undergone extreme reduction.

SUMMARY

The distribution of the Loranthaceae is closely related to climate, and the intensity of parasitism is influenced by illumination. Most Loranthaceae have been found to be restricted to particular species of hosts. 126 host species have been recorded. The haustorial system of the Loranthoideae and the Viscoideae differ in their general arrangement—the former generally have external "adventitious roots" whilst the latter have internal "cortical strands". The peripheral layer of cells of the haustorium of *Dendrophthoe falcata* is parenchymatous—no direct host-parasite xylem connections occur. Infection causes host cell hypertrophy, its extent being determined by both parasite and host. Tyloses and gummosis was seen in xylem vessels of *Thespesia populnea* close to the point of infection. Parasitism leads to death of the host distal to the point of infection. Loss in volume increment in timber crops, and reduction in size and quality of fruits in *Citrus* have been observed as a result of infection. *Viscum capitellatum* has been recorded as a hyperparasite on *Dendrophthoe falcata* suggesting potentialities of biological control. All of these points are amplified and discussed in the text.

REFERENCES

- ANGELL, H. R. et al. (1930)—The relation of protocatechuic acid to disease resistance in the onion. *Phytopathology* 20, 431-438.
- ASHWORTH, M. P. C. (1896)—The dispersal of mistletoe. *Indian For.* 22, 1-4
- BECKMAN, C. H. et al. (1953)—Host responses associated with the development of oak wilt. *Phytopathology* 43, 448-454.
- BERGDOLT, E. (1927)—Über die Saugkräfte einiger Parasiten. *Ber. dtsh. bot. Ges.* 45, 293-301.
- BIDIE, G. (1874)—Report on Neilgherry Lorantheaceous parasitical plants destructive to exotic forest and fruit trees. *Indian For.* 1, 299-302.
- BROWN, W. H. (1919)—*Vegetation of the Phillipine mountains*. Manila.
- DANSER, B. H. (1929)—On the taxonomy and nomenclature of the Lorantheaceae of Asia and Australia—*Bull. Jard. Bot. Buitenz.* 10, 291-373.
- DIXON, H. H. and ATKINS, W. R. G. (1915)—Osmotic pressure in plants. *Sci. Proc. R. Dublin Soc. N. Ser.* 14, 374-392.
- FISCHER, C. E. C. (1926)—Lorantheaceae of Southern India and their host plants. *Rec. Bot. Surv. India* 11, 159-195.
- GAUMANN, E. (1950)—*Principles of Plant Infection*. Transl. by W. B. Brierley, London.
- GILL, L. S. (1957)—Dwarf mistletoe on Lodgepole Pine. U. S. Dept. of Agr. For. Service Forest Pest Leaflet, 18.
- HARLEY, J. (1863)—On the parasitism of the mistletoe. *Trans. Linn. Soc. Lond. Bot.* 24, 175-196.
- HARIS, J. A. and LAWRENCE, J. V. (1916)—On the osmotic pressure of the tissue fluids of Jamaican Lorantheaceae parasitic on various hosts. *Amer. J. Bot.* 3, 438-455.
- HEINRICHER, E. (1929)—Almahliches Immunwerden gegen Mistelbefall. *Planta* 7, 165-173.
- HOLMES, C. H. (1951)—Climate and vegetation of the Dry Zone of Ceylon. (unpublished).
- HOLTERMANN, C. (1907)—*Der Einfluss des Klimas auf der Bau der Pflanzengewebe. Anatomisch-physiologische Untersuchungen in der Tropen*. Leipzig.
- KOELMEYER, K. O. (1957)—Climatic classification and distribution of vegetation in Ceylon. *Ceyl. For.* 3, 144-163.
- KAMERLING, Z. (1914)—Welche Pflanzen sollen wir "xerophyten" nennen? *Flora*, 106, 433-454.
- KEEBLE, F. W. (1896)—Observations on the Lorantheaceae of Ceylon. *Trans. Linn. Soc. Lond. Bot.* 2nd Series, 5, 91-117.
- KEILY, T. (1957)—Report on the decline problem of citrus in Ceylon. *Sessional paper* 9. Ceylon 8.
- KLEPAC, D. (1955)—Utjecaj imelena prirast jelovih suma (Effect of *Viscum album* on the increment of silver fir stands). *Sumarski List* 79, 231-244. (*Forestry Abstract*, 17 (3). 2947).
- LEWIS, F. (1934)—*The Vegetable Products of Ceylon*, Colombo.
- McLUCKIE, J. (1923)—Studies in parasitism. *Bot. Gaz.* 75, 333-369.
- NICOLOFF, TH. (1923)—Contribution a la physiologie de la nutrition des parasites vegetaux superieurs. *Rev. Gen. Bot.* 35, 545-552.
- PLAGNAT, F. (1950)—Le gui du Sapin. *Ann. Ec. Eaux For. Nancy*, 12, 155-231.
- RAUNKIAER, C. (1934)—*The Life Form of Plants and Statistical Plant Geography*. Oxford.

RICHARDS, P. W. (1936)—Ecological observations on the rain forests of Mount Dubit, Sarawak. *J. Ecol.* 24, 1-32.

——— (1957). *The Tropical Rain Forest*. Cambridge.

ROSAYRO, DE R. A. (1943)—The soils and ecology of the wet evergreen forests of Ceylon. *Trop. Agriculturist* 98, (2) 4-14. (3) 13-35.

RYAN, G. M. (1899)—Spread of *Loranthus* in the Konkan. *Indian For.* 25, 472-474.

SCOT, J. G. (1871)—Loranthaceae, the mistletoe order, germination and mode of attachment. *Jour. Agric. Hort. Soc. India.* 11, 257.

SINGH, B. (1954)—Studies in the family Loranthaceae. *Agra Univ. J. of Res.* 3, (2) 301-315.

SKENE, M. (1924)—*The Biology of Flowering Plants*. London.

SOMERVILLE, W. (1914)—The mistletoe in England. *Quart. J. For.* 3, 20.

STEVENSON, G. B. (1934)—The Life history of the New Zealand species of the parasitics genus *Korthalsella*. *Trans. Roy. Soc. New Zealand*, 64, 175-190.

STRUCKMEYER, B. E. et al. (1954)—Plugging of vessels by tyloses and gum in wilting oaks. *Phytopathology* 44, 148-153.

THODAY, D. (1951)—The haustorial system of *Viscum album*. *J. Expt. Bot.* 2, 1-19.

——— (1956)—Modes of union and interaction between parasite and host in the Loranthaceae (Viscoideae). *Proc. Roy. Soc. B.* 145, 531-548.

TRIMEN, H. (1895)—*A handbook of the flora of Ceylon*. London. III. 462-474.

TUBEUF, K. U. (1923)—*Monographie der Mistel*. Munchen and Berlin.



Plate I. *Viscum capitellatum*
hyperparasitic on
Elytranthe capitellata.

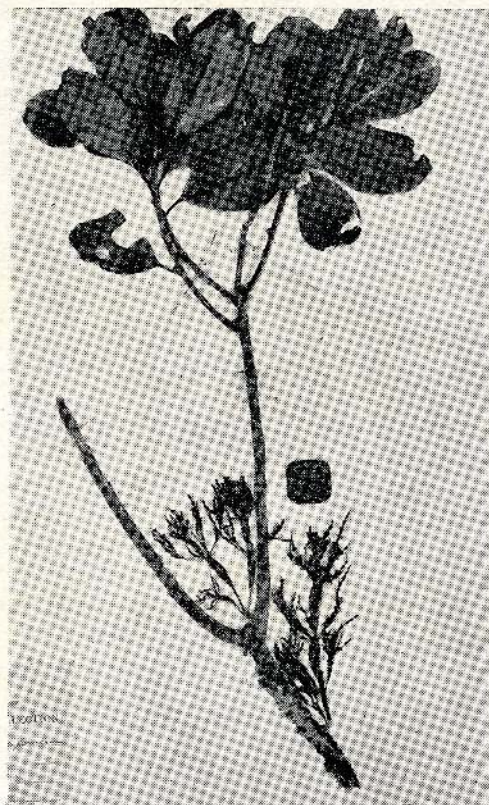


Plate II. *Korthalsella opuntia* on *Eureka* sp.

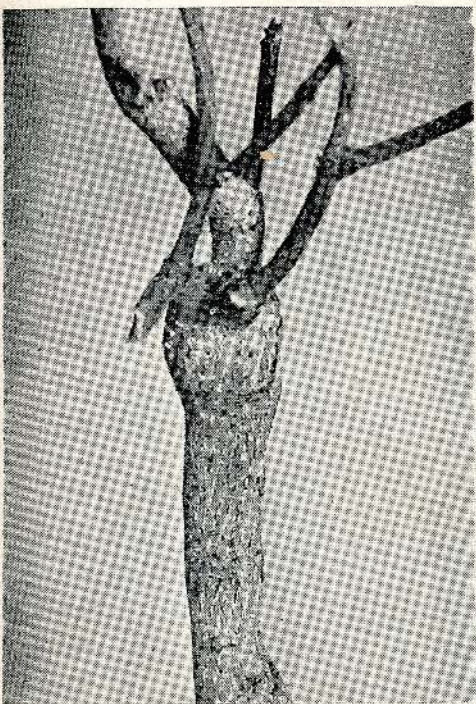


Plate III. *Viscum articulatum* on *Cassia marginata*. Note absence of external adventitious roots.

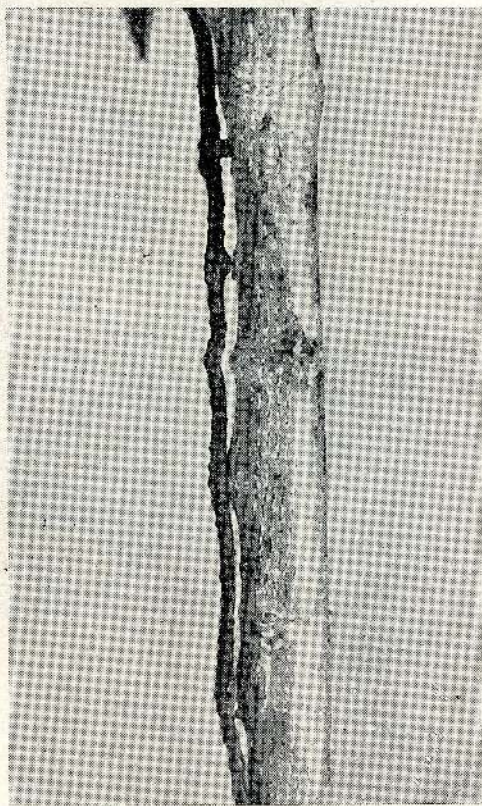


Plate IV. *Dendrophthoe falcata* on *Nerium* sp. showing connexion. (Compare with Plate IV).

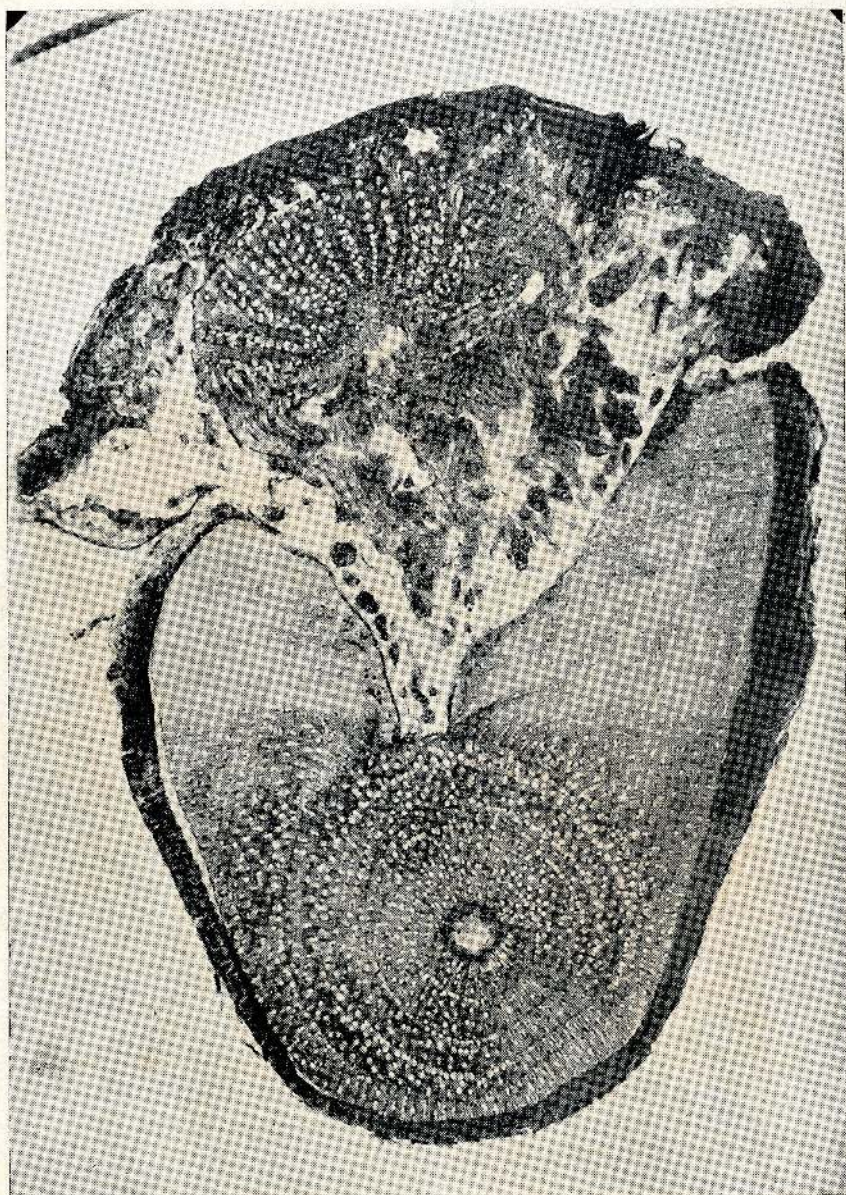


Plate V. Host-parasite connection (*Dendrophthoe falcata* on *Thespesia populnea*).

Appropriate Technology Services
121, POINT-PICCO ROAD
NALLUR, CHENNAI
No.



Plate VI. *Dendrophthoe falcata* (7 months old) on *pericopsis mooniana* grown with full overhead light.

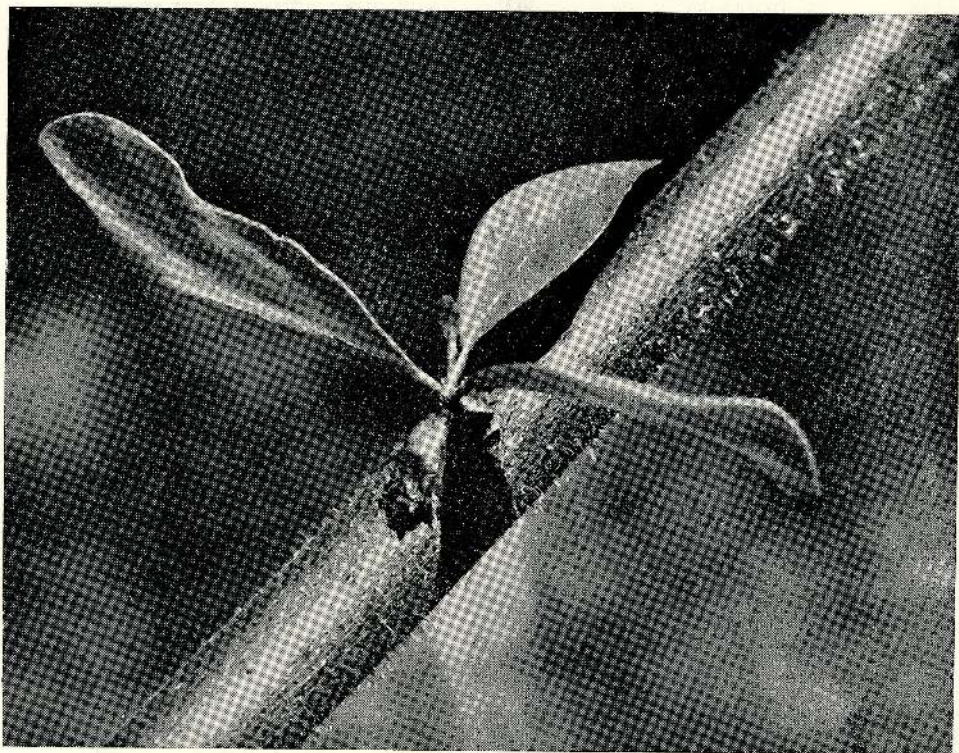


Plate VII. Seedling of *D. falcata* (6 to 7 weeks old) growing on *Broussonetia papyrifera* after artificial inoculation.

THE DIFFERENTIAL SHRINKAGE OF WOOD

L. C. A. Wijesinghe

INTRODUCTION

WOOD tends to adjust its moisture content to that of its surroundings, and such changes in moisture content are, within a certain range, accompanied by dimensional changes. In most woods longitudinal shrinkage (i.e. shrinkage along the grain) from the green to the oven dry condition is very slight, usually of the order of 0.1 per cent. Radial shrinkage is on an average about 5 per cent. and tangential shrinkage about twice as much. Differential shrinkage of wood in the radial and tangential directions is responsible for most of the defects, such as warping and checking, which occur in wood on drying. (See figs. 2—5). Despite the several hypotheses that have been advanced to explain differential shrinkage, the causes of this phenomenon are still not clearly understood. The author has here discussed the more recent work on the subject in relation to the main hypotheses.

STRUCTURE OF THE CELL WALL

AS a preliminary step it would be useful to give a brief account of the cell wall structure since all the hypotheses to explain differential shrinkage are based on the heterogeneous nature of the cell wall.

Cellulose which forms the skeletal or framework substance of the cell wall is in the form of long chain molecules composed of glucose residues. The cellulose molecules appear to occur in discrete aggregates called micelles or microfibrils, and are themselves linked to form larger units, the fibrils. The cell wall consists of three distinct regions: 1. the intercellular substance, which is a very thin layer consisting mainly of pectic substances, 2. the primary wall, which is built up of widely spaced and irregularly dispersed micelles arranged approximately at right angles to the long axis in prosenchymatous cells. This layer is heavily lignified. 3. the secondary wall. This forms the bulk of the cell wall and is composed largely of cellulose. The secondary wall itself consists of three zones with different fibrillar arrangements. The fibrillar orientation of the inner and outer zones (both very thin layers) varies from transverse to helices of comparatively low pitch (45° – 90° from the long axis), while that of the middle zone, which forms the bulk of the secondary wall, varies from longitudinal to helices of steep pitch (0° – 45°).

MOISTURE IN WOOD

MOISTURE is present in wood both as free water in the cell lumina and intercellular spaces and as films held between the fibrils of the cell wall. The free water is the more readily lost on drying, and its loss does not cause shrinkage of the cells. Loss of water from the cell walls, however, causes a drawing together of the micelles resulting in shrinkage. When wood is dried a stage is reached at which the cell lumina and intercellular spaces are free of water but the walls still almost fully saturated; this is called the *Fibre Saturation Point*. It is only on drying beyond this point that appreciable shrinkage of the wood occurs.

HYPOTHESES TO EXPLAIN DIFFERENTIAL SHRINKAGE

1. The Ray Hypothesis

Clarke (1930) found that rays dissected out from other tissues had a lower radial shrinkage than the intact wood. This has since been confirmed by Lindsay and Chalk (1954) and the present author (Wijesinghe, 1959) on different species. This observation forms the basis of the Ray Hypothesis, according to which, the rays having a lower radial shrinkage than the adjacent tissues, prevent complete shrinkage of the wood radially. The tangential shrinkage is not influenced similarly, as the rays are said to shrink as much as the other tissues in this direction. The low radial shrinkage of the rays is said to be due to their micelles being arranged radially i.e., along the ray length. McIntosh (1954), Lindsay and Chalk (1954) and the present author (1959) by an ocular experiment showed the existence of stresses between the rays and the adjacent tissues as implied by this hypothesis. From transverse sections they dissected strips containing ray tissue on one side and intervening tissues on the other. On drying, these strips bent in the manner expected, with the ray tissue on the outer or convex edge showing that the rays exert a restraining influence on the radial shrinkage of the other wood tissues. (fig. 6). The work of Ritter and Mitchel (1952) on the other hand appears to contradict the hypothesis. They found that ray cells shrink as much radially as the intact wood. Earlier, Ritter (1930) showed that in a number of species, radial shrinkage of isolated rays was higher than their axial shrinkage, contrary to that implied by the Ray Hypothesis; for if the micelles were arranged radially in the rays, axial shrinkage should be greater than radial. A similar result was obtained by the present author (1959) in sycamore where the radial shrinkage of isolated rays was 3.78 per cent and axial shrinkage slightly less (3.27 per cent.). However, in this species it was observed that the radial shrinkage of the intact wood (4.28 per cent) was higher than that of the rays; the latter could therefore exert a restraining influence on the radial shrinkage of the intact wood as visualised by the Ray Hypothesis; and that this was so was confirmed by the ocular experiment described above.

In a series of experiments on isolated tissues of *Artocarpus integrus* Merr., *Canarium zeylanicum* Bl. and *Acer pseudoplatanus* L. the present author (1959) showed that there are two independent factors responsible for differential shrinkage: 1. the restraining influence of the rays on the radial shrinkage of the other wood tissues (the Ray Hypothesis) and 2. an inherent differential shrinkage of the wood fibres. Fibres in transverse section were found to have a lower radial shrinkage in entire sections than when isolated from the rays, so demonstrating the first of the above factors. In *Artocarpus*, for example, the radial shrinkage of a row of fibres increased from 4.50 per cent. to 5.55 per cent. as a result of removing the rays. Despite this increase, however, the tangential shrinkage of the isolated fibres (8.20 per cent.) was appreciably higher than the radial shrinkage. The

ratio for the isolated fibre tissue then works out to

radial shrinkage
1.48, and this represents the inherent differential shrinkage of the fibres, the second factor mentioned above.

The results from all three species, while confirming that the rays are partly responsible for differential shrinkage, also established the existence of the other factor, namely, the inherent differential shrinkage of the fibres. The relative importance of the two factors was found to vary with the

species. In *Artocarpus* they appeared to be of equal importance while in *Canarium* the inherent differential shrinkage of the fibres was the predominant factor.

2. The Middle Lamella Hypothesis

According to this hypothesis which was advanced by Frey Wyssling (1940, 1943), shrinkage of woods is determined by the shrinkage of the middle lamella, instead of, as is generally assumed, by the shrinkage of the secondary wall. The shrinkage in any direction then depends on the sum of the shrinkages of all the middle lamellae lying across that direction. On this hypothesis the low longitudinal shrinkage of wood is readily explained, as the cross walls in wood are much less frequent in the longitudinal direction than either tangentially or radially. Frey Wyssling (1943) explained the difference between radial and tangential shrinkage as being due to the radial middle lamellae being thicker than the tangential ones. However, though this differential thickness of the middle lamella occurs in the tracheids of conifers, it is not found in the wood elements of most hardwoods. The present author (1959) observed that in *Artocarpus* the radial middle lamellae of the fibres appeared to be generally thicker than the tangential ones; but in *Canarium* and sycamore there was neither this difference nor a difference in the frequency of the radial and tangential middle lamellae. Frey Wyssling's hypothesis could therefore not explain the inherent differential shrinkage of the fibres in the latter two species.

There is as yet insufficient evidence on the subject to enable one to assess the importance of this hypothesis in explaining the inherent differential shrinkage of the wood fibres.

3. The Hypothesis based on the Predominance of Pits on the Radial Walls

According to this hypothesis which was advanced by Ritter and Mitchel (1952) the reduced radial shrinkage is due to the disturbance of the micellar structure in the radial walls due to pitting. The hypothesis assumes that pits are present mainly on the radial walls. Such an unequal distribution of pits was found in *Artocarpus* and *Acer* but not in *Canarium* (Wijesinghe, 1959). While admitting that in species where pitting is predominantly on radial walls, this factor may be a contributory cause of differential shrinkage, it is doubtful whether it plays anything but a minor role, since many species not showing such unequal pitting yet exhibit marked differential shrinkage.

4. The Hypothesis based on Differential Lignification of the Radial and Tangential Middle Lamellae

This hypothesis was put forward by Bosshard in 1956. He supported Frey Wyssling's hypothesis and added that where there is no difference in the frequency or thickness between the radial and tangential middle lamellae differential shrinkage is caused by differential lignification of this layer. This hypothesis should be investigated further in order to determine its importance in relation to the above mentioned inherent differential shrinkage of fibres.

CONCLUSIONS

IT may be concluded that no single hypothesis by itself can explain differential shrinkage as there are at least two independent causes, namely, 1. the restraining influence of the rays on the radial shrinkage of the other wood tissues (The Ray Hypothesis) and 2. the inherent differential shrinkage of the fibres. No definite explanation of the second factor is yet available ; but differences in thickness, frequency and lignification of the middle lamellae and unequal distribution of the pits on the walls may be casual factors.

REFERENCES

BOSSARD, H. H. (1956)—“Uber Die Anisotropie der Holzschwindung”. *Holz a. Roh-u. Werkst.* XIV 285-95.

CLARKE, S. H. (1930)—“The Differential Shrinkage of Wood”. *Forestry*, IV. 93-104.

FREY-WYSSLING, A. (1943)—“Weitere untersuchungen uber die Schwindung Holzes”. *Holz a. Roh-u. Werkst.* III. 349-53.

FREY-WYSSLING, A. (1943)—“Weitere untersuchungen uber die Schwindung anisotropie des Holzes.” *Holz a. Roh-u. Werkst.* VI, 197-8.

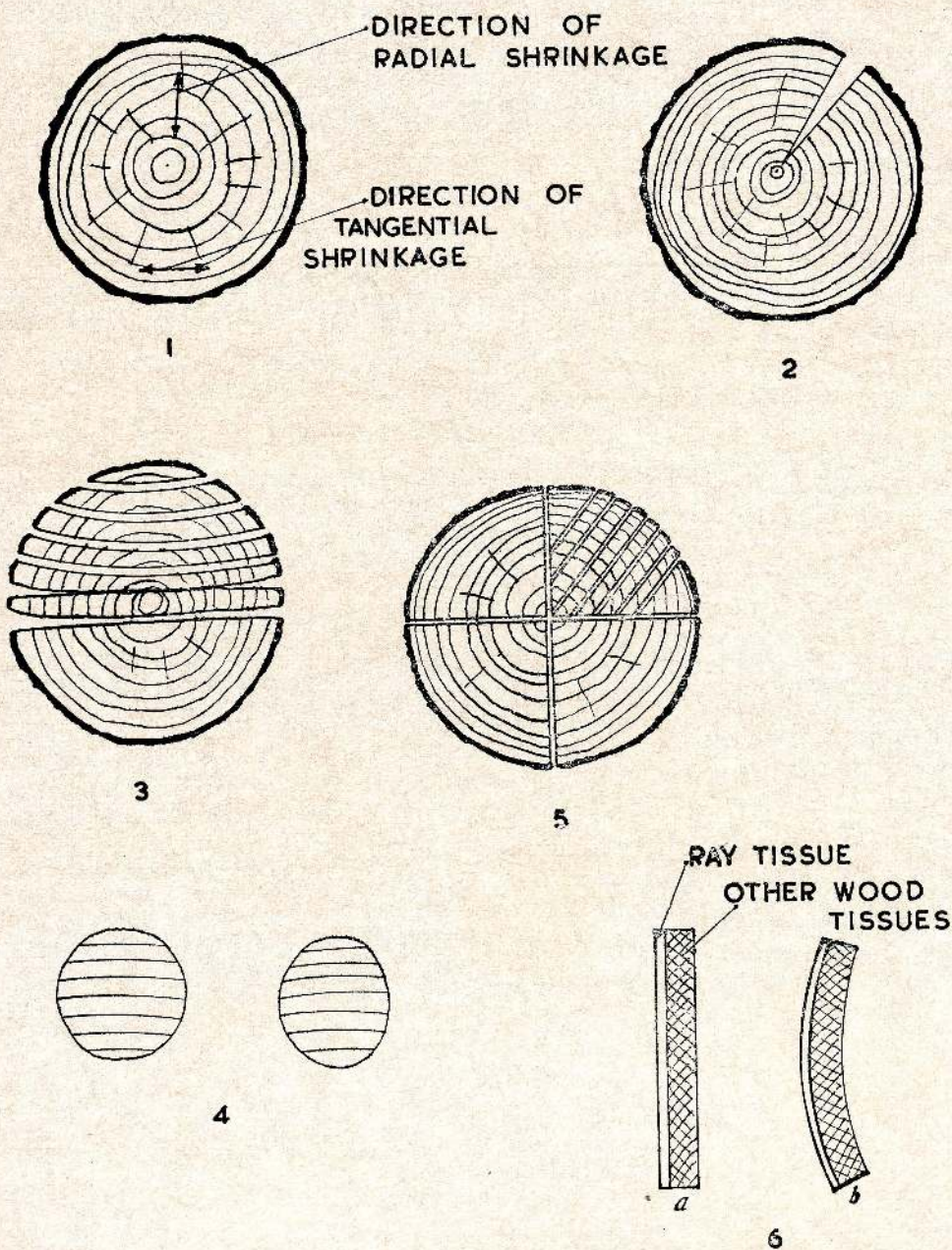
LINDSAY, F. W. and CHALK, L. (1954)—“The Influence of Rays on the Shrinkage of Wood”. *Forestry*, XXVII. 16-24.

McINTOSH, D. C. (1954)—“Some Aspects of the Influence of Rays on the Shrinkage of Wood” *J. For. Prod. Res. Soc.* IV. 39-42.

RITTER, G. J. (1939)—*Paper Trades J.* CVIII. 334. (Paper not available ; quoted by Barkas, W. W. (1941). “Wood-Water Relationships VI”. *Trans. Faraday Soc.* XXXVIII. 535-47

RITTER, G. J. and Mitchel, R. L. (1952). *Paper Trades Industry, Mount Morris, Illinois*, XXXIII. 1189-93. (From *For. Abs.* XIII. 4183, original not seen).

WIJESINGHE, L. C. A. DE S. (1959). “The Shrinkage of Rays and Fibres in Wood”. *Forestry*, XXXII. 31-8.



Figs. 1 to 6—Diagrams showing: 1. Directions of Radial and Tangential shrinkage; 2 to 4. Effects of Differential Shrinkage; 2. Radial crack; 3. Warping of plain sawn planks; 4. Distortion of a circular piece of wood; 5. Quarter-sawn planks do not warp from differential shrinkage; 6a. Strip of tissue dissected from a transverse section, with ray tissue on one side and other wood tissues on the other. On drying, it bends [6b] with the ray on the convex side showing that the ray restricts the radial shrinkage of the other tissues.

FIELD KEY TO THE IDENTIFICATION OF WET EVERGREEN (RAIN FOREST) TREE SPECIES

R. A. de Rosayro

IN the following pages, the writer has attempted to synthesize in tabulated form the information contained in two earlier articles entitled :

- (1) "Field Characters in the Identification of Tropical Forest Trees" published in the "Empire Forestry Review", Volume 32, No. 2, June, 1953, pages 124-141. (Corrections and addenda in Volume 32, No. 3, September, 1953, page 205).
- (2) "The Field Characters of Trees of the Tropical Wet Evergreen Forests of Ceylon" which appeared in the "Ceylon Forester", New Series, Volume 1, No. 1, January, 1953, pages 25-34 and No. 2, July, 1953, pages 67-71.

For use and check in the field, the writer has adopted the tabulated form which appears to be more appropriate for the purpose. This is a simplified form of the Graphical Field Key method originally worked out by H. C. Dawkins for the Forest Trees of Uganda (Graphical Field Keys of Uganda Trees, 1—Forest Trees, Mengo District, East African Agricultural Journal, Vol. XVII, No. 2, October, 1951, pages 1-15). The writer has also adopted a similar form of differentiating between trees at the principal canopy levels, viz., the upper canopy, sub-canopy and understory.

The tabulated form in which the Key is presented is primarily intended as a means to identification and study and will not by itself be adequate for specific identification. However, certain important additional characters of the Leaf are given where they will help to fix the identity of the species. For further information on the methods used and for fuller detail of the species covered by this Key, the writer's papers referred to, may be consulted.

FIELD KEY TO THE IDENTIFICATION OF WET

(to be used

Note : The following conventions are adopted :—

CAPITALS — Trees of upper canopy (eco-dominant) layer or emergents in
Simple letters underlined : Trees of sub-canopy in primary forest or
 Simple letters : Low trees or tall shrubs of understory, e. g. ,Walla -

I. PRIMARY EXTERNAL BARK OR BOLE CHARACTERS

I. Bark armed with spines or prickles (juvenile feature)	II. Trees showing marked buttresses	III. Trees with bark dehiscing markedly	IV. Trees without marked bark dehiscence, but outer bark distinctly cracked or ridged
(1) <u>Spines</u> : • <u>Katukenda</u> (<u>Scolopia acuminata</u>) • Katukurundu (<u>S. schreberi</u>) • Uguressa (<u>Flacourtia ramontchi</u>) • Pathkela (<u>Bridelia moonii</u>)	(1) <u>Stilt-rooted buttresses</u> : • <u>Dawata</u> (<u>Carallia brachiata</u>) • <u>UBBERIYA</u> (<u>C. CALYCINA</u>) (Young trees -) • Pathkela (<u>Bridelia moonii</u>) • Ketakala (<u>Bridelia retusa</u>)	(1) <u>Dehiscence in papery flakes</u> : • <u>Alubo</u> (<u>Syzygium makul</u>) (2) <u>Dehiscence in large rectangular flakes set obliquely in whorls</u> : PATHRU - YAKAHALU DUN (<u>SHOREA OBLONGIFOLIA</u>)	(1) <u>Bark in parallel longitudinal raised ridges or furrows</u> : • <u>TINIYA</u> (<u>DOONA CONGESTIFLORA</u>) • MAWARA - DUN (<u>SHOREA DEALBATA</u>) • <u>HULANIDDA</u> (<u>S. STIPULARIS</u>) (branchlets stipular) • <u>Pepaliya</u> (<u>Aporosa latifolia</u>) (closely set ridges)
(2) <u>Prickles</u> : • <u>Katu-imbul</u> (<u>Bombax malabaricum</u>)	(2) <u>Plank Buttresses</u> : • <u>Kekuna</u> (<u>Canarium zeylanicum</u>) (extreme form) • <u>Netaw</u> (<u>Xylopia parviflora</u>) • <u>Malaboda</u> (<u>Myristica dactyloides</u>) • <u>TINIYA</u> (<u>DOONA CONGESTIFLORA</u>) • <u>Na-imbul</u> (<u>Harpullia arborea</u>) • <u>Diyapara</u> (<u>Wormia triquetra</u>) • <u>Godapara</u> (<u>Dillenia retusa</u>)	(3) <u>Dehiscence in irregular scales or flakes</u> : • <u>HORA</u> (<u>DIPTEROCARPUS ZEYLANICUS</u>) (large rectangular scales) • <u>BU-HORA</u> (<u>D. HISPIDUS</u>) (small, fish-like scales) • <u>DORANA</u> (<u>D. GLANDULOSUS</u>) (irregular scales) • <u>PINI - BERALIYA</u> (<u>DOONA OVALIFOLIA</u>) • <u>Diyapara</u> (<u>Wormia triquetra</u>) • <u>NA</u> (<u>MESUA FERREA</u>) • <u>Pihimbiya</u> (<u>Filicium decipiens</u>) (compound feathery leaf) • <u>TAWENNA</u> (<u>PALAEQUIM RUBIGINOSUM</u>) (leaves red underneath) • <u>Katugodapara</u> (<u>Bryophyllum ellipticum</u>)	(2) <u>Bark with longitudinal parallel cracks or fissures</u> : • <u>PALAEQUIM SPP.</u> • <u>Hedawaka</u> (<u>Chaetocarpus castanocarpus</u>) • <u>Dodankaha</u> (<u>Memecylon grande</u>) • <u>Weikaha</u> (<u>M. ovatum</u>) • <u>BERALIYA DUN</u> (<u>HOPEA JUCUNDA</u>)
	(3) <u>Reticulate or latticed buttresses</u> : • <u>Ficus spp.</u> (<u>nuga</u> , etc)	(4) <u>Dehiscence in irregular sheets or scrolls</u> : • <u>Syzygium spp.</u> (<u>Dambu</u> , etc) (Flat, sheet like) • <u>Kataboda</u> (<u>Cullenia</u>) spp. (2) (sheets, rolled up) • <u>Hampalande</u> (<u>Terminalia parviflora</u>) (silvery grey bark) • <u>Malaboda</u> (<u>Myristica dactyloides</u>)	(3) <u>Bark with longitudinal irregular cracks or fissures</u> : • <u>Etamba</u> (<u>Mangifera zeylanica</u>) (4) <u>Bark with deep boat shaped cracks</u> : • <u>Kinas</u> (<u>Calophyllum spp</u>) (5) <u>Bark with both longitudinal and transeverse cracking</u> : • <u>Guru-king</u> (<u>Calophyllum calaba</u>) • <u>Kankumbul</u> (<u>Pygeum zeylanicum</u>)

EVERGREEN (RAIN FOREST) FOREST TREE SPECIES with a Flora)

high (primary) forest, e.g. HORA—DIPTEROCARPUS ZEYLANICUS (80–150 feet)
upper canopy in secondary forest, e. g., diyapara — Wormia triquetra (50–75 feet)
Gyrinops walla (15–30 feet)

I a. SUBSIDIARY EXTERNAL FIELD CHARACTERS			
V. Trees without marked bark dehiscence or furrowed or cracked bark i.e. "Smooth" bark	Bole Form	Crown Form	Bark Colour
(1) <u>Raised lenticular pits present</u> • <u>Jak</u> (<u>Artocarpus integra</u>) • <u>Del</u> (<u>A. nobilis</u>) • <u>Kinas</u> (young trees) (<u>Calophyllum</u> spp.)	(1) <u>Tall cylindrical boles:</u> HORA group DUN group PALAQUIUM group <u>Etamba</u> etc	(1) <u>Small compact Crowns:</u> HORA group DUN group	(1) <u>Black or blackish bark:</u> • <u>EBONY</u> family • <u>Malaboda</u> (<u>Myristica dactyloides</u>)
		(2) <u>Large leafy Crowns with horizontal or flexed branches:</u> <u>Anonaceae</u> (<u>Netaw</u> , <u>Dathketiya</u> , <u>Atuketiya</u> etc.)	(2) <u>Yellowish coloured bark:</u> <u>Kinas</u> (<u>Calophyllum</u> spp.)
(2) <u>Transverse ridged rings (hooped bark) present:</u> • <u>Mendoras</u> (<u>Vatica</u> spp.) • <u>Hal</u> etc. (<u>Vateria</u> spp.) • <u>Uruhonda</u> (<u>Lasianthera apicalis</u>)	(2) <u>Fluted boles:</u> <u>Milla</u> (<u>Vitex pinnata</u>) NA (<u>MESUA FERREA</u>) <u>Kataboda</u> (<u>Cullenia</u> spp. <u>Syzygium</u> spp etc.)	(3) <u>Pendulous branches and leaves:</u> • <u>DIYA-NA</u> (<u>MESUA THWAITESII</u>) • <u>Walu-kina</u> (<u>Calophyllum bracteatum</u>)	(3) <u>Light ashy bark:</u> • <u>Andunwenna</u> (<u>Illex zeylanica</u>) • <u>Syzygium</u> spp. • <u>Bomi</u> (<u>Litsea glutinosa</u>) • <u>Hampalanda</u> (<u>Terminalia parviflora</u>)
(3) <u>Irregular shaped leaf scars present:</u> • <u>Andunwenna</u> (<u>Illex zeylanicus</u>)		(4) <u>Candelabra like branching:</u> • <u>KIRIHEMBILIYA</u> (<u>PALAQUIUM PETIOLARE</u>) • <u>Molpedda</u> (<u>Isonandra lanceolata</u>)	(4) <u>Bark with red mottlings:</u> • <u>Kokun</u> (<u>Kokoona zeylanica</u>) • <u>Diyataliya</u> (<u>Mastixia tetrandra</u> var <u>thwaitesii</u>)
(4) <u>Bark "dimpled" i.e. with circular depressions or pock marks:</u> • <u>Syzygium</u> spp			
(5) <u>Bark peeling off readily when pulled</u> • <u>Ipetha</u> (<u>Cyathocalyx zeylanicus</u>) • <u>Walla</u> (<u>Gyrinops walla</u>)			

II. FUNDAMENTAL

(a clean cut exposing the

VI. Definite exudation from the cut bark				VII. No Exudation from bark but exudation from wood alone (Resinous or oily)
i. Lactiferous	ii. Resinous or oily	iii. Watery	iv. Tarry	
(1) <u>Latex creamy or (turning) dirty white on exposure:</u> • <u>Jak</u> (<i>Artocarpus integra</i>) & • <u>Del</u> (<i>A. nobilis</i>) (white blaze) • <u>Molpedde</u> (<i>Bonandra lanceolata</i>) (dark red blaze)	(1) <u>Resin yellow:</u> • <u>Kinas</u> (<i>Catophyllum</i> spp) • <u>NA</u> (<i>MESUA FERREA</i>) (2) <u>Resin colourless or whitish:</u> • <u>Kekuna</u> (<i>Canarium zeylanicum</i>) (plank buttresses strong aromatic smell) • <u>DIYA-NA</u> (<i>MESUA THWAITESII</i>) (pendulate long leaves) • <u>WANAMI</u> (<i>MADHUCA FULVA</i>)	(1) <u>Red or reddish exudation:</u> • <u>Irira</u> (<i>Horsfieldia irya</i>) (light red) • <u>Malaboda</u> (<i>Myristica dactyloides</i>) (dark red black bark) • <u>Ruk</u> (<i>Horsfieldia iryagedi</i>) (dark red, feathery leaves) (2) <u>Colourless exudation:</u> • <u>Arida</u> (<i>Camposperma zeylanicum</i>) (light coloured bark) • <u>Etamba</u> (<i>Mangifera zeylanica</i>) (dark brown bark) (Exudation frothy when rubbed in both) (Also found to a small extent in <u>Hedzwaka</u> (<i>Chaetocarpus castanocarpus</i>) & <u>Uruhonda</u> (<i>Lasianthera apicalis</i>))	<u>Black, tarry exudation:</u> All <u>Badulla</u> (<i>Somecarpus</i>) spp. (Exudation first as little dots, later coagulating)	(1) <u>Only exudation from wood</u> • <u>DORANA</u> (<i>DIPTEROCARPUS OLANULOSUS</i>) (<u>WELIDORANA</u> produces only scanty exudation) • <u>MENDORA</u> (<i>VATICA CHIMENSIS</i>) (exudation slow) (2) <u>Resinous exudation from wood</u> • <u>HORA</u> (<i>DIPTEROCARPUS ZEYLANICUS</i>) (Exudation immediate and profuse) • <u>NA-MENDORA</u> (<i>COTYLOBIUM SCABRIUSCULUM</i>) & • <u>HAL</u> (<i>VATERIA COPALLIFERA</i>) (exudation slow)
(2) <u>Latex pure white:</u> • <u>Gonna</u> (<i>Ficus callosa</i>) (dark brown blaze) • <u>Huga</u> (<i>Ficus abyssinica</i>) (pink blaze) • <u>Rukkatenna</u> (<i>Aistonia scholaris</i>) (yellowish blaze exudation profuse) • <u>Lawulu</u> (<i>Chrysophyllum roxburghii</i>) (yellowish blaze exudation sparse) • <u>KIRIHEMBILIYA</u> (<i>PALAEQUIM PETIOLARE</i>) • <u>TAWENNA</u> (<i>P. RUBIGINOSUM</i>) (exudation profuse) • <u>RATATIYA</u> (<i>P. THWAITESII</i>) • <u>KIRIPEDDA</u> (<i>P. GRANDE</i>) (exudation sparse) (all <i>Palaquiums</i> show pink fleshy blaze with white streaks) • <u>WANAMI</u> (<i>MADHUCA FULVA</i>) • <u>Munamal</u> (<i>Mimusops elengi</i>)	(3) <u>Exudation oily</u> • <u>Najumbul</u> (<i>Harpullia arborea</i>) (blaze changes colour from pink to brown)			
(3) <u>Latex bright yellow:</u> • <u>Goraka</u> (<i>Garcinia cambogia</i>) • <u>Koketiya</u> (<i>G. terpinophylla</i>) (orange periphery)				
(4) <u>Latex orange or saffron:</u> • <u>Gokaty</u> (<i>G. morella</i>)				
(5) <u>Latex pink:</u> • <u>Madol</u> (<i>G. echinocarpa</i>)				

CHARACTERS OF BLAZE

bark layers and wood)

VIII. Freshly cut bark gives a pungent or aromatic smell	IX. COLOUR AND OTHER FEATURES OF BLAZE			
	i. Marked colour change in inner bark on exposure	ii. Inner bark distinctively coloured	iii. Distinctively streaked inner bark	IV. Colour and Texture
(1) Strong smell of bitter almonds • Totol (<i>Trichadema zeylanica</i>) (large leaf, large petiole) • Kankumbala-Hulanhi • Pygeum zeylanicum • Wal-divul (<i>Hydnocarpus venenata</i>) (not so strong)	(1) Rapid change from dark brown or reddish to purplish (leaves purple stain on hills) • <i>Syzygium</i> spp. (2) Light brown or cream to dark yellow or orange • <i>Carallia</i> spp. (3) Yellow with concentric rings to dark brown • <i>Kudumirissa</i> (<i>Randia gardneri</i>) • <i>Galix</i> (<i>Gardenia latifolia</i>) 4 White with dark brown streaks to saffron yellow <i>Homenelia</i> (<i>Diospyros</i> spp.) (5) Yellow (with white streaks) to red Nedun (<i>Pericopsis mooniana</i>) (compound leaf, bean smell) (6) Pink turning brown Mora (<i>Nephelium longumum</i>) (Dry Zone mostly, compound leaf) (7) Pink turning purple (with purple cambium ring) Andunwenna (<i>Ilex zeylanica</i>)	(1) Middle layer black • Ebenaceae (outer bark thin, hard & brittle) (2) Brilliant orange • Kokun (<i>Mokona zeylanica</i>) (best observed by scraping base of tree) (3) Yellowish pitted layer • Etamba (<i>Mangifera zeylanica</i>) (4) Green layer • HAL (VATERIA COPALLIFERA) • Dunmadala (<i>Stereospermum cheilonoides</i>) (5) Purplish red layer • Masmaru (<i>Adenantha aglaeosperma</i>) Nedun (<i>Pericopsis mooniana</i>) (6) Red layer • Geta-badulla (<i>Samocarpus parviflora</i>) • Otha (<i>Macaranga digyna</i>) (red, pitted) (7) Light pink layer Katukenda (<i>Ecolopia acuminata</i>)	1 Alternate dark & light brown striations: • Diyapara (<i>Wormia triquetra</i>) (2) Dark brown streaks, turning black against a coppery background: • Godapara (<i>Dillenia retusa</i>) (3) Wavy reticulate dark streaks against brown background • Welipenna (<i>Anisophylla cinnamomoides</i>) (leaf tri-nerved)	(1)a. Blaze red or reddish brown with hard and brittle outer and inner bark. • Hedawaka (<i>Chaetocarpus coriaceous</i>) • Bu-hedawaka (<i>C. pubescens</i>) (1)b. Reddish with fibrous layer DUNS (<i>DOONA & SHOREA</i> spp.) Katugedapara (<i>Bryophyllum ellipticum</i>) (2) Pink blaze Born (<i>Litsea glutinosa</i>) (bark soft and mealy) Bridelia spp. Cullenia spp. Hunokirilla (<i>Glochidion zeylanicum</i>) (pinkish brown, fibrous inner bark) (3) Deep yellow or orange blaze: • Milla (<i>Vitex pinnata</i>) (tri-lobed leaf, winged petiole) • Ma-otha (<i>Macaranga digyna</i>) • PANAMORA (<i>DOONA & LONGA</i>) Gulumora (<i>Cryptocarya wightiana</i>) (yellow turning brown) Walkopi (<i>Canthium didymum</i>) (large leaf 8"x3") (4) Light-coloured blaze Diyataliya (<i>Mastixia tetrandra</i>) (outer bark brittle and powdery) Pelieng (<i>Murumia zeylanica</i>) (outer bark brittle and milky, inner fibrous) Liyan (<i>Homium zeylanicum</i>) (outer bark light brown inner bark yellow with light streaks, leaf with serrate margin) Talang (<i>Litsea gardenii</i>) (leaf large over 9") Urhonda (<i>Lasiandra apicalis</i>) (blaze resembles marble) Dunmadala (<i>Stereospermum cheilonoides</i>) (with green outline) Ipetha (<i>Cyathocalyx zeylanicus</i>) (bark peels off easily) Atuketiya (<i>Polyalthia acuminata</i>) (smell of pepper) Angana (<i>Simonius jambosella</i>) HAL (VATERIA COPALLIFERA) (green layer)
(2) Smell of cinnamon: • Kurundu (<i>Cinnamomum zeylanicum</i>) • Wal-kurundu (<i>C. multiflorum</i>)				
(3) Smell of winter green • Kududaula (<i>Mediutsea involucrata</i>) • Gulu-mora (<i>Cryptocarya wightiana</i>) (underside of leaf ashy coloured) Gerata (<i>Symplocos cuneata</i>)				
(4) Terenbinthate smell Ankenda (<i>Acronychia pedunculata</i>) Lunankenda (<i>E. vodia lunankenda</i>)				
(5) Pungent smell of black pepper Ipetha, netaw, dathkeliya, atuketiya (<i>Cyathocalyx Xylopi</i> , <i>Polyalthia</i> spp.)				
(6) Smell of freshly sawn timber ALL DUNS (<i>DOONA, SHOREA</i> spp.) (inner bark fibrous)				



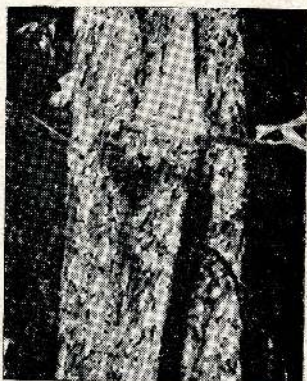
Alubo—*Syzygium makul*
(See Column III, Panel (1))



Pathuru—*Yakahalu Dun-shorea*
oblongifolia
(See Column III, Panel (2))



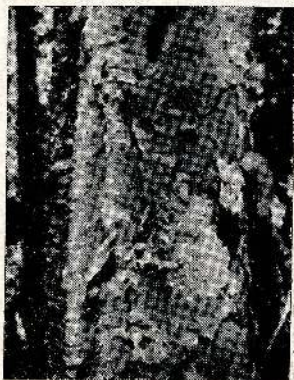
Hora—*Dipterocarpus zeylanicus*
(See Column III, Panel (3))



Na—*Mesua ferrea*
(See Column III, Panel (3))



Dambu—*Syzygium gardneri*
(See Column III, Panel (4))



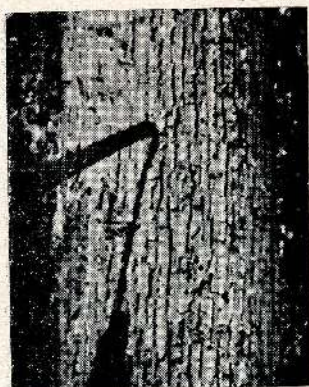
Kataboda—*Cullenia rosayroana*
(See Column III, Panel (4))



Tiniya—*Doona congestiflora*
(See Column IV, Panel (1))



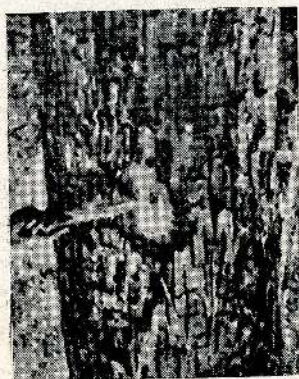
Pepaliya—*Aporosa latifolia*
(See Column IV, Panel (1))



Kiripodda—*Palaquium grande*
(See Column IV, Panel (2))



Etamba—*Mangifera zeylanica*
(See Column IV, Panel (3))



Gurukina—*Calophyllum calaba*
(See Column IV, Panel (5))
(& Column (IV) II—Panel (1))



Mendora—*Vatica chinensis*
(See Column V, Panel (11))



Andunwenna—*Ilex Zeylanica*
 (See Column V, Panel (111))
 (& Column (IX) 1—Panel (7))



Diyapara—*Wormia Triquetra*
 (See Column IX, (111) Panel (1))

(Photographs by R. A. de Rosayro)

REVIEWS

THE AGING OF APICAL MERISTEMS

A. E. K. Tisseverasinghe

IT is more true to say that a plant is as old as its apical meristems than that a man is as old as his arteries. The concept of aging meristems is not a new one but for a long time it was nothing more than a nebulous idea. This idea began to be expressed in a concrete form and given its due place in the study of plant physiology as a whole, particularly in its application to silviculture only a decade or two ago, especially by the Russian School. Different aspects of this theory have been subject to experimental study by workers in various countries but now for the first time we have a comprehensive paper dealing with the history, experimental verification of and conclusions to be drawn from, the acceptance of the idea of meristematic aging. This paper by Schaffalitzky de Muckadell, a research worker in the Horsholm arboretum of the Royal Veterinary and Agricultural College of Copenhagen is titled "*Investigation on Aging of Apical meristems in woody plants and its importance in Silviculture*" (Kandrup & Wunsch's Bogtrykkeri, Kobenhavn—1959), reprinted from "Det forstlige Forsogsvaesen Denmark", Vol. XXV.

The paper consists of three chapters of which the first is a most thorough review of all the earlier literature in which references, either implied or explicit, are made to meristematic aging. In view of the fact that the concept of meristematic aging has been formalised relatively recently, it would surprise many readers to find that the author has quoted from a paper published in 1795 in which the idea is expressed that grafted clones age at the same rate as the original stock from which the clone was derived. The experiment of comparing grafts from bearing branches with grafts from low epicormics was also carried out by this same author in the eighteenth century.

The aging of apical meristems causes trees to pass through various development stages which may or may not be well marked. These stages could roughly be characterised as juvenile, adolescent and mature. In many tree species the juvenile form differs so markedly from the adult that in some cases the juvenile form has been described as a separate species. The author deals in detail with the history of the false genus *Retinispora* which was later proved to be a group of plants which never leave the juvenile stage and which are in fact, various species of *Chamaecyparis* and *Thuja*. Examples of marked differences in juvenile forms are not wanting in Ceylon, e.g., Palu (*Manilkara hexandra*) which for several years of its life (perhaps 20-30) grows almost like a climber and which in its mature form is a forest giant. Again Jak (*Artocarpus integra*) and Gan Del (*Artocarpus nobilis*) have entire leaves in the adult form, but often have incised leaves in the juvenile form. Now, if by mutation, these juvenile forms get fixed, a new species or genus would be created. This, of course, is a generally accepted mode of evolution in the animal world, where fixed juvenile forms may evolve into types which are entirely different from the normal adult forms.

There is a large amount of literature dealing with grafting and other experiments on cultivated fruit tree varieties, which is exhaustively reviewed by the author. The author warns against confusion which might result from determination of plant forms by causes other than meristematic aging. He distinguishes between *cyclophysis*, which is conditioning as a result of meristematic age, *topohysis*, conditioning by the shoot order and *periphysis*, conditioning by environmental factors. This paper is concerned with cyclophysis and it is important to make sure that characters which are due to topohysis or periphysis should not be thought to be conditioned by cyclophysis. One important experiment by Romberg to prove cyclophysis is cited by the author. When juvenile and adult scions were grafted on to a mature stock, the scions retained their juvenile and adult characters respectively. Of course, the juvenile scions later developed maturity but this was a relatively long process.

The author also discusses the phenomenon of rejuvenation in his review of literature. True rejuvenation has however only been produced twice. The first occasion being the conversion of the adult form of *Hedera helix* to the juvenile form by grafting a juvenile form on the adult. Very recently the adult form of *Hedera canariensis variegata* was rejuvenated by spraying the shoots with the exciting new chemical, gibberellic acid.

The author has carried out an impressive series of experiments designed to prove (1) the existence on an old tree of meristems which remain juvenile and (2) that the juvenility is retained even when these meristems are grafted on to other stocks. One of the difficulties in this type of experiment is to determine for certain,

which features in a particular species can be cleared as juvenile. He has selected 11 different species: In *Fagus sylvatica* (Beech) *Quercus robur* and *Q. petraea* (Pedunculate and sessile oak) and *Carpinus betulus* (hornbeam) the juvenile character is winter leaf-retention and the experiments on Beech clearly demonstrate the fact that low epicormics are juvenile shoots and retain their juvenility as compared with shoots from terminal buds of old trees, when both varieties of shoot from the same tree are grafted on to the same stock. In *Quercus borealis*, red autumn coloration of the leaves was the juvenile feature. In *Fraxinus excelsior* (Ash) and *Ulmus carpinifolia*, leaf shape and form was used to compare juvenile and mature stages. In *Robinia pseudoacacia*, thorniness was the juvenile feature. In *Acer pseudoplatanus* and *Syringa vulgaris* (Lilac), forking of the main stems was the mature character. In the former species, forking takes place after flowering while in the latter it is purely a feature of maturity which apparently occurs very early. The author makes the interesting observation in this connection that early forking of the shoots prevents Lilac from becoming a big tree and it remains a shrub. In the case of Sycamore, the juvenile stage is long, hence forking takes place late in life, after a big bole has been formed. In the case of *Populus X canadensis serotina*, the better capacity of cuttings from juvenile shoots to take root was demonstrated. The rooting capacity of cuttings from epicormic shoots two metres above the ground was found to be significantly higher than that of cuttings from shoots with flower buds. Even more interesting from a silvicultural angle was the question as to whether the growth rate of the juvenile cuttings was higher than that of the mature cuttings. There is no proof of this in the author's experiments and in cases where it did occur he admits that it may have been due to periphysical causes. In experiments with Black poplar in Russia (Anic 1950), it was found that the quality of shoots produced from cuttings of epicormic shoots was very low. The present author apparently found no significant difference. From all these experiments it is quite clear that there are development stages in the growth cycle of woody plants and also that there are physiological changes in the apical meristems of these plants which influence growth. The writer also points out that in certain species such as cultivated fruit tree varieties, the juvenile forms have been lost as a result of continuous propagation by grafting. This is most undesirable, from a forestry point of view, since the period of maximum growth is the juvenile stage. He has indicated that juvenile stages may have been lost in certain poplars which have been continuously propagated by cuttings.

In Chapter III the author discusses the physiological and silvicultural aspects of the concept of meristematic aging. Further experiments with Beech showed that (1) In Beech (and perhaps several other species too) the juvenile forms flushed later than the adult forms. (2) Dense shade kept Beech regeneration in a leafless (apparently adult) form, but when shade was removed, the plants gradually became leaf retaining (juvenile). This shows that the juvenile stage was prolonged by shade and therefore that a good stand can be made even out of densely shaded Beech regeneration by careful tending.

The question of flowering is another important aspect of physiological age. Normally low epicormics and (in the case of Beech) winter-leaf-retaining shoots do not flower. Flowering in low epicormics however has occasionally been observed. By grafting experiments however, the author showed that the flowering of these juvenile shoots was due to environmental causes and such flowering shoots revert to the juvenile stage when environmental conditions were improved. This conclusion is extremely useful since it tends to prove that all low epicormics are in the juvenile stage. In the author's words "there is no stage difference between dormant and adventitious buds". The question arises of course, as to whether true adventitious buds are ever found in a tree or whether all buds on a tree arise from buried dormant bud initials. If the author's contention is accepted, it would mean that there are physiological age differences in the cambium of a tree, i.e., the cambium in the lower part of the tree being physiologically younger than the cambium in the upper part. There are no grounds for such a belief and it is likely that physiological age changes are a necessary concomitant of growth. Thus since cambial cells are constantly dividing it is probable that physiological age changes take place in them. It is dormant buds which are in a stage of "suspended animation".

In connection with flowering the writer makes certain interesting observations on Teak which will be of interest to foresters in Ceylon. Teak in Ceylon, sheds its leaves during the drought period in the dry season—June-July-August. Leaf retention during this period is a juvenile character in Teak, i.e., trees which do not shed their leaves, also do not flower. Thus the longer the period of leaf retention, the better the growth. The precise effect of shade on flowering needs further investigation. The author mentions the view of Gram and Syrach Larsen that shade inhibits flowering in Teak. At the same time he has shown that dense shade caused juvenile epicormics shoots to flower. Shade can act in two ways: (1) as a

purely periyhysical character, and (2) through its effect on cyclophysis. This may be relevant in considering why certain trees, e.g., Teak do not recover from early crowding while others such as Jak (*Artocarpus integra*) recover remarkably well even after dieback caused by shade has commenced. It should be remembered that both species are pronounced light demanders and that both species flower and fruit fairly early in life. Does shade in the case of Teak accelerate physiological age change while age change is suspended in Jak? Or is this phenomenon conditioned by some other factor which causes different reactions to the same environment?

The author's experiments to prove greater growth vigour in juvenile forms led to the result that randomly selected seedlings outstripped in growth clones specially selected for suspected vigour. This is probably due to the meristematic age of the clonal material and the author does not recommend further expansion of clonal cultivation. In Ceylon, grafting in silvicultural practice is in a purely experimental stage and there is no likelihood in the near future of attempting clonal cultivation as in Denmark. However, Rubber and Tea planters who propagate clones would profit from a study of this aspect of meristematic aging.

For foresters in Ceylon, one of the most important conclusions to be derived from this study is that great care must be exercised when collecting seed. Normally, the tendency would be to collect seed from the earlier and most profusely fruiting trees. *But these are the very trees from which seed must not be collected.* Early fruiting, i.e., early maturity, is a heritable character and it is in the interest of foresters to propagate trees in which the juvenile stage (stage of maximum growth) is as long as possible. This is a rather difficult task, since environmental causes also influence early fruiting, but it is essential to keep this in mind when collecting seed if the plantation stock is to be improved. Alternatively, of course, seed orchards as in Denmark may be established to facilitate seed collection from good stock.

Anyone reading the paper cannot but be impressed by the immensity of the task undertaken by the author. He is to be congratulated on his successful attempt to co-ordinate so many apparently unrelated concepts into a composite whole and on the vast amount of experimental work done, which in forestry practice is necessarily slow and difficult.

TROPICAL SILVICULTURE, VOL. I, F.A.O.

Forestry and Forest Products Studies No. 13, F.A.O. Rome 1958 pp. 187

A. E. K. Tisseverasinghe

THIS is one of a set of three booklets dealing with Tropical Silviculture. Volume I which is reviewed here, deals generally with Tropical Silviculture with special reference to Natural Regeneration, while Volumes II and III are collections of papers which had originally been presented at the Fourth World Forestry Congress of 1954. Volume I has also been based on the papers presented at this same Congress and has been prepared by three officers of the Forestry Division of the F. A. O., Messrs. Irvine T. Haig, M. A. Huberman and U. Aung Din.

This volume deals with the Ecology and Silviculture of selected tropical forest communities, viz., Wet Evergreen Forest, Moist Deciduous Forest, Dry Deciduous Forest, Mangrove Forest, Bamboo Forest and Coniferous Forest. Considering the size of the volume, its scope would appear to be ambitious; but no doubt, the intention of the compilers was to summarize in as small a compass as possible the current views on the silviculture of these forest communities and also to discuss the current silvicultural practices in different parts of the tropical world. It would be unfair to expect from a work of this nature, detailed discussions on ecology or silvicultural practice; this is clearly impossible in a book which devotes only 20 pages to Wet Evergreen Forest. However, the authors have compensated for this by citing very long lists of references.

The descriptions of the physical factors in Wet Evergreen Forest is remarkably well condensed from Richards' treatise. The only mild criticism that can be made is that the Wet Evergreen Forest appears to have been looked at from a "foreign" viewpoint, as if it were something strange and terrible, demanding dramatic description. This is evident in the following paragraph:—

"The net result is a forest of great density, sometimes festooned with aerial roots, woody creepers and lianes, the forest floor rather open beneath, sun-flecked on

occasion but often densely shaded, the soil thinly covered with dead leaves or bare, except for fallen trunks or branches, a forest ordinarily remarkably uniform in general appearance and physiognomy, the entire ensemble creating a general impression of somberness and monotony, a forest with neither summer nor winter, spring nor fall, lacking all periodicity except in flowering."! The comment about monotony in the Wet Evergreen Forest seems rather strange to a forester!

In the Section on Silvicultural Practice, the authors enumerate the different methods used in different parts of the world but do not discuss their relative merits and suitability. Although as stated earlier, much discussion cannot be expected in a book of this size, it would appear to be necessary, at least to express some opinion on the applicability of these different practices. Whether, for instance, the different methods practised in India/Ceylon, Malaya and Africa are dictated by differing silvicultural requirements of the different communities, or whether these methods are arbitrary introductions dictated by considerations other than silvicultural. The authors appear to be rather impressed with the new method practised in Malaya, but it would be pertinent to inquire whether the contemporaneity of the new Malayan method and the development of mechanised logging in the Tropics is only a happy coincidence or whether silviculture is being asked to make a case for the clear felling practices demanded by mechanised logging. There is also insufficient consideration paid to the possible differences in the Rain Forest types in different parts of the world. It does not follow that merely because the physiognomy is uniform, silvicultural practices can also be uniform. This has been the source of many difficulties in the past when methods evolved in one country, particularly in countries practising advanced forestry such as India and Malaya, were transported wholesale to other countries. Malaya is today considered to be a leader in the field of the silviculture of the Wet Evergreen Forest Type, but their drastic method of reproducing the forest should be tried out with great care before it is introduced elsewhere. Insufficient attention appears to have been paid to the selection system (as distinct from "selective" logging) which is practised in modified forms both in India and Ceylon under conditions which are somewhat special to these two countries.

The description of silvicultural practice in the Wet Evergreen Forests of Africa, is concise and clear. One has to agree with the authors conclusion that the Tropical Shelterwood System must be *simplified* and the *number of operations drastically reduced* if it is to survive.

The authors describe in some detail the enrichment planting which appears to be much more widely prevalent in Africa than in other parts of the Tropical Zone. Perhaps this tendency is a result of heavy exploitation in the past or it may have found ready acceptance because of its simplicity. In Ceylon, enrichment planting with Mahogany (*Swietenia macrophylla*) in lines, has recently been intensified. This however is practised only in *degraded* or very poorly stocked forest. As in Africa, simplicity of operations enables very large extents to be so treated annually and Mahogany being a shade bearer, problems are made much easier. The various methods of enrichment planting described by the authors certainly merit consideration by Tropical foresters in all parts of the world.

The Sections dealing with the other forest communities are not discussed here since they are of little interest in this country, but they follow the same lines as the description of physical features and silviculture of the Wet Evergreen Forest type.

All in all, the book is an extremely useful account of silviculture in the tropics; the authors have had a very difficult task before them of boiling down all the available information into one little booklet. It is easy to criticise such a book, but no amount of criticism can detract from its great value.

CEYLON TREES—by T. B. WORTHINGTON

(published by the Colombo Apothecaries' Co., Ltd., Colombo, 1959. Price Rs. 40)

R. A. de Rosayro

T. B. WORTHINGTON's book on Ceylon Trees can, perhaps, be best described as a "Treasury of Ceylon Trees". It is in no sense, nor was it the author's intention that it should be, a comprehensive treatise on the trees of Ceylon. It is the result of many years of patient and painstaking collection, of careful check, systematic analysis and protracted study. Mr. Worthington is widely known in planting circles as an amateur botanist. It is less well known, perhaps, that he has become no less than an authority on Ceylon flora. He has devoted his years of

retirement to the arduous and by no means inexpensive task of building up the finest private herbarium in the Island, supplemented by samples of timber and bark of the most important trees.

During the years, Mr. Worthington has accumulated a collection of over 6,500 specimens, carefully classified and catalogued. He has been in constant touch with the most important and renowned Herbaria in the world, including Kew in England, the Rijks herbarium of Leiden, Holland, the Herbarium Bogoriense of Indonesia, the Singapore Herbarium and our own small but no less well-known Herbarium at Peradeniya. From his unique and wide collection covering most of the flowering plants of Ceylon, Mr. Worthington has selected 430 tree species for illustration and description.

His book is primarily intended for the layman. Each tree species is presented on a single page with a photographic illustration of a fresh specimen generally with flowers or fruits and with the minimum of descriptive detail (origin, habitat, main characters of the tree, bark, flower, fruit and timber). His is by no means an amateurish effort to bring together the chief trees of Ceylon nor has the selection of trees been made at random. The choice of species has generally been carefully made, the descriptions, though erring perhaps on the side of brevity, are reasonably accurate and embellished with many of Mr. Worthington's personal observations (including measurements of tree heights and girths), pithy and original remarks. The explanations of the use of the Latin names of genera or species is particularly apposite and useful to the beginner; so also are the meanings of the local names of well known species, though sometimes the interpretations are not strictly correct. A notable example is the "Mi" tree which he calls "Mousey Mi". The "Mi" tree now named *Madhuca longifolia* is common in village gardens in the Dry Zone. The resemblance of its flowers to mice so strikingly brought out in the illustration (page 306) has perhaps suggested to Worthington, the origin of the name "Mi" meaning "Mousey". Actually the name is derived from the Sinhalese word for "honey" and in fact the Latin name *Madhuca* is derived from the Sanskrit "Madhu" (so I am authoritatively informed) which means honey. A sweet, intoxicating drink is extracted from the flowers of a similar species *Madhuca latifolia* (mentioned by him) in India.

The value of Mr. Worthington's book lies in the unique series of illustrations reproduced and reduced to exactly 1/3 the scale of the original specimens from photographs taken mostly from freshly collected material by the author. These photographs are by themselves no mean achievement, as they are, with a few exceptions, of a high standard and in many illustrations show either the flowers or fruits, or both. It is a pity that the reproductions are not uniformly good; the patchy or blotchy appearance of many plates, is probably due to deterioration of the original photographs and occasionally to poor printing.

Those who know the forests of Ceylon well, will realize that it is no easy task to collect specimens in flower or fruit, especially of the trees which form the principal species of rain forest. Not only is it physically difficult to get at the crowns, but the irregularity and infrequency of flowering and the inconspicuous nature of many flowers and fruits renders collection a well nigh impossible feat. Mr. Worthington's illustrations of the *Dipterocarpaceae* for instance, (the "Dun" family) characteristic of rain forest in Ceylon comprise a highly representative series of specimens, many of which bear flower or fruit. The few poor pictures which must inevitably occur, in no way detract from the professional excellence and wealth of detail conveyed by these photographs. Personally, to me they are more satisfying than line sketches or drawings; however realistic or artistic they may seem, they are no substitute for the real living specimens.

It is both unwise and, perhaps, unfair to the author to treat his book as a Flora of Ceylon or a Dictionary of Ceylon Trees. It is far removed from a standard Flora in its purpose and scope of treatment and is not intended to replace a proper Flora for the purpose of botanical study and classification. Trimen's "Flora of Ceylon" published between 1894 and 1900 with a supplement by Alston in 1931 still remains the standard work on the subject. From time to time, popular local or abridged Floras or Check Lists have been published, notably Fredrick Lewis' "The Trees and Flowering Plants of Sabaragamuwa and the Western Provinces of Ceylon" (1902) and "Vegetable Products of Ceylon" (1934), the latter, despite its unattractive title being a most interesting and an authoritative account of the more important Ceylon trees and plants. More recently a "Check List for Ceylon" was published by the Imperial Forestry Institute, Oxford (1939) complied by L. A. J. Abeyesundere and R. A. de Rosayro with the staff of the Institute. The latter incorporates the revisions of Alston and comprises 832 species of trees and shrubs with short descriptions of the more important species. It might interest

botanists to know that Willis' "Catalogue of Flowering Plants and Ferns of Ceylon" (1911) has been brought up to date by Dr. Abeywickreme of the University of Ceylon and will, we hope, be published shortly.

Trees and shrubs form approximately a fifth of a total of 2,808 species of flowering plants found in Ceylon of which 809 are endemic to the Island. Mr. Worthington's book covers 430 species of trees including 330 indigenous species and 100 exotics. The selection of trees would appear to be conditioned at least to some degree by the availability of good specimens, suitable for illustration. There is, therefore, more representation given to exotics and roadside trees from which collections of suitable material are readily made. The forest species of Ceylon, especially those of the rain forest in the Wet Zone, are not adequately covered. There are omissions of some fairly common trees notably in the following families characteristic of this Zone:—the *Dipterocarpaceae* (the *Dun* family), *Guttiferae* (the *Kinas*), *Sapotaceae* (the *kirihibiliya*—*kiripedda* group), *ubberiya* in the *Rhizophoraceae*, the genus *Memecylon* of the family *Melastomaceae* (the "Kaha" group of species) among others. Reference to King and Alston's important paper "The Botanical Identity of Tawenna and allied timbers" (Annals of the Royal Botanic Gardens, Vol. II, 1930) would have prevented errors of nomenclature and notable omissions of the *Palaquium* group, e.g., *kirihibiliya* is *Palaquium petiolare* not *P. grande*. Worthington has religiously followed Trimen in his arrangement of families not taking into account that several recent changes in the transfer of species have been made, for instance satinwood is now in the family *Rutaceae* (the orange family); the fig family (the genus *Ficus*) has now been placed with the genus *Artocarpus* (jak, del, etc.) under *Moraceae* (not *Urticaceae*); the genus *Hydnocarpus* is now under *Flacoutiaceae* (not *Bizaceae*), etc. There are also some avoidable mistakes in the spellings of Latin names, e.g., page 4, *Michelia champac* for "champaca", "*Mitregyna*" (pages 293, 294) for "*Mitrageyna*" etc. Some of the obsolete names of species have been given, e.g., *Careya arborea* for *C. coccinea*. This species is also wrongly placed under the *Myrtaceae*. It is now under the *Lecythydaceae*. Mr. Worthington's book gives an excellent and up-to-date representation of the exotics, notably the genus *Eucalyptus* on which he has published a very comprehensive paper (with Dr. Gorrie), in the "Ceylon Forester" (New Series, 1953, published bi-annually by the Forest Department). He has been intimately connected with the introduction and popularisation of several exotics as garden and roadside trees; one at least, *Cassia spectabilis*, introduced by him in 1928 has become naturalized.

Those who expect to use this book as an Encyclopedia of Ceylon trees are likely to be disappointed. Perhaps larger plates, fuller descriptions and the inclusion of more species would have been more rewarding, but this doubtless would have put up the already high price well above the reach of those interested in trees. Neither can it be expected to serve as an infallible and ready guide to identification. The preparation and operation of simple dichotomous Keys to many hundreds of tree species is a formidable task and cannot be attempted without detailed treatment and used without a knowledge of the fundamentals of systematic botany. Those interested will find a reference to the identification of trees on "field characters" i.e., the external characters especially characters of the bark and blaze which has been applied to the rain forest trees of Ceylon, among the references given by Mr. Worthington.

Mr. Worthington's book definitely meets a pressing need for a popular and illustrated book on Ceylon trees. It should find a place in the shelves of all those interested in the study and preservation of our rich and beautiful flora. To schools especially, the book will be especially useful in stimulating an interest among children in the trees around them, in our forests and parks. To the novice, as Mr. Worthington puts it, it should help in identifying "at least some of his trees". The excellent Index at the end of the book gives a complete list of local names, both Sinhalese and Tamil (and even Hindi and other East Indian languages when they apply), the Latin names of species and families. The method of using the book is to check back against one of the names and compare a fresh specimen against the correct illustration. The brief descriptions will facilitate identification.

While strongly commending Mr. Worthington's book to the layman and student alike, I would suggest an early revision, amplifying his descriptions, modernizing his treatment, making the necessary corrections and expanding it to take in all the important trees of Ceylon.

[Reprinted from the "Ceylon Observer", August 9, 1959, with kind permission of the Editor.]

අප ලැබූ වන විද්‍යා පුහුණුව

TRAINING IN FORESTRY

ඇස්. ඩී. ඊ. වින්සන්ට්
(S. D. E. VINCENT)

“ මංකි බ්‍රිජ් ” හෙවත් වදුරු පාලම අපට කිසි දිනක අමතක නොවෙයි. ගිය වසර (1958) නිමවී යද්දී වදුරු පාලම ළඟ පිහිටි කැලෑ කඳවුර කළ ආරාධනය අපි පිළිගනිමු. මේ වසරේ (1959) දුරුතු මස එක් දිනකදී අපි ඔබතුමයා ළඟට ලඟා වුනෙමු. ඔබතුමයාගේ දෙරටුව අසල, පසෙකින් ඇසල රුක මල් පොකුරු දොරින් බිඳ පිළිගත් හැටි අපට මතකය. මේ රුක වටා සෙලවෙමින් තිබුණ දිගැති ඇයල කරල් වදුරන් බහුල තැනක් බවට සාක්ෂි දුන් හැටි ද අමතක නොවේ.

දැන් මේ වසර ගෙවී යයි. අපේ රජයේ අගනා සේවයේ, රන් අකුරෙන් ලියවිය හැකි වසරකි, මේ එක්දහස් නවසිය පනස් නවය. විදුහල් මව කරුණා පෙරදැරිව කළ සේවය අපමණය. ඔබෙන් ලඟදී වෙන්වී යාමට සූදනම් වන අපි කෙසේ කෘතගුණ සලකමුද ?

වන රෝපන සංරක්ෂණ සංවර්ධන විද්‍යාව, (Silviculture) උද්භිද විද්‍යාව, (Botany) දූව මැනීම, (Mensuration) වන මිනීම, (Forest Surveying) උපයෝගී කරණය, (Utilization) පාලනය, (Forest Management) වන පාලනය ආදී නොයෙක් වන විද්‍යාවට (Forestry) අයිති විෂයයන් ගැන අප ලබාගත් දැනුම මෙපමණකැයි අපට කිව නොහැකිය. මෙපමණකින් විදුහල් මව සෑහුනේ නැත. ප්‍රායෝගික අවබෝධයද (Practical Knowledge) දියුණු කිරීම සඳහා නොයෙක් කැලෑ වර්ගයන්ගෙන් යුත් ලක්දිව මුල් ස්ථාන කිපයක කඳවුරු බැඳීමට ඇ පිළියෙල කළාය. මෙන්න අප දුටු කැලෑ බිම් සමහරක් :

වග—සඳහට කොලබර තෙත් වනාන්තර කලාපය

මැදින් මස එක් දිනකදී වග කඳවුර බලා යාමට අපට විදුහල් මව ඉඩ දුනි. සති තුනක පමණ කාලයේදී උස් හොර දුන් වර්ගයේ හැඩිදැඩි රුක් පෙල, සඳහට කොලබර කැලෑ බිම්වල ආඩම්බර පැ හැටි අපි නෙතින් දුටුවෙමු. එක් තැනකදී යාතුරල විද්‍යාව ((Phenology) සම්බන්ධ දෑ අත්හද බලන කැලෑ බිමක්ද, තව තැනකදී මීල්ල, අලුබෝ, දෙල් සෙවන ඇතුළු හෝ නොමැතිව වැඩෙන හැටි අත්හද බලන වෘක්ෂෝද්‍යානද (Open Shelterwood Gardens) දැක ගැනීමට වගදී වාසනාව ලැබුණි. දූව කඳ වැඩෙන අන්දම පරීක්ෂා කර බලන ආදර්ශ පාන්ති (Experimental Plots) දුටු අපි ඉමහත් ප්‍රායෝගික දැනුම තව තවත් තර කර ගනිමු. මේ අගනා පර්යේෂණ ක්‍රම තවදුරටත් සාර්ථක කිරීමට අපි වගදී වග කීමට පංගුකාරයින් වුනෙමු.

කිලිනොච්චිය—සඳහට කොලබර වියලි වනාන්තර කලාපය

විදුහල් මව සිරිලක කතරන් වෙනවාට අයතුටු බව හැහුනේ අප වියලි කලාපයේ කඳවුරට යාමට නියම කළ දිනයේදීය. බක් මාසයේ සති දෙකක් කාලයේදී දිවයිනේ උතුරු දෙස සැරිසරා නැරඹූ යැව් අපි අමතක නොකරමු. පලෙහිදී දුටු කස (Casuarina Equisetifolia) වගාව ක්ෂේම භූමියක සිටි දරයි. මෙවැනි වගා වැලි සහිත වියලි බිම් ගොවිතැන් බිම් බවට හැරවීමට අවශ්‍ය බව රජයට දැන් හැඟී ඇති බව අපට කිලිනොච්චිය කඳවුරේදී දැන ගැනීමට ලැබුණි.

නැවත විදුහල් මව තුරුලේ දෙවෙනි වාරය අපි ගත කෙළෙමු. වෙසක්, පොසොන් සහ ඇයල මස මැද කාලය වනතුරු අපි වන විද්‍යාවට අදාල ඉහතකී විෂයයන් හදාරා විඩාවට පත්

වුනෙමු. මේ බව දැනගත් විග්නල් මව අපට ගත සුව දීමට අමතක නොකළාය. වග, තෙත් කලාපයේ දී පවා නියා යමයේ පිඩා වින්ද බව ඇ හොඳින් දැන සිටි නියා උඩරට සිසිල ගෙන දෙන හපුතලේ කඳවුරට යෑමට ඇ පිළියෙල කළාය.

හපුතලය—උඩරට කඳුකර වනාන්තර කලාපය

උඩරට මනරම් කඳුකර කැලෑ බිම් බැහැ දැකීමට භාග්‍ය ලැබූ අපි සිසිල් සුලගේ සිසිල රජ විඳිමින් හපුතලේ “නිවාඩු නිවසේ” ලැගුම් ගනිමු. “ඊයුකැලිප්ටස්” (*Eucalyptus*) වර්ගයට අයිති උස් රුක් පෙල මන්ද මාරුතයෙන් සෙලවී යෙලවී හිස් නම්‍ය, පට්ටිපොල, කඳපොල ආදී නොයෙක් ස්ථානවලදී අපට පිළිගත් හැටි දිවි දැති තෙත් අමතක නොවේ. රජයේ “ටර්පන්ටයින්” කැලෑ යනු එහි දතෝ ඒවාට පටසකි. ඕස්ට්‍රේලියාවේ ජනම හිමිකම් පවසන “ඊයුකැලිප්ටස්” (*Eucalyptus*) වර්ගයේ “රොබස්ටා” (*Eucalyptus Robusta*) “ග්ලොබියුලස්” (*Eucalyptus Globulus*) “මයික්‍රොකොරිස්” (*Eucalyptus Microcorys*) “සැලිග්නා” (*Eucalyptus Saligna*) “මැකුලේටා” (*Eucalyptus Maculata*) “පිලුලාරිස්” (*Eucalyptus Pilularis*) “සිට්‍රියොඩොරා” (*Eucalyptus Citriodora*) “ටෙරිටිකොර්නිස්” (*Eucalyptus Teroeicornis*) “රෙග්නන්ස්” (*Eucalyptus Regnans*) සහ සයිප්‍රස් නමින් හැඳින්වෙන “කුප්සරස්” වර්ගයේ “මැක්කොකාපා” (*Macrocarpa*) “ටොරුලොසා” (*Torulosa*) “ලොසන්තානා” (*Lawsoniana*) “කෙටියානා” (*Knightiana*) “සෙම්පර්වර්නස්” (*Sempervirens*) ආදී නොයෙක් පිටරට නම් ලත් රුක් උඩරටට දූව, දර සපයමින් රජයේ කැලෑ අප තමයි පවසමින් උඩරට යන කාටත් හඳුන්වා දෙයි. පට්ටිපොල, නවාන කදිම අගය ඇති තැනකි, අප දුටු. ඉහත සඳහන් පිටරට නොයෙක් රුක් ජාතීන් තවත් බිමෙන් උළිමහනට එන හැටි දුටු අපි මව්න වුනෙමු. රුක් පැලෑටි “කුඩා පැල” (*Basket plants*) මගින් දිවයිනේ අවශ්‍ය ස්ථානයන් කරා ගෙන යන්නේ බොහෝ විට මේ පට්ටිපොල මධ්‍යම තවත් බිමෙන්ය. ඇල්ල, දියතලාව, කඳපොල, ඇතලපිටිය ආදී නොයෙක් තැන්වලදී සිනහ වෙමින් නැගී එන ඒ රුක් පෙල අපට ලෙහෙසියෙන් අමතක නොවේ.

නත්තල ගස් ගැන නොයෙක් දෑ අසා සිටි අපට ඒවායේ උත්පත්තිය දැක ගැනීමට වාසනාව ලැබුනේ උඩරටදීය. නත්තල් ගස් වර්ගයේ රුක් පෙළින් ගහන රජයේ කැලෑ බිම් කීපයක් දුටුවෙමු. මේ සඳහා “පෙපෙනස්” (*Pinus*) වර්ගයේ ගස් ප්‍රයෝජනය සඳහා ගනිති. “පැටුලා” (*Patula*) “ඉන්සිග්නිස්” (*Insignis*) “රේඩියේටා” (*Radiata*) “කැරිබියා” (*Carribeeae*) “ලොංගිපෝලියා” (*Longifolia*) එම වර්ගයට අයිති යමහරක්ය. “රොක් සයිප්‍රස්” යනුවෙන් හැඳින්වෙන කඳු බිමහි වැවෙන තවත් වර්ගයකි. “කැල්කරාටා” (*Calcarata*) “රොබස්ටා” (*Robusta*) “ග්ලූකා” (*Glauca*) ආදිය මේ ගස් සයිප්‍රස් වර්ගයට අයිති සමහරක්ය.

නුවරඑළිය ප්‍රදේශ ආසන්නයේ දිනක දුටු සුලං තීර (*Windbelts*) අපි අමතක නොකරමු. සුලං රකුසාගේ පරම යතුරෙකි, ඒ සුලං තීර. වැලිමඩ-නුවරඑළිය මහ මාවත අද්දර පාලුගම ප්‍රදේශයෙහිදී දුටු සුලං තීරයෝ ඉමක් නොමැති ප්‍රයෝජන ගෙනදෙන අසුරු අපට හොඳහැටි පෙනී ගියේය. එම සුලං තීර ක්‍රමය ආරම්භ කිරීමට පෙර නුදුරු පාසලක වහලය සුලංගින් නොසිතිය හැකි දුර ප්‍රමාණයකට ගෙන ගිය බව මෙහිදී දැනගැනීමට ලැබුණි. රජය සුලං තීර ක්‍රමය ඉතා අගය එකක් බවට තරයේ සලකා තිබේ. කැලෑ සහ ගොවිකම් දෙපාර්තමේන්තු එක්වී මේ සුලං තීර ව්‍යාපාරය සාර්ථක අන්දමින් ගෙන යන බව අපි මෙහිදී දැන ගනිමු.

කුරුණෑගල—අන්තර් කලාපයේ වනාන්තර

උඩරට කඳුසිරි නැරඹූ අප නිකිති මස එක් දිනකදී ගමන් කළේ දැකුගල් පුරට හෙවත් කුරුණෑගලටයි. වියළි සහ තෙත් කලාපයේ සඳහරින වනාන්තර පිළිබඳව පාසැල් ජීවිතයේදී ඉගෙන ගැනීමට හැකි විය. නමුත් කුරුණෑගල ආසන්න ප්‍රදේශයේ පිහිටි අන්තර් කලාපයේ

(Intermediate Zone) කැලෑ බිම්, කැලෑ නිලධාරීන්වූ අපට ඉඳුරාම වෙනස් ඡේදයක් විය. තෙත් කලාපයේ (Wet Zone) මුල් තැනක් ගත් උස් හොර ගස ලග වෙලත් ගසකි. එසේ නැත්නම් හල්මිල්ල ගසකි. අන්තර් කලාපයේ මිහිම හැඟුනේ මේවා දුටු අපටය. තෙත් කලාපයේ යහ වියලි කලාපයේ (Dry Zone) හොඳින් වැඩෙන පිහිඹිය සහ කඩුඹේරිය අන්තර් කලාපයේ සැම තැනකදීම පාහේ අපට දකින්නට ලැබුණේය. ඒ ප්‍රදේශය මේ දෙවර්ගය වැටීමට ඉතා සුදුසු බව අපට හොඳින් දැනගැනීමට ලැබුණි.

කොස්-මහොගනි කදිම වගාව අන්තර් කලාපයේ මිහිම හොබවමින් වයඹ දිව්‍යන පොබවයි. කුඹුල්පොල නවන විස්තර පහසුවෙන් සඳහන් කිරීමට හැකියාව නොමැත. ප්‍රමාණයෙන් අත්කර දෙකක් පමණ වූ මේ නවන මෙන් නව කදිම තැනක් අපි මීට පෙර නුදුටුවෙමු. පාත්ති තුන්සියයක් පමණ ඇති මේ නවත් බිමෙහිදී, කැකුළු දත් පා සිනහවෙන ළදරු තෙත්ක පැළ දුටු අප සිත් ඉමක් නොමැතිව ප්‍රබෝධ විය. ලක්ෂ දෙකක් පමණ තෙත්ක පැළ, දැනට සිටිමින් සඳහා පිළියෙලවී තිබීම දිව්‍යනේ වයඹ කොටසට ඉමහත් ආඩම්බරයකි.

සුන්දපොල කැලෑ වගාව පිටරැවියන්ගේ පවා සිත් දිනාගත් තැනකි. කදිම මහොගනි සහ වගාව දුටු කාගේ සිත් ප්‍රීති නොවෙත්ද? හේන්පිට-ගෙදර-ලන්ද, කිරිදිගොල්ල, බඩ ගොමුව, ගොන්දෙතිකන්ද, කැන්දපන්න, දවටගොල්ල, හබ්බිලිකන්ද, බජ්ජන්ගොඩ ආදී නොයෙක් ස්ථානවලදී දුටු කැලෑ වගා බිම් සුන්දපොල කැලෑ වගාවට දෙවෙනි නොවේ.

හිරියාල හත්පත්තුවේදී සමුපකාර ව්‍යාපාරයෙන් රජයට ඉටුවීගෙන යන සේවය අපට දැකගැනීමට හැකි විය. පැපොල් සහ අනික් ගොවි ද්‍රව්‍ය නිපදවාගත් සමගම ඒ රජයේ කැලෑ බිමහි කොස්, යුනු මිදෙල්ල ආදී ද්‍රව්‍ය ජාතීන් වැවෙයි. මේ වගාව ජනාගහනයට සුලුපටු සේවයක් නොවෙයි.

කුලියපිටියට නුදුරු තැනක පිහිටි කඳවුරේ සතියක් ගත කළ අපට අන්තර් කලාපයේ අගය තවදුරටත් දකින්නට ලැබුණේය. කොස්, මැහොගනි, දෙල්, හොර, නැදුන් පාදී අගනා රුක් තුරුල්වූ කන්කානියමුල්ල, හොරකැලේ, දික්කැලේ, බා-හැඩවක ආදී තැන්වල වන වගා අපි අමතක නොකරමු. මෙයින් හොරකැලේ හොර වගාවට මුල් තැනක් දිය හැකිය.

එලිපහලිවූ අන්තර් කලාපයේ කැලෑ අඳ ක්‍රමයෙන් වියලි කලාපයේ කැලෑ බිම් තත්වයට පෙරලෙන බැව් පෙන්නුම් කරයි. මේ විපතීන් ඒ වටිනා කැලෑ බිම් ප්‍රවේශම කිරීම අප හැමගේ යුතුකමක් බව සඳහන් කිරීමට අපි කැමැති වෙමු.

ආපසු විදුහලේ මව ලඟට ලඟාවූ අපට අත්වූ ප්‍රායෝගික දැනුම මෙපමණකැයි ඇට දන්වා තිමි කළ නොහැකිය. ලැබූ ප්‍රගුණව අපමණය. ඉමහත් සේවය කළ ඔබ හිමි විදුහල් පතිටද දෙවූ කනිටු උපදෙසුන්ටද අප තුනී පිරිනමමින් අද හෙට දිනකදී අපි කෘතඥ සලකා නව තවත් නෑණ වඩවා ගැනීමේ අවියෙන් ඔබතුමියගේ තුරුලෙන් වෙන්වී යන්නෙමු.

“ වන වගා අප හැමා කර සද ”—මේ වැකිය මට හැකි නම් පහල බාලාගයේ මුල් පිටුවෙහි අප දුටු “අප රට සහ ” යන්න ලඟට එක් කරමි.

Appropriate Technology Services

121, POINT-A-TO-POINT ROAD

NALLUR, CHENNAI

No.