

PROCEEDINGS
OF THE
ALL-INDIA TROPICAL MOIST EVERGREEN
FOREST STUDY TOUR AND SYMPOSIUM

MARCH-APRIL, 1960



सत्यमेव जयते

FOREST RESEARCH INSTITUTE
DEHRA DUN

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RECOMMENDATIONS OF THE ALL-INDIA TROPICAL MOIST EVERGREEN FOREST SYMPOSIUM

The All-India Tropical Moist Evergreen Forest Symposium as recommended under Recommendation No. (1) of Item No. I.B.(iv), (v) of the IX Silvicultural Conference, 1956, and approved by the Government of India, Ministry of Food & Agriculture (Agri.) under their No. 21-25/59-FD dated 26th June, 1959, was held during March-April 1960. The study tour included visits to the Tropical Moist Evergreen Forests of Mysore, Kerala, Madras, Andamans, Assam and NEFA. The Plenary Session of the symposium was held at Shillong from 22nd to 24th April, 1960, and the following recommendations were adopted.

GENERAL

Policy and Objects of Management

Recommendation 1—Most of the Tropical Moist Evergreen Forests of India are so located that their protective functions are of paramount importance. Consistent with this primary consideration, it is necessary to step up the productivity of the forests to the maximum possible extent.

Ecological Aspects

Recommendation 2—As far as possible, the evergreen character of the forests be maintained in working these forests.

Recommendation 3—Evergreen forests of the post-climax nature, as are met with in the States of Madras and Assam, should be cautiously worked because they are highly unstable and any drastic change may alter the forest composition abnormally.

Recommendation 4—In inaccessible areas, evergreen forests have escaped the depredations of man. Suitable areas from such forests should either be constituted as 'Nature Preserves' or made into 'Preservation Plots'.

Silviculture

Recommendation 5—Evergreen forests which are located in the catchment of important rivers, where their primary function is of protection, should be worked under the Selection System. The exploitation diameter limit and the yield should be so fixed that no permanent gaps are caused in the upper canopies.

Evergreen forests mainly managed for the production of timber may preferably be worked under the Irregular Shelterwood System. In areas where the number of mature and overmature trees is proportionately higher, the surplus growing stock of such trees should be removed in the first one or two felling cycles to facilitate the application of the Irregular Shelterwood System.

Recommendation 6—'Refining' which includes removal (cutting or poison girdling) of uneconomic secondary species, at least one or two years in advance of the main fellings, may be adopted in suitable areas where such an operation is likely to ensure adequate regeneration of valuable species, which may be regularly tended to secure establishment.

Recommendation 7—Regeneration surveys, in advance of the main fellings, and also from time to time subsequently, should be made a regular feature for assessing the regeneration status of the forest with a view to applying proper silvicultural treatment in order to secure adequate natural regeneration. The proper techniques of Regeneration Surveys for evergreen forests should also be worked out.

Management

Recommendation 8—Evergreen forests are, as a rule, inadequately exploited. Therefore, the means of communications should be improved and modern methods of logging should be adopted in order to enhance their economic value.

Recommendation 9—Creation of compensatory plantations elsewhere, in order to make up for the deficiency of regeneration in worked-over and untended evergreen forests cannot be deemed to be a satisfactory silvicultural practice. Efforts should be made to obtain regeneration on all worked areas by carrying out proper and timely cultural operations.

RESEARCH

Ecological Aspects

Recommendation 10—Distribution of species in the evergreen forests of India should be studied and correlated with the climate of the region, geological history, biotic influences, etc.

Recommendation 11—A thorough typological study of the evergreen forests of India should be made to delineate well-defined types, sub-types and constituent plant communities. Apart from the floristics of these classes emphasis should also be placed on the structural make-up of the forest profile.

Recommendation 12—Syn-ecological status of the individual types and sub-types of the evergreen forests should be determined.

Successional studies both in the primary and secondary evergreen forests should be carried out and the dynamic tendencies of each stage should be evaluated.

Recommendation 13—Autecological studies on economically important species and their most common associates in the evergreen forests should be carried out, with regard to light requirement, moisture balance, root competition, nutrition partition, nutrition uptake, etc.

Recommendation 14—Micro-climatic studies in the evergreen forests should be started. These studies should be carried out separately for each forest type and each layer of the forest profile, in respect of such elements as rainfall, humidity, temperature, light, wind, etc.

The micro-climatic changes attendant upon such forestry operations as lifting of the canopy, lowering the canopy, refining, brushwood cutting, etc. should also be assessed.

Recommendation 15—Soils of the evergreen forests should be studied in detail, both morphologically in the field and critically in the laboratory. Correlations with vegetation types may also be investigated.

The effect of various forest operations on the properties of the soil, particularly with regard to laterisation, should be studied. The effect of such operations on fluctuations of the permanent water table should also be investigated.

Recommendation 16—The effect of fires, grazing, shifting cultivation and plantation crops such as tea, coffee, rubber, cardamom, etc., on the site factors in the evergreen forest zone should be studied.

Recommendation 17—Reed formations (*Ochlandra* spp.) in the evergreen forests of Kerala are of great economic importance. Ecological studies of reed communities should be made with particular reference to the associated tree crop.

Recommendation 18—Studies on the regeneration complex of each type of evergreen forests should be made, with special reference to distributional patterns, indicative role of associates, site conditions, etc.

Recommendation 19—Introduction of deciduous elements in the evergreen forests is said to enhance the productivity of these forests. Experiments designed to enhance the productivity, without deteriorating the soil, should be tried.

Silviculture

Recommendation 20—There are many gaps in our knowledge of the silvicultural, ecological and phenological characteristics of important species of the evergreen forests. Detailed studies should be initiated in respect of the more important species such as *Dipterocarpus* spp., *Mesua ferrea*, *Hopea* spp., *Shorea assamica*, etc.

Recommendation 21—Canes form an important economic constituent of evergreen forests. Intensive studies on the silviculture of canes should be taken up with a view to their proper management.

Recommendation 22—Experiments on natural regeneration techniques including lifting and lowering of the canopy should be conducted, with reference to the regeneration of economically important species.

Recommendation 23—Tending of regeneration in the evergreen forests is a costly operation; it also makes a heavy demand on labour. Hence there is a general tendency to neglect it, much to the detriment of healthy growth of the new crop. It is, therefore, essential to work out methods involving less labour and expense in order that such tending may be regularly carried out.

Recommendation 24—Enrichment planting is by far the surest method of enhancing the productivity of the evergreen forests. Planting techniques, including tunnel planting, gap planting, etc., should, therefore, be subjects of detailed study. Knowledge should also be gathered in respect of correct nursery techniques, proper sizes of transplants, suitable time for planting, optimum espacement (intermediate thinnings being contra-indicated due to the high cost of transplants and the low thinning returns), etc., in respect of economically important species.

Recommendation 25—Studies in the possibility of establishing commercial plantations of fast-growing indigenous and exotic tree species on evergreen forest sites should be taken up.

Management

Recommendation 26—Utilization of the secondary timbers of the evergreen forests should be improved by seasoning, preservative treatment, etc. Their mechanical properties and pulping qualities should also be investigated in order to increase their utility for particular uses in industries such as those manufacturing paper pulp, veneers, chipboards, fibreboards, etc.

Recommendation 27—Volume, Yield and Stand tables for economically important species should be prepared.

Recommendation 28—Adequate number of Sample Plots, L.T.I. Plots, Continuous Inventory Plots, etc., should be laid out.

SUMMARY OF DISCUSSIONS OF STATE SYMPOSIA

TROPICAL MOIST EVERGREEN STATE SYMPOSIUM (MYSORE STATE)

(Held on 13th March, 1960 at Makut)

Besides the delegates and the observers constituting the Tropical Moist Evergreen Study-Tour Party, Dr. K. Kadambi, Chief Conservator of Forests, Shri J. Mascranehes, Conservator of Forests, Coorg Circle, and the local forest officers participated in the discussions.

2. *Shri S. K. Seth* (F.R.I.) requested Dr. K. Kadambi to review the general situation with regard to evergreen forests in the Mysore State so that discussions could be taken up under the headings of (i) Ecological aspects, (ii) Silviculture, and (iii) Management.

3. *Dr. K. Kadambi* (Mysore) stated that prior to 1930, exploitation of the evergreen forests was mostly confined to accessible localities like Agumbe, and only 2 to 3 species like *Hopea*, *Artocarpus*, etc. were extracted. With the establishment of the wood preservation plant at Bhadravati more intensive selection fellings commenced. Treated *Dipterocarpus* sleepers were being supplied to the railways. With increased rural electrification, demand for poles accordingly increased manifolds. Similarly the plywood factories established were requiring more and more of the softwoods. Therefore, these ever-increasing demands caused the working of the evergreen forests to be progressively heavier and heavier. Thus, the areas worked in the past indicate a panorama of sites subjected to varying intensities of working.

4. The working plan formulated in early forties for the Agumbe evergreen forests took advantage of the results obtained under various intensities of working and prescribed the method of canopy-lifting, followed by intensive cultural operations, as the surest method of regenerating these forests. Unfortunately the fellings made to lift the canopy were not uniform in intensity and also the subsidiary cultural operations were not duly attended to. During the past few years, however, these areas are being gone over under cultural operations. The heavily worked areas are fully stocked with young poles and are being freed to develop further.

5. Attempts were also made to plant *Hopea* in gaps of 5 to 10 acres. Tending operations were followed only for a few years and thus a uniform stocking of young crop could not be obtained. The surviving stems are 30' to 40' in height.

6. In the Coorg areas selection fellings have been tried and the regeneration occurring in gaps has been tended adequately. The results are encouraging. In Kanara area, the method of working followed hitherto was of exploiting the softwoods only. A working plan is being prepared for these areas.

7. *Dr. K. Kadambi* (Mysore) further said that for the unworked evergreen forests, it is desirable to introduce exploitation slowly so that the regeneration may keep pace with the amount of overwood removed. In such areas, therefore, the first felling cycle should aim merely on the exploitation of over-mature trees on selection basis. In subsequent felling cycle intensity of working may be heavier, amounting to that of irregular shelterwood system. Such a plan of working induces adequate regeneration to re-stock the area fully.

8. *Shri J. Mascranehes* (Mysore) added that the diffused working as is done under the selection system is usually costly and should on no account be taken up departmentally.

Ecological Aspects

9. While initiating the discussions, *Shri S. K. Seth* (F.R.I.) said that if the evergreen forests are considered as a broad vegetation formation, the various floristic associations met with, can be explained on the basis of soil variations, aspect, slope, etc. However, soil is by far the most important single controlling factor and particularly the degree of laterization together with the condition and location of the lateritic pan. The study of soil-vegetation complex is, therefore, very important.

10. *Shri M. A. Waheed Khan* (F.R.I.) elucidated further on ecological aspects and reiterated the views that though the typological, floristic and successional studies are necessary in primary forests for understanding the structural make up from time to time, a

thorough study of secondary succession is more important, particularly in the context of regeneration operations. In case of moist sal it has been observed that if the vegetation approaches the climax stage, sal fails to regenerate but slight retrogression induced by fires, grazing or heavy fellings brings about a change under which regeneration comes up prolifically. Similarly in the case of evergreens it seems likely that a retrogression if induced by heavy fellings, there is a hope of obtaining adequate regeneration. Kamphole coupes worked on this basis substantiate this view.

11. Study of secondary succession is also necessary because of intense soil changes involved by way of soil-wash, laterization and compaction of top soil.

12. *Shri K. K. Nair* (F.R.I.) held the view that conversion of the evergreen forests to single species culture is not advisable. The drastic change involved may deteriorate the site quality abnormally.

13. *Shri S. K. Seth* (F.R.I.) agreed with the view that the study of secondary succession is of immense importance but doubted the validity of the remark if site deterioration is a necessary accompaniment of monoculture practices. In fact, the productivity of the evergreen forests can only be enhanced by concentrating economic species at the expense of the multifarious inferior species.

14. *Dr. J. S. P. Yadav* (F.R.I.) commented on the organic matter content in soil profiles examined in the State. His observations revealed that the maximum concentration of organic matter usually occurs in top layer whereas incipient infiltration goes far deep into the profile. Under the natural vegetation cover, therefore, the fertility status of the soil is fairly good but its maintenance under varied systems of fellings is a matter of further study. However, it seems highly probable that the litter formed by certain species may play an eminent role in the turnover of plant nutrients. Special attention to such species during the course of fellings is therefore desirable.

15. He further commented that the clay content of the soil governs the moisture status of the profile. The lateritic soils as are found under the evergreen cover, have a varying proportion of clay content and as such the varying moisture status reflects particularly on the condition and development of the regeneration complex. The concretionary soils with a low water retentivity bear a relatively poor growth, and the seedlings find difficult to establish themselves. On the deeper soils with a high clay content, the associated vegetation is usually luxuriant and regenerates freely.

16. *Shri S. K. Seth* (F.R.I.) observed that the degradation of the soil must be carefully watched. Under openings and consequent exposure of the soil leads to excessive leaching, soil wash and hardening of the lateritic mass. Retention of clay and humus can, however, be ensured if fast growing species are either encouraged to appear naturally or introduced artificially in the gaps created.

Silviculture

17. *Shri S. K. Seth* (F.R.I.) continued and said that in respect of the evergreen forests choice of a silvicultural system should effectively guard against the deterioration of the site and at the same time disturb the vegetation sufficiently so that natural regeneration may appear with ease. To meet these two divergent demands irregular shelterwood system appears to be most suitable. The orthodox selection system though suitable for preserving the site characteristics is not drastic enough to induce regeneration. The success achieved under selection system at some places is more due to deviations made from the standard selection fellings, almost amounting to irregular shelterwood system.

18. In the regeneration complex induced the distributional pattern is that of a mosaic. Small to large patches of single species appear. Thus the homogeneity with regard to regeneration of economic species is not maintained. This distributional pattern arises as the seed mother trees are not uniformly distributed. Therefore, to have a uniform distribution of economically important species resort shall have to be made to enrichment stocking either by sowing or planting, particularly in patches where inferior species congregate.

19. He agreed with the views of *Dr. K. Kadambi* that the hitherto unworked evergreen forests should be gone over under selection fellings till all the over-mature stems are exploited. Later on irregular shelterwood system may be applied. He also drew attention to the operation of "refining" as is being practised in Tropical Africa. The inferior species are removed 2 to 3 years in advance of the main fellings. The resultant second growth forest is particularly rich in economic species.

20. Once the regeneration is obtained on the ground, subsequent tending for a number of years is very essential. A tending period of 3 to 5 years is usually sufficient.

21. *Shri Krishnamoorthy* (D.F.O., North Coorg, Mysore) said that in his division evergreens were worked both under selection and irregular shelterwood systems. The results obtained under the selection system are very encouraging. He also informed that under this selection system 7 to 8 trees per acre of the top canopy are removed.

22. *Shri J. Mascranehes* (Mysore) further explained that though the working plan does not prescribe removal of more than 6 trees per acre, a slight deviation has been made to meet the demands of timber and also to make the annual coupe a financial success.

23. *Shri M. A. Waheed Khan* (F.R.I.) remarked that from what has been said it transpires that though a substantial deviation has been made from orthodox selection system, which may amount to almost irregular shelterwood system, the stamp of selection system is still maintained. It is, therefore, erroneous to believe that the success achieved is as a result of selection working.

Management

24. *Shri S. K. Seth* (F.R.I.) said that most of the points which should have been discussed under "management" have already been covered. He, however, drew attention to regeneration surveys for assessing the progress achieved from time to time. The sampling technique is still to be evolved. Depending on the stocking and distribution of regeneration, the sampling technique will vary. He, therefore, suggested that if regeneration data are collected in telescopic plots of sizes ranging from 6' x 6' to about 33' x 33' and about 40 to 50 sites are thus investigated, the data collected may be analysed to determine an efficacious method.

25. *Shri M. A. Waheed Khan* (F.R.I.) suggested that several areas in the State have been worked under varying intensities. If all such areas are first classified according to topography, elevation, aspect and soil conditions, and then their history of working is traced particularly with regard to the number of trees removed per acre, the regeneration surveys will indicate the efficacious method of working. These indications will go a long way in formulating working prescriptions and guiding working of the evergreen forests, till definite researches are made in this regard.

TROPICAL MOIST EVERGREEN STATE SYMPOSIUM (KERALA STATE)

(Held on 23rd March, 1960 at Trivandrum)

Besides the delegates and the observers constituting the Tropical Moist Evergreen Study-Tour Party, *Shri M. P. George*, C. C. F., Kerala State, *Shri K. Krishnamoorthy*, C. F., Quilon Circle, *Shri C. M. John*, C. F., Chalakudy Circle, *Shri P. Narayana Nair*, C. F., Calicut Circle and a number of District and Working Plans Officers participated in the discussions.

2. While initiating the discussions, *Shri S. K. Seth* (F.R.I.) observed that the population density in the Kerala State is high (over 1,000 persons per sq. mile) and therefore there is an immense pressure on forested lands both for the extension of cultivation and maximum yield of forest produce. The preservation of forested lands, however, can be ensured if the objects of management, in order of priority, are: (i) proper land use, (ii) maximum production per unit area, and (iii) adequately meeting the demands of the region.

3. The private forests and at places (e.g., the Cardamom Hill Reserve) the large encroachments in the Govt. reserves are entirely devoted to production of cash crops like rubber, cashew, coconut, tapioca, tea, cardamom, etc. The practice followed is admirably suited to the preservation of site characteristics and may be termed ideal if soil conservation measures are also adopted simultaneously. Under such a method of cultivation, the financial returns obtained annually are very high and if the practice of forestry is to survive in this State it will have to compete well with cash crop production and produce equally lucrative financial results. Production of fuel for local consumption cannot continue to be a long-term object of management because a number of hydro-electrical projects are being developed to supply energy at a comparatively low cost. Apparently, therefore, the small patches of evergreen forests, which are uneconomic units from the point of view of management may profitably be allotted for the production of rubber and cardamom if a pressing need arises for doing so. The continued fertility of the site may, however, be ensured by

retaining an adequate vegetation cover or artificially providing the same. Such a transformation of patchy forested lands may be inevitable in a heavily populated region. A rational policy of this nature shall have to be adopted because it is foreseeable that in due course of time even the larger blocks will be fragmented and a large proportion of them devoted to the production of cash crops if the population pressure continues to increase.

4. *Shri M. P. George* (Kerala) informed that the distribution of the evergreen forests in the Kerala State is rather peculiar. They extend from about 800' to 5,000' elevation. The best stands of these forests occur in the Cardamom Hill Reserve but have mostly been converted to Cardamom Plantations. Also the fresh-water swamps have mostly disappeared as they were the first to be excised for cultivation. A considerable portion of the evergreen forests has lost its true character and may only be regarded as semi-evergreens of a marginal nature.

5. The evergreen forests in the Kerala State are worked under selection system, particularly to meet the demands of the plywood industry. The number of species utilized for this purpose, however, is very limited and therefore it is necessary to popularise the remaining host of species which occur in these forests.

6. The evergreen forests of the State are vanishing fast due to the development of hydel projects in high hills where the evergreen forests are located in particular. The Edki project will submerge about 250 sq. miles of the evergreen forests in due course of time. Protection of the remaining forests, therefore, is absolutely necessary. Continued annual fires convert the evergreen forest to grassland but with protection the grasslands are gradually colonised by the evergreen tree species. The role of fire protection, therefore, in the technique of regeneration of these forests is paramount.

Shri M. P. George (Kerala) quoted example of a private forest owner in Malabar who has successfully regenerated the evergreen forests. The technique adopted by him is to take out the selection trees and also all the inferior species up to 6" diameter. Canes are not cut. Seeds of economic species are sown broad-cast and the area is rigidly protected against fire and human interference. The area is successfully regenerated in due course of time.

7. *Shri K. Krishnamoorthy* (Kerala) was critical of the expanding hydro-electrical projects in the State. He emphasised that for the very existence of these projects, preservation of the evergreen forests in the high hills is essential. Usually the irrigation channels run dry during summer season when water is required the most. Further expansion of such irrigation projects of doubtful utility should be limited to save the evergreen forests from wholesale devastation.

8. *Shri K. Krishnamoorthy* (Kerala) also expressed the view that research should be conducted to find use for the multi-specific flora of the evergreen forests which is utilized only partially, at present.

9. *Shri S. K. Seth* (F.R.I.) replied that the main aim in the management of the evergreen forests should be of maximum production and for this purpose concentration of economic species is essential. This may either be achieved by enrichment planting or sowing or even by introducing the exotics. Merely focussing the attention on determining the economic uses of all the naturally occurring species is not expected to yield the maximum financial results.

10. *Shri V. Govinda Menon* (S.F.R.C., Coimbatore) expressed the view that the evergreen forests must be preserved to save the hydel projects from being silted up. The role of the evergreen forests in regulating the stream-flow must be appreciated.

11. *Shri M. P. George* (Kerala) explained that under the prevailing circumstances there is no go but to reorient our planning on multi-purpose use of land. The questions of satisfying the acute land-hunger and drawing maximum financial returns from land by cultivating cash crops cannot be ignored. He further stated that only last year the Government were desirous of extending one lakh acres of rubber plantations in the evergreen forests. Though, at present, only about 8,000 acres have so far been handed over for this purpose, it seems certain that in near future all plantable land will thus be got converted. Considering the force of circumstances, *Shri George* said, it is in fitness of things that the Forest Development itself takes up the culture of rubber plantations. Such an exigency is nothing new in the practice of forestry if we remember that about 90 per cent of the pine forests in the Himalayas are managed solely for resin-tapping.

12. *Shri S. K. Seth* (F.R.I.) announced that as the discussions on general topics were over, further discussion would then be confined to (i) Ecological aspects, (ii) Silviculture, and (iii) Management.

Ecological Aspects

13. *Shri S. K. Seth* (F.R.I.) continued and observed that in the Travancore area of the State, evergreen forests have been worked drastically mainly for the production of cash crops. In this area, therefore, ample opportunities are available to study the course of secondary succession, particularly with regard to effects of fires and the changes involved in the soil complex. The widely dispersed small patches of forest can best be made more productive by introducing deciduous species. He exemplified this view by stating that in tropical Africa, evergreens are felled in parallel strips and deciduous species are introduced artificially. Similarly in South America the evergreens are being gradually replaced by *Eucalyptus grandis*.

14. In the northern part of the State (e.g. Silent Valley Forests) there are large blocks of almost virgin forests. They should be studied ecologically with regard to floristics, typology, successional trends, structural composition, soil complex, etc.

15. *Shri M. A. Waheed Khan* (F.R.I.) informed that recently a Swedish scientist, Dr. S. S. Peterson has worked on productivity trends of various vegetation formations of the world. This research has further been continued by Prof. Weck in Germany and he has concluded that the productivity of tropical evergreen forests if judged by the amount of wood produced per unit of area, per annum, is lower than that of a moist deciduous formation. He, therefore, suggested that if the object of management is to enhance the productivity of these forested lands, a drastic change in the evergreen character of the vegetation is imperative.

16. *Shri S. K. Seth* (F.R.I.) elaborated on this aspect of productivity and informed that in the Ecology Section of the Forest Research Institute a map of India is being prepared showing the climato-isophytes and productivity correlations. It is intended to correlate both climate and soil with the maximum productive capacity of various vegetation formations. The evergreen forests are thus included. The preliminary indications are that to enhance the productivity of evergreen forests, it is necessary to introduce deciduous element in the structural make-up of these forests. Thus the climax stage should be retrogressed so that a seral community capable of producing the maximum is built up. In this connection, exotics may also play an eminent role. To keep up the high pitch of productivity, however, frequent re-introduction of new stock is necessary.

17. *Shri M. P. George* (Kerala) enquired if the introduction of the exotics would not deteriorate the soil.

18. *Shri S. K. Seth* (F.R.I.) replied that large-scale plantations of exotics are in existence since centuries in Europe, particularly on podsol soils. No marked deterioration in these soils has yet been noticed. It is, therefore, believed that under tropical conditions, no change in soil complex is expected for the first 1 to 2 rotations.

19. *Shri M. A. Waheed Khan* (F.R.I.) elucidated further on this point and remarked that geologically podsoles are immature soils and their static condition under exotics is conceivable. However, soils of the Indian peninsula, particularly under the tropical moist evergreen forests are of great antiquity and practically mature. Effects produced by exotics on such soils are yet to be studied.

20. *Shri K. K. Nair* (F.R.I.) suggested that the evergreen forests should be preserved for the production of softwoods.

21. *Shri S. K. Seth* (F.R.I.) replied that whenever adequate working in the evergreen forests is done, in the second growth forest, there is always a concentration of a few species only. These species may either be economic ones or otherwise. If the choice is for softwoods only, the regeneration complex may be tended appropriately to achieve this object. It is, however, certain that the achieving of the original floristic composition in the regeneration complex is neither possible nor desirable. Also, the economic utilization of all the inferior species is not the pressing need at present.

Silviculture

22. *Shri S. K. Seth* (F.R.I.) continued and said that the silvicultural systems adopted for the working of the evergreen forests should aim to regenerate them mostly with economic species. Usually the regeneration complex in an evergreen forest is in the form of a mosaic. Patches of inferior species should, therefore, be replaced artificially with economic species. Enrichment planting or sowing is, therefore, an important operation

in regeneration practices of the evergreens. In wet evergreens mere sowing, as is being practised in the Andamans is enough, but in semi-evergreens desired success is achieved only by planting.

23. *Shri A. I. Iyppu* (Kerala) informed that in 1920 Fischer's burn in Palghat Division was clearfelled and planted up with natural seedlings of *Palaquium* and *Artocarpus hirsuta*. Seeds of *Dysoxylum* were also dibbled. These attempts, however, failed and the area was again burnt and planted with species like *Vateria*, *Palaquium*, *Hopea*, etc. Still the results were not very encouraging. With protection afforded, however, the area was gradually stocked first with *Acrocarpus fraxinifolius* and subsequently by *Hopea parviflora*. On the other hand, artificial regeneration in gaps with *Mesua*, *Hopea*, *Calophyllum*, etc., proved successful. Attempts at regenerating the forests naturally were also made by manipulating the overhead canopy. The strip regeneration plots at Shendurney are an outstanding example where desired success has been achieved. He emphasised that if the evergreens are heavily worked and tending operations coupled with fire protection are continued for some years, plentiful regeneration comes in and establishes. In unworked areas, on the other hand, there is a usual lack of advance growth.

24. *Shri A. I. Iyppu* (Kerala) suggested that reed formations are of fair economic importance to the State and as this formation also appears to be long persisting, it should be thoroughly studied ecologically.

25. *Shri S. K. Seth* (F.R.I.) stated that if 7 to 8 top-canopy trees per acre are removed and adequate fire protection is provided, regeneration comes in easily. Reeds, if excessive in the locality should be continually suppressed till the tree species have grown sufficiently. This tending operation may, therefore, be necessary for 3 to 5 years. Canopy lifting coupled with enrichment stocking is by far the surest method of regenerating the area with desired species. Therefore, the silvicultural system adopted should be a compromise between the true selection system and the irregular shelterwood system.

26. *Shri K. K. Nair* (F.R.I.) pointed out that the working plan prescriptions are usually vague on tending operations. Also no rigidity is adhered to in executing these operations timely and adequately. He suggested that compartment and coupe histories should be introduced as a measure of control.

27. *Shri M. P. George* (Kerala) said that there is no difficulty in introducing compartment and coupe histories and also in actually carrying out the tending operations, as the annual coupes are only about 300 acres in extent. It is, however, only a matter of establishing healthy practices in due course of time.

28. *Shri S. K. Seth* (F.R.I.) observed that to ensure scientific working of the evergreen forests, it is but essential to have definite working plans with clearly defined prescriptions, compartment histories, control forms and all the rest.

Management

29. *Shri S. K. Seth* (F.R.I.) continued and said that the overwhelming mass of inferior species must be got rid off before any regeneration operation of economic species succeeds. This operation is known as "refining" and is usually done 2 to 3 years in advance of the main fellings. Such a drastic working is essential. The selection system as is being followed at present, merely depletes the forests in selection trees, progressively at each felling cycle.

30. While commencing working in a virgin evergreen forest, the first one to two felling cycles should concentrate merely on liquidating the over-mature trees. This operation should then be followed by heavy working amounting to that of an irregular shelterwood system. The regeneration comes in adequately and if necessary may also be restocked artificially.

31. For the forests which have already been worked heavily, the shelterwood system can still be applied by lowering the exploitable girth limit and protecting the advance growth.

32. *Shri K. Krishnamoorthy* (Kerala) opined that under shelterwood system when plentiful trees are felled damage to standing growth is enormous and may prove disadvantageous.

33. *Shri S. K. Seth* (F.R.I.) said that felling damage is inevitable and occurs in all types of forests. Usually the refining operation induces lot of regeneration and even after damage caused due to main fellings, adequate regeneration continues to exist on the ground to restock the area fully.

TROPICAL MOIST EVERGREEN STATE SYMPOSIUM
(MADRAS STATE)

(Held on 24th March, 1960 at Kanyakumari)

Besides the delegates and the observers constituting the Tropical Moist Evergreen Study-Tour Party, Shri T. Jeydev, C. F., Madura Circle, and local District and Working Plans Officers participated in the discussions.

2. While initiating the discussions, *Shri S. K. Seth* (F.R.I.) observed that the extent of the evergreen forests in the Madras State is rather limited (about 150 sq. miles). Also they are confined to elevations between 2,000' to 5,000' and their distributional pattern is wholly patchy, except a few compact blocks of 3,000 to 4,000 acres. Some of these patches represent only the post-climax stages on moisture-laden sites along water courses. Usually, the areas around these patches are devoted to cardamom and tea cultivation. The pressure of demand for the extension of cultivation in these areas is heavy. Considering the criterion of maximum land-use this demand plays a dominant role in the ultimate management planning of these forests.

3. Under the current management practice, about 2 to 3 selection trees are removed from each acre of the annual coupe. This method necessarily involves a diffused and extensive working but is obviously cut short due to small extent and scattered nature of the constituent blocks. For exceptionally small and uneconomic blocks it is desirable to augment productivity by intensive working and if necessary by artificial regeneration operations, so that they may continue as forested lands. If the diffused and selective working in such areas is allowed to continue it is not difficult to foresee that the cash crop plantations will wipe out these forests in course of time. An indication of this nature is already available round about Nagarcoil and Shaikalmudi where the evergreen forests are leased out for the cultivation of cash crops.

4. Till intensive silvicultural practices are extended to the smaller blocks of the evergreen forests and till the leasing of these areas for cash crops is continued, maintenance of site fertility, should be ensured by incorporating suitable stipulations to lease deeds. Density of over-head tree species like *Grevillea*, mango, etc., and their replenishment at regular intervals and if necessary, some solid conservation measures should be prescribed. The larger blocks should continue to be under forests but it is desirable to enhance their productivity either by suitable silvicultural methods of obtaining natural regeneration of economic species or by stocking the area artificially. It is, probably, only the monoculture of economic species like *Dipterocarpus*, *Hopea*, etc. which can give financial returns compatible with cash crop production.

5. *Shri T. Jeydev* (Madras) reviewed the current forest management practices in the Madras State and remarked that so far as the small patches of evergreen forests are concerned they can best be managed by leasing them for cardamom cultivation. With regard to larger blocks, it is desirable to manage them as forests. After evaluating the pattern and distribution of various age classes, the true selection system may be applied, as is practised in Europe.

6. *Shri S. K. Seth* (F.R.I.) informed that the applicability of selection system for managing these evergreen forests is questionable. Firstly, the silvicultural refinement required is of a high technical order, and secondly a definite proportion of economic species is not ensured in the regeneration complex. This is also evident from the fact that the selection system, hitherto followed, has not yielded any substantial results. There are indications that with every felling cycle passed, the number of available selection trees progressively decreases. Also considering the fact that the evergreen forests are scattered about in small patches mostly, the adoption of a selection system is not justified, because, the annual coupe will either be too small or will be scattered at several places, and can hardly be an economic proposition for working.

7. *Shri G. J. Raja Singh* (Working Plans Officer, Madras) said that in South Madras, cardamom cultivation is usually done on slopes at 2,500' to 3,500' elevation. In general, a cardamom cultivator looks after the land carefully and thereby maintains the fertility of the site. The tree canopy retained varies from 0.8 to 0.9.

8. *Shri V. Govinda Menon* (S.F.R.C., Coimbatore) opined that the evergreen forests should be managed as such. Their evergreen nature should on no account be impaired. Usually, these patches of evergreen forests are located at the head of the streams and therefore their perpetuation is essential in regulating the stream-flow.

9. *Shri G. B. Dashputre* (Bombay) said that if an adequate tree cover is provided as is usually maintained in cardamom cultivation and also if the lease deeds are suitably worded to ensure this cover in perpetuity, there is hardly any ground for apprehensions.

10. *Shri S. K. Seth* (F.R.I.) further amplified that the requirement of not changing the evergreen character of these forests necessarily means their maintenance at a climax stage. In India more than 80% of the forests are managed and maintained at several stages and the vast expenses of the sal and moist teak forests are the outstanding examples. It has lately been proved that from the point of view of productivity (*i.e.* volume production per unit area per year) it is only the sub-climax or a similar seral stage which produces the maximum. Changing of the evergreen character of these forests should, therefore, be an important object of management.

11. *Shri K. K. Nair* (F.R.I.) remarked that for the isolated blocks of small extent as are obtainable in Madras, utilisation of the areas by leasing out for cardamom cultivation may be justified.

12. *Shri V. Govinda Menon* (S.F.R.C., Coimbatore) was not fully convinced and he again advocated the maintenance of the evergreen character of the forests. *Shri S. K. Seth* (F.R.I.) said that a certain amount of flexibility is necessary in our mode of thinking and approach to the problem of maximum utilization of land. The forests which are protective in function should be maintained as such but as regards other forest lands the question of maximum land utilization cannot be ignored. Similarly in areas where demand for agricultural land is acute, marginal adjustments between forest and agriculture lands are inevitable.

13. *Shri D. K. Deshmukh* (Mysore) informed that in inaccessible areas of North Coorg Division of Mysore State cardamom cultivation is allowed under the working plan prescriptions.

14. Summarising the discussions, *Shri M. A. Waheed Khan* (F.R.I.) observed that so far as the larger blocks of evergreen forests are concerned there is no diversity of opinion and it is unanimously agreed that they should be managed as such but the attention should be focussed in increasing the proportion of economic species in second growth forest, either by manipulating the regeneration complex or preferably by artificial means. Refinement fellings made a few years in advance of the main fellings and broadcasting seed of economic species after clearing the undergrowth may serve the purpose provided rigid schedule of cultural operations for a few subsequent years is followed. With regard to smaller patches of evergreen forests, it is also agreed that they should continue to be managed as at present but introduction of intensive silvicultural practices should be made at the earliest so that the financial returns obtainable may compare well with those of cash crop plantations. Till such measures are adopted, adequate stipulations should be added to the lease deeds so that site characteristic may at least be maintained, if not improved.

TROPICAL MOIST EVERGREEN STATE SYMPOSIUM (THE ANDAMAN & NICOBAR ISLANDS)

(Held on 8th April, 1960 at Port Blair)

Besides the delegates and the observers constituting the Tropical Moist Evergreen Study-Tour Party, *Shri M. M. Srinivasan*, C.C.F., Andaman and Nicobar Islands, *Shri J. C. Varmah*, C.F. and a number of local Forest Officers participated in the discussions.

2. *Shri M. A. Waheed Khan* (F.R.I.) requested the Chief Conservator of Forests to review the general situation with regard to evergreen forests in the Andaman and Nicobar Islands, so that discussions could be taken up under the headings of (i) Ecological aspects, (ii) Silviculture, and (iii) Management.

3. *Shri M. M. Srinivasan* (Andaman & Nicobar Islands) circulated a note prepared by *Shri J. C. Varmah*, reviewing the situation with regard to Forests and Forestry in the Andaman & Nicobar Islands. In brief he dwelt on the forest types and floristic associations met within the Islands and observed that till 1950, the energy of the Forest Department was concentrated mainly on lumbering and extraction of timber. The first working plan was implemented in 1951 and by way of obtaining the natural regeneration it prescribed brushwood cutting, gradual lifting of canopy and retention of about six seed-bearers per acre. The experience gained so far indicates that if brushwood cutting is thorough and seeding is done at least in patches where advance growth is wanting, retention of seed-bearers is not necessary. Also the removal of seed-bearers at a subsequent date causes damage to

promising growth and is not an economic proposition to work the area for reasons of low yield obtainable. The current practice of securing natural regeneration is to carry out advance brushwood cutting, seeding on the whole area and felling and girdling of the entire overwood within 2 to 3 years.

4. The conversion period adopted is 100 years and the annual total area worked in all the three Divisions of the Islands amounts to about 8,500 acres. This extent of the annual coupe is the minimum possible for reasons of heavy cost involved in extraction operations. Labour is not only limited and costly but has to be recruited from the main land, mostly Bihar and Kerala. Current colonisation operations are fairly promising but have not yet yielded results in easing the labour tension. Also, to work the vast area of the annual coupes effectively extraction operations have to continue incessantly throughout the year and during the hot weather paucity of drinking water is a serious hindrance. Thus a heavy strain caused merely to complete the extraction obligations hardly leaves any chance for attending to natural regeneration over the entire area worked. The force of circumstances has compelled to restrict the regeneration operations to smaller areas and only about 1,800 acres (about 600 acres in each of the three Divisions) are followed up repeatedly with subsidiary tending operations to have a full stocking of second growth forest. To compensate loss of regeneration over the remaining area of 6,700 acres (8,500—1,800=6,700 acres) a system of compensatory plantations has been evolved, wherein 750 acres of teak plantations and 400 acres of matchwood plantations are raised. The rate of growth of the existing plantations favourably indicates that the expected high yields in the plantations will be sufficient enough to make up this loss.

5. *Shri M. A. Waheed Khan* (F.R.I.) enquired about the ultimate fate of the vast areas left over as wholly unattended.

6. *Shri J. C. Varmah* (Andaman and Nicobar Islands) stated that the untended areas are usually of the moist evergreen type in which advance growth ordinarily occurs in sufficient quantities. Heavy working of the overwood, as is being practised in the Islands stimulates rapid growth and apparently there are no serious apprehensions to guard against.

7. *Shri M. M. Srinivasan* (Andaman and Nicobar Islands) remarked that a Silviculturist has recently been appointed and in due course of time the regeneration behaviour of the untended areas will be assessed to reorient the silvicultural practices, if necessary.

8. *Shri M. A. Waheed Khan* (F.R.I.) remarked that almost a decade has elapsed since *Shri Chengappa's* working plan was introduced. It is extremely necessary to assess results of working under that plan particularly as the revised-working plan is being formulated. He further suggested the assessment of colonisation impact on the distribution and extent of the evergreen forests.

9. *Shri M. M. Srinivasan* (Andaman and Nicobar Islands) replied that under colonisation schemes only low-level *gurjan* forests occurring along water-courses are being cleared and the estimated extent is about 20,000 acres. Considering the vast forested areas of the Islands, the change imposed is negligible.

10. *Shri K. K. Nair* (I.F.C.) observed that as a result of intensive fellings the second growth vegetation particularly abounds in weed species like *Macaranga*, *Leea*, *Trema*, etc. For the adequate stocking and healthy growth of the economic species it is but imperative that at least one to two tending operations are carried out.

11. *Shri M. M. Srinivasan* (Andaman and Nicobar Islands) said that the strength of the permanent labour on the Islands is 4,500 only. Also it is costly. Monthly wages of a labourer for a month of about 23 days are Rs. 67. Under the existing circumstances, therefore, it is not practicable to extend tending operations over extensive areas. Also, as the silviculture of the evergreen species is little known it is risky to divert the limited labour and financial resources to this end.

12. *Shri H. Kakoti* (Assam) while emphasising the need for tending operations informed that in Assam, the evergreen forests whether worked under selection system or a type of shelterwood system with seed-bearers regeneration has constantly failed to appear if the follow-up operations are not paid attention to.

13. *Shri M. A. Waheed Khan* (F.R.I.) stated that in the evergreen forests environmental conditions for the growth of vegetation are not only the best but are also so uniform that any species may occur at any one place. The distribution of species, therefore, is highly over-dispersed. Such a situation in respect of economic species presents a difficult problem

for the purposes of natural regeneration. The regeneration complex on the other hand is an intricate mosaic in which the species distribution is highly under-dispersed. Therefore, the patches of inferior species deserve a special attention so far as their replacement by economic species is concerned. This can be achieved either by regulating the intensity and nature of felling the overwood or by seeding the patches profusely with economic species. An assessment of the desired intensity of overwood felling and retention of advantageous species may be made by examining the hitherto worked but untended areas.

Ecological Aspects

14. *Shri M. A. Waheed Khan* (F.R.I.) continued and said that if the evergreens are considered as a broad vegetation formation, the occurrence of various floristic communities may be correlated with changes in soil, elevation, aspect, etc. Evaluation of typological, floristic, structural and successional details as governed by the characteristics of the site is, therefore, necessary. Generally speaking, the soils of the Andaman evergreens widely differ from their counterparts in the Western Ghats. In the Western Ghats the geological formation is mainly of granites and metamorphic rocks like gneisses and schists. The soils derived are mostly lateritic in nature. Generally, a layer of 1' to 2' in thickness, compact and vesicular in structure lies about 2' to 3' below the ground level. Wherever this layer is exposed as a result of washing away of the top soil, an almost inert stratum of hard laterite is formed which inhibits occurrence of useful species. In the Andamans, however, the general geological formation is sandstone with such associated rocks as conglomerates and grits. At places pockets of localised clay deposits or extensive volcanic intrusions occur. Soils derived from sedimentary formations, as in Kitang, are yellowish brown in colour, well drained but have developed an incipient compact layer similar to that of the Western Ghats. They support an evergreen vegetation only if the water table is within about 10 ft. of the ground level, otherwise deciduous vegetation predominates. Heavy working of evergreen forests in these soils accentuates the pace of natural regeneration. Soils derived from volcanic formations develop differently according to the prevailing drainage pattern. In valleys (as in Shoalbay Coupe II), up to about 300 ft. elevation, dark ashy grey heavy clay is formed, and the drainage is strongly impeded. They support an evergreen vegetation but with heavy working water-logged conditions develop further almost to the exclusion of all the economic species. On highest elevations (as in Shoalbay Coupe I) the same geological formation, under free drainage, develops reddish brown clayey loamy on which heavy working of the evergreens results in prolific regeneration of the economic species. *Shri M. A. Waheed Khan*, therefore, suggested that a thorough study of soil-vegetation complex is necessary to devise suitable silvicultural practices for individual sites with a view to obtaining natural regeneration of the desired species.

15. He further said that a peculiar ecological aspect of the *Dipterocarpus* forests in the Andamans is the occurrence of several species of the same genus, in an intimate mixture. Such a floristic composition usually indicates that the plant community has not yet attained its climax status. As the *Dipterocarpus* species are economically important the silvicultural practices must be so designed as to arrest the succession at this economic stage.

16. *Shri M. A. Waheed Khan* (F.R.I.) also emphasised the necessity of studying secondary succession, particularly in context of the heavy working as is practised in the Andamans, and also as large worked areas remain untended. A definite knowledge of the course of such a succession may lead to reorient the current silvicultural practices, if necessary.

17. *Dr. J. S. P. Yadav* (F.R.I.) said that the water-logged clay soils in the low lying situations are intensively affected by gleying and deserve to be managed with utmost caution. Heavy working of forests on such soils accentuates water-logging conditions which may be unfavourable for a satisfactory reappearance of economic vegetation. It is likely that water-logging may lead to a greater release of certain trace elements which may further aggravate the situation and as such this aspect has to be carefully examined.

Silviculture

18. *Shri K. K. Nair* (I.F.C.) while commenting on the silviculture of the evergreen forests in the Andamans, observed that the method of advance brushwood cutting, coupled with seeding and canopy-lifting appears to be admirably suited in obtaining full stocking of regeneration. Typical examples of this nature were seen at Kitang and Porlob. Tending, however, is an integral part of subsidiary operations and deserved to be practised more frequently and extensively.

19. He further desired that the feasibility of multi-rotational management of the evergreens, i.e. 100 years for hardwoods (exploitable girth 60" and over) and 50 years for matchwood (exploitable girth 48" and over), may be discussed. However the extension of teak plantations is a feature worthy of continuance.

20. *Shri M. M. Srinivasan* (Andaman and Nicobar Islands) observed that extraction of floaters alone will create problems for the extraction of sinkers and the regeneration of floaters will also pose to be a problem. As such he observed that multi-rotation management may not be practicable.

21. *Shri M. A. Waheed Khan* (F.R.I.) commented that the impression gained after inspecting the various regeneration coupes is that regeneration occurs only in small to large patches and the so-called regenerated areas are never fully stocked with young growth. The mosaic pattern of regeneration complex continues to persist. The concentration of economic species is around the seed mother trees or where the areas have been sown artificially. Replacement of inferior species by economic ones is decidedly a matter for grave consideration, firstly to augment the potential productivity of the habitat, and secondly to reduce cost of extraction at the time of exploitation.

22. With regard to the concept of "multi-rotational" theory, *Shri M. A. Waheed Khan* (F.R.I.) observed that the silvicultural requirements of the hardwood and softwoods are antagonistic to each other. The softwood species which are strong light-demanders can hardly be expected to regenerate and establish themselves at the mid-rotation age for the hardwoods, particularly under the thick over-head canopy of the latter. He further said that the distributional pattern of the softwoods is specific and they mostly concentrate towards the drier end of the moist evergreen forests. Under such circumstances it is desirable to separate out the management of these species under distinct working circle.

23. *Shri M. M. Srinivasan* (Andaman and Nicobar Islands) replied that the difficulties involved in extraction have forced the department to adopt a system of multi-rotation. He, however, assured that within about 10 years the labour problem and extraction difficulties would be surmounted and the standard uni-rotation practice would be adopted.

24. *Shri M. A. Waheed Khan* (F.R.I.) enquired regarding the thinning policy followed for the young stands of evergreen forests. He also desired to know if it is a fact that the softwoods like *papita* (*Sterculia campanulata*) if allowed to grow free from competition develop a spongy heart.

25. *Shri J. C. Varmah* (Andaman and Nicobar Islands) said that there is no demand for thinning material. Also there is an acute paucity of labour and staff. Thus, no thinnings are carried out. Thinnings would be carried out only when the market for poles is developed or the stems have grown sufficiently to be saleable.

26. As regards development of a spongy heart in *papita* he said that the matter is still under investigation at the Forest Research Institute, Dehra Dun.

27. *Shri K. K. Nair* (I.F.C.) suggested that under such circumstances the poisoning of the unwanted stems may prove useful.

28. *Shri M. M. Srinivasan* (Andaman and Nicobar Islands) informed that an enquiry in this connection has already been made to the Forest Research Institute, Dehra Dun.

Management

29. *Shri A. I. Iyppu* (Kerala) said that whether they are evergreen forests of the Western Ghats or the Andamans, their history of management is practically the same. As only a few species were commercially important, the earlier attempts of management were based on selective lumbering. Even with more and more of the new species coming in use, the original pattern of working continued though the same area was gone over again and again for the exploitation of particular species. In Andaman forestry, however, a bold departure has been made as the concentrated fellings amount to almost shelterwood or clear fellings. Unfortunately, as the regeneration and tending operations are not followed up over the entire area gone over, there seems to be a strong case to develop use of inferior species so that the utilisable yield per unit of area may be increased and a consequent reduction may be affected in the annual cut. Probably it would not be difficult to follow up regeneration and its establishment and development, on such limited areas.

30. *Shri K. K. Nair* (I.F.C.) suggested the establishment of hardboard and chipboard factories.

31. *Shri G. B. Dashputre* (Bombay) enquired as to how far the use of seasoning kilns and preservation plants have given a fillip to the utilization of the inferior species.

32. *Shri M. M. Srinivasan* (Andaman and Nicobar Islands) said that the establishment of a hardwood factory is not possible due to its heavy demands on fresh water. Also the seasoned and treated timbers have not become popular. He estimated that even by upgrading the use of the inferior species the gross yield can hardly be increased beyond 10%.

33. *Shri M. A. Waheed Khan* (F.R.I.) agreed with the views of the Chief Conservator of Forests and observed that though the use for most of the species of the rich multi-specific flora of the evergreen forests may be developed in due course of time, there is only a remote possibility of substantial enhancement in gross utilizable yield per unit of area. Concentration on a few important species only and augmenting their proportion in the crop by enrichment stocking, tending, etc., is a practical approach to the problem. He also drew attention to the researches made on potential productivity and suggested that the introduction of deciduous element in the worked-up evergreen forests is likely to bear fruitful results.

TROPICAL MOIST EVERGREEN STATE SYMPOSIUM (ASSAM STATE)

(Held on the 20th April, 1960 at Kohora)

Besides the delegates and the observers constituting the Tropical Evergreen Study-Tour Party, *Shri M. C. Jacob*, Chief Conservator of Forests, Assam, *Shri P. B. Kar*, Director of Forests, NEFA, *Shri P. Barua*, Conservator of Forests II, Assam, and a number of local Forest Officers participated in the discussions.

2. *Shri M. A. Waheed Khan* (F.R.I.) compared the evergreen forests of Assam with similar vegetation formation occurring elsewhere in India and observed that though the large part of these forests is located in the sub-tropics the composition and structure of the vegetation is essentially tropical in nature. The development of such a post-climax type of vegetation is primarily dependent on the peculiar climatic conditions enjoyed by these tracts and secondly the favourable textural composition of the prevailing soil type. The mean annual precipitation ranges from about 80" to 140". Its distribution is extremely favourable and hardly there is any month during which drought conditions prevail. The mean maximum temperature is only about 94° F and thus the evapotranspiration losses are of a low value. The high clay fraction in the soil improved moisture retentivity and thus the soil moisture balance through the course of the year is favourable enough to support the luxuriant type of tropical evergreen vegetation.

3. As compared to the lateritic soils of the Western Ghats or the sandy loam or clayey soils of the Andamans, the soils in Assam are primarily of alluvial nature except on low hills where sandy loam type of deep brown soils are formed *in situ*. The *bhabar* type of soils are extremely sandy and porous and a favourable soil moisture regime is caused due to occurrence of clayey or clay layers not far from the surface and developing a hanging water table. Such soils deserve adoption of careful management practices particularly while attempting to create the second growth forest. The original vegetation cover may bring about a substantial change in the soil to disturb the location of the perched water table. Clayey soil formations, on the other hand, continue to preserve the favourable site characteristics, except when heavy clay layers are close to surface and may develop boggy conditions on excessive elimination of the vegetation cover.

Assam evergreen forests mostly occur in the plains at low elevations, as compared to the mountainous or hilly tracts of high elevations in the Western Ghats and the Andamans. These favourable physiographic sites are less liable to soil-wasting, even after a heavy working of the protective vegetation cover.

4. *Shri M. A. Waheed Khan* (F.R.I.) then, requested the Chief Conservator of Forests, Assam to review the general situation with regard to evergreen forests in the State of Assam, so that discussions could be taken up under the headings of (i) Ecological aspects, (ii) Silviculture, and (iii) Management.

5. *Shri M. C. Jacob* (Assam) dwelt on the historical aspects of the evergreen forests of the State and said that not in distant past the evergreen forests extended over the greater part of the State but the gradual inroads made by agriculture pushed the tribal inhabitants to hills where they carried out extensive clearings for shifting cultivation. The biotic disturbances so caused have either produced the bamboo brakes or the scrub formations with scattered trees.

6. As regards the soils on which evergreen forests occur, *Shri M. C. Jacob* (Assam) added that besides the brown alluvial soils, red loams in East Goalpara Division also support this vegetation provided the depth is good, otherwise, a sal type of forest develops.

7. Floristically, the evergreen forests of Assam may be classified into three distinct types, viz.,

- (i) *Phoebes-Amoora* association,
- (ii) *Dipterocarpus-Mesua* association, and
- (iii) The mixed association.

The *Phoebes-Amoora* association is predominantly confined to porous *bhabar* soils, and the constituent species mostly belong to Lauraceae and Meliaceae families. These species usually produce large fruits incapable of wide dispersal, and regeneration appears below the mother trees only. The entire regeneration complex on the forest floor is, therefore, extremely patchy. Its full stocking can, however, be achieved either by adopting the Malayan technique of opening the canopy around seed mother trees and of expanding individual patches of regeneration through intensive cultural operations, or by resorting to artificial methods. A system of sowing or planting of large transplants, in strips 33' apart has been adopted and the results achieved are most satisfactory.

8. The *Dipterocarpus-Mesua* association responds well and produces abundant regeneration as a result of somewhat heavy fellings. The top canopy trees of the economic species are removed on a selection basis. The middle storey is not much disturbed, except for the removal or girdling of a few trees where advance growth exists. Intensive cultural operations are followed up for a few years and the whole area is adequately stocked with regeneration. The entire working is more or less akin to irregular shelterwood system. The point of special attention in this working is that the maintenance of a fair cover of undergrowth is very conducive to the appearance of regeneration.

9. The mixed association, as is found in Cachar area does not bear dominance of any one species. Such areas are worked under a system of compensatory plantations. The technique of assessing the occurrence and development of regeneration in worked areas should, however, be evolved.

10. *Shri M. A. Waheed Khan* (F.R.I.) said that the patchy nature of regeneration in second growth forests of evergreen type is a characteristic feature. The regeneration complex is in the nature of a mosaic. Thus, small to large patches of economic species occur widely dispersed. Under such circumstances achievement of uniform stocking of the economic species is dependent on enrichment sowings or plantings. On porous soils planting is more successful whereas on loamy to clayey soils even sowings are as effective.

11. Working under an orthodox selection system, preserves site characteristics, particularly soil erosion is not accentuated. Regeneration, however, fails to appear adequately. Under heavier working of the crop, amounting to an irregular shelterwood system regeneration appears prolifically but the site is liable to soil-wasting. Fortunately for Assam, the nature of terrain is such that the apprehensions of soil erosion are the least. The irregular shelterwood system of working is, therefore, most suitable for the management of *Dipterocarpus-Mesua* forests.

12. The observation that regeneration appears satisfactorily under a fair amount of undergrowth is worthy of careful note. The Assam evergreen forests being of post-climax nature and primarily conditioned on a favourable soil moisture regime, the retention of a light undergrowth maintains a cool and humid atmosphere in top soil layer and on the forest floor, which is congenial for the appearance and development of regeneration.

13. Assessment technique of regeneration in evergreen forests is dependent on the frequency and abundance of the seedlings on the ground. If pilot investigations are made by collecting data in telescopic plots of sizes ranging from about 6' x 6' to 33' x 33' and repeated for about 40 to 50 locations, statistical analysis may be made to evolve a suitable technique.

14. With regard to the method of compensatory plantation, *Shri M. A. Waheed Khan* (F.R.I.) observed that the untended areas are liable to serious deterioration. He suggested that till intensive and thorough regeneration operations are adopted to cover the entire area worked, it may prove advantageous to study the course of secondary succession and to favour such associate species, with which regeneration of economic species appears and develops.

15. *Shri M. C. Jacob* (Assam) said that *Shorea assamica* is a valuable component in certain parts of *Dipterocarpus-Mesua* forests. Its regeneration, however, is completely wanting. Factors responsible for such an inhibition should be studied. He also suggested that the volume and yield tables for the economically important evergreen species should

be prepared at the earliest. Also, as the thinnings are usually unsaleable, the standard for the initial stocking of the regeneration should be fixed.

16. *Shri M. A. Waheed Khan* (F.R.I.) informed that preparation of volume tables for some of the species is already in hand. A rapid progress in this connection may, however, be made if the local Forest Departments help in collecting field data on standard lines. As regards regeneration problems of *Shorea assamica* and the initial stocking of regeneration, research shall have to be planned with the cooperation of the Forest Research Institute.

17. *Shri M. C. Jacob* (Assam) said that the inaccessible evergreen forests are not worked on economic grounds. It is worth consideration if cardamom cultivation may be introduced in such areas.

18. *Shri K. K. Nair* (I.F.C.) said that when an area is put under cardamom cultivation, regeneration of tree species is completely eliminated. If the aim is to revert these areas to forest subsequently the proposition of cardamom cultivation may not be feasible.

19. *Shri M. A. Waheed Khan* (F.R.I.) observed that large-scale cardamom cultivation is in vogue in the States of Kerala and Madras. If the area is permanently dedicated to cardamom cultivation, it is necessary to guard against deterioration of site characteristics. This can, however, be achieved if adequate provision is made for anti-erosion measures and an everlasting vegetation cover is ensured by repeated planting of the shade trees from time to time.

20. *Shri K. K. Nair* (I.F.C.) suggested that the Coorg method of patch cultivation of cardamom may also be tried with advantage.

Ecological Aspects

21. While initiating the discussion on this subject, *Shri M. A. Waheed Khan* (F.R.I.) suggested that ecological studies, involving the entire soil-vegetation complex, are necessary both for the primary and the secondary forests. Typological, floristic, structural and successional studies are essential for classifying plant communities, as natural units of management. Also study of moisture and nutrient balances, emanating from soil studies, foliar analysis, nutritional experiments, etc., will go a long way in understanding the complete behaviour of regeneration complex. Studies on the light requirements of seedlings in the evergreen forests are equally important.

22. He further informed that the question of exploiting the potential productivity of the land should also be considered. Researches made elsewhere have indicated that the productivity of evergreen forests is enhanced a good deal if deciduous element is also introduced artificially. Field experimentation in this regard is a prime necessity.

23. *Shri S. Rajkhowa* (Assam) said that recently he made measurements in some of the plantations and the favourable indications of introducing a deciduous element were apparent.

24. *Shri M. C. Jacob* (Assam) agreed that experiments in this regard should be laid out.

25. *Dr. J. S. P. Yadav* (F.R.I.) reviewed the field observations made, with regard to evergreen soils in Assam and emphasised the role of soil moisture regime and water table as correlated with the appearance and establishment of regeneration. Soil moisture conditions are intimately linked with clay and organic matter fractions of the soil and water table fluctuates with the maintenance and removal of the vegetation cover. He cautioned that the silvicultural practices adopted should pay due heed to these important aspects.

Silviculture

26. *Shri K. K. Nair* (I.F.C.) commented that the enrichment planting and sowings as are adopted for *Phoebe-Amoora* types appear to be suitable. However, the aim should not be limited to raise only about 40 stems per acre. In *Dipterocarpus-Mesua* type the so-called selection system also produces satisfactory results. The actual working of the forest, however, amounts to irregular shelterwood system. The nomenclature in this regard should, therefore, be revised.

27. *Shri M. C. Jacob* (Assam) enquired about the period during which tending operations should continue to help regeneration.

28. *Shri M. A. Waheed Khan* (F.R.I.) said that in tropical Africa, an operation called "refining" is carried out about 2-3 years in advance of the main fellings. The inferior

species are removed or girdled in suitable proportions to achieve recruitment. If necessary sowings are also made. This operation is worthy of adoption and has already proved successful in the Andamans.

29. He also observed that under the present system of working in Assam quite a few large trees are left in the overwood and apparently it has not so far been decided whether they are to merge in the new crop or should be removed at some stage. Merging of these trees in the new crop is not possible as they are too big in size and suppress a lot of young promising stems. Removal at a late stage will cause enormous damage. He suggested that they should be removed as soon as the young crop has attained a height of about 20 ft. Probably girdling or poisoning may also be necessary if the trees could not be utilized.

30. As regards period for continued tending operations, *Shri M. A. Waheed Khan* (F.R.I.) said that the Assam Forest Department is most fortunate in having detailed plot histories for the areas already gone over. By correlating these histories with the actual results obtained fair deductions could be drawn. It seems likely that the tending period may last from 10 to 15 years.

31. *Dr. G. Panigrahi* (B.S.I.) suggested creation of nature reserves to protect certain rare species and relict vegetation for which Assam forests are well-known.

Management

32. *Shri A. I. Iyppu* (Kerala) commented on the management practices in Assam and exemplified analogous situations occurring in other parts of India. He said that apparently there was no valid justification for fixing a high exploitation girth of $7\frac{1}{2}$ feet. Probably it could be lowered down advantageously to meet the requirements of irregular shelter-wood system as is practised in Assam forests. He also advocated research on secondary species for their full utilization.

33. *Shri A. I. Iyppu* (Kerala) also opined that monoculture management of evergreen forests is dangerous, particularly in maintaining the site conditions.

34. *Shri K. K. Nair* (I.F.C.) objected to the system of compensatory plantations and suggested that a sound forestry practice must necessarily regenerate the entire area gone over under main fellings.

35. *Shri S. Rajkhowa* (Assam) informed that a revised plan is under formulation and it is contemplated to do away with the system of compensatory plantations.

36. *Shri M. A. Waheed Khan* (F.R.I.) said that the evergreen forests are exceptionally rich in their floristic composition. It is, therefore, not a practical proposition to deal with all these species silviculturally and to aim at reproducing the same floristic composition in the second growth forest. If the attention is fixed on about 3 to 6 species only, the silvicultural treatment is not only easy but also the productivity is considerably improved.

WELCOME SPEECH FOR THE MOIST TROPICAL EVERGREEN SYMPOSIUM

BY SHRI M. C. JACOB, I.F.S.,
Chief Conservator of Forests, Assam

HONOURABLE MINISTER, DELEGATES AND FRIENDS,

On behalf of the Forest Department of the State I have great pleasure in welcoming you to this All-India Tropical Moist Evergreen Forest Symposium organised by the Forest Research Institute, Dehra Dun. Many of you have been touring the evergreen forests of the different parts of India continuously for over a month now and have had discussions with the Officers-in-Charge of these forests of the different States, and have held State-level Symposia at different places. The present symposium is the culmination of your very important deliberations. We, in the State Forest Department, have been extremely happy that our State has been chosen as the venue for holding this meeting of experts in Tropical Evergreen Forestry and administrators of this type of forests, because a very considerable proportion of the forests of this State belongs to this type. We look forward to the expert and experienced guidance in the management and administration of these forests that will be available from you as a result of your visit and deliberations.

2. Shillong, being the headquarters of the North-East Frontier Agency Administration, which has also extensive forest areas of the Moist Tropical Evergreen type and being in close proximity to other administrations such as of the Naga Hills Tuensang Area and the Tripura and Manipur States, your deliberations here, I have no doubt, will also be greatly appreciated by these Administrations.

3. All these areas in the North-East Zone of India have got common problems in respect of forestry development, not the least among which is that of inadequate means of communication and consequent lack of industrial development leading to a present comparatively low level of timber consumption in the industries. However, even with this important handicap, as many of you must have noticed, there is a fairly flourishing plywood industry existing in the State devoted, till recently, to the production of tea chest plywood, having their raw material source in the evergreen forests of this State, the North-East Frontier Agency and the Naga Hills Tuensang Area. The production of commercial and ornamental plywood also has now commenced, having their main raw material source also in the local Moist Evergreen Forests. With the industrial development programme in the Third Plan including the establishment of pulp mills, paper mills, spun-silk mill, oil refinery, etc., it is anticipated that the local demand of timber for industrial housing, packaging, etc. will increase making further demands, particularly on our evergreen forests.

4. The State is also one of the largest suppliers of evergreen sleepers, requiring the preservative treatment to the Indian Railways and to considerable extent these evergreen forests form the source from which the sleepers are also supplied.

5. Evergreen forests are also the almost sole source of cane, nurture many types of medicinal plants and are the habitat of varied forms of wild animal life.

6. From the point of view of forest protection also, the evergreen forests play an important part in regulating the flow of streams emanating therefrom and the continued existence of this many-layered type of forests is vital to the interests of the State, as much of the floods and consequent damage annually caused to the State may perhaps be attributable to the destruction of evergreen forests from over large areas of mountainous country in the State consequent on shifting cultivation. In this process evergreen forests are very rapidly converted into less satisfactory soil and moisture-holding types such as bamboo forests, grassland, savannahs, etc. On these counts, the importance of this type of forest is great and increasing and it behoves us to ensure, in the national interest, that these forests are managed in the most efficient manner possible.

7. With the advancement of science, it is now possible to produce many types of materials almost as hard as steel from cellulose of almost any kind, strength and durability being created by suitable technical processes. In this context, the evergreen forests are perhaps the most efficient of Nature's laboratories for production of cellulose. It is, therefore, a happy augury that the Central Government is not only holding this symposium here but is setting up a Regional Forest Research Station at Gauhati in this North-East Zone of predominantly evergreen forest type and a Technological Laboratory at Jorhat, in close

proximity to the evergreen forests of this State, the North-East Frontier Agency and the Naga Hills Tuensang Areas. We, in the State are looking forward to the early completion of these research facilities so that the management of the forests of this type in the State can be conducted on the most efficient lines guided by the results of local research.

8. The Regional Station of the Botanical Survey of India which has been established about three years ago in Shillong has also been helping the State Forest Department by conducting studies on the structure and floristic composition of important evergreen forests of the State and the delegates will have an opportunity of having some ideas of the work done by this Regional Centre during their visit to the exhibition which is being organised by the Botanical Survey in connection with this Symposium.

9. The Central Drug Research Institute has also been taking considerable interest in the medicinal plant flora of this region and the researches of this Institute are also expected to add to the productivity of our evergreen forests.

10. With so much of scientific and technical interest focussed on the evergreen forests of this region and India as a whole we evergreen Foresters can confidently expect to make an effective contribution to the economic prosperity of India.

11. I once again extend our cordial welcome to all you specialists and administrators, now meeting together to work for this great objective. I regret that some of you had to suffer many inconveniences, owing to the cancellation of your flight to Assam to a certain moment of confusion as regards the commencement date of this session owing to the limitations of facilities available to my officers and perhaps owing to our own shortcomings and hope that you will excuse us.

12. I also welcome the many distinguished members of the public, the press and the official hierarchy who have assembled here to encourage us in our deliberations.

A DRAFT FOR THE SPEECH BY THE MINISTER FOR FORESTS, ASSAM STATE, INAUGURATING THE ALL-INDIA TROPICAL MOIST EVERGREEN FOREST SYMPOSIUM AT SHILLONG AT 10 A.M. ON THE 22ND APRIL, 1960.

I am grateful for getting this opportunity to inaugurate this Plenary Session of the All-India Tropical Moist Evergreen Forest Symposium and for selecting my State as the venue for it. I consider this a special honour conferred on my State and take it as a measure of importance attached by the Government of India to the efficient management of our evergreen forests which, in a considerable measure, not only subserve the national interests but so far as my State is concerned, also those of industrial advancement in my State.

2. Forests, which may be considered of the evergreen type occupy considerable stretches of the State of Assam and particularly predominate in the districts of Darrang, Sibsagar and Lakhimpur in the Brahmaputra Valley and also in the district of Cachar. Their total area may be about half that of the forest reserves in the State, *i.e.*, over three thousand square miles out of a total of about 6,700 sq. miles of forest reserves.

3. Evergreen forests, I understand, are generally climax formations, *i.e.*, forests whose ecological succession has reached the maximum stage of development, consistent with the climatic and soil conditions. High-land evergreen forests in the State are important source of industrial timber particularly timber for the manufacture of plywood and about 15 lakhs of cubic feet of timber of this type are exploited from the forests of the State annually, sustaining the most important forest industry existing at present in the State, namely, the tea chest plywood industry. It has been my endeavour to ensure that this plywood industry should be fostered to develop on efficient lines and it is imperative in this regard that the principal raw material which the industry obtains from the evergreen forests of the State should be available on a sustained and increasing basis. This can only be ensured by scientific management of these forests including effective steps at regeneration. In this regards, I am confident that the deliberations of you, specialists, will make an important contribution. I understand that there is a feeling among my officers that a great deal more requires to be learnt about the efficient management of these forests, comprised as they are of a large number of species. Till recently the emphasis so far as exploitation for plywood was concerned, had been only on two or three species occurring in these forests and predominantly on *hollong* and *makai*. The time has now come, however, when more and more species included in the approved list for plywood logs, as compiled by the Indian Standard Institution, will have to be used not only for tea chest plywood but for commercial plywood also. Naturally, hitherto, the management,

including regeneration, of only these few species had principally been aimed at by my Department. There is now, however, urgent and insistent need for a study of the silviculture and management of the other important plywood species of these evergreen forests if the industry is to prosper. Similar problems as regards silviculture and management of evergreen forests species, I dare say, are facing other State Governments also and I am sure that you will, during your deliberations focus your attention on these new problems which are facing you and will be able to come to satisfactory conclusions as regards the manner in which these urgent problems have to be tackled.

4. In my State, evergreen forests, in general, occur on lands which, *prima facie*, may appear as suitable for agriculture. Owing to pressure on land for agriculture, considerable areas which bore evergreen type of forests, not constituted as forest reserves, have been given for settlement with agriculturists before the expansion of the plywood and allied industries. A considerable proportion of the requirements of these industries, at present, are being met from the trees left on these agricultural lands particularly in the district of Lakhimpur and the forest reserves have been called upon hitherto only to a minor extent to provide the raw materials. But it is anticipated that within the next two or three years these sources of timber outside forest reserves are likely to be exhausted and almost complete reliance for sustaining the industry will have to be on the forest reserves. The need for efficiently solving the problems of management including the regeneration of all these different species of trees is, therefore, very urgent and I, therefore, welcome the opportunity given by the Government of India to the specialists to meet together in Assam and to visit some of these forests so that their combined wisdom may lead to a satisfactory solution of this very important problem facing my Department.

5. In attempting a solution of these problems of management and regeneration, I would particularly urge that the procedures and techniques suggested should be capable of quick and easy evaluation as regards the results achieved, as it is essential that we should be able to satisfy ourselves within a reasonable time that adequate increment and regeneration are being obtained, consistent with the progress of exploitation.

6. Not only is it in respect of supply of plywood for tea chests and for ordinary commercial uses that the evergreen forests of the State are important, they are yielding annually about a million cubic feet of sleepers and, from the point of view of sustained supply of sleepers to meet the increasing demands of our railway system also, it is essential that these forests should be efficiently managed on a sustained yield basis. Many of the species now accepted as sleepers after preservative treatment are new, and the silviculture of these species is inadequately studied. To focus attention on these problems also the importance of this Symposium is apparent.

7. The evergreen forests of some tracts of the Darrang and Goalpara East Divisions and to a less extent, of the Dhansiri Valley and Sibsagar Divisions, also produce the locally important timber called *bonsum*, which is being effectively used by the people of the State as a substitute for teak. As the demand for furniture timber and timber for doors and windows is increasing, with the growing prosperity of the people, it is necessary that the problems of management and regeneration of the *bonsum* forests also receive your attention.

8. Extensive areas of low-land evergreen forests occur in the State the principal produce of which is cane of different varieties, this, State being perhaps the largest supplier of cane to the markets of Northern India. Sustained and steady supply of cane is not only important for the local tea industry but also for the railways and the collieries, which use large quantities of cane baskets. Large areas of cane-bearing forests, not constituted as forest reserves, have had to be settled with agriculturists and the demand for cane can only be sustained by efficient management of the cane-bearing areas of the forest reserves. I understand that data on the silviculture and management of cane are at present inadequate. In view of the importance of cane to the national economy as well as to the revenues of the State I hope your deliberations will include within their ambit problems of the management including regeneration of cane forests.

9. There are some areas of evergreen forests in the State, which at present are so located that possibilities of exploitation of timber therefrom are somewhat remote, without investment of a great deal of capital. It may be that these forests can be utilised for growing under them certain important plants of economic value such as Ipecac, coffee, cardamom, pepper, cocoa, etc., the produce of which are less bulky and more costly than timber. The details of the techniques to be adopted and the safeguards that will have to be provided for the utilisation of these comparatively inaccessible evergreen forests for raising these important cash crops also merit your attention.

10. As a layman, I have ventured to offer these suggestions as regards some of the matters that may form the subject of your deliberations. You no doubt have other problems also to engage your attention and therefore, I do not like to detain you further from getting down to work.

11. I hope that you have had all the assistance that you required in the conduct of your field studies, from my officers and that you have had a fairly comfortable time during your stay in our forests. I trust that when after your deliberations, you leave the State you will do so with happy memories. On behalf of my officers, I offer my apologies for any inconvenience that might have been caused to you during your stay. I have now great pleasure in inaugurating this Plenary Session and to wish you all success during your deliberations.

Jai Hind.

VOTE OF THANKS BY SHRI T. N. SRIVASTAVA, DIRECTOR OF FOREST EDUCATION, FOREST RESEARCH INSTITUTE & COLLEGES, DEHRA DUN

HONOURABLE MINISTER, SHRI JACOB, GUESTS AND DELEGATES :

I feel greatly privileged to be present here in the Plenary Session of the Tropical Moist Evergreen Forest Symposium. To be associated with such an important event is a matter of singular import and pleasure to me. The Inspector-General of Forests and the President, Forest Research Institute & Colleges, though they would have loved to join us, could not come at this occasion because of pre-occupations. Our Silviculturist, Shri S. K. Seth, who has been conducting the tours, unfortunately fell ill and is in hospital at Madras. We shall miss him at this occasion.

Sir, it is a well-known fact that rapid advancement in scientific fields is possible only if the energies of experts are directed to function on a cooperative basis, experiences gained are pooled together for mutual benefits and the regional developmental plans are drawn up on national considerations. Of late, the necessity to augment the national forest resources has been keenly felt. And, considering the specific management and research requirements of individual forest types and forestry problems a series of study tours and symposia were thought of. The Tropical Moist Evergreen Study Tour and Symposium is the sixth one, so organised. The symposia held earlier dealt with *Vana Mahotsava*, Mangroves, Farm Forestry, Teak Forests and Dry Zone Afforestation.

The tropical evergreen forest is a type of vegetation formation which is well-known for its magnificence and luxuriance. The conditions for plant growth are at their best involving potential productivity of a very high order. In India such forests are located on the Western Ghats, in the States of Bombay, Mysore, Kerala and Madras, and also in the Andaman Islands and the State of Assam, including N.E.F.A. and Manipur. The ever-increasing expansion of agriculture and establishment of cash crop plantations have, however, caused these forests to be confined to hilly terrains of more or less inaccessible nature. The heavy costs of extraction involved, and the utilization of only a few component species of these forests, created conditions under which intensive forestry practices could not be planned. The around developmental activities, as are envisaged under our Five-Year Plans, have directed attention for the development of the Tropical Evergreen Forests as well.

A systematic and thorough study of the tropical evergreen forests was envisaged as early as 1929, when the Fourth Silvicultural Conference was held at Dehra Dun. The force of circumstances, then prevailing, however, caused this study to be continuously postponed although the desirability of such a study was reiterated in resolutions of Silvicultural conferences, subsequently held. We are glad to announce that this long pending study has now been completed and we are here to discuss the policy, ecology, silviculture and management of the evergreen forests of India.

The problems confronting the management of evergreen forests are many. The foremost is the re-orientation and reconciliation of policy with regard to expansion of cash crop cultivation, such as tea, coffee, rubber, pepper, cardamom, etc., within the limits of the evergreen forests. In States like Kerala and Madras where the population pressure guides the maximum and multiple utilization of land, evergreen forests have already given way in favour of cash crops. Situation in Assam, though under a different context is not dissimilar. Augmentation of productivity is another matter for serious consideration. Under the existing methods of exploitation and utilization, the productivity ranges from

about 0.1 to 0.2 tons per acre per year as against the potential productivity of well neigh 2 tons per acre per year. This serious gap shall have to be bridged by means of discovering the uses for secondary species, concentrating economic species in second growth forest either by silvicultural tools of manipulation of crop canopy and appropriately tending the natural regeneration complex, or by enrichment of stocking. Introduction of exotic species is also a matter worthy of careful consideration. The forest industries like plywood, hard-board, chipboard, etc., dependent on the products of the forests can survive and expand for the enhancement of the national economy, only if the productivity of these forests is increased manifolds.

Another important function, which the evergreen forests fulfil, by way of their situation in important catchment areas, and the luxuriance of vegetation cover which they produce, is the conservation of moisture and the regulation of stream-flow, on which the life of many a hydro-electric and irrigation projects depends. Intensive and extensive management of these forests, therefore, cannot be over-emphasised.

The study tour party of the Evergreen Forests Symposium visited the typical forests of the States of Mysore, Kerala, Madras, the Andamans, Assam and N.E.F.A. Besides the technical personnel of the Forest Departments of India, the Botanical Survey of India as well deputed observers. I thank that organisation for its close cooperation. During the course of the study tour the State Forest Departments took immense interest in taking round the party, looking after them, and discussing the problems thread-bare and thus making their experience, available for the mutual benefits of all. I thank them all for the hearty cooperation extended by them.

My special thanks are due to the Govt. of Assam for arranging the Plenary Session of the Symposium at Shillong. I also thank the Assam Forest Department and its officers for taking immense interest in making the stay of the delegates in their State comfortable.

Sir, I thank you in particular for snatching time from your busy routine and gracing this occasion by your presence. I am sure that with your blessings the symposium will produce valuable results.

I also thank the guests for gracing this occasion by their presence and the press for providing due publicity to this historical event.

I thank you once again, Sir.

SUMMARY OF DISCUSSIONS

PLENARY SESSION—22ND TO 24TH APRIL, 1960—SHILLONG (ASSAM)

22nd April, 1960

Shri M. C. Jacob (Assam)— The directive received indicates that a Chairman for this session is to be chosen from ourselves. I suggest *Shri V. S. Rao* for this purpose. (The election was unanimous).

Shri V. S. Rao (West Bengal)— I thank you for electing me the Chairman.

The proceedings can be divided into four sections, viz., (a) Policy and Objects of Management, (b) Ecological Aspects, (c) Silviculture, and (d) Management.

Shri M. A. Waheed Khan (F.R.I.)— I suggest that instead of taking up the discussions under each item separately it is preferable that the senior officers of the States where evergreen forests occur give a general review with regard to evergreen forests and forest practices in their States, and after that the summary of discussions of the State Symposia be read out, and discussion taken up on all items together state-wise. The points arising therefrom may be sorted out and final recommendations may be drafted under the four heads separately as suggested by the Chairman.

Shri V. S. Rao (West Bengal)— Now I call upon *Dr. Kadambi* to give a review about his State.

Dr. K. Kadambi (Mysore)— The evergreen forests of Mysore State are confined to the Western Ghat region, in a long narrow strip covering the crest of the Ghats and the valleys. The total length is about 250 miles and the width is about 30 miles. The rivers arising from these Ghats have cut deep gorges and the waterfalls are harnessed for generating electricity. In the plains, the same rivers are dammed for irrigation purposes.

The forests are typically of the moist tropical evergreen type. Frost is practically unknown. Altitude varies from 3,000 to 4,000 ft. rarely going upto 6,000 ft. Annual rainfall varies from about 150" to 475", and is mostly confined to the months of June to September. Pre-monsoon showers during April-May are common but there is always a gap of 3-4 weeks between these showers and the actual onset of the monsoons. The mean annual temperature varies from 18°-20°C. The underlying rock is generally granitic gneiss with a heavy topping of partially disintegrated laterite. The depth of laterite may be as much as 50 ft. but rock exposures are also common. Lateritic soil allows maximum run off, excessive seepage and is poorly retentive of moisture.

The productive potential of these forests is about 2 to 3 tons per acre. The enormous amount of cellulosic material produced in these forests is a lucrative asset to establish wood-based industries for the general economic development of the country.

In the evergreen forest distinct tiers are noticeable. The topmost canopy is about 150 ft. high and the important constituent species are *Dipterocarpus indicus*, *Calophyllum elatum*, *Mesua ferrea*, *Hopea parviflora*, *Holigarna arnottiana*, *Poeciloneuron indicum* (localised in distribution), *Palaequium ellipticum*, *Lophopetalum wightianum*, etc. The second storey consists of *Artocarpus integrifolia*, *A. hirsuta*, etc. In the third storey *Eugenia*s are by far the most dominant. The fourth storey consists of low-sized trees and the ground floor is covered with various shrubs.

The earliest attempts to manage these forests were limited to the exploitation of a few species, like *Hopea*, *Artocarpus*, *Poeciloneuron*, *Canarium*, *Cedrela*, etc. under a lax selection system. With the increasing demand for railway sleepers and the establishment of a Wood Preservation Plant *Dipterocarps* were being exploited under a regular Selection System. Trees of exploitable girth were enumerated and their gradual removal systematically by compartments was prescribed. The management system being still followed in parts of the old Mysore State is essentially the same. In portions of the old Bombay State which are now in the Mysore State, very little work has been done so far. Only recently, the demand for softwoods has extended to these areas and their exploitation is planned on a rough selection system. In the old Coorg State portion of the present Mysore State, the management of the evergreen forests is fairly intensive. Establishment of a tramway to transport timber has almost resulted in over-exploitation of nearby forests. The fellings have almost amounted to an irregular shelterwood system. However, the natural regeneration has come up

copiously and at places well-stocked young stands of valuable species are met with. The species which have so regenerated are *Hopea parviflora*, *H. wightiana*, *Vateria indica*, *Acrocarpus fraxinifolius* and *Lagerstroemia lanceolata*. *Poeciloneuron* forests which have been intensively worked for the last 25 to 30 years for transmission poles have also regenerated well. *Poeciloneuron* regeneration has come up very well. *Mesua ferrea* is also coming up under the low cover of evergreen bushes. Regeneration of *Dipterocarpus indicus* appears in groups and is satisfactory. It is, therefore, apparent that there is no dearth of natural regeneration but the main crux of the problem lies in tending operations. Several trials, in this connection, have been made. Firstly, cutting of the weed species (tree species which were not marketable) was tried but the regrowth was fast enough to choke the regeneration again. The next attempt was to lift the canopy gradually. In the first stage the lower-most tree layers were removed. It helped the regeneration a good deal. In the second stage trees of the middle tiers were to be removed but the local officers felt too much of a risk to open the canopy so drastically. The removal was therefore gradual. The results are very encouraging. Removal of the top-most canopy is being planned.

Plantation activities in the evergreen forests were attempted between 1918 and 1925. Underplanting of *Hopea parviflora* was done over 5,000 to 6,000 acres. However, the subsequent tending operations were never carried out. It is only during last 3 to 4 years that the plants which have come up in groups are being freed. Top storey is being removed in one stroke, and the long stagnating *Hopea* has responded well. The rate of growth is about 8 to 10 ft. per year.

Artificial regeneration of *Hopea* was also tried in 'tunnels'. For this purpose 10-15 ft. wide strips were cleared of undergrowth. Besides *Hopea*, species like *Mesua ferrea*, white cedar (*Dysoxylum malabaricum*) and *Artocarpus hirsuta* were also tried. Intensive and continued cultural operations are very necessary and therefore these attempts have been abandoned. Another method tried was to clear the entire underwood, leaving only the top canopy and planting *Hopea parviflora* at the beginning of the rains. Young plants, however, died probably due to water-logged conditions, developed at the height of rains. Planting was then deferred to early August. It gave good results.

Ecology of the evergreen forests is most interesting. There are two leafing seasons—one precedes the monsoons and the other follows it. The major flowering season coincides with the dry spell of the year during later part of December to the middle of February. A second conspicuous flowering season is soon after the rains in October. Accordingly the main fruiting seasons are also two. One coincides with the monsoon months from June to August and other sometimes in December. In the evergreen forests vegetative activity is at its lowest ebb during the rainy season and at highest just before and after the rains. This is contrary to the vegetative regime observed in moist deciduous formation. However, this fact is of paramount importance in planning the artificial regeneration operations in these forests.

Evergreen forests of Mysore State have not been fully tapped. There are several large areas which have not been touched at all. Roads are being constructed at a cost of Rs. 4.16 lakhs. In North Kanara forests only recently the demand for softwoods has extended. In northern ranges of Shimoga District intensive exploitation is in vogue for sometime past. Regeneration has kept pace with the exploitation but the tending operations present a problem.

As regards policy and objects of management of the evergreen forests in Mysore State, our sole concern is to bring all the forests under active working and increase their productivity in terms of valuable species. Constructing of more roads is an immediate necessity. Wherever new roads have been constructed the value of forest, in the shape of lease money, has increased four to five fold. The forests of Mysore State also cater to the wood-based industries of Kerala State. Thus the demand, particularly for softwood is immense.

Shri V. S. Rao (West Bengal)— We are thankful to Dr. Kadamby for his very interesting talk. I am convinced that we have acted rightly in requesting the senior officers to give us a resume of the problems and the status of the forests of their respective States.

It is interesting to learn that on the one hand there is a fear of not utilizing these forests properly, and on the other, there is a danger of over-exploitation. If the forest is under-utilized, it continues to be a forest but with intensive exploitation in roads of agriculture may diminish the forest limits. Experience of this nature is already available in Assam. The construction of roads and tramways involves a heavy cost of maintenance

and these projects can be profitable only if the forests are intensively worked within the economic range. All these points need very careful consideration.

I am glad to learn that wherever heavy fellings have been done natural regeneration has come up prolifically. Elsewhere, under similar conditions, swamping by weeds is a usual occurrence. The experience of Mysore, therefore, is very encouraging. The trouble there is merely to evolve suitable and cheap tending operations.

Dr. Kadambi's observations of two annual cycles of leafing, flowering and fruiting are interesting.

Shri R. R. Chaudhari (Maharashtra)—Bombay State has very little in the shape of evergreen forests. Also, they are not of much commercial importance. They are located on the crest of the Western Ghats. Total area under these forests is about 150 to 200 sq. miles, mostly in Poona, Satara, Kolhapur and Kolaba Divisions. They cover the catchment areas and are, therefore, allotted to the Unexploitable Working Circle. However, in places like Mahabaleshwar where there is acute demand for fuel and charcoal, some exploitation is done. Under this type of working only the dead and dying trees are removed. Some of the areas are almost inaccessible and manufacture of charcoal is the main operation there.

Mahabaleshwar forests are worked under improvement fellings. Selection fellings as were done in the past have been stopped. In the semi-evergreen forest of Kolhapur Division, clearfelling with planting by the agri-silviculture method is practised. There is no natural regeneration. The species commonly planted are cashew, *Syzygium cumini* and mango. Planting stock is raised in polythene bags.

Shri V. S. Rao (West Bengal)—From *Shri Chaudhari's* account of Bombay evergreen forests, it would appear that the way in which these forests are utilized and regenerated is going to alter the entire ecological status of these forests. Whether such a change is desirable is a matter for careful consideration. As regards agri-silviculture method of regeneration, my impression is that this method is best suited to moist deciduous forests.

Shri M. C. Jacob (Assam)—Past history of Assam forests indicates that about 75% of the forested land was under the evergreen forests. Shifting cultivation has, however, reduced this area substantially, making room for bamboo forests or grassland savannahs. Only small groves of religious sanctity are present as relict vegetation of the evergreens. The evergreen forests, therefore, are confined to the plains except in Cachar where even hills are clothed with this formation.

Assam evergreens are not the true tropical formations, except the ones in the Cachar District, as they wholly lie within the sub-tropics. The soils are mainly alluvial except in limited areas where even sedentary soils are found. The high and well-distributed rainfall coupled with the soil type is responsible for the occurrence of the evergreen forests. The *bhabar* soils which are usually porous and less retentive of moisture do not carry the evergreen forests. But the intrusions of red soils which are deep and more retentive of moisture support the evergreen forests. Such a controlling effect of soil type is exemplified in Goalpara East Division. The red soils in a predominantly *bhabar* tract, support *Bonsum-Amari* (*Phoebe goalparensis*—*Amoora wallichii*) forests. The dominant constituents of these forests belong to Lauraceae and Meliaceae. Both *bonsum* and *amari* are economically important species but they usually occur in large to small-sized patches in a general matrix of less important species. This matrix is being enriched along with the selection and improvement fellings for *bonsum* and *amari*. For enrichment operations, the top canopy is maintained intact and middle-storey is thinned. Line sowings are done and as the weed competition is not much the seedlings progress satisfactorily. Their growth rate is maintained by further lightening the middle canopy. This operation, however, proved a little wasteful in the matter of utilizing the seeds. Now the practice of sowing is given up and instead nursery plants of *bonsum*, *amari* and *Michelias* are planted out. Planting is done late during the monsoon, with a ball of earth around the roots. The planting may, however, continue upto the middle of January. Resort to this practice was necessitated by the fact that early rains planting was not successful due to heavy rainfall. During winter there is plenty of dew fall. Showers during summer are also not uncommon. Late planting, therefore, succeeds very well. Planting is done at 24' × 24'. Such plantings have already been made over about 3-4 sq. miles and the planted trees are already 15-20 ft. tall. Overwood is being gradually felled and converted. Other constituent species are also coming up naturally in the area.

In the Dipterocarp-*Mesua* type of forests, the top canopy species are *Dipterocarpus macrocarpus* and *Shorea assamica*. The under-storey consists of *Mesua ferrea*, *Vatica* spp., etc. About 30 years ago there was no demand for the top storey trees and they used to be recklessly girdled or felled. *Mesua ferrea* was marketable for poles and railway

sleepers. In those days, therefore, attention was mainly focussed on the regeneration of *Mesua ferrea*. With the establishment of a Treatment Plant at Naharkatia *Dipterocarpus macrocarpus* (*hollong*) has come up into great prominence as a sleeper wood. Similarly, *Shorea assamica* (*makai*) is extensively used for plywood. The management system followed for these forests is selection felling followed by intensive cultural operations for 3 years after exploitation, the cultural operations being repeated after a pause of a few years. The results obtained are very encouraging.

The demand for agricultural land is immense on Dipterocarp-*Mesua* type of forest. But looking to the high revenue yield realised from these forests it is desirable to maintain them as forests. Even those areas where Dipterocarp stocking is low, i.e., 2 to 5 trees per acre, should be constituted into reserved forest. A *hollong* tree 15-18 ft. girth and about 150 ft. tall fetches about Rs. 1,000.

The mixed evergreen type of forest occurs in Cachar area. *Dipterocarpus turbinatus* is found here. Economically important species (particularly the ones which yield sleepers) are found scattered. These forests are worked under a selection system. Exploitation is fixed by girth limit and regeneration is regulated by compensatory plantation. It is, however, not a satisfactory method. The compensatory plantations are mainly of *Lagerstroemia flos-reginae* which has a high demand for boat building. Also it is easy to raise these plantations. But the entire aspect of the evergreen forests was getting changed. Underplanting practice has, therefore, been introduced. *Dipterocarpus turbinatus* came up under the shade of *Tephrosia candida*. Compensatory plantations are now limited to stream banks where agri-silviculture method is followed as a means of providing work to Cinchona labourers.

Shri V. S. Rao (West Bengal)—Shri Jacob's remark that his evergreen forests lie within the sub-tropics is worthy of note. I believe that the latitudinal limits should not be applied so rigidly.

It is interesting to note that *bonsum* is a substitute for teak and it occurs in the evergreen forests. Also it could be raised artificially by using tall (upto 6 ft.) transplants. Also as one tree of *hollong* fetches as much as Rs. 1,000 it is high time that it is generally accepted that such forest lands should not be given away for cultivation.

As regards the removal of overwood after the establishment of the under plant material, the felling damage may possibly be avoided by poisoning the trees. I am not very happy with the idea of using poison on a large scale in any forest area, but if it is the only possible course it cannot be helped.

Shri P. B. Kar (NEFA).—Forests and Forestry in NEFA are nothing different from Assam. The exploitable forests in NEFA form a narrow fringe along the Assam border and they are located in hilly terrain. The evergreens abound in *Dipterocarpus macrocarpus* (*hollong*), *Shorea assamica* (*makai*), *Mesua ferrea* (*nahor*) and *Vatica lanceefolia*. Patches of *Phoebe goalparensis* (*bonsum*) and *Amoora wallichii* (*amari*) are also met with. Mixed evergreens also occur. The common marketable species in these forests are *hollong*, *Terminalia myriocarpa* (*hollock*) and *Altingia excelsa*.

The forest administration in NEFA is only 13-14 years old. Constitution of the main reserves is the immediate problem. Exploitation is limited to market demands. These markets are mostly in Assam. One plywood factory has, however, been established. Establishment of another factory is being contemplated.

In the eastern Himalayas where mixed evergreens predominate, the raising of plantations is the chief activity. The area is also being opened up by constructing roads. The exploitation is thus set off against the compensatory plantations raised. Due to labour shortage, the plantation activities are, however, limited. As regards the *hollong* forests the management and regeneration practices are the same as in Assam. The main difficulty is with regard to *makai* which is not regenerating. Even the assistance given by tending operations has failed to yield good results. We are now concentrating on the artificial regeneration of this species. It has been noticed that the viable seeds could be collected from the middle of March to middle of April. These seeds germinate well under shade and one year old seedlings can be planted out successfully. Sowing or planting of *makai* can, therefore, be tried in tunnels by cutting out weed growth.

During 1947-48, an area of about 4,000-5,000 acres was flooded and the tree crop completely died. The new silt was colonised by *Saccharum* spp. After 3 to 4 years it was noticed that seedlings of *hollock* (*Terminalia myriocarpa*) were also appearing

in the grass. The grass was cut and seedlings were tended. Within about 3 years *Saccharum* spp. completely vanished and the area is fully stocked with *hollock*. The area so treated is about 1,800 acres.

The present plantation activities relate to *hollock* only, as this species is easy to grow. Now we are also making extensive trials with *Cinnamomum* spp., *amari*, *Michelia excelsa* and *Chukrasia tabularis*.

Species like *Schima*, *Canarium* and *Ailanthus* are also coming into use. The silviculture of these species, particularly from the point of view of raising them in plantations, is to be studied.

Shri V. S. Rao (West Bengal)—In NEFA, the most immediate problem appears to be that of Forest Reservation. It is gratifying to note that a 20-mile wide belt along the Assam border is to be declared as 'Reserve'. Luckily this area is not much populated. Where the forests are riddled with villages, it is necessary to educate the people to take up forest work as a means of livelihood. Wood-based cottage industries may also be introduced.

There is also a suggestion to convert the evergreen forests into plantations of tea, coffee, pepper, rubber, medicinal plants, etc. They are apparently very lucrative ventures but the importance of the preservation of the flora, fauna and soil of evergreen formations should not be lost sight of. Also canes which occur in evergreen forests should be given due attention. Assam, NEFA and adjacent tracts are the home of canes and this source should be preserved and developed in the interests of the country.

Shri A. I. Iyppu (Kerala)—Evergreen forests in Kerala are confined to the Western Ghats and are linked at one end with those of Mysore State and at the other with the Madras State. The total area is about 900 sq. miles mostly located on the western side of the Western Ghats. A characteristic feature in the Western Ghats of the Kerala State is the development of a large number of hydro-electric projects. Large stretches of evergreen forests are thus being relinquished. Whatever little evergreen forests are left have to be worked rather intensively to feed a large number (about 18) of plywood factories, packing case factories, match factories, wood-based cottage industries, etc. Part of the required raw material is obtained from the forests of the adjoining States. At present we are still working our evergreen forests on a fairly conservative basis. The maximum exploitation amounts to about 2-3 trees per acre and no two trees removed are within a chain's distance of each other. Large gaps are avoided for the sake of regeneration.

Once the whole of the Kerala State must have been covered with evergreen forests. Indications of this nature are available from old groves preserved due to religious sanctity. With the increasing pressure of population, the evergreen forests are now confined to steep slopes and ridges. These forests, however, are well served with roads and there is also a tramway.

Much of the evergreen forest has already been brought under cardamom cultivation. The demand for cash crop plantations is still on the increase and recently there has been a proposal that about two lakh acres of evergreen forest should be set aside for rubber cultivation. Further extension of cardamom has, however, come to an end except in commercially poor types of evergreen forests.

Management in the evergreen forests of Kerala is on selection basis. Girth limits are fixed for individual species and they range from 6-8 ft. Similarly the number of trees removed per acre does not exceed 3. Silent Valley forests are an excellent example of well-preserved evergreen forests. Some of the forests have, however, been degraded due to biotic influences.

Our efforts to regenerate evergreen forests have so far been limited to small scale experiments. No large-scale regeneration operations have been tried. Gap regeneration was attempted in Silent Valley and results are successful. Tunnel planting has also been tried in Chandurni Valley and in Tennamalai area with good results. This aspect of evergreen forestry was not given due attention in the past as our energies were mostly concentrated on teak. It is, however, proposed to take up large-scale experiments on the regeneration of the evergreens in the near future.

Hardwood evergreens like *Hopea parviflora*, *Artocarpus hirsuta*, white cedar, etc. fetch about 8-10 per cubic foot. Management of these species together with the softwoods which are already in great demand, is important.

There are also large areas covered with reeds. The isolated trees found in them are species such as *Mesua ferrea*, *Calophyllum elatum* etc. Ecological studies of

these formations are likely to yield interesting and useful information. The exclusion of tree growth appears to be the result of intensive and long persisting biotic interference. Characteristic features and controlling factors of each association of the evergreen forests should also be evaluated.

Shri V.S. Rao (West Bengal).—The National Forest Policy aims at the increase of the forest area to about 33½% of the total land area. Therefore, the continued diminution of forested lands should be taken serious notice of. Not only are hydro-electric and irrigation projects submerging vast extents of forests but the population so displaced is being settled only in forests on the plea that no other land is available. The pressure of agriculture is also making continual encroachments all along the borders of the forests. Establishment of industries has also caused deforestation of large areas. It is a pity that even the evergreen forests which are located in remote areas are not free from such threats.

*Shri M.A. Waheed Khan** (F.R.I.).—So far as the management of the evergreen forests in the Andamans is concerned, I may point out in the very beginning that my knowledge is based only on a few days' tour in those forests and collection of necessary information from all possible sources, during that period.

The Andaman and Nicobar Islands are wholly situated in the tropics. The annual rainfall varies from about 80" to 120" and the mean annual temperature is in the neighbourhood of 94° F. The geological complex is predominantly of sand stone formations and some coarse material like conglomerate and braccia. Intrusions of volcanic formations are also available, e.g., serpentine rocks. These predominantly distinct geological formations give rise to two definitely distinct types of soils. The volcanic formations yield mostly the clayey soils and they are located in the valleys and on the lower reaches of the smaller hills. Water table is fairly high and water-logging is very often the case. In the sandy soils derived from sand stone and conglomerate formations, the percentage of sand is rather on the high side. Rate of infiltration is also very high and continued leaching has developed a layer of about 1-2 ft. in depth below 2"-3" top soil, which is somewhat compact and cellular in appearance. It is, I should say, an incipient stage of laterization. Distinguishing of these two soil types is important from the management point of view of the Andaman evergreens. Heavy working carried out on the clayey soils of volcanic origin leads to rising of the water table, creating conditions more of a boggy nature in which regeneration of the economic species almost disappears. The second growth forest is mostly of reeds and inferior tree species. On the other hand, heavy working of forests on sandy soils which are less retentive of moisture, the rise of water table is beneficial for the regeneration of the evergreen species.

The distribution of various forest types in these lands is very systematic. All along the coast there is a narrow fringe of mangroves. Although we are not dealing with this type at the moment, it will be quite informative to say that they are most magnificent and the best in the whole of India. Just above the mangrove fringe, the Evergreen Dipterocarp forests come in. Usually they are also in the form of a belt and may completely cover the smaller hills or only the lower slopes of the higher hills (the highest elevation is about 3,500 ft.). Within this belt, patches of moist deciduous forests also occur, wherever the solid rock is close to the surface. Transitional semi-evergreen type of forests are also met with. The higher slopes and ridges carry the moist or dry deciduous forests.

The activities of the Forest Department are mainly concentrated in the Andaman Islands and do not extend to the Nicobar Islands. The method of working employed in the past was mainly a system of lumbering, primarily aimed at getting the maximum timber volume for the sake of revenue. Silvicultural considerations are of most recent origin. The working plan formulated in 1951 prescribed the regeneration operation by gradual lifting of the canopy and retention of about 6 seed-bearers per acre. This method of regeneration was continued for a few years and plentiful regeneration appeared on the ground. Soon the question of removing the seed-bearers arose and simultaneously several difficulties cropped up. Firstly, the area yielded very little timber and the cost of extraction was very heavy. Secondly, the felling of large seed-bearers caused much damage to the young growth. To surmount these difficulties, retention of seed-bearers was eliminated and the main fellings now amount to clearfelling. The actual clearfelling process, however, is spread over a number of years. One to two years in advance of the main fellings brushwood cutting is done which involves clearing of shrubby growth together with trees of the lower canopy upto a height of about 20-40 ft. Dipterocarp seeds are sown broadcast. Apparently seeding is done as a regular feature in some places whereas in others it is done

*N.B.—In the absence of a representative of the Andamans Forest Department, Shri Waheed Khan (Forest Ecologist) who had recently toured the Andamans along with the Silviculturists of some other States in connection with this symposium offered to give his impressions of the Andamans forests and the silvicultural practices obtaining there.

only in those patches where advance growth of economic species is wanting. The main felling of the commercially important species lingers for 4-5 years. After the main fellings, intensive cultural operations commence along with which the girdling of the inferior species left in the overwood is also done. The regeneration comes up plentifully but it is mostly patchy. The well-stocked patches may range from a few yards to several acres. Even in the pole crop, the stocking is not complete.

The question of thinning the second growth forest has not yet arisen. It, however, appears that thinnings are not contemplated as the poles obtainable are not saleable in the Islands and the cost of transport to the main land is prohibitive.

The area annually exploited, is about 8,500 acres. Out of this, about 1,800 acres are repeatedly gone over, under cultural operations, till the area is adequately stocked with the second rotation crop of economic species. The remaining area of 6,700 acres is just left to itself. This is because of the paucity of labour for covering the entire area of 8,500 acres. The idea seems to be to compensate the loss of regeneration on 6,700 acres by raising 750 acres of teak plantations and 400 acres of matchwood plantations. It is apparently believed that this sort of compensatory plantation method will yield the increment which may be lost on the area of 6,700 acres which remains untended. I feel that it is necessary to evolve a most satisfactory solution of the problem.

From the utilization point of view the annual working area should be large enough to be economical, *i.e.*, to produce sufficient quantity of timber, so that costly methods of extractions may be introduced there. At present the cost of extraction is very high and makes an inordinately large demand on the annual budget. The main difficulty is with regard to the availability of labour. It is recruited mostly from the States of Bihar and Kerala. The Forest Department is maintaining a force of 4,500 labourers who are paid at the rate of Rs. 67 per person per month (month of 23 working days). Thus the present planning of all forestry operations is of necessity governed by this limitation in respect of labour.

Recently a plywood factory has been established at Port Blair. A chipboard factory may also be established. Possibility of establishing a hardboard factory is remote as the supplies of fresh water are very limited.

Shri V.S. Rao (West Bengal).—The most important problem of the Andamans appears to be the proper tending of the regeneration on the major portion of the annual coupe so as to avoid accumulation of large untended areas.

Shri C.A.R. Bhadrán (Madras).—Evergreen forests of the Madras State are in continuation of the evergreen forests of the Kerala State. The extent of these forests, however, is limited. The bulk of these forests has already been converted into more lucrative plantations such as tea, coffee, cinchona, cardamom and rubber.

The *shola* forests which cover the head waters of numerous little streams may well be described as Temperate Evergreens. They are located above 5,000 ft. elevation. Tropical evergreens are confined to 2,000-5,000 ft. elevation and below 2,000 ft. elevation the forests are either moist deciduous or dry deciduous.

The evergreen forests of the Madras State are subjected to acute pressure by local population. The management of the evergreen forests can, therefore, be viewed only as a part of the integrated land-use of the region as a whole. The *shola* evergreens had to be managed as such to regulate stream-flow. The low-elevation evergreens under well-managed conditions are expected to yield about Rs. 50-60 per acre per year. As against these financial returns a rubber plantation in the same locality yields a net revenue of Rs. 1,000 per acre per year. Apparently, a rubber plantation also provides as effective a vegetation cover for soil and moisture conservation as any we could visualise. Rubber plants are planted at 15' × 22' spacing, with a soil binding creeper on the ground. Within 2-3 years the ground is completely covered with this creeper and by 8th year full canopy of the rubber trees is formed. Thus the locality factors are maintained and the utilization of the land is upgraded several-folds. Some of the evergreen forests of the Madras State are therefore set aside for the formation of rubber plantations. While tapping for rubber, trees are not damaged in any way. The life of rubber tree is about 60 years and thus the rubber crop could be easily replaced at a cycle of 60 years.

Another profitable use of the evergreen forests is the cultivation of cardamom, without interfering with the evergreen nature of the forest. Cardamom is a shrub and its fruits are collected without disturbing the plant. The cardamom requires a reasonable amount

of overhead shade and therefore the tree crop is scarcely disturbed. Only a few trees from the middle or lower storeys are removed and shrubs are cut, which are substituted by cardamom. The net revenue realised from cardamom plantation is about Rs. 300 per acre per year. It is, however, important to point out that there are definite evergreen associations under which cardamom does well. On the lower elevations (2,000'-3,000') cardamom comes up very satisfactorily but on these elevations the percentage of economically important tree species is also high. If these trees are removed in increasing number, the openings caused may prove injurious to cardamom. In such areas it is desirable to evaluate whether to grow timber or cardamom. On higher slopes, the mixed evergreens do not contain an appreciable percentage of economically important trees. These are probably the best sights for the cultivation of cardamom. Even if cardamom is not grown there, improvement and enrichment of these forests is imperative.

Viewing the management of the evergreen forests from this angle, we could probably divide the available evergreen forests into three groups. The first group will include all those evergreen forests the conservation of which is essential from protection point of view. All the high-level *sholas* fall under this category. The second group includes evergreen forests of medium elevation in which the percentage of marketable species is low; but the extent of the forest blocks is large. In such forests intensive planting operations should be the rule. Attention should be concentrated only on a few important evergreen species, which have a high market value. The third group should include the smaller blocks of forests ranging in area from a few hundred acres to about 2,000-3,000 acres. These areas are probably best utilized under an intensive system of management, like the tea or coffee plantations.

Submergence and subsequent settlement of forest lands due to increasing hydro-electric and irrigation projects have caused an alarming situation. We have to admit the necessity of these projects and we cannot probably stand against them but we must insist that anything that could be possibly avoided should be definitely avoided.

As regards the reed formations, I have to mention that the reeds have already proved an important source of raw material for the paper mills. Whether we should be in a desperate hurry to restore these reed areas by any elaborate process of restoration to the original evergreen forest or we should continue to develop them intensively for reed production itself would be a matter for local investigation.

Shri V.S. Rao (West Bengal).—Management of forests and forest lands must be viewed from the national point of view. The target of 33 $\frac{1}{3}$ % of the total area to be brought under forests has not been yet achieved. Therefore putting forest lands for uses other than forestry should be a matter of grave concern, lest the forest lands may gradually slip from the Forest Departments. Obtaining the maximum financial returns cannot be the only criterion. The beneficial effects of forests on climate, soil and water conservation, agriculture, etc., cannot be ignored. In order that the impending timber famine in our country may be averted there is a strong case for maintaining every bit of forest land under forest only.

23rd April, 1960

Dr. G. Panigrahi (B.S.I., Shillong).—Evergreen forests of Assam and NEFA may be divided into broad vegetation formations, e.g., Tropical Evergreen Forests, Semi-Evergreen Forests and Montane Forests, as has already been done by Champion. Champion's classification is suitable but the data as collected by us so far indicate that the floristics and the extent of distribution of each type should be revised. I have given my views in detail and furnished the additional information in my paper contributed to the symposium.

Viewing the evergreen forests of India through the geological ages it is evident that there had been no appreciable change. Factors responsible for such a rigid stability are worth investigation. Cytological and genetical studies may probably be of much avail. However, it is well-known that the cytological changes going on in tropical vegetation are of a much higher order than those in Temperate Climates.

Shri V.S. Rao (West Bengal).—The facts regarding the distribution of evergreen species, particularly *Mesua ferrea*, are very interesting. This species occurs both in the north-east and southern evergreen forests of India. It is also astonishing to note that *Dipterocarpus macrocarpus* has remained unchanged through geological ages, though through genetical approach we wish to modify a species within one or two generations only. Researches on forest tree genetics is still in its infancy but it is time to make a start in this regard in India also.

Dr. K. Kadambi (Mysore).—Foresters have always been alert to recognise the changing specific composition of a forest. These are regarded as succession or retrogressive changes. The main factors responsible for such changes are (i) competition, (ii) soil changes, and (iii) cytogenetical alterations. With the increasing effect of biotic factors some of the species preponderate and others vanish. In the moist teak forest, teak continues to persist under the effects of fire. With the elimination of fire evergreen and semi-evergreen species invade and increase in proportion. Teak dwindles down and may even vanish. Similarly when a crop is repeatedly grown on a site, the soil characteristics change and the changed conditions may not continue to support the original type of crop. A change in composition is, therefore, inevitable. A situation of this nature is already met with in the Western Himalayas (Chakrata forests) with regard to fir forests. Cytogenetical changes as evidenced in seed races have long been recognised in the practice of forestry. In some of the countries, already there are laws to this effect where seeds of only particular races are collected for extension of forestry.

Shri K. K. Nair (I.F.C.).—Our knowledge of the silviculture of evergreen species, particularly with regard to regeneration operations and tending of young crops is very meagre.

In the evergreen forests of the Western Ghats no special efforts are made to obtain and tend the regeneration. Exploitation of the economically important species is done on a girth limit basis. In some of the States, e.g. Mysore, working plan prescriptions are fairly elaborate in respect of obtaining and tending the regeneration but they were never strictly followed. Consequently the exact technique of regeneration is not yet known. Similar is the case of artificial regeneration, although gap planting, tunnel planting, etc., have been tried.

In Kerala and Mysore States many wood-based industries are dependent on the evergreen forests. For the continuance of these industries it is desirable that the research be concentrated on augmenting the stocking of useful species in the existing forests. The risk of converting the evergreen forests into rubber, tea or cardamom plantations should be averted. There is greater need for the extension of the evergreen forests.

The focussing of attention on regeneration in evergreen forests is very necessary. Probably a regeneration survey should always be a necessary item of the prescriptions of the working plans for all such forests. Also, suitable criteria should be evolved to define the number of seedlings per unit area when it could be called fully-stocked. Similarly, the established and unestablished stages will have to be clearly recognised. The Malayan method of regenerating the evergreen forests takes cognisance of both the presence and adequacy of regeneration. The application of the shelterwood system is justified only if the fully-stocked second growth forest is ensured. Any deficiency in stocking must always be supplemented by artificial measures.

Shri A. B. Choudhary (West Bengal).—In West Bengal, the evergreen forests cover about 20 to 30 sq. miles of land. They are located in lower Kalimpong and due to peculiar floristic composition of these forests, Champion has designated them as "North Bengal Tropical Evergreen Forests". These species are common both to Assam and Western Ghat Evergreens. Species of *Dipterocarpus* and *Mesua* are, however, generally wanting.

In the lower hills of Kalimpong, Duar plains and Bhabar plains *Mesua ferrea* does occur. In the Duar plains *Mesua ferrea* is associated with *Saraca indica*.

In view of the peculiar nature of the evergreen forests of West Bengal a study of their ecology will be very useful.

Shri P. Venkataramany (F.R.I.).—Paucity of research on the silvicultural characteristics of the species in the evergreen forests is the most striking feature. As the demands of wood-based industries are increasingly felt on the evergreen forests, it is time to organise this research. Similarly there is a deplorable lack of growth data for evergreen species, both as individuals and as crops.

Considering that the growth conditions are by far the best in the evergreen forest regions, one is expected to get the highest return from these forests. But out of the vast multitude of species as they occur in the evergreen forests only a few species are economically important. The increment on unutilizable species is wasted. Usually, the standing volume is estimated as 50 tons of timber and 50 tons of fuel per acre. Thus the rate of wood production per acre per annum is about 0.5 tons. Actually the utilizable timber is estimated only as 0.1 to 0.2 tons per acre per annum. This is obtained by working the forests under the selection system with an exploitable girth of about 6 to 9 ft., and a felling cycle of 20 to 30 years. This yield of 0.1 to 0.2 tons per acre per annum is very low when

we remember that in comparable situations *Eucalyptus globulus* and *Acacia mollissima*, in the Nilgiris, can produce 6 tons per acre per annum. Similarly *Casuarina* on sandy coast produces 4 to 5 tons and teak about 1 ton per acre per annum. Thus there is an urgent need to improve the regeneration and management practices to augment productivity in these forests. This can be done by silvicultural research and proper management by converting the forests into evenaged or un-evenaged stands of a few selected valuable fast-growing species.

Research is also necessary to make use of hitherto un-economic species by seasoning, preservative treatment, etc.

Shri S. Rajkhowa (Assam).—In the evergreen forests of Assam there are three formations which are characterised by the dominance of only a few species in the top canopy, sometimes tending to be almost pure. These three formations are the Upper Assam *Mesua-Dipterocarp* formation, the Evergreen *Kayea assamica* formation, and the Cachar *Dipterocarp-Kayea-Palaquium* formation. It is possible to regenerate all these three types naturally at comparatively low cost, on account of the good seed dispersal of the dominant species which form more than 40% of the stems above 3 ft. girth, and the adaptability of the seedlings to the habitat factors. Out of these three formations, however, natural regeneration operations are done only in case of the first, and in spite of indications of good response to treatment, no systematic work on regeneration has been done on the other two formations as the dominant species in these formations, viz. *Kayea assamica*, *Palaquium polyanthum* and *Kayea floribunda* have no market at present. As far as I know, none of these species have been tried seriously for suitability as railway sleepers or veneers, though *Kayea floribunda*, which was peeled successfully in a local mill in Cachar was found to yield beautifully figured veneers. If use can be found for these species, there will be a scope for investing money on their natural regeneration operations; and the annual revenue from these forests which is barely two lacs of rupees now, can be raised to forty times that figure in the next twenty years or so.

In general vast areas of Assam are covered by semi-evergreens which are not so rich in stocking nor are dominated by only a few species, as in case of the *Bonsum-amari*, *Nahorhollong*, *Kayea assamica* or the *Dipterocarp-Kayea-Palaquium* formation. As regards regenerating these semi-evergreens the only practical method we found useful in the past was of "compensatory plantations". In this type of regeneration work in the evergreen and semi-evergreen forests, our experience has been, that here also a long looking after of forest regrowth is required—20 years, 30 years, sometimes 40 years. Those who visited Melang must have seen how these plantations are being overgrown with natural vegetation of the evergreens. This is one of the difficulties for which we have to be very selective about relegating all derelict areas to plantations because there is very quick change in the ecological set-up as soon as the plantations are formed and tall grass and weeds come in. In this context I showed the study-tour party a little experimental area I had in Melang which is on lines similar to those of Shri Khan's suggestion of introducing deciduous trees in the evergreens.

I have given a fairly comprehensive list of species occurring in these evergreen and semi-evergreen forests and it will be found therefrom that we have got in our evergreen forests certain deciduous elements, most of which are pioneers. So it is possible to introduce these pioneer fast growing species in the matrix of the evergreens by cutting lines which will enrich the forests definitely. I mention *Kydia calycina* and *Chukrasia tabularis* which are two of the pioneer species in evergreen forests. Other species which we might try are *Mansonia dipikae* and *Sterculia alata*. One of the difficulties in raising pure plantations or mixed plantations is the tremendous weed competition. Weeding is a mis-nomer in Assam. It often takes the shape of jungle cutting, climber cutting and weeding, all mixed together and it has to continue for 20 years or more and even when we think that the forest canopy is closed this operation has to go on. But I showed the study tour party an area where we removed all trees more than 20-30 ft. high and left standing all other trees which would ordinarily have been cut in the pockets of clear-felling and raising a good burn, and did not cut or burn the ground vegetation. Under such circumstances, transplanting of tall plants of fast-growing hardwoods which are strong light demanders survived under the open canopy of the middle storey species; at the same time, it was interesting to note that weed growth was kept absolutely under check, perhaps because we did not disturb the ground vegetation at all. This may prove to be a very fruitful field for the investigation of methods of planting in our semi-evergreen and semi-deciduous forests where we cater to the needs of only the big-sized timber. In this connection I would

advocate a complete reversal of the general practice of lifting the canopy from below when we resort to artificial regeneration; it is a better proposition to remove the canopy from above, remove all big trees and plant under the shade of low canopy trees up to 20 or 30 feet high. That way we avoid the felling damage in the first place and in the second place we can plant up our areas at low costs of formation and subsequent maintenance.

As regards spacing in such plantations, I should like to make one observation that the light demanders which come as pioneers, e.g., *Anthocephalus cadamba*, *Duabanga sonneratioides* and *Kydia calycina*, have got a habit of growing straight-boled. So initial close spacing (of 6'x6') and periodic thinning are unnecessary. We want to put about 75 trees per acre to begin with, even in the case of *Phoebe goalparensis* which is a slow grower; in this case the question arises as to how this tree will acquire a clean bole. My contention is that if we do not cut down any trees (even of species of poor value) growing in between our *elites*, *Phoebe* will have its bole cleaned of low branches by the shade cast by such species. All that is needed is selective shrub cutting in order to encourage the plants in their earlier stages. This method is likely to give us an unbroken canopy of useful species eventually.

As regards the assessment of regeneration in evergreen and semi-evergreen forests, a minimum of 4 plants of 6' to 20' height per quadrat of one chain by one chain would appear to be suitable as a criterion for considering an area regenerated. Allowing for soil changes, successful regeneration can be obtained on 75% of such quadrats in *Mesua-Dipterocarp* forests by about 3 years' repeated weeding and subsequent canopy opening in stages by way of thinning directed towards assisting the valuable species.

Dr. J.S.P. Yadav (F.R.I.).—So far as the soil factor is concerned, many aspects have already been discussed by the previous speakers. Although our knowledge about the soils of Tropical Moist Evergreen forests is limited, the various visits undertaken during the present Study-Tour have revealed that the site character plays a vital role in the development and distribution of these forests. The more important factors are:—

1. *Soil depth*.—On shallow soils the growth is very poor and the forests are generally of a deciduous nature, whereas the deep fertile soils bear a luxuriant growth of evergreen vegetation.
2. *Soil texture*.—Sandy soils, which have a very low capacity for retaining moisture and nutrients, do not provide a good medium for the best development of most of the important species. Clayey soils with a higher moisture and nutrient status, on the other hand, generally offer a favourable environment. As pointed out by the C.C.F., Assam, evergreen forests are altogether absent on the porous poor soils of the Bhabar tract, but they are found to grow luxuriantly in the pockets of red loam in the same area. An interesting instance of this nature was witnessed by the touring party in Batasipur north of Brahmaputra river where despite a good water table, deep sandy soil with only a thin loamy layer at the top fails to support *hollong* probably because this species has a higher requirement for moisture and plant nutrients. Almost similar conditions were observed by us in Lakhimpur Division south of Brahmaputra river. Sites having a sandy layer in the subsoil are associated with deficient regeneration of *hollong*, but where the soils contain a fair amount of clay both regeneration and growth of this species are satisfactory.
3. *Laterisation*.—Although the soils of the Western Ghats are mostly of lateritic nature, the areas characterised by feeble laterisation appear to be favourable sites. On the contrary, the soils which have become very hard and concretionary under conditions of advanced laterisation and have very little of real soil mass are not suitable for the growth of these forests. In Mysore such areas are at places occupied by grasses.
4. *Topography*.—Since many soil properties such as texture, depth, moisture regime, aeration and nutrient status are greatly modified by the topographical features, the variations in topography are reflected in the ultimate condition of the crop. It is not uncommon to find that the forest growth obtaining on the higher elevations with shallow and coarse soils is much inferior to that on the lower situations where both depth and texture have improved.
5. *Stoniness*.—The soils, which are free from or have very few boulders and stones, are generally good provided there is no compact clay pan or hard concretionary layer in the subsoil to prevent water movement.

6. *Water-table*.—In certain areas of Kerala, Andamans and Assam water-logging caused by high water-table particularly during the rains appears to be a limiting factor for the development of many important trees. *Myristica* swamps of Kerala State in localised situations are typical examples. In Andamans, *Dipterocarpus* is not doing well on water-logged areas in low-lying sites adjoining the streams where the soils are intensively gleyed, but this species is growing and regenerating luxuriantly on the high-lying sites having no signs of water-logging. It is, therefore, important that management practices involving heavy working like clear-felling should be employed in water-logged areas cautiously, so that water-logging is not further aggravated.
7. *Geology*.—The nature of soil is often governed by the kind of rock from which it is derived. In the Western Ghats the rocks are mostly granites and gneisses and the soils encountered in this region are lateritic, depending on the prevalent local conditions. In Andamans, we find sandstones, conglomerates and serpentine series. The soil is either sandy or clayey according to the nature of the rock which is ultimately reflected in the condition of the forests. In Assam, geological formation does not appear to be very important in the alluvial soils visited by the party, although C.C.F. Assam remarked that evergreen forests are also found on the hills where geological formation has a physical and chemical affinity with the soils present there. The alluvial soils manifest various types of stratification according to the nature of sand, silt or clay deposition at different depths. These variations in stratification largely condition the type and quality of the forests.

An interesting example, which demonstrates the importance of soil, was witnessed in Trivandrum Division of Kerala where three types of areas with almost identical climatic conditions were examined on the same day : (a) *Myristica* swamps, (b) semi-evergreen forests, and (c) evergreen forests. *Myristica* swamps have developed on gleyed soils in water-logged situations. Semi-evergreen forests are found on very bouldery soils with only a superficial thin layer of real soil mass. The evergreen forests occur on deep, well-drained and fertile soils which have very few stones but a good proportion of clay fraction.

Contrary to the general belief that the tropical soils are poor in organic matter owing chiefly to the favourable conditions for its rapid decomposition, it was observed that these soils contain a fairly good amount of humus especially in the top soil. Although the penetration of humus in the profile was found to be deep, its absolute quantity decreased considerably with the depth. In general, the fertility status of these soils appears to be quite satisfactory excepting those which are very sandy, bouldery or shallow. No doubt, the physical and chemical characteristics of these soils will be known more precisely after analysis of the soil samples collected during the study-tour are completed.

Shri M. C. Jacob (Assam).—What is generally the pH range in soils of the Western Ghat evergreen forests ?

Dr. J.S.P. Yadav (F.R.I.).—A few determinations made in the field indicate that the pH is generally 4 to 5. The soils are, therefore, acidic.

Shri M.A. Waheed Khan (F.R.I.).—I should like to talk on the ecological aspects of the evergreen forests and the possibility of ecological studies assisting in the actual art of silviculture, or forestry in general.

It is generally assumed that a Forest Ecologist is opposed to any attempts at altering the floristic composition of a forest. This is a gross mis-understanding. The forest vegetation may be manipulated in many ways but as long as it remains in consonance with the prevailing climatic and pedologic conditions, it may be considered good enough for perpetuation.

There is no objection to such manipulations and they are often necessary to utilize the full potential of the locality. It is, therefore, evident that it is not very necessary to maintain the evergreen character of the evergreen forests throughout if the full potential could be obtained by degrading the ecological status in order to facilitate the introduction of deciduous elements.

From the synecological point of view, the evergreen forests can be dealt with under two distinct types, viz. (i) the primary forests, i.e., the ones which are not unduly disturbed by man and his cattle, and (ii) the secondary forests, i.e., the areas where primary forest has been destroyed under *taungya* cultivation etc. and the second growth vegetation has subsequently covered the area. As regards primary forests it is necessary that some thorough

studies are taken up on typology, *i.e.*, determination of the definite floristic associations complete study of the floristics, structural make-up in forest profile, and the dynamics of the vegetation or the successional studies. If it is definitely known that the *Dipterocarpus* forest is a climatic climax there is no harm in dealing with such forest drastically for purposes of exploitation and regeneration. But if it is only a seral stage with comparatively unstable conditions, treatment of such forests will have to be done with utmost caution. Successional studies in secondary forests are equally important, particularly if their improvement is not to be taken up by artificial sowings, plantings, etc. In the context of the compensatory regeneration method, under which vast areas are left to nature after exploitation, a study of this type may be made use of to manipulate the intermediary stages so that the ultimate forest crop is fairly rich in economically important species. Even the initial exploitation fellings may be so designed that the suitable associates with which regeneration of economically important species come up prolifically may be preserved.

If we take the evergreen forest zone as one broad vegetation formation, because they are so alike in physiognomy, the varying floristic composition may be correlated with structural geology, elevation, aspect, development of soil profile and anthropogenic causes. Thus the distributional patterns of species are governed by certain set laws. Historical and geological aspects are equally important. With regard to distribution of evergreen species through the ages, the Malayan Forest Record—"Manual of Dipterocarps for Foresters" is very useful. Successional trends also continue to change the distributional limits of species. Study of these natural laws governing the distributional patterns of species is eminently important for a well-designed scientific management of these forests.

While considering the autecological studies it is well known that the evergreen forests, in general, are multi-layered in structure and the micro-climatic conditions of each layer are quite different from one another. Therefore a constituent species of such a complex community has to undergo varied micro-climatic conditions at different stages of development and growth. Thus a species may commence its life as a shade-bearer and may ultimately turn out to be a strong light demander. The light studies with regard to varying requirements of a species in the general make-up of the evergreen forests are very essential. The light conditions can be manipulated for the benefit of one or a group of species. Similarly, studies on moisture and nutrient balance of the important species are necessary. Finally the autecological and synecological studies shall have to be integrated with the soil studies and environmental conditions to understand the soil vegetation-climate complex fully.

From the successional studies as correlated with the potential productivity of the locality, it is easy to understand that the climax vegetation is not the best yielder. It does not harvest the potential productivity of the land completely. It is the seral or a sub-climax stage which utilizes the potential fully. It is amply evident even from the vast stretches of teak and sal forests of India. Thus the successional studies will go a long way in the management of the evergreen forests for their maximum productivity.

Studies on potential productivity made in Sweden and Germany have indicated that the evergreen forests do not produce the maximum. If the deciduous element is also introduced the productivity enhances considerably. Introduction of the fair proportion of deciduous species can be easily made in the second growth forest.

From successional point of view the evergreen forests of Madras and Assam may be regarded as post-climax. In Madras, these forests occur in pockets where apparently the soil moisture regime during the year remains favourable. In Assam, the low annual mean temperature coupled with the absence of a definite and long dry period, produce favourable conditions of growth, particular as the soil has a fair fraction of clay. Considerable caution has to be exercised in the management of such vegetation formations. Any drastic cutting may upset the balance, favouring a preponderance of deciduous species.

In evergreen forests of the Andamans, a number of species of *Dipterocarpus* are said to occur in intimate mixture. From the ecological point of view such a vegetation formation is of seral nature. Considering that the *Dipterocarp* species are valuable the management should be well-thought over so that there is no drastic change either to promote or degrade the successional stage. A seral stage is usually very unstable.

Ecological studies in the regeneration complex of the evergreen forests are also necessary. The general distribution pattern of tree species in an evergreen forest is usually of over-dispersed type, *i.e.*, every species has got equal chance to appear anywhere. The habitat conditions are uniform. The regeneration of these species, however, is highly under-dispersed, *i.e.*, it appears in patches large or small. The regeneration pattern is in the form of a mosaic. The distributional change involved from seedling stage to mature

stage is tremendous and during this period large numbers of seedling and saplings disappear. Considering this behaviour of regeneration in the evergreen forests it is essential that the patch regeneration of inferior species be replaced by enrichment planting or sowing to enhance the productivity of the forests in economically important species. The number of seedlings required per unit area for considering it fully stocked depends on the employment and efficacy of the follow-up cultural operations. If cultural operations are omitted even an abnormally large number of seedlings in the initial stages will not be sufficient as most of them are likely to die. If cultural operations are regularly carried out even a small number of seedlings may ultimately develop to maturity.

In a selection forest all age-classes are intimately mixed and are well represented. In an evergreen forest where only a few seedlings out of several thousands reach maturity application of a true selection system is not practicable. A uniform system or regular/irregular shelterwood system may be more feasible.

In Tropical Africa an operation known as "refining" has been applied to the evergreen forests. Under this operation inferior species are either cut or girdled at least 2-3 years in advance of the main fellings. If necessary the area is also seeded. The second growth forest obtained is fully stocked with economically important species.

Ecological studies on light requirement and root competition can help a good deal in designing the manipulation of the canopy in order to secure and establish the regeneration. They will help in deciding whether to lift the canopy from below or to remove it from above. The micro-climatic changes involved in such manipulations are important. The effect of removal or retention of brushwood is important in the same way.

Shri C. A. R. Bhadrans (Madras).—By way of further explanation to my earlier remarks it is reiterated that it is time to rationalise our approach to evergreen forests and classify them into three distinct groups. The first group includes all those forests which are primarily and wholly required for protective purposes. Utilization of these sites can be made if the management is consistent with this function. Cardamom, as is grown in South India, develops into a large leafy plant and admirably protects the ground. It merely replaces the shrub layer of the evergreen forest. Ground floor continues to collect leaf litter. The top canopy is undisturbed, except for a few stems in the middle storey. Thus the cardamom cultivation does not interfere with the protective functions of the site. However clearing the forest for the purpose of planting cardamom should not be allowed.

The second group of forests will include the bulk of the evergreen forests devoted mainly to the production of timber. These forests are over-ridden with inferior species and, therefore, introduction of intensive management is necessary to increase their utility and productivity. The third group will include small and uneconomic patches, interspersed amongst agricultural fields and cash crop gardens.

Shri M. C. Jacob (Assam).—Converting the evergreen forests either into cardamom or rubber plantations, brings about drastic changes. The tiered structure of the forest is modified and also the top height of plants is reduced. An evergreen forest may be 120 to 150 ft. tall but the rubber plantation is only about 50 ft. tall. Also litter falling on the ground is different in composition which may affect the fertility of the soil. It is, therefore, necessary that before such changes are contemplated, the protective functions of these cash crop plantations be evaluated.

Dr. K. Kadambi (Mysore).—It is not sound policy that just because a large number of species occurring in the evergreen forests are not utilizable at present the forests should be replaced by cash crops. Economic uses for the hitherto unutilizable species should be found out. Evergreen forest is highly susceptible to drastic changes and general degradation of the site is the usual outcome. A degraded evergreen forest site is completely lost. Therefore, wholesale conversion into rubber or cardamom plantations is not desirable.

Shri V. S. Rao (West Bengal).—Now we shall take the discussions on the "Ecological Aspects" of the evergreen forests.

Shri A. I. Iyppu (Kerala).—With regard to introduction of deciduous species in evergreen forests I have to observe that an attempt was made in the past to raise a teak plantation after clear felling of the evergreen forest. Teak has not responded well and evergreen species are once again colonising the site.

Shri M. A. Waheed Khan (F.R.I.).—Introduction of deciduous element in the evergreen forest and complete conversion of an evergreen forest into a deciduous forest are two different items. The suggestion offered is only to introduce the deciduous element for enhanced utilization of the potential productivity,

Shri C. A. R. Bhadrán (Madras).—Nothing in forestry should be regarded as drastic. There is an idea for the better management of the evergreen forests and there is nothing wrong in trying it on a small or large scale. It is a well-known fact that we have made no advances in the management of the evergreen forests and it is the function of this symposium to suggest suitable lines for trial.

Shri M. A. Waheed Khan (F.R.I.).—We may now take up the item of Silviculture, and I read out the relevant portions from the proceedings of the State Symposia so that the discussion may be started. (Relevant portions were then read out.)

Vast areas of the evergreen forests have been either not worked at all or only sporadically worked. They abound in mature trees. Exploitation of these forests will have to be regulated in such a fashion that regeneration keeps pace with the exploitation practices. It is, therefore, suggested that the mature and over-mature trees may be liquidated in one to two cycles and then irregular shelterwood system is applied. It has been noticed that wherever heavy fellings have been carried out in the evergreen forests regeneration has come up well and, with subsequent cultural operations, has also established adequately. Selection system as is usually practised has not given good results. Even areas which are prescribed for working under the selection system, and where regeneration has come up well, are invariably the result of deviations made from the usual prescriptions of selection working.

Dr. K. Kadambi (Mysore).—Both the irregular shelterwood system, and the selection system have been tried in the evergreen forests of Coorg. These forests have come under our management only recently and, therefore, I am not in a position to speak about the efficacy of any one system in particular. My own impression is that, there have always been a lot of deviations, and fires played inimical roles in the destruction of regeneration.

Shri M. C. Jacob (Assam).—I think somewhat drastic fellings as are contemplated under the irregular shelterwood system, are desirable.

Shri V. S. Rao (West Bengal).—Application of irregular shelterwood system to the evergreen forests is worth a trial. The idea of “refining” as was explained by *Shri Waheed Khan*, may also be tried.

Now we may switch on the management problems. I do not see much wisdom in the so-called “compensatory plantations”. If plantations are to be created they may be created in a separate series and should have no bearing on the areas naturally regenerated. The entire area of the evergreen forest which is exploited must also be regenerated fully. It would not be right to leave it uncared for and set to raise plantations elsewhere as a measure of compensation.

Shri M. A. Waheed Khan (F.R.I.).—In Andamans, annually an area of about 8,500 acres is exploited. Out of this exploited area, tending operations are limited to 1,800 acres only. The remaining 6,700 acres are left to nature. The natural regeneration lost on this area is said to be compensated by creating teak and matchwood plantations over an area of about 950 acres outside the evergreen forests. The annual loss of 6,700 acres is really enormous. As explained by *Shri Rao*, plantation areas should be separated out and something should be done to deviate the loss of 6,700 acres annually.

Shri M. C. Jacob (Assam).—In Assam also we have a similar system of compensatory plantations. We are, however, abandoning it.

Shri S. N. Dabral (F.R.I.).—Data on rate of growth for the evergreen forests are inadequate. For correct management practices such data are very essential. Continuous inventory plots covering about 40 to 50 acres should be laid out and measured periodically. The rate of growth so obtained would show the results of the application of particular techniques of working the forest.

24TH APRIL, 1960

Shri V. S. Rao (West Bengal).—Today we shall deal with the items of “Policy” and the “Objects of Management”.

The National Forest Policy lays down that the forest area in the country should be 33½% of the total land area. The total forest area in the country is about 20%. Even this forest is not fully productive. The really effective, economic and timber producing forest is only a small fraction of the existing forests. It is, therefore, necessary that the productivity of the existing forests be enhanced and if further extension of the forests is not possible at the moment, we may at any rate see that no existing forest lands be lost.

The existing forests should continue to be maintained as forests and there should be no attempt to give them away for other purposes.

Shri M. C. Jacob (Assam).—Cashewnut planting is already a recognised forestry practice. Rubber and cardamom plantations can, therefore, be started on the same analogy. In Assam rubber plantations were raised as early as 1907. So far as adequate provision is made to maintain the site characteristics, to me there is no danger in adopting the rubber or cardamom forestry.

Dr. K. Kadambi (Mysore).—Probably Shri Jacob wants to point out that the cultivation of cash crops can be taken up by foresters. In Mysore and Kerala States where demand for such crops is immense, private planters take hold of the land and it is almost impossible to oust them. Long cardamom leases were given in Coorg areas, with all the necessary precautions to maintain the site characteristics. Even then the area is destitute of regeneration of forest species and it cannot be taken back for purposes of rehabilitation. As the evergreen forest species are coming into prominence more and more, the main function of our forests should be to produce wood.

Shri C. A. R. Bhadrán (Madras).—Regarding cardamom cultivation, I wished it to be introduced in place of shrubby growth and only in those forests whose primary function is not to produce timber. This principle applies to rubber plantations and other cash crops as well. The areas which are fit for timber production should be maintained as such, but the others should be relegated to the crop of highest returns, provided the site characteristics are maintained.

Shri M. A. Waheed Khan (F.R.I.).—Shri Bhadrán's grouping of the evergreen forests into three classes is in consonance with the classification as given in the National Forest Policy. The objects of management which are based on the declared policy of the Government are dealt with in the Part II of the Working Plans and, therefore, it is for consideration, if this classification be adopted.

Management of small forest areas interspersed amongst cultivated lands always poses difficult problems. Situation of this nature also exists in the Berar plains of Maharashtra State. These forested areas are too small to be economic units from the point of view of protection and management. They started getting out of the hands of the Forest Department, when it was decided to manage them under an intensive system of *babul* plantations. Similarly, the small patches of evergreen forests in the Madras State will have to be brought under some system of intensive management so that they may be preserved as forest lands.

Shri V. S. Rao (West Bengal).—Large blocks of forests were already given away in the past for plantations of tea, coffee, rubber, cardamom, etc. The small remnant of forest we now have must be safeguarded for the production of wood in the larger interest of the nation.

Shri S. Rajkhowa (Assam).—In Assam, where the tea gardens stand now were once luxuriant *hollong* forests. Therefore, if the cash crops are to make further inroads into the evergreen forests the existence of the latter is very much jeopardized. I think we should concentrate and devote our energies and technical knowledge in the improvement of the so-called unproductive forest rather than think of handing it over for cash crop cultivation.

Shri R. M. Dass (Assam).—Pressure for the extension of agricultural lands is keenly felt on forest lands in Assam. The best utilization of unproductive lands, may it be for rubber, coffee or cardamom, will ensure its continuity as such under the Forest Department.

Shri V. S. Rao (West Bengal).—In winding up the discussions I have the following observations to make:—

Nowhere in the National Forest Policy is there any mention of the relinquishment of forests for the purpose of raising cash crops. The National Forest Policy was conscious of the serious inadequacy of our forests and has laid down as its goal the increase of forests by 50% of their present extent. If we keep on giving away forests for other purposes we shall never be able to reach that target. Everyone is aware of the difficulties of getting extra lands for afforestation.

Nor do I think that it is within the scope of a technical symposium such as this to attempt to discuss the relative merits of keeping a parcel of land under forests or of putting it to some other use altogether. What the symposium is required to suggest, as I understand it, is the best method of treatment to be applied to the Tropical Evergreen Forests in order to improve their condition. To put forward proposals for the total alteration of their forest nature cannot be within the terms of reference of such a symposium.

If small isolated blocks of forests have to be given for any other purpose either under local pressures or because they cannot be managed as forests as they are surrounded by unsympathetic population, or if the only hope of retaining some forest lands under the jurisdiction of the Forest Department is by undertaking to grow thereon cash crops such as rubber, cardamom, etc., it is purely a local question which is to be solved by the local forest officers as best they can. But such considerations cannot form the basis for a recommendation from a technical symposium of the kind we are concerned with at present.

There are many private agencies that have been engaged in raising large-scale plantations of tea, coffee, etc. and as already mentioned by me earlier vast areas of forest lands have already been given away for such purposes. As Foresters we know that the country's demand for timber is growing rapidly, but the gap between the demand and production is daily widening and the indications are that our country will shortly be faced with a timber famine. It is well known that timber is grown only by the Forest Department. No other agency in the country is interested or engaged in growing timber. It is, therefore, wrong to divert areas producing timber at present to other purposes.

It would not be correct to argue that in States where the proportion of forests to the land surface is more than $33\frac{1}{3}\%$ there is a case for giving up forests for other uses. Large regions of India such as the desert of Rajasthan and the great Ganga-Brahmaputra plains have practically no scrap of forests. The deficit in some regions will naturally have to be made up elsewhere. Otherwise the country as a whole can never hope to achieve self-sufficiency. Far from our being able to increase the extent of forests during the last 10 years we have lost much by submergence in river valley projects as well as by settlement of the persons displaced by the water reservoirs in other forest lands downstream. We have thus to make very much headway in the matter of consolidation of the forestry position in the country.

The Tropical Evergreen Forests have come into prominence recently due to the utility of their timbers for plywood, matches, packing cases, etc. Moreover many of them are situated in the catchment of rivers. Every attempt should be made to preserve them and manage them efficiently as well as to find uses for some of the lesser known species so that the forests may be managed to the best possible advantage.

VOTE OF THANKS

BY SHRI T. N. SRIVASTAVA,

Director of Forest Education, Forest Research Institute & Colleges, Dehra Dun

Mr. Chairman and Gentlemen ! Our symposium has come to an end. I on behalf of the Forest Research Institute must express my gratitude to all the members who have taken part in the symposium and given their cooperation to make it a success. I have heard the discussions in this symposium and I am fully convinced that the utility and need of such symposia is very great.

A lot of work has already been done on teak, sal and other forests but apparently the evergreen forests have not been given the same attention. An all-out effort both by State Forest Departments and the Forest Research Institute to do research in evergreen forests is called for. The discussion has produced various problems and very important points have been raised which have been discussed threadbare and the proceedings will prove very useful for the guidance of the States as well as the Centre and they will give food for further thought and consideration.

I must thank all the States who have had to make arrangements for the study-tour and conduct of the symposium and the officers who have taken part in the tours and deliberations, have given their views and written papers which have provided so much material for our consideration. I must thank especially the Chief Conservators of Forests of the various States and other senior officers who have managed to spare some time from their multifarious duties and busy work and have joined us in this plenary session as well as in the symposia at the State level. Unfortunately Shri Seth, the Central Silviculturist, who has been conducting this symposium and tour got ill and he is not amongst us today; we have missed some useful observations that he could have made. I hope, he will recover soon and will be able to assist when the proceedings will be drafted.

I must thank particularly the Chief Conservator of Forests of Assam, Shri Jacob and his officers, his Conservators—Shri Das, Shri Barua and D.F.Os., who have made our stay at Shillong so comfortable and made arrangements for the symposium. I must mention here the name of Shri Gagoi who has always been on the tips of his toes and looked after us from morning till evening and made us feel very comfortable indeed. And now I must thank you Sir, Mr. Chairman for ably conducting the symposium and making it a success.

Thank you.

TROPICAL MOIST EVERGREEN FOREST STUDY-TOUR NOTES ON LOCALITIES VISITED

MYSORE STATE

6TH MARCH, 1960

Camp : Sirsi (E. D. Kanara Division)

1. *Devimane L.T.I. Plot and adjoining area*—It is a typically west-coast semi-evergreen forest. It is characterised by the presence of the deciduous species like *Terminalia paniculata* and *Lagerstroemia lanceolata*. Of the total constituent species about 126 have been identified. Only 18 species constitute more than 1% of the crop individually. *Hopea wightiana* tops the list being 23% of the growing stock. The commoner species are :

I. *Hopea wightiana*, *Diospyros candolleana*, *Olea dioica*, *Syzygium cumini*, *Holigarna arnottiana*, *Pterospermum heyneanum*, *Memecylon edule*, *Cinnamomum* spp., *Syzygium gardneri*, *Artocarpus integra*, *A. hirsuta*, *Lophopetalum wightianum*, *Calophyllum elatum*, *Machilus macrantha*, *Mangifera indica*, *Mimusops elengi*, *Terminalia paniculata*, *Lagerstroemia lanceolata*, etc.

II. *Aglaia roxburghiana*, *Garcinia* spp., *Symplocos canarana*, *Canthium umbellatum*, *Euphoria longana*, *Aporosa lindleyana*, *Saraca indica*, *Litsaea* spp., *Flacourtia montana*, *Pouteria tomentosa*, *Madhuca longifolia*, *Hydnocarpus laurifolia*, etc.

III. *Strobilanthes* spp., *Psychotria dalzelli*, *Leea sambucina*, *Goniothalamus cardiopetalus*, *Litsea* spp., etc.

IV. Bamboos are practically absent.

V. Canes common and at places abundant. Regeneration of the main species is fair.

The terrain is sloping and the soil is dark brown loam with rock fragments.

Block XVIII—6—The forest is semi-evergreen type as at Devimane but the large-sized trees are conspicuously absent. The uniform pole-sized crop is difficult to account as the forests are said to be virgin. Soil is hard and lateritic. Probably the area was *jhumed* in the past, exposing the lateritic soil to harden up. The soil conditions are apparently not suited for the best development of the second growth forest.

For both these forests working plan is being prepared now. For the assessment of growing stock 10% strip enumerations are being done. Assessment of regeneration is proving difficult.

7TH MARCH, 1960

Sirsi to Jog Falls

1. *Kodkani L.T.I. Plot No. 1*—Area 6.50 acres. Altitude 2,000 ft. Rainfall 150". It is a semi-evergreen forest without *Dipterocarpus* spp. The important constituent species are : *Olea dioica*, *Aglaia roxburghiana*, *Diospyros candolleana*, *Lansium anomalayanum*, *Nephelium longana*, *Knema attenuata*, *Garcinia cambogia*, *Pterospermum reticulatum*, *Litsaea floribunda*, *Cryptocarya* spp., *Symplocos beddomei*, *Bischofia javanica*, *Lagerstroemia lanceolata*, *Flacourtia montana*, *Sideroxylon tomentosum*, *Myristica beddomei*, *Casearia esculenta*, *Holigarna grahamii*, *Machilus macrantha*, *Mallotus philippensis*, *Terminalia tomentosa*, *Cassia fistula*, *Trewia nudiflora*, etc.

8TH MARCH, 1960

Camp : Jog Falls (E. D. Kanara Division)

1. *Katlekan, L.T.I. Plot No. 2*—Area 27 acres. Altitude 1,900 ft. Rainfall about 200" with heavy mist in winter. The species in order of frequency of occurrence in this plot are *Nephelium longana*, *Dipterocarpus indicus*, *Hopea wightiana*, *Olea dioica*, *Lophopetalum wightianum*, *Syzygium gardneri*, etc. Soil is deep and clayey loam.

The adjoining forests are being exploited for the last few years. The species mainly extracted are *Canarium strictus*, *Machilus macrantha*, *Ailanthus* spp. and *Mangifera indica* for matchwood (exploitable girth 6 ft.), *Dipterocarpus indicus* and *Calophyllum elatum* for railways (exploitable girth 7 ft.) and *Lophopetalum wightianum* for slate-frames (exploitable girth 6 ft.).

There is a profuse regeneration of *Dipterocarpus indicus*. Other regenerating species are *Holigarna arnottiana*, *H. grahamii*, *Semecarpus travancorica*, etc. In moist depressions *Pinanga dixonii* forms gregarious masses.

2. *Hopea Plot at Malemane*—This plot was established in 1939, in a semi-evergreen forest with *Hopea parviflora* as an important crop constituent. Efforts in obtaining natural regeneration of *Hopea parviflora* were made by removing large trees and thus causing gaps in the canopy. The area is covered with *Hopea* saplings (10'—12' high) which are apparently not very vigorous. Gradual opening and lifting of the canopy is probably more tending efficacious as the evergreens in earlier stages need more of side-shade.

9TH MARCH, 1960

Jog Falls to Agumbe

10TH MARCH, 1960

Camp : Agumbe (Shimoga Division)

1. *Agumbe Forest Comptt. 1 & 2*—This is the evergreen forest with *Dipterocarpus indicus* and *Poeciloneuron indicum* as the main constituent species. Other associated species are *Hopea parviflora*, *Sterculia alata*, *Mangifera indica*, *Dysoxylum malabaricum*, *Artocarpus hirsuta*, *Artocarpus integrifolia*, *Calophyllum wightianum*, *Mesua ferrea*, *Garcinia morella*, *Diospyros ebenum*, *Cinnamomum zeylanicum*, *Vateria indica*, etc. Underplanting of economically important species has come up well but growth is checked due to lack of timely operations. Cultural operations are being resumed and intensified.

2. *Agumbe Comptt. 8*—The area was worked heavily in the past but timely cultural operations fell in arrears. The same are being continued now. Regeneration of *Dipterocarpus indicus*, *Poeciloneuron indicum* and *Mesua ferrea* has come up prolifically. Cleaning of competing shrubby growth is essential.

3. *Sleeper and Pole Operations*—Sleepers are converted from *Dipterocarpus indicus*, *Palaquium* spp., and *Poeciloneuron indicum*. The price of one B.G. sleeper obtainable is Rs. 22. Treated *Poeciloneuron indicum* poles (26 ft. long with 2½ ft. girth at thick end) are greatly in demand and are being extracted.

4. *Silvicultural Research Plots*—Experiments with evergreen species are being conducted with regard to best method of planting, time of planting, sowing, canopy manipulation for natural regeneration, underplanting, etc. Definite indications are not yet available.

5. *Sitanadi Valley Evergreen Forests*—These are virgin forests and admirably situated for constituting into a Nature Preserve.

11TH MARCH, 1960

Agumbe to Sakleshpur (Hassan Division)

On the way there are many coffee and rubber plantations.

12TH MARCH, 1960

Sakleshpur to Mercara

1. *Kemphole Ghat Forests*—The area receives about 250" of rainfall. The important crop constituents are *Dipterocarpus indicus*, *Vateria indica*, *Lophopetalum wightianum*, *Holigarna grahamii*, *Artocarpus hirsuta*, *Hopea wightiana*, *Calophyllum elatum*, *Cinnamomum zeylanicum*, *Mesua ferrea*, *Machilus macrantha*, *Hardwickia pinnata*, *Palaquium ellipticum*, *Ailanthus malabaricum*, etc. These forests are leased to Mysore Commercial Union Ltd. to remove *Cedrela toona*, *Myristica magnifica*, *Calophyllum elatum*, *Myristica malabarica*, *Vateria indica*, *Dipterocarpus indicus*, *Machilus macrantha*, *Mangifera indica*, *Hardwickia pinnata*, *Canarium strictum*, *Ailanthus malabaricum* and *Palaquium ellipticum*. Heavy working was done but the tending operations were not attended to. Regeneration of *Dipterocarpus indicus*, *Vateria indica* and *Hardwickia pinnata* is prolific. Cultural operations are being organised now.

13TH MARCH, 1960

Mercara to Tellicherry via Makut

1. *Watekuli Abandoned Coffee Estate*—It was originally an evergreen forest which was felled to form the coffee estate. Subsequently, the coffee estate was also abandoned and the whole area is now badly degraded with only tall grass as the vegetation cover. The area is being rehabilitated by planting. Some of the species tried are—*Dichopsis*, *Bischofia*, *Elaeodendron*, *Dipterocarpus indicus*, *Palaquium ellipticum*, *Artocarpus hirsuta*, *Hopea parviflora*, etc. Fast-growing *Erythrina* is also tried as a cover crop.

2. *Cardamom Plots in Chipplehole Forest*—An area of about 40,000 acres of inaccessible forest is allotted to Cardamom Working Circle. Leases are given for 21 years and cardamom cultivation is done by patch method whereby three-fourths of the area remains untouched. Cardamom cultivation adversely affects the regeneration of tree species and as the means of communication develop, cardamom cultivation will be abandoned.

3. *Sollecolly Regeneration Area*—The forest is being worked under Selection System since 1920. A tramway was also laid in the past and the working was rather heavy amounting to almost Irregular Shelterwood System. Regeneration of *Vateria indica*, *Calophyllum elatum*, *Dipterocarpus indicus* and other important species has come up prolifically. Repeated and intensive cultural operations are necessary.

4. *Introduction of Exotics*—Around the Makut Rest House, plantations of cashew, padauk (*Pterocarpus dalbergioides*) and Burma bamboo (*Dendrocalamus brandisii*) have been raised, since 1913. All the species have come up very well.

5. *Teak Plantations*—Between the years 1876 and 1890 about 760 acres of teak plantations were raised round-about the Makut R.H. Out of this, at present, there are only 240 acres bearing teak. The soil is extremely lateritic. Tall teak trees have come up but the diameter increment is poor and extremely disproportionate. Natural regeneration of *Hopea parviflora*, *Artocarpus hirsuta*, *Dipterocarpus indicus* and other evergreen species has invaded these plantations.

6. Mysore State Symposium was held. Summary of discussions is given separately.

14TH MARCH, 1960

Tellicherry to Coimbatore via Podanur

MADRAS STATE

15TH MARCH, 1960

Camp : Coimbatore (Coimbatore South Division)

1. *Punachi Range Forests*—The forests are situated in the Annamalai Hills, at an elevation of 2,000—4,000 ft. with an annual rainfall of about 125 inches. Originally these forests extended over an area of about 100 sq. miles, but now more than half the area has been cleared for tea and cinchona plantations. The remaining forest is dense and tall. Common important species are *Mesua ferrea*, *Palaquium ellipticum*, *Calophyllum elatum*, *Artocarpus integrifolia*, *Vateria indica*, *Cedrela toona*, and *Dysoxylum malabaricum*. In the middle storey *Nephelium longana*, *Macaranga* spp., *Lansium anamalayanum* and species of *Litsaea* and *Myristica* are prominent. In general, *Palaquium-Mesua* association in drier areas and *Poeciloneuron-Cullenia* association in wetter areas are distinguishable.

The forests are being worked under selection system on a 30-year cycle. The exploitable girth is 7 ft. and not more than 5 trees are allowed to be felled per acre. Underplanting is also prescribed but not practised. Natural regeneration is coming up well except that of *Mesua ferrea*.

An area of about 2,000 acres has been leased for cardamom cultivation, for 25 years.

16TH MARCH, 1960
Coimbatore to Palghat
KERALA STATE

17TH MARCH, 1960

Camp : Palghat (Palghat Forest Division)

1. *Silent Valley Reserve*.—It is situated in Mannarghat East Range, with an area of 22,120 acres. Altitude ranges from 2,500 ft. to 7,000 ft. Rainfall varies from 100" to 300". The sub-tropical evergreen forests occur above 5,000 ft. elevation. The common species occurring are *Calophyllum elatum*, *Actinodaphne hookeri*, *Litsaea stocksii*, *Cinnamomum sulphuratum*, *Canthium didymum*, *Eugenia* spp., *Rhododendron arboreum*, etc. The tropical evergreen forest is characterised by species like *Cullenia excelsa*, *Machilus macrantha*, *Palaquium ellipticum*, *Poeciloneuron indicum*, *Eugenia* spp., *Mangifera indica*, *Artocarpus integrifolia*, *Cinnamomum zeylanicum*, *Holigarna* spp., *Hopea* spp., *Litsaea wightiana*, etc.

Only light selection fellings were done in the past for such species as *Mesua ferrea*, *Palaquium ellipticum* and *Calophyllum elatum*. Some of the remoter areas are still virgin. Dribbling of seeds of *Acrocarpus fraxinifolius*, *Artocarpus hirsuta* and *Hopea parviflora* in gaps was tried during 1928 to 1930 but was given up as the success was not significant. Gap planting was also attempted though partial success was achieved, the operation was not followed up. The present selection working aims a rotation of 210 years and a felling cycle of 30 years. Exploitable trees to be removed per acre are 3 with a proviso to increase to 6 if demand arises.

2. *Comptt. 16 of Attapaddy Valley*.—This area was worked by the Hope Timber Syndicate during 1948-49. About 1,000 trees scattered over 971 acres yielded 120,000 c. ft. of timber. The species mainly exploited were *Mesua ferrea*, *Cullenia excelsa*, *Mangifera indica*, *Dichopsis elliptica*, *Calophyllum elatum*, *Machilus macrantha*, *Artocarpus* spp., *Bischofia javanica*, *Cedrela toona* and *Myristica malabarica*.

18TH MARCH, 1960

Palghat to Peermade, via Trichur

19TH MARCH, 1960

Camp : Peermade (Kottayam Forest Division)

Cardamom Hill Forests

1. *Kallar Valley*.—The whole of the Cardamom Hill Reserve once carried dense evergreen forest. Some *Vateria indica*, *Machilus macrantha* and *Calophyllum elatum* trees over 7 ft. in girth were extracted in the past, on selection basis, but cultural operations were not done. Trees belong to Forest Department and the land to Revenue Department. The latter department is granting Cardamom leases in this area. Encroachments in the Reserve are also common. Regeneration of tree species is scanty. Common tree species found are : *Vateria indica*, *Machilus macrantha*, *Calophyllum elatum*, *Cullenia excelsa*, *Mesua ferrea*, *Cedrela toona*, *Palaquium ellipticum*, *Bassia longifolia*, *Nephelium longana*, *Myristica attenuata*, *Canarium strictum*, etc.

2. *Pampadamparai Cardamom Estate*.—Everything except the topmost canopy of the evergreen forest is felled. Dead trees in the top canopy are replaced by fresh plantings of fast growing species.

Cardamom yields about 100 lbs. per acre per year and the current sale price is Rs. 13 per lb. Cardamom cultivation gives very lucrative profits.

20TH MARCH, 1960

Peermade to Trivandrum

21ST MARCH, 1960

Camp : Trivandrum (Trivandrum Forest Division)

1. *Coupe III, Vamanapuram Plantations*.—Area 96.5 acres, year of formation : 1952. A good teak plantation. In 15 acres, *Artocarpus hirsuta*, *A. integrifolia* and *Sterculia campanulata* were also tried with teak. *Artocarpus hirsuta* has come up well. Teak

plantations are raised by *taungya* method, with tapioca. The lessee pays a rental of Rs. 5 per acre. Planting is done at 6' x 6'. Cost of formation is Rs. 16.50 per acre only.

2. *Sastanada Swamp (Kulathupuzha Range)*.—This is a *Myristica* swamp and the commonly occurring species are *Myristica magnifica*, *M. canarica*, *M. attenuata*, *M. malabarica*, *Lophopetalum wightianum*, *Eugenia montana*, *Hydnocarpus wightiana*, *Diospyros microphylla*, *Alpinia galanga*, etc. These swamps are not worked except for *Coscenium fenestratum* which sold as a minor forest produce. Many of such swamps have already been cleared for cultivation.

3. *Reed areas*.—The common reed *Ochlandra travancorica* flowered some 3 years back. Young growth is coming up gregariously. The reed is used for paper pulp.

4. *Cheenakala Forest*.—It is a shallow valley with reddish yellow loamy soil with plentiful large boulders and rock outcrops. The forest is said to be virgin. There is plentiful regeneration of *Vateria indica*, *Hopea parviflora*, *Lophopetalum* spp., *Diospyros microphylla* etc. *Leea sembuca* is the commonest. Large trees are absent except a few scattered trees of 4 ft. girth. Probably, the area was heavily worked in the past.

5. *Cheenakala Abandoned Coffee Estate*.—Area 40 acres. This coffee estate was abandoned 10 years ago. The area is being colonised by *Hopea parviflora* and *Vateria indica*.

6. *Punmudi Hill Forest (Kallar Valley)*.—The area is worked under selection system with a rotation of 150 years and a felling cycle of 30 years. Exploitable girth prescribed is 6 ft. The current exploitation practice removes about 1.8 trees per acre. The main species are *Poeciloneuron indicum*, *Dipterocarpus indicus*, *Penanga dixonii*, *Artocarpus hirsuta*, *Cinnamomum zeylanicum*, *Actinodaphne madraspatana*, *Vateria indica*, *Semecarpus auriculatus* etc. Regeneration of most of the species is present. The working plan prescribes artificial regeneration in 11 ft. wide strips cleared of middle and lower canopies. The species recommended for regeneration are *Dipterocarpus indicus*, *Cedrela toona*, *Dysoxylum* spp., and *Vateria indica*. This operation has not been done so far.

22ND MARCH, 1960

Thenmala Forest Division

1. *Arippa Plantation of Hopea parviflora*.—Area 19 acres. The area was a grassland which was planted up with *Hopea parviflora* during 1922 and 1926. Planting was done at 9' x 6'. The plantation is thriving well. The average height is about 60 ft. and girth 24 inches. Natural regeneration of mahogany, *Macaranga*, *Cinnamomum*, *Xanthoxylum* and *Salmalia* is also coming up.

2. *Chudal F.S. of Shendurni Range*.—This is a continuous stretch of evergreen to semi-evergreen forests with patches of moist deciduous forests. The constituent species in the evergreen forests are—*Dipterocarpus indicus*, *Machilus macrantha*, *Dichopsis* spp. *Mesua ferrea*, *Calophyllum elatum*, *Hardwickia pinnata*, *Poeciloneuron indicum*, *Artocarpus integrifolia*, *A. hirsuta*, *Diospyros microphylla*, *Bischofia javanica*, *Palaquium ellipticum*, etc. Regeneration of *Dipterocarpus indicus* is profuse. Other well regenerating species are *Hopea parviflora*, *Vateria indica*, *Artocarpus hirsuta* and *Hardwickia pinnata*.

Working is done by selection fellings and about 2 trees per acre are removed.

23RD MARCH, 1960

Kerala State Symposium was held. Summary of discussions is given separately.

24TH MARCH, 1960

Trivandrum to Kanyakumari via Nagercoil

MADRAS STATE

Tirunelveli South Division

1. *Balamore (Muthukazhi) Reserve Forest*.—The evergreen forests occur in this region in irregular patches amongst the vast areas of tea and coffee plantations. The commonly occurring species are *Hopea parviflora*, *Calophyllum elatum*, *Palaquium ellipticum*, *Gluta travancorica*, *Sterculia foetida*. Middle storeys are completely wanting. Shrubby growth is thick and mainly of *Calamus gamblei*, *Pandanus*, *Strobilanthes*, etc. Regeneration is sparse and mainly of *Vateria indica* and *Palaquium ellipticum*. The working plan prescribes these

areas for cardamom cultivation. Plots of 25 acres are leased with an initial premium of Rs. 200 to Rs. 500 per acre and an annual rental of Rs. 2 to Rs. 3 per acre during the first 5 years. Afterwards the rate of rental is increased to Rs. 7 per acre.

2. Madras State Symposium was held at Kanyakumari. The summary of discussions is given separately.

25TH & 26TH MARCH, 1960

Kanyakumari to Pondicherry

Vegetation cartography maps of South India were examined at the French Institute, Pondicherry.

27TH MARCH, 1960

Pondicherry to Madras

28TH MARCH, 1960

At Madras

29TH MARCH to 3RD April, 1960

Madras to Port Blair

ANDAMAN & NICOBAR ISLANDS

3RD APRIL, 1960

South Andamans Forest Division

1. *Coupe No. 2, P.B.I. Shoalbay F.S.*—It is located near Mannarghat village. Terrain is broken and hilly. Area 1,648 acres (non-tidal forest). It is a moist evergreen forest. Mature and over-mature *gurjan* (*Dipterocarpus kerrii*) trees are fairly plentiful and evenly distributed along the ridges and upper slopes, and scattered over the lower slopes. *Gurjan* constitutes about 32% of the total growing stock. The dominant associate species are *Artocarpus chaplasha*, *Parishia insignis*, *Endospermum malaccense*, *Planchonia andamanica*, *Canarium euphyllum* and *Podocarpus neriifolia*. About 600 acres of the coupe are fully worked and regenerated.

The regeneration operation consists of cutting the brushwood in advance of the main fellings. In main felling all trees up to a minimum girth of 6 ft. are felled. For 3 to 4 years following the main fellings intensive weeding and tending operations are carried out which include brushwood cutting and felling and girdling of inferior tree species. The cost is about Rs. 50 per acre.

Main fellings almost amount to clearfelling, except the retention of advance growth. Seed is broadcasted in areas where advance growth is lacking. In heavily cleared areas *Evodia glabra* and *Lagerstroemia hypoleuca* come up gregariously.

The yield of commercial timber obtainable in the first rotation is about 20 tons per acre. The proportion of commercial species increases a good deal in the second rotation crop, with an estimate of about 60 tons per acre.

Regeneration of *Dipterocarpus kerrii* is patchy and mostly confined to hill tops (elevation 500 ft.). Slopes are deficient.

2. *Coupe No. 1, P.B.I. Shoalbay F.S.*—Area 1,608 acres (non-tidal forest). Along the eastern and western boundaries there is a narrow belt of mangrove. The remaining area is moist evergreen forest with the exception of a small patch of deciduous forest in the eastern corner. *Dipterocarpus kerrii* is the main species constituting about 30% of the growing stock. At places it forms pure patches. The important associated species are *Artocarpus chaplasha*, *Parishia insignis* and *Endospermum malaccense*. *Padauk* (*Pterocarpus dalbergioides*) is the main species in the deciduous patch.

About 600 acres of the coupe yield 7,800 tons of commercial timber. The entire area is fully regenerated after 3 years intensive cultural operations. Concentration of regeneration is, however, in patches.

5TH APRIL, 1960

South Andamans Forest Division

1. *Barataga Camp, Coupe No. 13.*—Area under main fellings. Extraction is done by elephants, tractors, tramways and rafts.

2. *Coupe No. 10 : 1958 teak plantation.*—Area 82 acres. Stump planting was done in May 1958 at an espacement of 12' × 12'. The plantation is formed in the original deciduous forest. Cost of formation is Rs. 216 per acre. Height of plants—maximum 20 ft., minimum 3 ft., average 10 ft.

Planting espacement is rather wide and the cost of weeding is Rs. 25 per acre.

Adjoining Semi-Evergreen Forest.—There is a lot of natural regeneration of *Pterocarpus dalbergioides*, *Canarium euphyllum* and *Anthocephalus cadamba*. In 1957 commercial trees were exploited and the canopy was lifted to about 40-50 ft. from the ground. Shrub-cutting was done and followed by burning. Broadcast sowing of seeds was done and the plants are 6 ft. tall. Three weedings were done—I weeding (Rs. 30 per acre), II weeding (Rs. 25 per acre), and III weeding (Rs. 15 per acre). The total cost of regeneration is Rs. 120 per acre.

6TH & 7TH APRIL, 1960

Middle Andamans Forest Division

1. *1939 Regeneration Area of Porlob Island.*—Area 111 acres. In 1939, trees over 6 ft. in girth were removed and wholesale clearance of undergrowth was done. The canopy was lifted to about 60 ft. by girdling the inferior tree species.

There is a patch mixture of the evergreen and deciduous forests. Deciduous forests were burnt before seed fall. No burning was done in the evergreen forests.

In 1949, the new crop attained a height of 40 ft. and a girth of 18", with 205 stems per acre. The dominant species were *Dipterocarpus* spp., *Sterculia campanulata*, *Lagerstroemia hypoleuca* and *Pterocarpus dalbergioides*.

In 1950, first thinning was done, allowing an espacement of about 1/3rd the height to dominant stems. The crop has attained a height of 75 ft. and girth of 43", with 100 stems per acre.

The cost of regeneration was Rs. 23 per acre (convict labour being paid @ Rs. 11 per month).

2. *1940 Regeneration Coupe.*—Area 427 acres, elevation 0'—200', rainfall 120 inches. *Dipterocarpus turbinatus* is the main species. Other associated *gurjan* species are *D. griffithii*, *D. incanus* and *D. costatus*. *Sterculia campanulata* is also present.

Mass-regeneration method was adopted and in June 1940 shrubby layer was completely removed along with the commercial species. Some poles and middle-aged trees were retained. During the rains of the same year abundant regeneration of *gurjan* and *Sterculia campanulata* came up. Canopy was lifted to 80—100 ft. and intensive weeding and climber-cutting operations were repeatedly done.

In 1955, the crop attained a height of 70 ft., girth 40 inches, with 128 stems to an acre.

The area is fully stocked with second rotation crop.

3. *1934 Kyitaung Regeneration Area.*—Deciduous forest 100 acres and evergreen forest 75 acres.

Evergreen forest consists of *Dipterocarpus turbinatus*, *Sterculia campanulata* and *Canarium euphyllum*. In December 1933, commercial fellings were carried out leaving a few, well-scattered seed-bearers. Canopy was lifted to about 30 ft. and there was lot of advance growth. In 1934, two weedings were done and in 1935, canopy was further lifted to 60—70 ft., particularly in patches where regeneration failed to develop adequately. Total expenditure till 1940 amounted to Rs. 25 per acre. In 1950, thinning was carried out at a cost of Rs. 7/11/- per acre. In 1959, old advance growth which was retained to merge in the new crop was removed. Total removals (mostly *gurjan* and *Sterculia campanulata*) amounted to 2 trees per acre.

Young crop is well-stocked and healthily growing.

8TH APRIL, 1960

Port Blair.—Andaman & Nicobar Islands State Symposium was held. Summary of discussions is given separately.

8TH TO 12TH APRIL, 1960

Port Blair to Calcutta

13TH & 14TH APRIL, 1960

At Calcutta

ASSAM STATE

15TH APRIL, 1960

Calcutta to Dhekiajuli via Gauhati

Camp : Dhekiajuli (Charduar Reserve Forest)

1. *Phoebe goalparensis* plantation of 1938.—Rainfall 80"—100"; elevation 300—400 ft.; area 3 acres. Originally, the area carried a semi-evergreen type of forest with *Bonsum* (*Phoebe goalparensis*)—*Amari* (*Amoora wallichii*) association. The area was felled in February 1939 and then sown. During May to August 1938, weedings were done and in October 1938 transplanting was carried out. Weeding and climber-cutting were done regularly till 1942. Supplementary transplanting was done in June 1948 and thinnings were carried out in 1958-59. Trees have attained a height of 55 ft. and girth of 18 inches.

2. *Bonsum* plantation of 1941.—Area 10 acres. Clearfelling was done during 1940, and sowings and transplantings were undertaken during April 1941, after burning the debris. Weedings and further transplantings continued till 1948. The trees have attained a height of 40 ft. and a girth of about 18 inches.

3. 1959 *Bonsum* Nursery.—Area 1 acre. *Bonsum* seeds ripen in autumn. Dried seeds are preferred in the nursery. No pretreatment is done and sowings are done in December. Seed beds should have light shade for successful results. About 11 mds. of seed are sown per acre. Seeds germinate within about 20 days and the germination per cent is 70 to 80. Seedling per cent is 40. Three to four year nursery seedlings which are 4 to 6 ft. tall are used for planting out. Seedlings are pulled out from the nursery bed and a ball of earth is applied for planting out. Root-shoot cuttings give good survival per cent but the rate of growth is slow. While planting out, leaves are stripped off except the topmost pair. Planting is done in T-notches.

4. *Assisted Bonsum Regeneration Plot* of 1958.—Area 15 acres. Brushwood cutting was done on 5 ft. wide strips, placed 12 ft. apart, during July and August 1958. Large transplants (6'—14') were planted out 12 ft. apart. Climber-cutting and weedings are continuing. Weedings are necessary only for first two years. Cost of formation varies from Rs. 30 to Rs. 35 per acre.

5. *Assisted Bonsum Regeneration Plot* of 1957.—Area 10 acres. Brushwood and trees of miscellaneous species were felled during June-July 1957. Planting was done in lines 18 ft. apart and 8 ft. apart within the lines. Weedings have been done regularly and the average height of plants is 7 ft. and girth 3 inches. When the plants are fully established the overwood would be girdled or extracted.

6. *Assisted Bonsum Underplanting* of 1943.—Plants have attained a height of 25 ft. and girth of 8 inches.

7. *Assisted Bonsum Underplanting* of 1951.—Area 25 acres. Clearing of brushwood and felling of trees of miscellaneous species together with all the trees of the lower canopy were carried out during May-June 1951. Planting was done during August 1951. Weedings and casualty fillings were continued till 1957. The area is well-stocked with new plants with an average height of 15 ft. and of 6" girth.

8. *Comptt. 3, Sopai Block, Charduar Reserve.*—A soil pit was examined.

16TH APRIL, 1960

Dhekiajuli to Kohora

17TH APRIL, 1960

Kohora to Jeypore—Camp : Jeypore

1. *Hollongapar Reserve, Plot No. Mg/16(b).*—Area 25 acres. It was an attempt to obtain regeneration *de novo*. The operation commenced in 1940. Old trees and selected stems of overwood were marked and sold. Lower storey and shrub layer were retained

except where seedlings came up. In such areas thinning in the overwood and shrub-cutting around the plants were done. Weeding and cleaning operations were perused and repeated for about 15 years. Plants of *Mesua ferrea*, *Magnolia* spp., *Vatica lanceaefolia*, *Baccaurea sapida*, *Pterospermum lanceaefolium*, *Elaeocarpus* spp., etc. have come up, mostly of inferior species. The method of regeneration has not proved an entire success.

2. *Hollongapar Reserve, Plot No. Mg/3a.*—Area 100 acres. Aided natural regeneration operation was taken up in 1925. Top canopy was partially removed and 6 ft. wide strips, 33 ft. apart were cut. Seeds were dibbled and also transplants were planted out. *Hollong* (*Dipterocarpus macrocarpus*) was mostly sown at 6 ft. apart. For the first six years intensive weedings were done. *Hollong* has attained a height of 70 ft. and a girth of 3½ ft. Usually the rate of growth of *hollong* seedlings is about 1½ to 2 ft. per year.

3. *Hollongapar Reserve, Plot No. Mg/5(b).*—Aided natural regeneration area of 1929. A soil pit was examined.

4. *Silvicultural Experimental Plantations at Meleng Centre.*—Rainfall 80", elevation 392 ft.

(a) 1958 *Plantation of Terminalia myriocarpa* (*hollock*): Weedings are done in 4 ft. wide strips, with 3 weedings in 1st year, 2 weedings in 2nd year and 1 weeding in 3rd year. *Hollock* was planted.

(b) 1957 *Plantation of hollock*: Plants have obtained a height of 8 ft.

(c) *Experimental sowings of hollong*: *Hollong* was sown in 6 ft. wide strips, placed 33 ft. apart. Growth of *hollong* is being watched under weeding and no weeding.

18TH APRIL, 1960

Lakhimpur Division, Jeypore Range

1. *Comptt. No. 206, Plot No. JP/1.*—Area 45 acres. Natural regeneration plot of 1929. It is a small hillock with well-drained, yellow and clayey soil. The original forest crop has *hollong* in top storey and *nahor* (*Mesua ferrea*) in the lower canopy. All large-sized trees were removed and lift of the canopy from below was tried. Seedlings of *hollong* and *nahor* were tended on a cycle of 3 years. In 1936, all the miscellaneous species up to 18 inches in girth were removed. *Nahor* has almost completely covered the area. *Hollong* is sporadic. Attempts are still made to increase the proportion of *hollong*. The expenditure so far incurred amounts to Rs. 23.16 nP. per acre.

2. *Comptt. No. 207, Plot No. 10.*—Area 400 acres. Attempts at natural regeneration were made in 1946. However, during 1942 to 1945 fellings were done approximating to the removal of about 2 trees per acre. Intensive cultural operations were carried out and the cost of tending per acre, so far incurred, is Rs. 10.95 nP. Results are satisfactory.

3. *Comptt. No. 207, Plot No. 9.*—The area was worked during 1945-1946. *Makai* (*Shorea assamica*) natural regeneration has not yet fully stocked the area.

4. *Comptt. No. 205, Plot No. JP/8.*—Area 165 acres. The area was worked in 1943-44 and all exploitable trees were removed. First three tending operations were done in alternate years, comprising cutting of climbers, and interfering shrubs and miscellaneous trees. The up-to-date cost incurred is Rs. 13.70 nP. per acre. Regeneration of *hollong* is plentiful, attaining an average height of 50 ft. and a girth of 15 inches. *Nahor* is absent.

5. *Comptt. 237, Shukanjudi Area.*—Crop is predominantly of *makai* (*Shorea assamica*). A soil pit was examined.

N.E.F.A. AREA

6. *Makai (Shorea assamica) Experimental Plantation of 1958.*—A plot of ½ acre was chosen under moderate forest canopy of *Shorea assamica* and stacking was done at 9' × 9'. At each stake one ft. diameter patches were cleared and sown with *Tephrosia candida* on the periphery to provide shade. Both sowing and planting (2-year old transplants) were tried. Average height of plants in both the cases is 2½ ft.

Tinsukia Range, Lakhimpur Division

7. *Borjan Centre, Plot No. 4.*—Area 750 acres. It is a tall *hollong* forest with no *makai*. Middle storey is absent. Exploitation was done in 1940, removing about 2 trees per acre. Cultural operations have been taken up to free the natural regeneration.

8. *Kherjan Regeneration Area, Comptt. 38, Plot No. 2.*—Area 49.75 acres. Regeneration attempts were made in 1948-49. The overwood consists of huge and scattered trees of *hollong*. The area is fully stocked with *hollong* regeneration and looks like a plantation. Av. ht. 35 ft., Av. girth 15'. The overwood should be removed but it will cause lot of damage to young plants.

9. *Kherjan Regeneration Area, Comptt. 38, Plot No. 1.*—Same as above. A soil pit was examined.

19TH APRIL, 1960

1. *Powai Reserve, Comptt. 52.*—The area was worked in 1946-47. *Hollong* trees have been mostly taken out. Young plants are coming up well. A soil pit was examined.

2. *Upper Dehing Reserve, Comptt. 50.*—Area 286 acres. Exploitation was done in 1937-38 and 898 trees were removed. Tending operations were done and *hollong* natural regeneration has come up well.

Tirap Division

1. *Subsidiary Silvicultural Operation Area of 1957.*—After the main fellings intensive cultural operations were carried out at a cost of Rs. 5 per acre. *Miconia cordata* has come profusely through which regeneration of *hollong* and *hollock* is appearing with difficulty.

2. *Aided Natural Regeneration Area of Namphuk R.F.*—Regeneration has come up successfully, particularly in patches.

3. *Naychik Range Aided Natural Regeneration Area of 1952.*—The area was flooded in 1947 and earthquake followed in 1950 and 1951. The whole area got silted up to a depth of about 8 to 10 ft. The new alluvial deposit was colonised by *Saccharum* grass which persisted for 2 to 3 years. In the grass cover, seedlings of *hollock* (*Terminalia myriocarpa*) appeared and the grass was cut. Continued subsidiary cultural operations were carried out to tend the regeneration and the *hollock* plants have attained a height of 40 ft. with an average girth of 15 inches. *Hollong* (*Dipterocarpus macrocarpus*) regeneration is now appearing on forest floor. The area is an interesting example of primary succession in *hollong* forest of Assam-NEFA area.

20TH APRIL, 1960

Jeypore to Kohora

1. *Abhoypur Reserve, Comptt. 17, Plot No. 5.*—Area $\frac{1}{2}$ acre. In June 1947, sal (*Shorea robusta*) sowings were done, followed by hoeing, weeding, etc. Weedings were done till 1951 and thinning was done in 1956. Plants have attained an average height of 32 ft. and a girth of about 13 inches. A soil pit was examined.

2. *Abhoypur Reserve, Comptt. 21, Plot No. 1.*—Area 100 acres. In 1946 the area was cleared of underwood and sown with Smith's mixture (*Terminalia myriocarpa*, *Mesua ferrea*, *Artocarpus chaplasha* and *Amoora wallichii*). Weedings were done in 1947 to 1949 and manipulation of overhead canopy was carried out in 1951. In the young crop *Mesua ferrea* is by far the commonest with a height of 55 ft. and girth 20 inches.

3. *Abhoypur Reserve, Comptt. 18, Plot No. 6.*—Area 100 acres. The original forest comprised of *Artocarpus chaplasha*, *Michelia* spp., *Amoora wallichii*, *Cinnamomum cecidodaphne*, *Mesua ferrea*, etc. Regeneration operations commenced in 1951, by cutting tunnels (4 ft. wide and 24 ft. apart) in the underwood. Sowings and plantings were tried on the cleared lines, with such species as *hollong*, *nahor*, *bonsum*, *amari*, *Artocarpus chaplasha*, etc. In 1956, miscellaneous species in the overwood were felled. *Hollong* (*Dipterocarpus macrocarpus*) has come up well. Plants in gaps have developed the best. They have attained a height of 15 ft. and a girth of 3 inches. Overwood should be cleared, preferably in two stages.

4. *At Kohora.*—Assam State Symposium was held. Summary of discussions is given separately.

21ST APRIL, 1960

Kohora to Shillong

22ND TO 24TH APRIL, 1960

At Shillong

Plenary Session of the Evergreen Symposium was held. Summary of discussions is given separately.

SOILS OF THE TROPICAL MOIST EVERGREEN FORESTS OF INDIA

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Introduction

Soils of the tropical evergreen forests are formed under conditions of heavy rainfall and high atmospheric humidity with a moderate temperature for the greater part of the year. The average annual rainfall is usually much above 60 inches and the morning atmospheric humidity is seldom less than 80 per cent. These soils bear the most luxuriant vegetative growth which prevents a major portion of the sunlight from reaching the ground and thus greatly minimises the desiccating effect of the sun. Since the trees occurring in these communities have a higher physiological need for moisture than their counterparts growing in drier areas, it is essential that the local soil should possess a high water-storage capacity to meet the demand. This largely depends upon the texture, structure, stoniness, depth and slope of the soil and on the depth of the ground water level. Even in certain evergreen forest regions it is not uncommon to find patches of mixed deciduous vegetation on the soils which have a very low water retaining capacity due either to their very coarse texture or to their open nature. The pockets of deciduous growth on such soils are more marked, especially if the annual rainfall is confined to a relatively short period. In these localities the evergreen forests tend to occupy shady valleys and moist cool aspects where conditions are comparatively more favourable.

General Features

Soils of the above climatic region are characterised by wide differences in many physical and chemical properties, depending upon elevation, parent material, topography and other factors. They differ in their capacity to resist erosion and to maintain a humus reserve. A thorough knowledge of these differences is of considerable importance in understanding the distribution and composition of the vegetation. A majority of these soils, however, have certain properties in common. Beadle (1954) stated that the rain forests occur on the soils of a high phosphorus content. In general, the soils of the evergreen forests are red, yellow or dark in colour and are acidic in nature with a low content of bases. They do not usually support tree species which have a relatively high demand for elements like calcium. As a result of leaching the older soils become depleted of silica and are enriched in sesquioxide; the ratio of silica to sesquioxide serves as a useful index of the extent of maturity of these soils. The red colour of the tropical soils is mainly due to the presence of iron oxide, and it changes to yellow in areas where the iron oxides are more highly hydrated. On the whole, these soils can be divided into two broad groups—(i) soils in the uplands developed from the bed rock, and (ii) soils in the low lands developed from the alluvial material brought from the uplands and deposited in the lower positions. The soils of the former group are relatively shallow, poor and rocky, while those of the latter are deep, fertile and fine-textured.

Differences between soils of temperate and tropical regions

Broadly speaking, soil formation both in the tropics and in temperate regions is widely associated with accumulation and subsequent hardening of free sesquioxides. These accumulations are apparently similar in their morphological features, but they take place in different ways and in different geological periods thus enabling a distinction to be made between the soils of the two regions. In the soils of the temperate regions, sesquioxides are translocated and accumulate in the lower horizons, leaving behind silica in the surface layer. This results in a high silica-sesquioxide ratio of these soils. In tropical climate, the decomposition of silicates is accompanied by a removal of silica, leaving free alumina and ferric oxides in the upper layers of the soil, which result in a low $\text{SiO}_2/\text{R}_2\text{O}_3$ ratio. The consequent red colour is further intensified by a low content of dark humic substances and a high degree of oxidation, and constitutes a characteristic morphological feature which distinguishes the two soils. In brief, under humid tropical conditions leaching of silica predominates in contrast to that of sesquioxides in the temperate climate, the laterite soil being the most characteristic soil type of the former. The dark-red, hard and infertile wide sheets of laterite commonly found in the tropics have led many to conclude that this is the final residue of soil forming processes and represents the death of the soil.

In temperate regions the prevailing low temperatures reduce the biological activity to a minimum and bring about accumulation of raw humus at the surface. Under these conditions the vegetative material affects soil development after its return to the ground surface and during its subsequent humification. On the other hand, tropical soils associated with a high temperature and adequate moisture status are characterised by intense biological activity, rapid decomposition and mineralisation of organic matter and expensive turn-over of the plant nutrients. This offers an explanation for a relatively low accumulation of organic matter in the tropics, although an enormous quantity of vegetative debris falls on the soil surface every year. A rapid circulation of the plant nutrients by the luxuriant vegetation is one of the most characteristic features of the soils of the tropical moist evergreen forests. This shows that unlike temperate regions living vegetation is the more directly active soil forming agent in the tropics. However, the soils and vegetation of the tropical and temperate regions differ in that the generic nature of the vegetation is of little significance in the former. Owing to a rapid oxidation of organic matter in the tropics very little humus is leached down. Mohr (1930) stated that above an average temperature of 15° C no organic matter is carried in the water of a well-aerated soil.

In general, soil formation under tropical conditions differs from that under temperate climate by having a different rate of mineralisation of organic matter. Under the former, mineralisation of the organic matter is more important than humification and, therefore, carbonic acid is the principal soil forming agent, whereas the role of organic acids is of a minor significance. At higher altitudes in the tropics, however, the conditions are relatively more like those prevalent in a temperate humid climate where the decomposition of organic matter is less rapid. Consequently, both carbonic acid and humic acids influence soil formation. Schuylenborgh (1958) has reported the following data on the relationship between the temperature and the rate of decomposition of organic matter under humid tropical conditions.

Temperature	Rate of destruction of organic matter	Aoo horizon
16.5-20°C (low)	slow	thick (3-5 cm)
20.0-22.5°C (moderately high)	rapid	moderately thick (2-3 cm)
22.5-26.5°C (high)	very rapid	thin (0-1 cm)

According to the above worker humic acid is a more important soil forming factor than carbonic acid at altitudes higher than 1,000 metres under a monsoon climate. Hong and Schuylenborgh (1959) quoted the following formula to calculate temperature t° in degrees centigrade in relation to the elevation h in hectometres $t^{\circ} = 26.3 - 0.6 h$.

The solubility of the decomposition products of the primary minerals determines to a large extent, the relative mobility of Al_2O_3 and Fe_2O_3 at different altitudes. Since Al_2O_3 is more soluble in water than Fe_2O_3 , the former is much more mobile than the latter at the lower altitudes. Reverse is the case at higher altitudes where the two elements form complexes with humic acids. The iron complexes are more soluble than the aluminium complexes with the result that iron is more mobile than aluminium. This leads to a decrease of the molar Al_2O_3/Fe_2O_3 ratio of the clay in the lower layers. It has been observed that laterization ascends to higher altitudes under less humid conditions.

In tropical climate itself, soils show wide variations according to moisture conditions. In an earlier communication Yadav (1960) stated that the soils of dry zones, which develop under conditions of high temperature and aridity with scanty rainfall, are characterised by high pH values, greater amount of bases and a low content of organic matter. A restricted leaching of the soil ingredients results in an ill-defined profile development. Soils of the moist region, on the other hand, have low pH values, deficient amount of bases and a variable content of organic matter. Intensive leaching which takes place in these soils, is mainly responsible for a poor base status and results in a relatively better profile development. Under arid conditions, the influence of vegetation on the soil is still less marked as compared to the moist areas. Ray Chaudhuri (1941) recognized three broad soil types in the moist tropical region of India : (i) red loams, (ii) red earth, and (iii) laterite soil.

- (i) Red loams characterised by argillaceous soil with cloddy structure and presence of only a little concretionary material.

- (ii) Red earths where the top soil is loose and friable but rich in concretions of sesquioxide character.
- (iii) Laterite soil where the surface is more akin to red earths but with the presence of a definite layer of vesicular laterite earth below.

Clay Minerals

As a result of peculiar conditions of weathering and leaching most soils in the areas of tropical evergreen forests appear to be composed chiefly of kaolinite clay mineral. The important factors in determining the constitution of the clay fraction of the soils are the inherent base status of the parent material, the leaching potential of the environment and the age of the land surface. A preponderance of kaolinite type minerals is often associated either with soils derived from acid rocks of low inherent base status, or with conditions of prolonged leaching. A large proportion of kaolinite appears to be related to the low base exchange capacity, poor nutrient retaining capacity and narrow range of available moisture of these soils. Grim (1942) found the following ranges of base exchange capacity for the various pure clay minerals :—

Kaolinite	3-15 m.e. per 100 g.
Illite	20-40 m.e. per 100 g.
Montmorillonite	60-100 m.e. per 100 g.

Montmorillonite is the dominant clay mineral present in the black cotton or *regur* soils, while illite is more commonly associated with the alluvial soils. Since most soils contain two or more clay minerals, a known base exchange capacity does not necessarily give direct evidence of the nature of the clay mineral. Nevertheless, a low value might indicate the predominance of kaolinite. The soils formed under higher rainfall are in general more leached and more deeply weathered than those in the lower rainfall and thus relatively richer in kaolinite.

Important factors which influence the soil characteristics

(a) *Parent material*.—Parent material plays a vital role in influencing the character of soil derived from it. However, a difference in temperature and other environmental factors with a change in the altitude is, at places, responsible for the development of different soils on the same parent material, as evidenced by the occurrence of mixed black and red soils in certain localities. Seth (1959) described in detail the effect of different geological formations on the nature and composition of soils formed from them. In general, basic igneous rocks give rise to fine-textured, dark-coloured, fertile and less acidic soils, while the acid counterparts produce coarse-textured, red, poor and acidic soils. In areas where granites and schists occur together, they produce distinctly different soils. Granites are coarse-textured and massive, and disintegrate slowly. Schist is highly metamorphosed and disintegrates more rapidly, thereby forming localities of low relief. Soils derived from granite are coarse-textured, light-coloured and relatively infertile, whereas those formed from schist are medium-textured, brown and often moderately productive. Much of the fine material appears to develop from micas contained in the schist, while sand and gravel are mostly derived from feldspars and quartz contained in the granites. Likewise, other rocks, e.g. sandstone, limestone exert specific effects in governing the properties of soils. It would appear from a later discussion that the effect of geology on soil formation is most marked in the Andaman island.

(b) *Topography*.—The land in the zone of tropical moist evergreen forests is, in general, hilly and precipitous and is intersected by numerous narrow ridges and valleys. The soils on the hill tops, ridges and upper slopes are coarse, shallow and poor; the soils on the middle and lower slopes, except where subjected to intensive erosion, are fairly deep and moderately fine-textured, and those in the valleys are very deep and fertile. The drainage of the soils is obviously better at higher elevations than in valleys. This leads to the formation of red soils on the top of hills and yellow soils in the valleys.

Jenny et al. (1948) found that the nitrogen content of the Colombia soils increased markedly with altitude and decreased with mean annual temperature. The C/N ratio also increased with altitude and decreased with temperature. The remarkable effect of elevation on weathering of minerals and leaching of the elements is well illustrated by the analytical data (18) from laterite soils of Malabar area which indicate that the silica-sesquioxide ratio and pH values generally increase as the elevation decreases.

Elevation	pH	SiO ₂ /R ₂ O ₃
6,500 ft.	4.04	1.32
4,200 ft.	3.61	1.66
3,000 ft.	4.28	1.79
1,200 ft.	5.77	2.08

However, the significance and value of SiO₂/R₂O₃ ratio may be more important in the case of igneous rock-weathering products and soils, and less in the case of sedimentary rock products.

The development of soil on any site is mainly determined by the local topography through its effect on water movement, especially in areas which receive medium rainfall. Three principal soil types are distinguished for the three categories of topographical sites: (i) High level sites are occupied by soils called *eluvial* on account of eluviation of the soil profile either by downward movement of the dissolved and suspended material in the soil horizons or by the washing away of particles from the surface, (ii) Slopes have soils called *colluvial* which are formed from the material left after the eroded particles from above have been sorted out, depending upon their density; (iii) Low lying sites have soils called *illuvial* which are formed by an accumulation of all such colluvial material which is not retained on the adjacent slopes. In certain areas these sites also receive alluvial material brought from a distance chiefly by the agency of water. The relative proportion of alluvial and colluvial material depends on local relief and rainfall.

The texture becomes finer in the lower horizons and also from eluvial to illuvial soils. All soils are generally acidic, the acidity being more in eluvial than in illuvial soils. The SiO₂/R₂O₃ ratios of comparable eluvial samples vary inversely with the rainfall. This ratio is highest in illuvial soils. Such a topographical sequence of soils is termed *catena*. The vegetation, which develops on the three types of sites is intimately related to the nature of soils and follows the same pattern as the *catena*. Further variations in the type of soils and vegetation on a given topographical unit are brought about by changes in micro-relief and are of considerable significance at times. Such topographical patterns of soils and vegetation have been observed by numerous workers under tropical conditions (Greenwood 1938, Vine 1941, Morison et al. 1948 and Nye 1955).

The depth of soils, which often varies from a few inches to several feet according to the topographical features, plays an important role in conditioning tree growth. The shallow soils are associated with a low water-retaining capacity and provide limited exploitable volume for the development of the root system. The ill-effects of moisture deficiency are still accentuated if the nutrient status of such soils is also low. The deeper soils with better moisture relations, higher nutrient reserve and greater exploitable volume afford a favourable environment, unless the presence of an impermeable layer, or of a badly structured horizon in the profile becomes a limiting factor by reducing the feeding zone of the root system.

(c) *Organic matter*.—Under an evergreen forest canopy a large quantity of vegetable debris falls on the surface. It is estimated (3) that about 20 tons of organic material is added per acre every year. The vegetable debris, which decomposes rapidly through the prevalent intense microbial activity, helps in returning the nutrients and in maintaining the overall fertility, especially of the upper layers of the soil. It is not wrong to say that the evergreen forests build up the fertility of their soils themselves. There is, however, a great variability in the nature and quantity of the organic material deposited on the floor, depending upon the site, stocking, species and age of the forest flora. There is some evidence to indicate that the litter of the subordinate vegetation in the forest stands has its own significant contribution in the maintenance of the general nutrient cycle.

The importance of humus in creating soil fertility is more marked in the case of shallow soils overlying the bed rock, which are otherwise of a very poor quality. However, in areas where accumulation of organic matter is prevented by rapid surface run-off, the soil is usually very low in fertility. From the soil fertility point of view it becomes highly desirable to preserve the humus layer. Attempts should be made to adopt those silvicultural and

management practices which not only increase timber production but also assist in preserving the humus in such sites. Every care is required to check erosion wherever it creates a problem by removing this important ingredient.

The tropical moist evergreen forests of India cover an appreciable area which can be divided into three major regions : (1) The Western Ghats of the Peninsula, (2) Eastern Sub-Himalayan tracts and Upper Assam, and (3) Upper slopes of the hills in the Andamans. According to the soil map of the country (1954) prepared by the Indian Agricultural Research Institute, New Delhi, the following nine soil groups are recognised in these regions :

1. Laterites (high and low level)
2. Red loam
3. Laterite soil (old alluvium)
4. Medium black soil of trap and gneissic origin (plateau)
5. Red gravelly soils
6. Alluvial soils
7. Hill soils
8. Mixed red and black soils
9. Coastal alluvium (new).

The various physical and chemical characteristics of the important soil groups have been described in detail previously by Yadav (1960), and as such these details have been deliberately omitted in the present paper. Out of the soil groups mentioned above, the laterite soils and red loam appear to occupy the largest area in this zone. General characteristics of the soils found in the three major regions are given separately.

1. Soils of the Western Ghats

General features.—The Western Ghats, in the evergreen forests zone lie several miles from the Arabian sea in north to south direction, and the whole region is hilly and undulating with a slope towards the west. A series of hilly ridges project out from the main ghats. This region receives a heavy rainfall from the south-westerly monsoon, and covers most of Kerala State and parts of Mysore and Madras States. The evergreen forests occur at an altitude ranging from about 200 to several thousand feet.

The region of Western Ghats can be divided into three physiographic units: (i) hills, (ii) valleys, and (iii) sea coast. The eastern portion is very rugged with broken hills intersected by many rivers. The broad sea belt consists of sandy soils, and the mainland between these two areas contains residual laterite. The hilly land in the western part of Mysore State, called Maland, comprises of Shimoga, Kadur and Hassan districts. This tract forms the eastern face of the Western Ghats and is a part of the continuous belt of the evergreen formation.

Geology.—The ghats consist of old crystalline rocks. Granites and gneisses, considered to be of archaen age, are the chief geological formations, but they are frequently traversed by other rock series, viz. schists, quartzites etc. Gneisses are mainly of biotite type. Lateritic formations are of widespread occurrence and are found largely in a belt at varying depths on the hills. Alluvium occupies the river banks. Grey fossiliferous limestones, which are associated with a series of sands, clays and shales and are capped by laterite, resemble Cuddalore sandstones and occur largely in Travancore.

Soils.—The following main soil groups are met within this region :

1. Laterites (high and low level)
2. Red loam
3. Medium black soils (plateau)
4. Hill soils (undifferentiated)
5. Red gravelly soils
6. Alluvial soils including coastal alluvium
7. Mixed red and black soils.

Red soils cover a very large area in the Peninsular India outside the area of Deccan trap and a strip of coastal alluvium. They vary greatly in fertility, but are in general deficient in nitrogen, phosphorus and lime. They are derived from micaceous granite and gneiss, and are acidic. They are sometimes found mixed with other soils. They are sandy loam to clayey loam in texture and have a low nutrient holding capacity. The texture of the soil depends largely on the relative proportion of kaolin, silicic acid and ferric hydroxide and these proportions vary with the mineralogical make-up of the rocks. The presence of iron compounds makes the resulting soil more open and easily drained. An admixture of sandy material from an adjacent quartzite or sandstone renders the resulting soil a red heavy loam.

Laterite soils are both *in situ* and sedimentary formations and are relatively much poor in almost all the plant nutrients, viz. nitrogen, phosphorus, potash and calcium. The low fertility status combined with their hard vesicular structure makes them unfavourable for the growth of economic tree species. These soils have poor water holding capacity, acidic reaction and a low base exchange capacity. The general morphological description of a laterite soil from Malabar district is given below.

0 - 6 in.—Generally red, gravelly loam.

6 - 65 in.—Red, gravelly loam, murrum laterite mixed with plenty of nodular iron in concretionary pieces.

Below 65 in.—Red soil mixed with yellowish white material, honey-combed laterite rock, yellowish material entrapped in the vesicles.

Alluvial soils are not so important as the red or laterite soils in this tract with respect to the growth of evergreen forests. They occupy small pockets in the low-lying situations or along the coast. The composition of the strata varies with the nature of the material brought from outside. These soils are deep and have near-neutral pH values. They are poor in nitrogen content, average to low in phosphates, but are usually rich in potassium, lime and many other plant nutrients.

Black soils are more fertile and have a higher cation exchange capacity than the red counterparts. They contain an appreciable quantity of lime, magnesia, potash, iron and aluminium, but are poor in nitrogen, organic matter and phosphoric acid.

Peaty or *Kari* soils are particularly found in certain areas of Kerala State and owe their origin to the accumulation of large quantities of organic matter. They are black, heavy and highly acidic, the pH being as low as 3.9. The acidity is due to the decomposition of organic matter under anaerobic conditions. They contain 10-40% organic matter, 0.2-0.7% K_2O and 20-30% sesquioxides.

Analysis of a large number of soils from the areas having tea and coffee plantations has been undertaken. The data show that tea soils are clayey loam to sandy loam in texture and have pH values in the range of 4.5 to 6.5. They are deficient in bases and phosphoric acid, but are rich in organic matter and nitrogen, the nitrogen content being rarely less than 0.1 per cent. Because of their lateritic nature they contain about 20 to 35 per cent of sesquioxides. The coffee soils are fairly coarse in texture with near-neutral pH, and are rich in nitrogen, available phosphoric acid and potash, but contain only a fair amount of organic matter (i.e. 5 to 7%).

2. Soils of Andamans

General features.—The terrain in the Andaman islands is mostly hilly and undulating with an irregular and broken surface. There is almost no level ground except a few scattered alluvial plains, especially in the middle Andamans. The ridges on the eastern side of the islands are, in general, higher than those on the west; the slopes of the hills in the latter are frequently precipitous. Numerous tidal creeks penetrate far inside these islands and receive drainage of the inland area. The area under evergreen forests includes the upper slopes of the hills and micaceous sandstone sub-strata in the south and middle Andamans.

Geology.—Two geological formations are of more common occurrence, (1) Eocene sedimentaries which consist of sandstones and conglomerates, and (2) serpentine series. In the middle Andamans the serpentine series consist of jaspars, limestone and quartzites with occasional outcrops of calcareous gneiss. In the main group of these islands, i.e. north,

middle and south Andamans, the predominant formation is that of sedimentaries, whereas serpentine series of igneous rocks occupy the hills and ridges and at places appear as outcrops. In the other associated islands only one of the two formations usually occurs to the virtual exclusion of the other.

Soils.—The Andaman islands appear to represent a tract where the nature of the soil is governed largely by the kind of geological rock from which it is formed. The sedimentary rocks give rise to a coarse and infertile sandy loam soil which is excessively permeable. The serpentine series of igneous rock, on the other hand, produce a deep and fertile dark red loam which is relatively less permeable. However, in areas which lie along the banks of the streams, or which form valleys, low lying situations and inner extensions of the tidal flats, the role of the underlying rock in conditioning the nature of soil is of least significance. These areas are occupied by alluvium which is transported by water from elsewhere and, therefore, it has no genetic relationship with the underlying rock.

Unfortunately, precise information on the physical and chemical characteristics of these soils is entirely lacking, since no systematic soil study or survey worth the name seems to have been undertaken in these islands. There is no doubt that in view of the great economic value of the forests in these islands, a systematic study of the soils is an urgent necessity for a thorough understanding of the soil-vegetation complex.

The nature of soil appears to be an important factor in influencing the growth, composition and distribution of the forests. It is not uncommon to find the evergreen and deciduous vegetation under similar conditions of rainfall, climate, elevation, topography etc.; the difference in the soil condition is the chief predisposing element for this varied growth. Owing to a relatively fine texture and great depth the soil produced from the serpentine series is capable of retaining large quantities of moisture for a long period. This ensures plentiful supply of moisture throughout the year and affords favourable conditions for the growth of evergreen forests. The coarse and porous soil derived from the sedimentary rocks, on the other hand, is able to hold little water, thereby creating drought conditions which allows deciduous vegetation to grow. In a region of sedimentary rocks clothed with deciduous vegetation the outcrops of the serpentine series become markedly conspicuous by the dense cover of the evergreens (mainly *Dipterocarpus* spp. and *Artocarpus* spp.). In general, the alluvial soils carry dense magnificent forests of *Dipterocarpus alatus* along with other species.

3. Soils of Assam

General features.—The area under evergreen forests in this region includes Sikkim, slopes of the Eastern Sub-Himalayan range and Upper Assam. The evergreen forests of Assam occupy a major portion of Lakhimpur, Sibsagar and Cachar districts, and almost a continuous narrow belt along the foot of the Himalayas stretching from the extreme north-east corner to the west. *Dipterocarpus macrocarpus*, *Mesua ferrea*, *Shorea assamica* and *Terminalia myriocarpa* are the principal species.

The State of Assam can be divided into two main physiographic tracts—(i) the valleys, of the rivers, and (ii) hill ranges. The Brahmaputra and Surma valleys, which constitute the alluvial plains, are of greater importance. Each is bounded on three sides by the hills. A large quantity of silt is deposited by the rivers along their banks which are, at places, raised much higher than the neighbouring country. Since these rivers traverse tracts of different geological formations the composition of the alluvium varies from place to place. The Assam range of the mountains separates the Surma and Brahmaputra valley and lies in a east-west direction. The hills are intersected by numerous streams. The low-lying areas in the north contain a good deal of “kulkani” land which is dotted with a series of mounds of varying size believed to be formed from the casts of earthworms.

Geology.—The geological formations of the State of Assam, as described by Evans (1927), consist of the following:—

1. Sedimentary—(a) Alluvium, (b) Tertiary, (c) Cretaceous, and (d) Gondwana.
2. Igneous and metamorphic.

Alluvium occupies a large part of the State and is of a varied character. Tertiary beds include a variety of sandstones, conglomerates and shales, and represent many series

such as Dehing series, Tipan series, Surma series etc. Cretaceous beds are mainly sandstones, conglomerates and shales. Gondwana beds include quartzite and shales also. On the whole, igneous rocks are not many, but basalt is the most important member. Gneisses, schists and quartzites constitute the older metamorphic rocks. Granite and dolerite are found as intrusions into the metamorphic rocks. Most of the low hills, which consist of the Shillong metamorphic complex, are composed chiefly of gneiss similar to that forming the Peninsula. A large part of the area covering Shillong plateaus and the north Cachar and the Naga hills is occupied by metamorphic rocks of great age, schists, quartzites, and gneisses with intrusions of granites, dolerites etc. The gneiss is made up of magnetite and very little of hornblende and mica. Many of the tea gardens overlie the beds of Tipan series. The valley plains owe their origin to the alluvial material brought down by the Brahmaputra and its tributaries.

Soils.—Broadly speaking, the soils on the old alluvium and on the hills, which have undergone weathering and which are easily amenable to the effects of leaching, have an acid reaction. The new alluvial soils adjoining the river banks are less acidic and are very frequently neutral or even alkaline. The acidity of the soil appears to increase with rainfall and heaviness of clay. As compared to the soils of the valleys, those on the hills have a higher content of organic matter and nitrogen presumably due to their virgin nature. The soils of the State can be classified into the following principal groups :

1. Alluvial soils
2. Red loam
3. Laterite soil (old alluvium)
4. Laterites (high and low level)
5. Hill soils.

1. *Alluvial soils.*—The alluvium of Assam valley is supposed to be resting upon a bed of gneiss which lies at a great depth. Alluvium includes a large variety of soils from coarse water-borne stony deposits to silts of the finest texture. According to the age and formation the alluvium is divided into two classes (a) recent alluvium, and (b) old alluvium. The two types of alluvium show considerable variation in their physical and chemical composition according to the nature of geological formations from which they have been brought down by the rivers. The recent alluvium is best represented by the deposits of the Brahmaputra river. This is characterised by a grey thin top layer of silty loam with a subsoil of coarse sand, occasionally mixed with pebbles and boulders, and has a higher content of colloidal material. The old alluvium is best represented by the deposits of the Dehing river, and has a characteristic yellowish to reddish colour indicating a high degree of oxidation. This alluvium lies at a higher elevation than the former and can be seen to appear in pockets through the new alluvium at some places. The soils of the old alluvium are generally deep and loamy with occasional beds of fairly pure clay and frequent patches of coarse sand which are mixed with boulders. The recent alluvium is near-neutral to alkaline in reaction, while the old alluvium is acidic in reaction and has a relatively higher content of organic matter (2).

According to the local classification the alluvial soils are divided into two distinct groups (a) Brahmaputra series, and (b) Dehing series. The soils of the Brahmaputra series are derived from the eastern Himalayas composed mainly of volcanic rocks with a narrow fringe of Gondwana and Tertiary rocks. They are rarely more than three feet deep and are almost neutral to alkaline in reaction, the pH lying in the neighbourhood of 6.1 or higher. The soils of the Dehing series, on the other hand, are derived from the Patkoi hills composed entirely of Tertiary rocks. These soils are relatively much deeper and are acidic in reaction with an average pH of 5.2 to 5.5. In general, the soils become finer in texture with a proportionate increase in acidity and humus from north to south. The absence of tea gardens in the tract of Brahmaputra series can be attributed mainly to the higher pH values of these soils. The analytical data of the soil samples from different areas located in Dehing alluvium are given below which show a considerable variation in their composition (15).

Item of analysis	Zone I		Intermediate zone between I & II	Zone II	Zone III
	South Tingari	Dum Duma		Dibrugarh	Hakati
			Panitola		
<i>Mechanical analysis</i>	%	%	%	%	%
Coarse sand	31	29	26	13	6
Fine sand	28	30	27	35	11
Silt	16	16	22	26	36
Fine silt	10	7	6	4	23
Clay	10	12	13	17	14
Loss on ignition	4.62	5.16	5.44	4.16	7.25
<i>Chemical analysis</i>					
Granddeau organic matter	1.64	1.86	1.37	1.51	—
Nitrogen	0.113	0.109	0.131	0.090	—
Available phosphoric acid	0.007	0.017	0.011	0.006	—
Available potash	0.007	0.016	0.017	0.008	—
Available lime	0.057	0.057	0.061	0.025	—
Acidity (Hopkins)	533	130	190	560	—
Insoluble siliceous matter	87	84	83	82	—

Dum Duma and S. Tingari—soil in a belt along the foot of Naga hills.

Dibrugarh—soil in a belt far away from Naga hills.

Panitola—soil intermediate between Dibrugarh and Dum Duma.

Hakati—soil on the north bank of the Dangori river, which represents the Brahmaputra alluvium.

An examination of the data reveals that soils of zone I contain more coarse sand and less fine fraction than those of zone II. The soils of zone III, on the other hand, contain the highest proportion of fine fraction and the lowest amount of coarse material. Chemically, the Dum Duma soils appear to contain a somewhat higher percentage of organic matter, nitrogen, available phosphoric acid, available potash and available lime as compared to the Dibrugarh soils, although soils of S. Tingari are more akin to the latter.

The two soil series support two distinct types of forest vegetation, namely (a) *Hollock* (*Terminalia myriocarpa*) community in the zone of Brahmaputra series, and (b) *Hollong* (*Dipterocarpus macrocarpus*) community occurs on the soils of Dehing series, since the requirements of the two species for soil pH and moisture content are different. *Hollock* is able to thrive on soils of low acidity and of higher moisture content, whereas *hollong* requires a perfectly drained sandy loam soil having acidic reaction. Besides, there are other instances to show that a difference in the soil conditions plays a vital role in the distribution of the species. *Vatica lanceaefolia*, *Forrestia hookeri*, *Calamus* spp. and *Pinanga gracilis*

grow in low-lying areas with high moisture status; *Girardinia heterophylla*, *Flogocanthus thyrsiflorus* and *Calamus leptospadix* are found on well-drained soils at the foot hills; and *Meliosma simplicifolia* prefers sandy situations.

2. *Red loam*.—Raychaudhuri (1941) has examined several profiles of red and laterite soils of Assam. Morphological description of a typical red loam profile is given below:—

Locality—Nongpoh, Khasi and Jaintia hills.

0-6 in. Reddish grey, loamy, granular, plant roots.

6-42 in. Yellowish, loamy, columnar, small iron nodules.

42-50 in. Blackish red clayey, concretinary.

50-72 in. Red, clayey, concretinary.

The red loams are argillaceous and have been found to be weathered to a greater or less extent. Raychaudhuri and Mukherji (1941) showed that the profile samples of red soils from Assam seem to contain considerable amount of unweathered materials, as revealed from the comparatively small proportion of the total which is dissolved by boiling hydrochloric acid and subsequently by potassium hydroxide. All the red soils of Assam appear, therefore, to be immature and may be classed, with a few exceptions, as red loams. Analytical results of a typical profile of red soil from Assam are given below:

Depth	Total SiO ₂ (acid and alkali soluble)	R ₂ O ₃ in Hcl extract		SiO ₂ /R ₂ O ₃ (molar)
		Al ₂ O ₃	Fe ₂ O ₃	
0-3 in.	11.4%	7.8%	19.5%	1.0
3-20 in.	10.8	9.0	10.0	1.2
20-32 in.	11.4	6.6	15.6	1.2
32-48 in.	7.9	4.1	4.0	2.1

The red bank soil has been recognised to be a predominant soil type of Assam (Meddlit, 1855 and Coulson, 1942). This soil type is mostly associated with the Tipan sandstones which are found all over Assam, and is distinctly more reddish and heavier than the common old alluvium soils. The red bank soil is regarded as archaean, since it is believed to represent the sediment laid down in Thetys sea many thousands of years ago. The red colour is due to the ferruginous material contained in them.

A large number of soil samples have been analysed by the Indian Tea Association for their mechanical composition and other properties. From the results of the various analyses it is possible to recognize many local types. Almost all textural grades are distinguishable, e.g. clayey, loamy, sandy, silty or a combination of them.

The characteristics of the laterite soils are similar to those found in Malabar area.

Sub-montane tract.—This tract lies in the north along the foot hills and includes two main soil types—(1) Bhabar and (2) Tarai. The Bhabar soil occurs at the foot of the hills and consists of a layer of sandy loam underlain by deep deposits of water-borne boulders of sandstone, quartz, schists and conglomerates. Because of the porous nature of the soils this formation does not retain adequate moisture and remains dry in spite of a heavy annual rainfall. The Tarai soil is clayey in texture and contains a deep humus layer. Unlike the former this soil is associated with an excessive amount of moisture due both to the high water table and to a relatively greater content of silt and clay fraction.

Conclusions

From the foregone account it is evident that the soils of tropical moist evergreen forests differ widely in many fundamental characteristics, namely depth, texture, structure, porosity, drainage, moisture storage capacity, pH and nutrient retaining power, all of which influence tree growth although in general they are characterised by a breakdown of silicates, leaching of silica leading to a low SiO₂/R₂O₃ ratio, acidic reaction, deficient base status and a rapid decomposition of organic matter. A large quantity of vegetable debris, which falls on the soil surface every year from the growing luxuriant vegetation, helps in maintaining the soil fertility as a result of heavy turn-over of nutrients. However, there appear to be certain sites where soils are unable to retain adequate amounts of moisture, humus, and plants nutrients presumably owing to their shallowness, coarse texture or erosiveness, and

may fail to support sustained growth of the forests for an indefinite period. The situation is still aggravated by the intense competition for nutrients that exists between the various main and associate species.

Despite the immense potential of the evergreen forests and the profound influence that the soil conditions have on their production, it is indeed regrettable that relatively very scanty information is available about these soils. Systematic studies on the following aspects are necessary in order to gain precise knowledge of the entire soil-vegetation complex with the ultimate object of adopting most suitable silvicultural and management practices in the forests.

1. To evaluate the type, and extent of competition for nutrients and moisture that may exist between the principal and subordinate species.
2. To determine the kind and amount of vegetable debris that falls on the floor under each forest community and also its rate of decomposition.
3. To assess the effect of organic matter on the physical and chemical properties, particularly the nutrient cycle of the soils.
4. To examine the nutrient supplying power of the soils in relation to the requirement of the important tree species.
5. To estimate the capacity of soils for retaining moisture, humus and nutrients under different topographical conditions.
6. To evolve soil suitability index for the important species.
7. To study the regeneration status of the economic trees under varied edaphic factors.

REFERENCES

1. Beadle, N.C.W. (1954)—Soil phosphate and the delimitation of plant communities in Eastern Australia. *Ecology* 35 : 370-75.
2. Bor, N.L. (1938)—A sketch of the vegetation of the Aka hills, Assam—A synecological study. *Ind. For. Rec. (N.S.)*, Vol. I (4).
3. Champion, H.G. (1936)—A preliminary survey of the forest types of India and Burma.
4. Coulson, A.L. (1942)—Water supply of the Darrang District, Assam, *Mem. Geo. Sur. India*, LXXX, Water Supply paper No. 3, 1941. Govt. of India Press, Calcutta, 1942.
5. Deans, H.S. (1936)—Working plan for the Andaman forests, 1936-66.
6. Evans, P. (1926)—A summary of the geology of Assam.
7. Greenwood, M. (1938)—Some Gold Coast soils. *Third West Africa Agric. Conf. Papers* 101-18.
8. Grim, R.E. (1942)—Modern concepts of clay minerals. *J. Geol.* 40 : 225-75.
9. Hong, T.K., & Schuylenborgh, J. van (1959)—On the classification and genesis of soils, derived from andesitic volcanic under a monsoon climate. *N.J. Agric. Sci.* 7 : 1-21.
10. Jenny, H., Bingham, F., and Badilla-Sarravia, B. (1948)—Nitrogen and organic matter contents of equatorial soils of Columbia. *Soil Sci.* 66: 173-186.
11. Meddicot (1955)—Geological notes on Assam and the Hill to the South. *Mem. IV*, 3, 416.
12. Mohr, E.C.J. (1930)—Tropical soil forming processes and the development of tropical soils. Translation by R.L. Pendleton, Univ. Philippines Expt. Sta. contribution No. 655, pp. 214.
13. Morison, C.G.T. et. al. (1948)—Tropical soil vegetation catenas and mosaics. A study in the south-western part of the Anglo-Egyptian Sudan. *J. Ecol.* 36: 1-84.

14. Nye, P.H. (1955)—Soil forming processes in the humid tropics. *J. Soil Sci.* 6: 51-83.
 15. Purkayastha, C. (1936)—Working Plan for the plains reserve on the south bank of the Brahmaputra river in the Lakhimpur division, Assam, Appendix I, page 119.
 16. Raychaudhuri, S.P. (1941)—Studies on Indian red soils III. General morphological characteristics of some profiles. *Indian J. Agric. Sci.* 11: 220-235.
 17. Raychaudhuri, S.P. and Mukherji, M.K. (1941)—Studies on Indian red soils IV. Nature of the weathering complex as determined by the Van Bemmelen-Hissink method of HCl extract. *Indian J. Agric. Sci.* 11: 236-242.
 18. Report (1953)—All India Survey Report. *I.C.A.R. Bull.* 73.
 19. Schuylenborgh, J. Van. (1958)—On the genesis and classification of soils derived from andesitic tuffs under humid tropical conditions. *N.J. Agric. Sci.* 6 (2) : 99-111.
 20. Seth, S.K. (1959)—Management of dry zone soils. *Ind. For.* 85 (2): 75-109.
 21. Vine, H. (1941)—A soil catena in the Nigerian Cocoa belt. *Farm and Forest* 2: 139-41.
 22. Yadav, J.S.P. (1960)—Soils of the dry zone of India. *Ind. For.* 86 (274-295).
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A SUMMARY OF TENDING PRESCRIPTIONS FOR OBTAINING NATURAL REGENERATION IN THE TROPICAL WET EVERGREEN FORESTS OF THE WESTERN GHATS

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The tropical wet evergreen forests of the Western Ghats extend from the Southern limits of Bombay State to Kanyakumari district of Madras State through Mysore and Kerala States. The bulk of the tropical evergreen forests of Western Ghats are in the States of Mysore and Kerala.

The forests conform in general to the vivid description of tropical rain forests by Troup. There is considerable similarity in the flora, though associations and variations occur owing to factors such as locality, altitude, moisture and soil. According to Champion's classification the main forests come under 1 AC3, Southern Tropical Wet Evergreen Forests.

"The process of natural regeneration in tropical forests is no doubt exceedingly complex, and, though its practical importance to the forester is obvious, surprisingly little is known about it" observes Richards. This statement is very true considering the available information on the subject, after a century of forest management in many parts of the country. The prescriptions regarding natural regeneration, with very few exceptions refer to the bringing up of existing regeneration of a few selected economically valuable species, by selective tending and canopy lifting after timber exploitation. A study of the prescriptions in the various working plans reveal the inadequacy of knowledge and also provisions for promoting and bringing up natural regeneration in the tropical wet evergreen forests. An account of the various measures prescribed in the concerned working plans (current and past in some cases) for fostering natural regeneration in the different forest divisions of the regions is given below for purposes of comparative study.

I. MYSORE STATE

(a) Shimoga and Sagar Divisions (1941—1961)

The observations are that the advance growth present in adequate quantities can be established by carrying out sufficient weeding and cleaning operations repeatedly at adequately close intervals of time and that subsequent growth depends upon lifting of the canopy from below upwards by repeated fellings. Despite the favourable indications that a shelterwood system can meet the conditions prevailing, the working plan officer found it impossible to prescribe a standard shelterwood system due to the lack of knowledge of the extent to which the overhead cover should be opened for assisting the regeneration without encouraging an invasion by weeds. Therefore, no definite practical guide could be laid down on this point.

In the absence of a recognised silvicultural system the irregular shelterwood Working Circle has been mainly formed with the object of prescribing the tending of the regeneration found in areas felled for poles, sleepers and timber of various kinds during last three decades. Only subsidiary silvicultural operations are prescribed. The felling and regeneration scheme is as follows:

(a) *Initial stage:*

- (1) Removal of all undergrowth of the forest except the regeneration and advance growth of the silviculturally preferred species which are *Hopea parviflora*, *Artocarpus hirsuta*, *Artocarpus integrifolia*, *Dysoxylum malabaricum*, *Dipterocarpus indicus*, *Poeciloneuron indicum*, *Diospyros abenum*, etc.
- (2) Removal of all underwood of the forest consisting of short boled (under 30' high) species with spreading crowns which often fill the space.
- (3) Cutting of all climbers.

(b) *Intermediate stage:*

- (1) Periodic removal of the middle layers of the canopy except trees and poles of the *elite* species, as the regeneration becomes established.

- (2) Undergrowth cutting and climber cutting wherever necessary, to favour the seedlings, saplings and poles of *elite* species.
 - (3) Removal of seedlings and saplings of species other than *elite* ones, where they are interfering with the growth of the *elite* ones.
- (c) *Final stage:*
- (1) Removal of all overwood stems of the *elite* species of and above exploitable size, which have remained unfelled during the initial and intermediate stages.
 - (2) Climber cutting.

Though the regeneration is slow to establish, the height growth is fairly rapid, once the seedlings get established. It is assumed that in twenty years the regeneration can be sufficiently well established to permit the removal of overwood. The duration of intermediate and final tending stages is also twenty years. As this work is *still in an experimental stage and our knowledge of the silvicultural requirements of tropical evergreen species is insufficient, it is advisable* to proceed cautiously and to have a long regeneration period than a short one. Total tending period is sixty years. The results achieved as a result of work done during the last twenty years of the initial stage will make an interesting study.

(b) **South Kanara Division (1932—42)**

The natural regeneration in the evergreen and semi-evergreen forests are tended as follows:—

After five years from the year of timber extraction, regeneration in the worked coupe is tended, (1) by freeing *Hopea parviflora* and *Artocarpus hirsuta* from weeds to a radius of 3 feet around each plant and removing creepers, (2) removal of interfering branches and low shade where necessary.

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|---------------------------------|--|
| Tenth year: | One climber cutting. |
| Eleventh year: | Inspection by D.F.O. |
| Twelfth year to Fifteenth year: | Further reduction as ordered by D.F.O. |

(c) **North Coorg Division**

In the exploited areas of the past, tending of existing regeneration which is under suppression is prescribed. The tending is to be done after heavy rains. No useful species are to be felled. Climbers and unwanted shrubby growth is to be cut. Jack trees which hinder regeneration are to be frill girdled and poisoned. Unwanted mother trees standing over regeneration are to be poisoned and killed.

In the Selection Working Circle also the prescriptions are for removal of noxious weeds, climbers and shrubby growth interfering with regeneration of valuable species in the year after felling. Tendings are repeated in the 6th and 12th year.

II. KERALA STATE

(a) **Wynaad Forest Division (1940-41 to 1949-50)**

Regeneration.—It has been generally observed that the natural regeneration of valuable tree species such as *Mesua ferrea*, *Palaquium ellipticum*, *Vateria indica*, *Calophyllum elatum*, *Hardwickia pinnata* and *Dipterocarpus indicus* is generally abundant in the evergreen forests and that advance growth and poles of such species are by no means infrequent. Artificial regeneration of gaps has not given results commensurate with the time and money devoted to it.

Tending in natural forest.—25 acres of the previous year's worked coupe are taken up for tending. A suitable area containing appreciable quantities of advance growth and poles of valuable species is selected at the time of marking. By advance growth is meant, established regeneration about three feet in height. The selected area is tended by removing the lower and middle canopy trees standing over advance growth, by removing the top canopy over the poles and by judicious thinning among the latter. The removal of trees in the lower and middle canopies is effected by felling, girdling, or frill poisoning (with a solution such as sodium arsenate). Trees in the top canopy are to be removed as a rule by girdling or frill poisoning. Here also the prescriptions are on an experimental basis. Only a small portion of the area worked received tending.

(b) **Palghat Division (1934 to 1943)**

Tending of natural regeneration in gaps.—Natural regeneration of valuable species like *Mesua ferrea*, *Palaquium ellipticum*, *Calophyllum elatum*, *Hopea glabra* and *Poeciloneuron*

indicum in all the gaps created by fellings are to be tended. Probably tending will be necessary for two years. Tending will consist of keeping the heads of the established natural regeneration and advance growth of valuable species free from weeds and quick growing softwoods, so as to give more light without unduly exposing the soil to desiccation. *Mesua ferrea* is to be given preference to all other species.

Tending of natural regeneration in unfelled parts of the coupes.—Natural regeneration of valuable species occur in considerable quantities all over in all stages of development.

Tending of valuable species.—Groups of *Palaquium* are prominent. It is desirable to tend such regeneration every year. But in the present state of knowledge about silvicultural needs of *Shola* species this is not considered possible now. However, the marking officer, when he goes round the coupe, is to carry out a certain amount of tending at small extra cost. The marking officer is to carry out tending of the natural regeneration of valuable species over the whole coupe to the extent possible along with marking, 2 or 3 mazdoors will be taken and will cut back such growth as he instructs them to remove for the purpose of assisting the natural seedlings and saplings that may come across. Climbers are to be cut.

Tending natural regeneration over one-tenth of the area on an experimental basis.

1. Poles are to be left to look after themselves.

2. Promising patches of unestablished and established regeneration of valuable species are to be tended by judicious removal of undergrowth. The object is to let in light through top and middle canopies (unestablished regeneration means seedlings below 9" in height; established regeneration is between 9" and 2½'). Undergrowth of valueless shrubby growth upto 15' high and *Strobilanthes* must be cut. Care should be taken not to cut too much.

3. Promising advance growth (including saplings) of the valuable species are to be tended by judicious removal, wherever required, of the undergrowth and the valueless middle storey trees upto 6" in diameter, interfering with admission of light. The object is to provide ample light through top canopy.

4. *Strobilanthes* must be cut below the node from where roots run into the soil.

5. *Mesua ferrea* is to be given preference over all other species with the exception of *Acrocarpus fraxinifolius* and *Dysoxylum malabaricum*.

(c) Chalakudi Forest Division (1954-55 to 1968-69)

Natural regeneration of valuable species is to be tended wherever they occur to an appreciable extent.

(d) Malayattur Forest Division (1947-48 to 1961-62)

Natural regeneration is unsatisfactory due to rank growth of unwanted species. The incidence of merchantable species is comparatively low in the older girth classes. No attempt at regenerating the evergreens has been made in the past and the successful methods of regeneration are in the experimental stage.

(e) Quilon Forest Division (1944-45 to 1958-59)

Natural regeneration in Yerur reserve is encouraging. In some areas scanty natural regeneration of all useful species are to be sponsored and tended wherever they occur in the regeneration strips.

(f) Konni Forest Division (1947-48 to 1961-62)

Natural regeneration of all the useful species to be sponsored and tended wherever they occur and is of any appreciable extent.

No artificial regeneration of the evergreen forest is now prescribed. This is to be considered and prescribed during the next revision of the plan.

(g) Shencottah Division (1945-46 to 1959-60)

Natural regeneration of evergreen species is to be sponsored and tended in the regeneration strips.

(h) Trivandrum Division (1953-54 to 1967-68)

Natural regeneration of good species is generally satisfactory in the selection coupes and this is to be taken advantage of replacing the trees which are exploited. No artificial regeneration is to be done in the coupes as the best method of conducting artificial regeneration

in such areas is still only in the experimental stage. All that is to be done, therefore, to foster natural regeneration is to take *advantage of existing advance growth for replacing the trees removed* in selection fellings. The following cultural operations should be done in the selection coupes.

- (1) Climbers will be cut throughout the coupe before felling operations are completed. Climbers must be cut as often as possible in places where natural regeneration comes up well so as to relieve young seedlings from suppression.
- (2) A general cleaning is to be done in every coupe in the second and third years after the felling operations have been completed.
- (3) Pure patches of pole crop of the merchantable species are to be thinned silviculturally and the selection marking in the surrounding crop is to be regulated so as to provide sufficient light and space for the necessary development of the advance growth.

III. MADRAS STATE

(a) South Coimbatore Division (1954-55 to 1968-69)

Natural regeneration of the important timber species is plentiful but usually remains suppressed for lack of opening of the canopy and proper tending. In *Hopea-Mesua* association natural regeneration of *Hopea parviflora* is dense and *Mesua ferrea* also regenerates freely. Such natural regeneration remains in a suppressed condition for a long period, but responds quickly if sufficient light reaches it through the top canopy. In *Palaquium-Mesua* association natural regeneration of *Palaquium ellipticum* is more prolific than that of *Mesua ferrea*. Since *Palaquium* is a better shade-bearer than *Mesua ferrea*, there is a marked tendency for the former to oust latter. In *Poeciloneuron-Cullenia* association there is always a dense mass of natural regeneration of *Poeciloneuron indicum* and all age classes are found represented. In fact, there is a marked tendency towards the crop ultimately becoming almost pure *Poeciloneuron indicum*.

Lower girth classes are considered to be well represented in the crop and conditions for natural regeneration and advance growth may be considered satisfactory.

It is recognised that it is desirable to undertake measures to increase the proportion of utilisable species in the crop. Indications are that this can be achieved by controlled thinning of the canopies and underplanting of the desired species such as *A. hirsuta*, *Dipterocarpus indicus*, *Acrocarpus fraxinifolius*. The thinning should create conditions suitable for these species to develop but should leave the evergreen character of the forest more or less unaltered. Progressive opening of the canopy upward, to keep pace with the development of the introduced plants has to be effected preferably by girdling or prescribing the trees to be removed (in order to avoid felling damage).

The removal by felling and girdling is, however, limited to an average of three trees per acre and not more than six in any one acre including felling for coupe working.

(b) Tirunelveli Division (1934-35 to 1943-44)

Natural regeneration.—There is regeneration of *Aglalia roxburghiana*, *Artocarpus hirsuta*, *Gluta travancorica*, *Palaquium ellipticum* and *Mesua ferrea*. Such regeneration stagnates until a gap in the canopy admits sufficient light to enable it to shoot up. *Little is known as regards the light requirements of such seedling growth* but such research as has been done on the subject points unmistakably to the fact that a light opening of the canopy immediately above regeneration of the more valuable species is definitely beneficial. The work however, requires not only a good knowledge of the seedling stages of the various species, but also a high degree of silvicultural skill on the part of the officer conducting the operation. This naturally restricts the scope of tending operations. It is accordingly prescribed that the canopy be opened over natural seedling and young pole regeneration, under the personal supervision of the Divisional Forest Officer and his gazetted assistant, over an area of twentyfive acres annually in the coupe under exploitation. The opening must be done cautiously to begin with as we know nothing about the extent to which light ought to be admitted and the upper storey must not be interfered with until some experience has been obtained. Four mazdoors per acre should be able to carry out the work prescribed. This work is to be done just before the south-west monsoon. At the time of marking climbers must be cut.

DISCUSSIONS

A study of the results of tending natural regeneration in Shimoga, Wynaad, Coorg, Palghat, Trivandrum and Tirunelveli divisions should to some extent enable us to infer the lines on which a bold start for regular tending has to be made on a large scale at least to cover up the entire worked areas to bring up the regeneration of valuable species. The need for this is apparent from the prescriptions for natural regeneration contained in the various working plans, which are either of experimental nature, in the absence of adequate data or are too general to be effective at all.

Recruitment of regeneration.—Hardly any information is available regarding (i) the manipulation of the canopy for the recruitment of regeneration where it does not exist, (ii) the number of seedlings and saplings per unit area, that should be present in an area to be considered as adequately stocked, and (iii) the size that the regeneration of different species should attain to be reckoned as established.

After assessing the result of research done in the field of natural regeneration so far, if necessary fresh experiments have to be laid out, on a co-ordinated basis, to cover the fields in which there is still paucity of information.

Regeneration surveys should invariably be done to assess the regeneration status. Occular estimates should not be the sole guide for determining the adequacy of regeneration.

REFERENCES

1. Working Plan for the Ghat forests 1941—1961, by Krishnaswamy Kadambi.
2. Working Plan for the North Mangalore Forest Division 1932—42, P.W. Davis and M.H. Krishnaswamy.
3. Working Plan for the Evergreen forests of Coorg, by K.K. Somiah.
4. A revised working plan for the forests of the Wynaad Division 1940-41 to 1949-50, by T.V.V. Ayyar.
5. A working plan for the Ghat forests of the Palghat Division 1934 to 1943, by T.V.V. Ayyar.
6. Working Plan for the Chalakudi Forest Division 1954-55 to 1968-69, by T.P. Viswanathan.
7. Working Plan for the Malayattur Forest Division 1947-48 to 1961-62, by N. Sreedharan Pulai.
8. Working Plan for the Konni Forest Division 1947-48 to 1961-62, by N.N. Menon.
9. Working Plan for the Quilon Forest Division 1949—59, by N.N. Menon.
10. Working Plan for the forests of Shencottah Division 1945-46 to 1959-60, by N.N. Menon.
11. Working Plan for the Trivandrum Division 1953-54 to 1967-68, by P.T. Devany.
12. Working Plan for South Coimbatore Division 1954-55 to 1968-69, by Bhojashetty.
13. Working Plan for Tinnevely-cum-Ramnad 1934-35 to 1943-44, by E.A. Lasrado.

NATURE RESERVES OF TROPICAL RAIN FORESTS

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Summary

The probable reasons for inadequate attention to the study of tropical rain forests, and the resultant lack of information on many a vital problem concerning these forests are stated.

The importance of tropical rain forests as natural laboratories for biological study is emphasized.

The necessity of maintaining undisturbed nature reserves in the three different zones in India, where tropical rain forests are found is given. Compilation of information with international co-operation is suggested.

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The tropical rain forests comprise about half of world's forest areas. Despite this fact, apart from selective exploitation of a few utilisable or marketable species, till recently, comparatively little attention has been paid to these forests from the point of view of scientific study. These forests are generally situated in the warm undeveloped tropics with rather a hot and humid oppressive climate. Combined with this and the relatively higher current utilisable value of various timbers, obtainable from the coniferous and deciduous forests has been responsible for diverting the attention of ecologists, botanists and foresters away from the tropical rain forests.

Perhaps the unfortunate part is, that when some attention was paid to these forests in the course of the last century and during recent years, it was mainly towards the clearing of this dense mass of "useless jungle" for the purpose of growing plantation crops such as rubber, coffee, tea, cinchona, tapioca, and even cereal crops. The lamentable destruction of evergreen forests for extension of agriculture under "Grow more food campaign" and shifting cultivation have taken place even during recent years and are still current in some of the densely populated regions of this country. The adverse effects of the large scale destruction of tropical rain forests situated as they are, on the steep slopes of the Western Ghats and other hilly regions often in areas with a rainfall of 100"—300" can well be imagined. Apart from the role of serving as the "raiment" for the earth's surface, these forests have also become economically very valuable with the development of timber using industries during recent years. Therefore, from the point of view of physical benefits as well as store houses of timber, canes and other economic products, these forests have emerged from obscurity and deserve due attention.

Apart from these considerations, foresters concerned with the management of tropical rain forests are confronted with many a problem, on account of the lack of information on important aspects such as the physical life of the various species, their representation in the various classes in a mature undisturbed forest, the changes in the distribution of the various species in different age classes as the crop advances in age, their rate of growth during the different stages of the development and also whether the floristic composition of the rain forests remains constant, the effects of selective logging, selective tending and canopy manipulation and various other aspects.

The role of the tropical rain forests as great laboratories of nature for biological study and research is yet to be fully recognised. It is considered that the tropical rain forests have been the centre of evolutionary activity from which the rest of the world's flora has taken shape. The plant evolution in the tropics has not been interrupted by seasonal checks. Further the warm temperature conditions might be more favourable for the survival of mutations. This role of considerable scientific and botanical importance may not be played by tropical rain forests in the future, as hitherto, mainly as a result of progressive reduction in the area occupied and discontinuity of vegetation. At this juncture one cannot but feel how true the observation by Van Steenis that "Most studies of vegetation have been carried out in Europe and I am of the opinion that owing to a paucity of material these investigations have begun with an inverted view point. When studying the manifold

types of vegetation, comparing them and relating to each other one ought logically to start with the richest and to derive from it less complicated impoverished types which have arisen from it by selection. The richest type of vegetation in number of species, volume and density, is found in the tropics. It is not the impoverished anthropogenic vegetation of Europe which should be the starting point of ones investigations" is true to the latter. Let us hope that tropical rain forests will not be wiped out before the scientists focus their attention on them. Unless positive steps are taken to preserve the tropical rain forests there might be room for regret.

With the selective exploitation in progress over most of the easily accessible tropical rain forests, shortly the position will be, that undisturbed natural tropical rain forest may not exist to any appreciable extent to serve as the great laboratories they are of nature, for the biologists, foresters, and others interested in this wide and still little known field of study. To meet this end it is the responsibility of the countries endowed with tropical rain forests to maintain undisturbed nature reserves of large extent apart from the worked reserved forests. The large voids in the knowledge of the rain forest can be eliminated only by the efforts of generations of devoted scientists and naturalists. Albert National Park in Belgian Congo is an example of nature preservation worth emulating in other regions also.

In India where the tropical rain forests are distributed in different regions of the country far apart, the forests of each region having its own characteristics, there is a strong case for maintaining a number of nature reserves, maintenance of which should be governed by a common policy throughout the country. In each of the zones, viz. 1. Western Ghats (Mysore, Kerala and Madras States), 2. Eastern Zone (Bengal, Assam and NEFA), and 3. Andamans representative areas should be selected for preservation as nature reserves. Though the Third Silvicultural Conference held at Dehra Dun in 1929 suggested measures for the preservation of natural fauna and flora, except for a few protected trees, and preservation plots of limited extent, no appreciable steps have been taken towards the preservation of large compact areas of forests as nature reserves. Unless action is taken without further delay it may be too late. Such reserves should be formed in every country of the world having this magnificent and bountiful gift of nature. The co-ordinated collection of information by an international organization like the F.A.O. will help to unveil the little known facts about the tropical rain forests.

Acknowledgement: This note is based upon Prof. P. W. Richard's monumental work
"The Tropical Rain Forest."

AN INVENTORY OF SAMPLING METHODS APPLIED IN CASE OF THE TROPICAL MOIST EVERGREEN FORESTS

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Abstract

This paper gives an inventory of sampling methods applied to the tropical moist evergreen and semi-evergreen forests of India. The two techniques of sampling wood volume and other yields in the evergreen forests are (1) Linear Tree Increment Plots and (2) Partial enumeration of standing crops in large forest tracts. Under the latter technique various sampling schemes applicable to these types of forests are discussed. A 5-10% systematic sampling with two random starts is considered very convenient and economical to evergreen plains forests as this method gives more precise results than a stratified random sampling with two units per stratum. Partially systematic line-plot survey can also be suggested to evergreen plains forests if multi-stage sampling is possible. As regards hilly tracts, stratified random sampling is recommended with various blocks as strata and compartments or sub-compartments as sampling units.

General

Sampling in forestry is done both for estimation of forested land area and standing timber volume. The former is no more a serious problem now as only a little forest land remains unsurveyed and unmapped. Usually the problem of sampling for estimation of wood volume and other yields, is tackled under three main techniques:—

1. Sample plot method for regular even-aged forests,
2. Linear Tree Increment Plot method for irregular uneven-aged forests, and
3. Partial enumeration of standing crops in large forest tracts.

Sampling Techniques Adopted in Tropical Moist Evergreen Forests

For the techniques described hereunder, the tropical evergreen forests also include the tropical semi-evergreen types of forests. Thus the inventory of sampling techniques discussed may be applicable to the following forests types as distinguished by Champion:

1. Tropical wet evergreen forests (1a, 1b).
2. Tropical semi-evergreen forests (2a, 2b) and their edaphic (E) and seral variants (1S and 2S). These types are commonly met with in the States of Mysore, Kerala, Madras, Andamans and Assam.

Evergreen forest is a heterogenous mixture of life-forms and age classes. Therefore, the sample plot method which is applicable to regular and even-aged forests is not of much avail in the study of the evergreen forests. We are then left only with the latter two methods. The States of Bengal, Madras and Uttar Pradesh laid out a number of linear sample plots in mixed crops which later on came to be known as 'Linear Tree Increment Plots'.

In the year 1923, Shebbeare, Silviculturist Bengal, laid out Linear Tree Increment Plots in the forests of Buxa and Jalpaiguri divisions. At the time of the Third Silvicultural Conference, 1929, Homfray discussed the procedure of laying out linear sample plots and said:

"Lines were marked on the map *at random* and laid out on the ground afterwards; this prevented any attempt to select the best areas which might be the case if lines were selected on the ground. The width of the line was one chain and the length might have varied from half to two miles until it reached some convenient boundary. Every tree of 5" diameter and over at breast height whose centre occurred within the lines was numbered by a tin plate. Trees under 5" diameter were ignored. Diameter measurements were taken every two years for the first four years and thereafter every three years".

At the Fourth Silvicultural Conference, the procedure of laying out Linear Tree Increment Plots in Madras and Uttar Pradesh was again discussed and regarding the Uttar Pradesh plots, Mobbs remarked:

“The lines certainly include almost every possible sub-type. What is not certain, is that the proportion of these sub-types is more or less the same as their proportions in the main types as a whole.”

As regards the Madras linear sample plots, Laurie said:

“It is assumed that the plots have been selected so as to cover the whole range of quality and geographical distribution to be studied and that the plots are typical of the forests as regards uniformity and density, and that they will give diameter increment data for trees of every crown and canopy class.”

In the absence of a standard procedure, very little work was done in the analysis of data collected at successive measurements from these plots. In the year 1939, Bakshi Sant Ram, in an appendix to Laurie's paper, prescribed a standard procedure for laying out Linear Tree Increment Plots. This procedure is finally given as Appendix XIII in the Silviculture Research Code Volume 3—Tree and Crop Measurement Manual by Griffith and Jagdamba Prasad.

The existing number of Linear Tree Increment Plots in the tropical evergreen forests is small. They are enlisted in the subjoined statement.

State	Division	No. of Linear Tree Increment Plots.
Mysore	East Kanara	2
Mysore	West Kanara	2
Mysore	Coorg	2
Madras	South Coimbatore	1
Kerala	Palghat	1

The 1939 Linear Tree Increment Plots of East and West Kanara were laid out with a view to facilitate the identification of the complex tree flora of the local tropical wet evergreen forests and determine the rate of growth of individual tree species. The data collected at three successive measurements from 1939 to 1949 were subsequently analysed and published (Mathauda 1953). The average rates of growth of 19 most frequently occurring species were determined and presented in tabular forms which have been reproduced and given as Appendices I and II. The former shows the rate of diameter growth of different tree species along with age and the latter shows time taken by different tree species to cross different diameter classes.

With the help of permanent sampling units (L.T.I.P.), precise increment calculation is possible while with temporary sampling units only the growing stock can be assessed. With repeated sampling, increment can also be calculated but with the usual sampling intensities, standard error is very high.

Partial Enumeration of Standing Crops in Large Forest Tracts

The Sixth Silvicultural Conference held in Dehra Dun in April 1945, recommended on the urgent need for large scale enumerations to assess the vanishing resources in both, the regular and irregular forests. In pursuance of this resolution, Dr. Griffith examined many records of cent per cent and partial enumerations and tried various model sampling methods. He published eleven Indian Forest Leaflets (Silviculture Nos. 83 to 91, 93 and 96 entitled “The Efficiency of Enumeration”. In these leaflets, he showed that intensive and expensive 100% enumerations are not necessary. Sampling estimates of timber volume are sufficiently reliable for all practical purposes. Two of these leaflets, Nos. 84 and 86 dealt with Champion's Group 1a—Southern tropical wet evergreen forests, C3 Western tropical evergreen (Karian Shola of Tunacadavu range of South Coimbatore division), and Group 1b—Northern tropical wet evergreen forests, C2 Upper Assam tropical evergreen (Lakhimpur forest division).

With regards to the study of the Upper Assam and the Madras tropical wet evergreen (Karian Shola) forest data, the summary drawn by Dr. Griffith is reproduced below:—

- “1. Intensive and expensive 100% enumerations are not necessary in order to obtain a reasonable estimate of the growing stock. Enumerations of 5% or 10% are probably sufficient for most practical purposes.
- “2. Systematic sampling gives us more accurate estimations than random sampling provided it is carried out with a full appreciation of the probable trends of the fertility gradients of the forest.
- “3. Whatever the intensity of enumeration some 30 to 60 separate estimates of the volume per acre in each square mile of forest will probably give us a sufficiently accurate estimate of the total volume and enable us to calculate its precision. This is an economically reasonable number of figures for the computers to calculate with.”

The conclusions arrived at by Dr. Griffith had been carefully examined by several statisticians. In this connection, Dr. Finney observes:

“Though a systematic sample may be expected usually to give an estimate more precise than would the corresponding stratified random sample, this is not necessarily true. For some types of variation the precision for the systematic might be lower, and no general statistical theory can state that one will always be better.”

In view of this criticism, the Seventh Silvicultural Conference held in October-November 1946, adopted the following resolution:

“The Central Silviculturist should continue to keep closely in touch with eminent statisticians in order to obtain a mathematically satisfactory method of calculating the precision of the estimates of systematic sampling of systematically arranged data.”

Before the inception of the Statistical Branch, Mt. Stuart enumeration data of the Madras moist mixed deciduous forests were sent by the Central Silviculturist for analysis to Dr. Finney. He wrote two papers which appeared in *Forestry* and later on published as an Indian Forest Bulletin No. 146. Dr. Finney used these data in a comparison of different strip sampling procedures. He calculated variances for unrestricted random strip sampling, stratified random sampling taking either two strips or one strip from each block and systematic sampling at different sampling intensities between 1 in 2 and 1—32. He further described the methods of obtaining variances for different sampling schemes.

The results derived by him clearly show that sampling for the estimation of volumes of standing timber can give a reliable figure for all practical purposes. A stratified systematic sample consisting of 30—35 strips and representing about 1 strip in 5 or 1 in 8 of the whole forest, was fairly certain to give an estimate within 5% of the truth. He finally concluded that although for the data examined systematic sampling proved more precise than stratified random sampling, the former cannot be recommended since no assessment of the sampling error is possible in this method and hence the latter one should be followed.

During 1953-54, the Working Plan Officer of Lower Assam Circle carried out 10% and 5% systematic one chain wide strip enumeration respectively in the Kaphitali and Disama Reserves of the Nowgong forest division (semi-evergreen forests).

In case of the Disama Reserve, under 5% systematic strip sampling, 40 strips were enumerated. So as to allow for the systematic sample, the 40 strips were considered as 20 contiguous pairs 1-2, 3-4, ... 39-40 and the variance of the general mean calculated with following formula:

$$V(\bar{y}_w) = \frac{4(1-f)}{\left\{ \sum_1^{40} (w_i) \right\}^2} \left[\frac{w_1^2 w_2^2}{(w_1 + w_2)^2} (y_1 - y_2)^2 + \frac{w_3^2 w_4^2}{(w_3 + w_4)^2} (y_3 - y_4)^2 + \dots + \frac{w_{39}^2 w_{40}^2}{(w_{39} + w_{40})^2} (y_{39} - y_{40})^2 \right]$$

Where f = sampling intensity,

w_i = area of the i th strip in acres,

y_i = mean number of trees per acre in the i th strip, varying from 1 to 40.

In case of the Kaphitali Reserve where under 10% systematic strip sampling only 13 strips were enumerated, no contiguous pairs could be formed. Hence Yates' formula (7.5g)

given on page 197 of his book 'Sampling Methods for Censuses and Surveys' (second edition) was used to calculate the variance of the general mean, *i.e.*

$$V(\bar{y}_w) = \frac{(1-f) \text{sq}}{\{\sum (w_i)\}^2}, \text{ where } \text{sq}^2 = \frac{\sum w_i^2 (y - \bar{y}_w)^2}{(n-1)}$$

The results of statistical analysis for Disama and Kaphitali Reserves are reproduced as Appendices III and IV. They show the estimated mean number of trees per acre \pm standard error by girth classes for each tree class.

Recently partial enumerations have been taken up in North Kanara, to cover about 850 square miles of unorganised forests mostly semi-evergreen to evergreen in nature. The procedure adopted is a "Stratified random sampling with strips as sampling units". Single stage sampling is being carried out in the sense that the selected strips are being completely enumerated for all species. The width of each strip is two chains. For an area to be enumerated a base line is laid out on 4" = 1 mile map running along general direction of the contours. The base is divided into strata by lines running at right angles to it and 40 chains apart. Twenty strips, each two chains wide are marked in each stratum running across the contours.

With the help of the Table of Random Numbers, in a stratum two strips are selected at random and the same procedure is followed for all the strata. The intensity of sampling is approximately 10%. Each sub-block is being enumerated on these lines.

This area under survey is very much cut up, precipitous and at places inaccessible. Generally the undergrowth is very thick and overgrown with climbers and lianes thereby retarding the progress of line cutting. Therefore, the method of survey adopted is proving costly, strenuous and slow.

As recommended by Seth (1951-c), the sampling procedure for this undulating area should have been "Stratified random sampling with compartments or sub-compartment or topographical sections as sampling units" and not the strips as sampling units.

As no valid assessment of the sampling error is possible from a systematically selected sample, some statisticians have been attempting to evolve appropriate forms of systematic sampling which could provide an acceptable valid estimate of the standard error of the mean of a systematic sample. In a paper on "Some sampling methods on forest surveys", very recently published in the December 1959 issue of the *Indian Forester*, J. N. K. Rao has discussed some aspects of systematic sampling and also suggests a modification of this method which gives a fairly close approximation to the sampling error. He considers that systematic sampling with multiple random starts is quite expedient and convenient in the field and also provides a reasonably accurate estimate of the sampling error. Further, he considers that a systematic sampling with two random starts is expected to give more precise results than a stratified random sampling with two units per stratum. The former method is also preferable to systematic sampling with a single random start which does not provide a valid estimate of the sampling error. The procedure of systematic sampling with two random starts, simplifies the field work and provides a sort of check on gross non-sampling errors involved in the enumeration. This, however, needs further investigation to check its reliability for different types of forests.

REFERENCES

1. Finney, D. J. (1949)—"The Efficiency of Enumerations" (Statistical). Indian Forest Bulletin No. 146, published by F.R.I., Dehra Dun, India.
2. Mathauda, G. S. (1953)—"The tree species of the tropical Evergreen Ghat Forests of Kanara and their rate of growth", *Ind. For.*, pp. 208—218, April 1953.
3. Griffith, A. L. (1945)—"The Efficiency of Enumerations" (Silviculture) Indian Forest Leaflet No. 86, Upper Assam Tropical Evergreen Forest, F.R.I., Dehra Dun, U.P.
4. Griffith, A. L. (1945)—"The Efficiency of Enumerations" (Silviculture), Indian Forest Leaflet No. 84, Madras Tropical Evergreen Forest, F.R.I., Dehra Dun, U.P.

5. Nair, K. R. (1950)—“Sampling Techniques”. *Indian Forester*, pp. 1—4, Jan. 1950.
6. Rao, J. N. K. (1959)—“Some sampling methods in Forest Surveys”, *Indian Forester*, pp. 723—727, Dec. 1959.
7. Seth, S. K. (1951 a)—“Sampling and Assessment of Forest Crops”, U.P. Bulletin No. 21.
8. Seth, S. K. (1951 b)—“A comparative study of some patterns of systematic partial enumerations for the plains sal (*Shorea robusta*) forests, Proc. of the VIII Sil. Con., pp. 376—391.
9. Seth, S. K. (1951 c)—“A comparative study of some patterns of a partial sampling suitable for the hills”, Proc. of the VIII Sil. Con., pp. 395—409.
10. Yates, F. (1953)—“Sampling Methods for Censuses and Surveys”, second edition, Charles Griffin & Company Limited, London.

APPENDIX I

Rate of diameter growth for various tree species
Diameter at breast height.

Age counting from the 4 inches d.b.h. stage	<i>Aglaia roxbur- ghiana</i>	<i>Diospyros candol- leana</i>	<i>Diospyros oocarpa</i>	<i>Dipterocarpus indicus</i>	<i>Garcinia cambogia</i>	<i>Holigarna grahamii</i>	<i>Hopea wightiana</i>	<i>Ixora brachiata</i>	<i>Knema attenuata</i>	<i>Lansium anomalayanum</i>	<i>Myristica beddomei</i>	<i>Myristica malabarica</i>	<i>Nephelium longana</i>	<i>Nothopegia dalzellii</i>	<i>Olea dioica</i>	<i>Polyalthia fragrans</i>	<i>Pterospermum reticulatum</i>	<i>Sageraea laurifolia</i>	<i>Syzygium gardenii</i>			
10	4.6	4.3	4.4	7.7	4.3	5.0	4.7	4.3	4.6	4.4	4.5	4.6	4.7	4.4	4.6	5.0	5.0	4.5	4.7
20	5.3	4.7	4.9	8.4	4.7	6.0	5.5	4.7	5.2	4.9	5.1	5.3	5.4	4.8	5.1	6.3	6.0	5.0	5.7
30	6.1	5.0	5.5	2.2	5.2	7.1	6.4	5.1	5.8	5.4	5.7	6.0	6.3	5.3	5.8	8.1	7.0	5.6	6.2
40	6.9	5.4	6.1	10.0	5.7	8.2	7.3	5.5	6.4	6.0	6.3	6.8	7.1	5.8	6.5	10.2	8.1	6.2	7.2
50	7.8	5.9	6.8	10.8	6.3	9.3	8.2	5.9	7.1	6.7	7.0	7.5	8.0	6.4	7.3	12.4	9.1	6.8	8.2
60	8.7	6.3	7.6	11.8	6.9	10.4	9.3	6.3	7.7	7.4	7.6	8.3	9.0	7.1	8.2	14.7	10.1	7.4	9.4
70	9.6	6.8	8.3	12.7	7.6	11.6	10.4	6.7	8.4	8.2	8.3	9.2	10.1	7.8	9.1	17.0	11.2	8.1	10.8
80	10.6	7.4	9.0	13.7	8.4	12.7	11.5	7.1	9.1	9.1	9.1	10.0	11.3	8.6	10.1	19.2	12.3	8.8	12.2
90	11.6	8.0	9.8	14.7	9.3	13.9	12.8	7.5	9.8	10.0	9.8	10.9	12.6	9.5	11.1	21.3	13.4	9.5	13.8
100	12.6	8.6	10.6	15.7	10.3	15.2	14.0	7.9	10.5	10.9	10.6	12.7	13.9	—	12.3	23.4	14.5	10.3	15.6
110	13.6	9.3	11.4	16.7	11.3	16.5	15.4	8.3	11.3	11.9	11.3	12.6	15.4	—	13.6	—	15.6	11.1	17.6
120	14.7	10.1	12.2	17.7	12.4	17.8	16.8	8.7	12.0	12.9	12.1	13.5	17.0	—	15.0	—	16.7	11.9	19.6
130	15.8	10.9	13.0	18.8	13.6	19.1	18.3	9.1	12.8	13.9	12.9	14.4	18.8	—	16.5	—	17.8	12.8	21.8
140	17.0	11.8	13.7	19.8	14.9	20.4	19.7	9.6	13.6	—	13.7	15.3	20.6	—	18.1	—	18.9	13.7	24.1
150	18.1	12.8	14.5	20.9	16.2	21.8	21.2	10.0	14.4	—	14.5	16.2	22.6	—	19.8	—	20.0	14.7	26.5
160	19.4	13.8	15.3	22.0	17.6	23.2	22.7	10.4	15.2	—	15.3	17.1	—	—	21.6	—	21.2	15.7	28.9
170	20.6	14.9	16.1	23.2	19.0	—	—	—	16.1	—	16.1	18.0	—	—	23.5	—	—	16.7	—
180	—	16.2	17.0	24.4	—	—	—	—	17.0	—	16.9	18.9	—	—	—	—	—	—	—
190	—	17.5	17.8	15.6	—	—	—	—	17.9	—	17.7	19.8	—	—	—	—	—	—	—
200	—	—	18.5	26.8	—	—	—	—	18.8	—	18.5	—	—	—	—	—	—	—	—
210	—	—	19.3	28.0	—	—	—	—	19.7	—	19.3	—	—	—	—	—	—	—	—
220	—	—	—	—	—	—	—	—	20.7	—	20.1	—	—	—	—	—	—	—	—

APPENDIX II

Time taken by various tree species to cross different diameter classes.
No. of years required to cross the diameter class

Diameter (b. h.) class	<i>Aglaia roxburghiana</i>	<i>Diospyros candolliana</i>	<i>Diospyros oocarpa</i>	<i>Dipterocarpus indicus</i>	<i>Garcinia cambogia</i>	<i>Holigarna grahamii</i>	<i>Hopea wightiana</i>	<i>Isora brachiana</i>	<i>Knema attenuata</i>	<i>Lansium anamalayanum</i>	<i>Myristica beddomei</i>	<i>Myristica malabarica</i>	<i>Nephetium longana</i>	<i>Nothopegia dalzellii</i>	<i>Olea dioica</i>	<i>Polyalthia fragrans</i>	<i>Pterospermum reticulatum</i>	<i>Sageraea laurifolia</i>	<i>Styzygium gardneri</i>
4"-6"	29	53	38	—	46	20	26	53	33	40	36	29	27	43	33	18	20	37	27
6"-8"	23	38	28	—	29	18	22	50	31	27	29	27	23	29	25	11	19	32	21
8"-10"	22	28	26	25	22	18	19	47	29	23	27	24	19	24	21	10	20	27	16
10"-12"	21	23	26	22	19	18	17	—	27	21	27	23	17	—	18	9	18	25	15
12"-14"	19	20	25	21	17	17	16	—	25	20	25	22	14	—	16	9	19	22	12
14"-16"	18	17	25	20	16	16	14	—	24	—	25	22	14	—	13	9	18	20	11
16"-18"	17	14	25	20	14	15	14	1	23	—	25	23	12	—	13	9	18	—	10
18"-20"	16	—	—	19	—	15	14	—	21	—	25	22	11	—	12	9	18	—	9
20"-22"	—	—	—	18	—	14	13	—	—	—	—	—	10	—	11	9	17	—	9
22"-24"	—	—	—	17	—	15	14	—	—	—	—	—	—	—	10	10	—	—	9
24"-26"	—	—	—	17	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8
26"-28"	—	—	—	16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8

APPENDIX III

Mean number of trees per acre \pm standard error by girth classes for each royalty class of trees

5% partial enumeration in Disama Reserve, Nowgong Division, Assam.

Total area=27,712 acres.

Number of strips enumerated=40.

Girth class \rightarrow Class of trees \downarrow	3'-4' (under)	4'-5' (under)	5'-6' (under)	6' and over
A	0.098 \pm 0.0095 (9.7)	0.16 \pm 0.012 (7.5)	0.11 \pm 0.12 (10.9)	0.23 \pm 0.018 (7.8)
B	0.34 \pm 0.024 (7.1)	0.24 \pm 0.013 (5.4)	0.15 \pm 0.015 (10.0)	0.19 \pm 0.014 (7.4)
C	0.30 \pm 0.018 (6.0)	0.19 \pm 0.014 (7.4)	0.18 \pm 0.019 (10.6)	0.32 \pm 0.026 (8.1)
D	2.61 \pm 0.087 (3.3)	1.36 \pm 0.030 (2.2)	0.76 \pm 0.032 (4.2)	1.00 \pm 0.041 (4.1)
E	1.45 \pm 0.054 (3.7)	0.74 \pm 0.034 (4.6)	0.36 \pm 0.020 (5.6)	0.19 \pm 0.013 (6.8)
F	3.24 \pm 0.150 (4.6)	1.38 \pm 0.058 (4.2)	0.52 \pm 0.027 (5.2)	0.39 \pm 0.025 (6.4)
A+B+C+ D+E+F (Combined)	8.04 \pm 0.74 (3.4)	4.08 \pm 0.105 (2.6)	2.08 \pm 0.074 (3.6)	2.33 \pm 0.074 (3.2)

N.B.—Figures in brackets show S.E. expressed as % of mean.

APPENDIX IV

Mean number of trees per acre ± Standard error by girth classes for each class of trees.

10% partial enumeration in Kaphitali Reserve, Nowgong Division, Assam.

Total Area=721 acres.

Number of strips enumerated=13.

Girth Class→ Class of trees ↓	1'-2' (under)	2'-3' (under)	3'-4' (under)	4'-5' (under)	5'-6' (under)	6' and over
A ..	1.82±.782 (42.9)	1.41±.607 (43.0)	1.49±.596 (39.9)	.97±.255 (26.3)	.31±.085 (26.6)	.16±.051 (31.1)
B ..	..	..	.62±.157 (25.2)	.48±.111 (23.3)	.43±.085 (19.9)	.25±.077 (31.3)
C ..	...	..	.64±.163 (25.5)	.44±.071 (16.0)	.48±.133 (27.9)	.33±.120 (36.6)
D ...	..	..	1.10±.167 (15.2)	.81±.113 (14.0)	.44±.122 (27.5)	.43±.088 (20.6)
E ..	..	..	.58±.167 (30.6)	.51±.101 (19.8)	.16±.067 (40.9)	.15±.051 (34.5)
F ..	..	..	2.30±.394 (17.1)	1.43±.244 (17.1)	.59±.058 (9.8)	.16±.036 (22.0)
A+B+C+ D+E+F (combined).	1.82±.782 (42.9)	1.41±.607 (43.0)	6.73±.762 (11.3)	4.63±.392 (8.5)	2.41±.218 (9.0)	1.48±.217 (14.7)

N.B.—Figures in brackets show S.E. expressed as % of mean.

NEED OF ECOLOGICO-PHYSIOLOGICAL STUDIES IN TROPICAL EVERGREEN FORESTS WITH SPECIAL REFERENCE TO LIGHT

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It is commonly observed that certain undetermined causes usually effect the proper development of some of the important forest tree species. In many localities inferior species invade the natural zone of economically important species and the natural regeneration of the former spreads prolifically at the expense of the latter. Various factors responsible firstly for the trend of succession taking place in these forests and secondly for the poor development of some of the species are imperfectly understood. Due to the occurrence of numerous species in evergreen forests the incidence of important species is usually small. The basic requirements and the silvicultural characters vary widely from species to species with the result that for meeting the demands for timber etc. comparatively larger areas have to be worked out.

Some isolated field experiments and observations have been made but there has been no attempt so far for determining the basic requirements for light and nutrients of the species by scientifically acceptable techniques. Also no systematic data has so far been collected on phytosociology as well as on soil properties. There is thus an urgent necessity for extensive studies to assess quantitatively the different ecologico-physiological and edaphic factors governing the growth and distribution of the species of evergreen forests.

Champion has classified evergreen forests of India in two broad classes, viz. (i) Southern Tropical Evergreen Forests (Kerala, Mysore, Madras and Andamans island) and (ii) Northern Tropical Evergreen Forests (Assam, West Bengal and NEFA.). They occur on flat or hilly ground up to about 760 meters, extending further up the valleys to about 1,060 meters. In western ghats the evergreen forests ascend up to about 1,370 meters.

The mean annual temperature lies between 22°C—26°C. Mean January minimum lies between 10°C—21°C. In southern tropical forests it is usually about 20°C and in northern tropical forests it is usually about 13°C. Annual rainfall is above 2,000 mm and rarely below, 1,600 mm.

Evergreen forests are characterised by luxuriance of vegetation which may differentiate itself into three or more tiers. The emergent layer is sparse but the continuous top canopy is dense and consists mainly of lofty trees reaching a height of about 45 meters or more, often with high plank buttresses. The middle storey consists of evergreen trees, struggling hard for light and the lowest layer consists of dense shrubby evergreen vegetation. The ground cover is very sparse and grasses are very few or absent. The species are very numerous but gregariousness is strikingly absent. There is an abundance of thick stemmed climbers, climbing palms and epiphytes (avoids, ferns, orchids, selaginella and lichens). The undergrowth is often a tangle of canes, creeping bamboos and palms. The most common species of evergreen forests of India are as follows:

TOP STOREY—*Dipterocarpus indicus*, *D. macrocarpus*, *D. costatus*, *Shorea assamica*, *Hardwickia pinnata*, *Vateria indica*, *Artocarpus hirsuta*, *A. integrifolia*, *A. chaplasha*, *Mesua ferrea*, *Acrocarpus fraxinifolius*, *Palaquium ellipticum*, *Poeciloneuron indicum*, *Hopea parviflora*, *H. odorata*, *H. wightiana*, *Cullenia excelsa*, *Calophyllum tomentosum*, *C. elatum*, *Syzygium* spp., *Amoora canarana*, *A. wallichii*, *Dysoxylum malabaricum*, *Michelia champaca*, *Machilus macrantha*, *Planchonia andamanica*, *Canarium manii*, *Kayea assamica*, *K. floribunda*, *Heriteria acuminata*, *Vatica lanceaefolia*, *Terminalia myriocarpa*, *Echinocarpus assamicus*.

MIDDLE STOREY—*Albizia julibrissin*, *Carallia integerrima*, *Hemicyclia elata*, *Elaeocarpus serratus*, *E. tuberculatus*, *Cinnamomum zeylanicum*, *C. glanduliferum*, *Polyalthia fragrans*, *Nephelium longana*, *Acronychia laurifolia*, *Cyclostemon macrophyllus*, *Memecylon caeruleum*, *Cryptocarya ferrarsi*, *Actinodaphne obovata*, *Turpinia pomifera*, *Magnolia pealiana*, *Meliosma simplicifolia*.

UNDERGROWTH—*Psychotria truncata*, *Macaranga roxburghii*, *Murraya koenigii*, *Leea sambucina*, *Strobilanthes callosus*, *S. iniocephalus*, *Helictres isora*, *Calamus* spp., *Callicarpa lanata*, *Laportea crenulata*, *Pandanus* spp., *Webera cryombosa*, *Glycosmis pentaphylla*, *Pinanga disconii*, *P. gracilis*, *Saprosma ternatum*, *Amblianthus multiflora*, *Osbeckia* spp., *Melastonia malabaricum*, *Alpinia allughas*, *Calamus erectus*, *C. flagellum*, *C. latifolius*, *Ixora* spp.

CLIMBERS—*Entada scandens*, *Bauhinia* spp., *Gnetum scandens*, *Tinospora cordifolia*, *Cocculus macrocarpus*, *Spatholobus roxburghii*, *Butea superba*, *Acacia* spp., *Combretum* spp., etc.

Light Conditions

Light is one of the most important factors governing the distribution, development and regeneration of species. No other single factor has such a direct bearing upon forest growth, particularly in the evergreen forests. Light effects the natural reproduction of species, the artificial raising of seedlings for plantation, and is an important factor to be considered in regulating the degree of cutting and thinning etc. It largely determines the vigour and height growth of the seedlings and saplings, the character of the ground vegetation, seed production and various other phenomena upon which the management of the forests depends.

Light effects the plant growth through its nature, intensities and duration. There are two types of variations to which plants are subjected. They are: (i) variations which are caused by differences in latitude, altitude and climate, (ii) variations which are caused by local obstructions such as aspect, forest canopy, etc.

Both of these classes of variations change the intensity and quality of light. Variations in light caused by any of these factors affect the rate of photosynthesis and thereby the growth of plants.

In evergreen forests where the canopy is very dense, the light falling on the forest floor may be greatly reduced in intensity, by as much as 90 to 99%. Moreover the intensity fluctuates almost continuously due to the movement of the foliage. In evergreen forests where with an understorey of young trees and shrubs the light intensity above the second storey is near about 20% while it is reduced to about 5-1% below it.

Light intensity indirectly effects to some extent the mineral nutrition of plants, particularly the process of nitrogen metabolism. Unless plants receive enough light for rapid photosynthesis, nitrogen is not rapidly utilized with the result that in turn carbohydrates are not utilized effectively. Low light intensity stimulates height growth at the expense of diameter growth, top growth at the expense of root growth, leaf area development at the expense of leaf thickness and succulence at the expense of strength and sturdiness.

Though under natural conditions the intensity of light which is usually available to plants is sufficient for their normal developmental processes it may only be just sufficient. But as in nature unfavourable conditions almost always prevail simultaneously, with this "just sufficient" amount of light, plants are unable to manufacture enough food reserves with the result that under field conditions they cannot survive indefinitely.

The dense canopy of evergreen forests not only reduces the intensity of light but the quality of light is also greatly changed due to differential absorption and reflection by the foliage. Thus there is considerable difference in the quality of light which is received by the top canopy (receiving direct sunlight) and the second storey, shrub layer and ground cover (receiving diffused or filtered light in which green is predominant). Many workers have investigated the effect of red and blue light and they have found that these are more efficient for photosynthesis than green light. When plants are deprived of blue but are grown with the full complement of red and infra-red, they develop many of the characteristics of etiolated plants. The reduction in the red and blue in the spectrum reduces the photosynthesis, but plants do survive nevertheless. And therefore, the quality of light can be taken as having a secondary influence on the survival of the tree seedlings occurring on the floor of the forest. But again these small changes in spectral energy distribution of light in the forest may go a long way towards making many of the seedlings of important tree species healthy enough to withstand unfavourable conditions.

Light is also supposed to play an important role in forest succession. But there is some difference of opinion with regard to this. It is commonly assumed that the inability of some seedlings to grow is due to the fact that they are unable to grow in the shade cast by the top or second storey. This failure of seeds to germinate may also be attributed to deficient light although many evergreen species require shade for their seeds to germinate. The tolerant species if they are once established, can exist for a long time without making

appreciable growth; on the other hand intolerant seedlings, even if established, soon die out. This results in an understory made up almost entirely of shade tolerant species. Wherever favourable light conditions occur, due to death or removal of large trees or due to thinnings in the understory the tolerant seedlings increase in growth and they, therefore, gradually increase in proportion at the expense of others. These tolerant species may not be good from the economic point of view. If so it may be necessary to stop this line of succession and try to create conditions in which desired species come up.

To evaluate the role of this factor the following studies are suggested. Experiments should be conducted individually for important species under natural forest conditions as well as in the laboratory.

1. *Field experiments*—Field experiments with regard to light conditions should be carried out in areas where there is good, fair and poor regeneration of species under investigation. In such localities the amount of light available on the forest floor in different seasons should be measured and correlated with the seedling height, leaf area, root development as also diameter and height of older trees.

2. *Laboratory experiments*—In laboratory experiments the emphasis should be laid on intensity, duration and quality of light. Seedlings of the species should be grown under different combinations of these three factors and the effect of each treatment should be correlated with root-shoot growth and foliar expansion. Detailed chemical analysis of every part of the plant should be done to have an idea of the effect of each treatment on the production of organic matter, chemical constituents of the plant and the uptake of all the essential plant nutrients.

Phytosociological studies

Detailed phytosociological studies should be conducted. The forests should be studied by transect and list count quadrat methods to determine the ecological status of different plant communities, detailed floristic composition and relationship with ground floor communities and tree seedling growth. Study on succession status of all layers of vegetation including ground flora will give an idea of succession which will be of importance in the management of these species.

Analysis of soil and plant material

Representative soil samples from varying depths including surface litter should be collected. Analysis of plant material of complete seedlings growing under different conditions, mature trees (bark, wood, leaves and roots) should be done. Complete analysis of soil and plant parts will give an idea of mineral uptake from the soil, and its distribution in different plant parts.

Nutrition

Considerable attention has been paid to the relationship between plant growth and the mineral composition of plants and soils in order to determine the level of soil fertility and the nutrient requirements and mineral deficiencies of plants. Due to the presence of numerous species in the evergreen forests it may be expected that one or the other micro- or micro-elements may be limiting the growth of some species.

Under certain conditions the nutrients absorbed by the plants may also be used as indices of soil fertility, particularly in association with soil analysis. Unfortunately none of the species occurring in evergreen forests have been investigated in the past from this angle. The nutrient requirements of seedlings are best ascertained from sand or water culture experiments in which controlled amounts of various chemicals are added. With this end in view, sand culture, water culture and soil culture experiments should be conducted to determine the optimal levels of N, K, P, Ca, Mg, etc. For the soil culture experiments seedlings should be grown in typical forest soils and for sand culture in inert sand. The growth in shoot, root, and leaf expansion should be correlated with different treatment combinations. The soil culture experiments will give an idea about the soil suitability indices for different species.

Studies on competition between main and associated species

The element of competition is one of the most important factors affecting plant growth. Wherever the struggle for a place in which to germinate and to grow, or to obtain light or food, can be demonstrated, a competitive relationship is established. Competition among species affects the distribution of species and the development of plant communities. Local conditions of climate and soil may be progressively and more or less profoundly modified by the vegetation itself, thus gradually affecting the aggressiveness

of the combatants to different degrees. This often happens in the competition between different species or between different plant communities. The competition between the individuals of a community is the more intense the more closely they agree in their requirements for light and nutrients. In evergreen forests such conditions can be easily expected due to the great abundance of ground cover. Therefore, it can be assumed that the seedlings of valuable species may be suffering due to the presence of great number of other inferior species. Studies conducted by many workers have shown that both light intensity and root competition are important factors in the growth of plants under forest canopies and that improved growth can be brought about by the elimination of root competition or increase in light intensity.

Therefore, considering the importance of competition in relation to establishment and development of natural reproduction, with regard to light and materials assimilated from the soil, studies on competition are necessary.

For this purpose seedlings of main species should be grown separately with the associated species. There should be two sets of experiments in which light and nutrient should be controlled. The effect of each treatment should be correlated with the growth of the seedlings.

These extensive studies are likely to yield useful scientific data and will provide systematised knowledge with regard to light and nutrient requirements of some of the evergreen species under various types of soils, site characteristics and other factors which promote or inhibit the growth of species. A critical study of the results of such an investigation will further render possible a precise appraisal of the ecological and edaphic factors leading to the succession in evergreen forests.

REFERENCES

1. Bhatnagar, H.P. (1959)—The effect of root competition on the growth of sal natural regeneration. *Ind. For.* 85 : No. 7.
2. Clements, F.E. & Long, F.L. (1934)—Factors in the elongation and expansion under reduced light intensity. *Plant Phys.* 9 : 767-782.
3. Coventry, B.O. (1917)—Correlation between light and soil requirements of a species for its natural regeneration. *Ind. For.* Vol. 43, No. 4.
4. Jester, J. R. & Kramer, P.J. (1939)—The effect of day length on the height growth of certain forest tree seedlings, *Jour. For.* 37 : No. 10 : 796.
5. Pearson, G.A. (1930)—Light and moisture in forestry. *Ecology* 11 (1) : 145-159.
6. Seth, S. K. & Bhatnagar, H.P. (1959)—Soil suitability index for sal (*Shorea robusta*) natural regeneration. *Ind. For.*, Vol. 85, No. 11.
7. Shirley, H. L. (1929)—The influence of light intensity and light quality upon the growth of plants. *Amer. Journ. Bot.* 16 : 354-390.
8. —(1935)—Light as an ecological factor and its measurements. *Bot. Rev.* 355-381.
9. Zon, R. & Granes, H.S. (1911)—Light in relation to transect growth. U.S. Deptt. Agric. For. Service Bull.

STUDIES ON THE VEGETATION OF HUMID TROPICS OF INDIA

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Abstract

The paper deals with the vegetation of the Humid Tropics of the Western Ghats. Areas of Belgaum, North Kanara, Shimoga, Chikmaglur, Coorg and Kerala have been described in a comprehensive manner.

The vegetation in Belgaum consists of scrubby deciduous jungles with species like *Anogeissus latifolia*, *Terminalia tomentosa*, *Diospyros melanoxylon*, *Ixora*, *Randia brandisii*, *Gymnosporia* sp., *Chloroxylon swietenia*, *Zizyphus* sp. and others. The moist deciduous forests have species like bamboos, *Emblica officinalis*, *Terminalia paniculata* with *Xylia xylocarpa* and *Tabernaemontana heyneana* on better sites.

In North Kanara three distinct vegetation types are met with. Along north-east, scrubs are usually of *Gymnosporia* mixed type communities. The laterite scrubs along the coast and in central plateau have evergreen species of *Gardenia*, *Glochidion*, *Syzygium* and others. The deciduous forests have species like *Tectona grandis*, *Terminalia tomentosa*, *Emblica officinalis*, *Kydia calycina*, *Dillenia*, *Adina* and others; while the moist deciduous forests are dominated by one or other species of bamboo with usual deciduous components. The semi-evergreen type has *Xylia-Tabernaemontana* communities over most of the areas, which progress into evergreen forms of *Diospyros-Polyalthia-Myristica* and *Cinnamomum-Olea-Myristica* type.

In Shimoga and Chikmaglur observations have been recorded for some of the scrub, deciduous and semi-evergreen forests. The chief components met with here are: *Anogeissus latifolia*, *Bridelia stipularis*, *Carissa* sp., *Emblica officinalis*, *Flacourtia indica*, *Gymnosporia* sp., *Zizyphus* sp., *Tectona grandis*, *Terminalia tomentosa* and others. Moist deciduous vegetation has more of bamboos; while the semi-evergreen type, i.e. dominated by *Memecylon-Olea-Cinnamomum* type and several other mixed evergreen communities.

Coorg presents a variety of vegetation types from scrub to *Shola* forests. The scrubs have the usual thorny components. The deciduous forests have for the most part a mixed composition of Teak/Bamboo-*Terminalia* types. The semi-evergreen vegetation has *Litsea*, *Callicarpa*, *Xylia* and others with an understorey of bamboos (*Dendrocalamus strictus* and *Bambusa* bamboo) and with associates like teak and *Phyllanthus*. The evergreen vegetation consists of *Myristica*, *Mesua*, *Calophyllum*, *Palaquium* and others.

In Kerala also, the same vegetation types are met with. The best type developed is a Tropical Wet-Evergreen forest having *Mesua*, *Calophyllum*, *Myristica* and other evergreen associates.

The status of various types is also discussed.

The term humid tropics corresponds to areas which are characterised by features of high rainfall and temperature throughout the year, with little or no winter and high humidity and no snow or fog. These conditions of climate have developed on almost all types of soils, "Tropical rain forests type" which is the climax form of vegetation over large areas. In India, the humid tropical areas occur chiefly along the high rainfall belt of Assam in the north-east and along the Western Coast (including parts of Kerala, Mysore and Bombay State) in the south-west. These forests assume a great significance on account of their variety of flora and the economic wealth they contain.

The work on the Humid Tropics of the Western Ghats was started in 1956 by the Botanical Survey of India, Poona. Since then, the areas of Belgaum, Kanara, Coorg and Kerala have been explored.

Broadly speaking, three vegetation types are met with in the area:

- (a) Scrubs.
- (b) Deciduous forests.
- (c) Evergreen forests.

BELGAUM AND KOLHAPUR— (B.S. AHUJA)

The area under investigation includes the district of Belgaum (Mysore) and Kolhapur (Bombay) situated approximately between latitude 15.5°N and 17.2°N and longitude 73.7°E and 75.5°E along the Western Ghats. This is a mountainous region having an average altitude ranging between 1000-3000 ft. above sea level. Towards north and east, the area is open and under cultivation, and the forests are common only in the western and southern parts of the districts.

Geologically, the area is formed of granites and gneisses. There are also schists of Dharwar series, quartzite and limestones of Kaladgi series and basalt belonging to the Deccan Trap system. Laterite is common towards the extreme west. The soil can be classified into two types:-

- (i) Red soil, derived from the decomposition of granite, laterites and red clay.
- (ii) Black soil formed from the decomposition of basalts and sometimes gneisses and riverain alluvia.

The climate of the area is chiefly monsoonic. The rainfall varies between 150 cm. to 500 cm. and temperature between 50°F-105°F.

Vegetation

The following vegetation types are met with in the area:-

1. Semi-evergreen forests,
2. Deciduous forests, and
3. Scrub forests.

Semi-evergreen forests.—These forests occur along the south-west region of the area and have been studied at Radhanagari, Khanapur, Jamboti, Londa and Nagarhalli. These are the areas where rainfall, humidity and temperature conditions are usually high. The trees do not attain a height that is characteristic of typical evergreen forests.

The common top storey components are: *Alseodaphne semecarpifolia*, *Cinnamomum zeylanicum*, *Dillenia pentagyna*, *Memecylon talbotianum*, *Holigarna grahamii*, *Olea dioica*, *Syzygium* sp., *Terminalia chebula*, *Vitex altissima*, *Xylia xylocarpa*, etc.

The second layer consists of *Diospyros paniculata*, *Careya arborea*, *Glycosmis pentaphylla*, *Lagerstroemia lanceolata*, *Litsaea zeylanica*, *Mangifera indica*, *Memecylon edule*, *Ochrocarpus longifolius*, *Pygeum gardneri*, *Flacourtia montana*, *Terminalia paniculata*, *Trema orientalis*, *Tabernaemontana heyneana* and *Wendlandia notoniana*.

The third layer consists of *Carvia callosa*, *Callicarpa lanata*, *Canthium dicoccum*, *Flacourtia ramontchii*, *Ixora nigricans*, *Leea indica*, *Maesa indica*, *Mussaenda frondosa*, *Murraya koenigii*, *Mappia foetida*, *Pandanus*, *Randia* sp., *Psychotria*, *turncata* etc.

The common climbers are *Derris scandens*, *Elaeagnus conferta*, *Entada phaseoloides*, *Gnetum ula*, *Diosorea* sp., *Hoya* sp., *Heptapleurum venulosum*, *Piper nigrum*, *Piper* spp., *Smilax zeylanica*, *Toddalea aculeata*, *Wagatea spicata*, *Zizyphus oenoplia*, etc.

The ground flora consists of saplings of the dominant trees and small herbs like *Actinopteris dichotoma*, *Curcuma* spp., *Arisaema* spp., *Pteris aquilina*, *Pteris quadriaurita*, *Optismenus* spp., *Solanum ferox*, *Sida* sp., etc.

Succession

The forests of the area are under biotic interferences, i.e. cutting, lopping, grazing, fires, etc. for a very long time. So the forests of today are the result of interaction of many factors with their corresponding effect on the plant environment. The scrub jungles represent the degraded form of a dry-deciduous forest. The succession of the area in general can be represented by—

Semi-evergreen forests (*Cinnamomum-Memecylon-Olea* type).

↑

Moist deciduous forests (*Xylia-Bamboo-Terminalia* type).

↑

Deciduous forests (*Teak-Terminalia* type).

↑

Scrub forests (*Randia-Gymnosporia* type).

NORTH KANARA—(R. K. ARORA)

The district of North Kanara is situated on the north-west of the Mysore State along the western ghats between 13°55' N and 15°31' N, and 74°9' E and 75°10' E. Because of high rainfall and humid tropical conditions of high humidity and temperature the area is eminently suitable for the growth of luxuriant vegetation of evergreen forests.

Topographically, the area consists of a central upland covering about 3000 sq. miles and the low lands on the west and north of the district, covering about 1800 sq. miles.

Geologically, North Kanara is formed mainly of granite, gneiss and laterite. The underlying rock at places may also be metamorphic (quartzite, shale), especially in the north-east. The hill tops are usually covered with laterite, with rock outcrop on the surface. Alluvial deposits also occur and the alluvial soils bear good teak-bamboo type forests.

In the district, two types of soils, i.e. black and red, are met with. The red soils which are derived from the disintegration of granite/gneiss bear a vegetation of *Myristica*, *Diospyros*, *Cinnamomum*, *Olea* and others. The red soils from laterite bear *Cinnamomum*, *Tabernaemontana*, *Aporosa*, *Macaranga*, *Actinodaphne* with *Xylia*-Bamboo types. Laterite scrub on hard shallow soil supports *Pavetta*, *Gardenia*, *Ixora coccinea*, *Flacourtia* and *Glochidion*. Black soils may also support evergreen or deciduous vegetation. Hard shallow soil supports a mixed deciduous scrubby vegetation with *Flacourtia*, *Gymnosporia*, *Ixora parviflora*, *Carissa*, *Bridelia stipularis* with *Diospyros melanoxydon*, *Buchanania latifolia*, *Butea*, *Cassia*, etc. On deep alluvial soils, Bamboo-Teak*, *Anogeissus latifolia*, *Phyllanthus emblica*, *Kydia*, *Grewia tiliaefolia*, *Adina*, *Dillenia*, *Terminalia* etc. On maturity, the black soil changes to red soil and on these bamboo-*Xylia* mixed types develop. These red soils on leaching change still further and develop a brownish colour. On such deep soils an evergreen vegetation of *Xylia*, *Olea*, *Tabernaemontana heyneana*, *Terminalia* exists.

The climate of the area is typically monsoonic. Rainfall varies from 100 cm to 125 cm in the north-east to over 500 cm in the central, southern and coastal areas. Temperature remains moderate (75° F to 90° F) in the coastal and adjoining areas, while in north-east and central region it shows a variation between 50° F to 90° F.

Vegetation

The forests of North Kanara district are rich in their variety of flora. The vegetation varies from north-east to central, southern and coastal areas of the district. The following vegetation types are met with :

Evergreen type.

Deciduous type.

Scrub type.

There is no clear demarcation in the distribution of these types from one another, and so intermediate types are often to be seen. Thus adjoining a scrub may be a deciduous forest, and in an area with deciduous vegetation (teak forest), bamboo types and semi-evergreen types with *Tabernaemontana heyneana*, *Terminalia tomentosa*, *Xylia* and others may be seen. However in general, the distribution of these types is governed by factors of soil, amount of rainfall and heat and the topographical features.

Evergreen Forests.—The evergreen forests are found in the central uplands of the district. The Jog, Katgal, Yellapur—all these areas contain high evergreen forests exhibiting characteristic stratification with the first storey exceeding 125'. Some of the top storey trees in these forests are : *Artocarpus* spp., *Alseodaphne semecarpifolia*, *Cinnamomum zeylanicum*, *Diospyros microphylla*, *Elaeocarpus tuberculatus*, *Garcinia* sp., *Holigarna grahamii*, *Hopea wightiana*, *Litsaea stocksii*, *Lophopetalum wightianum*, *Macaranga peltata*, *Polyalthia fragrans*, *Ponteria tomentosa*, *Strychnos nuxvomica*, *Terminalia belerica*, *Vitex altissima*, etc.

The second storey in these forests is less prominent with an average height of 50' or so, depending upon the type of forest and the first storey species. Some of these trees are: *Actinodaphne hookeri*, *Alstonia scholaris*, *Aporosa lindleyana*, *Careya arborea* (occasionally along edges), *Cinnamomum zeylanicum*, *Diospyros* spp., *Flacourtia montana*, *Holigarna arnotiana*, *Linociera malabarica*, *Olea dioica*, *Terminalia chebula* and *Xylia xylocarpa*.

*Mixed forests predominate with *Dendrocalamus strictus*, *Bambusa bambos*, teak.
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The third storey attains a height of about 20'. The species met with are : *Callicarpa tomentosa*, *Canthium dicoccum*, *Ixora brachiata*, *Leea indica*, *Psychotria* spp., *Randia*. Among climbers and shrubs, *Allophyllus cobbe*, *Calycopteris floribunda*, *Chasalia curviflora*, *Cissus* sp., *Clerodendron infortunatum*, *Entada phaseoloides*, *Cyclea* spp., *Asparagus racemosus*, *Gnetumula*, *Hemidesmus indicus*, *Murraya koenigii*, *Naravellai zeylanica*, *Piper nigrum*, *Pothos scandens*, *Rubia cordifolia*, *Smilax zeylanica*, *Wagatea spicata*, *Zizyphus rugosa*, etc.

The ground flora consists of saplings of above trees. Among other plants, *Curcuma* sp., *Costus speciosus*, *Melanthesa turbinata*, *Murraya* and *Pteris quadriaurata* are more common.

The tree trunks are occupied by a rich growth of orchids (*Aeroides* sp., *Bulbophyllum* sp., *Pholidota imbricata*), ferns, i.e. *Pleopeltus* and few fungi borne on decaying woods.

These forests are significant in showing (a) stratification, (b) rich growth of lianes, (c) epiphytic flora, (d) a peculiar ground flora of tree seedling, few *Scytamineae* and ferns like *Pteris* spp., *Nephrodium* and *Gymnopteris subcrenata*.

Successional trends

The general successional trend is shown below:—

(<i>Diospyros-Myristica-Cinnamomum</i> type) Evergreen	} (Climax)
(<i>Xylia-Tabernaemontana</i> type) <i>Xylia</i> Semi-evergreen		Red soil
(Bamboo type)	} Moist deciduous
(Teak type)		Deciduous
(<i>Ixora-Gymnosporia</i>)	} Black soil

Succession in North Kanara forest.

SHIMOGA AND CHIKMAGLUR—(B. S. AHUJA)

The area under investigation includes the districts of Shimoga and Chikmaglur (Mysore State) situated approximately between latitude 13° 8' N and 14° 8' N and longitude 75° 0' E and 76° 2' E. The area is covered by more or less small hills having an altitude ranging from 1200-6000 ft. above sea level.

Geologically, most of the area consists of granite, gneisses and laterites. Laterite outcrops are seen on the surface at several places. The colour of the soil varies from red to dark brown.

The climate is typically monsoonic, with annual rainfall of 500 cm. The rainfall varies to a great extent in the area, maximum being at Agumbe (also known as Cherrapunji of Mysore, 875 cm) in the western region and minimum being at Kedur (85 cm) in eastern region.

Depending on climate, geology and soil etc., different vegetation types met with are: (i) Evergreen/Semi-evergreen, (ii) Deciduous, and (iii) Scrub. *Sholas* occupy the higher elevation and are common on the hill tops at some places.

A large portion in the western region is being utilised in the cultivation of coffee, tea, cardamom etc.

Evergreen and semi-evergreen forests—These forests are confined mainly to the west of the area, where conditions of high rainfall, humidity and temperature are prevalent.

The common plants in these forests are :—

Actinodaphne angustifolia, *Actinopteris dichotoma*, *Carvia cellosa*, *Canthium dicoccum*, *Cinnamomum zeylanicum*, *Dillenia pentagyna*, *Derris scandens*, *Elaegnus conferta*, *Flacourtia montana*, *Garcinia morella*, *Glycosmis pentaphylla*, *Holigarna grahamii*, *Ixora nigricans*, *Leea indica*, *Litsaea zeylanica*, *Macaranga roxburghii*, *Maesa indica*, *Mussaenda frondosa*, *Memecylon edule*, *Mappia foetida*, *Oberonia recurva*, *Oberonia brunoniana*, *Olea dioica*, *Pteris aqualina*, *Pteris quadriaurata*, *Pandanus tectorius*, *Piper nigrum*, *Pothos scandens*, *Smilax zeylanica*, *Symplocos spicata*, *Syzygium cumini*, *Tabernaemontana heyneana*, *Vitex altissima*, *Wagatea spicata*, *Xylia xylocarpa*, *Zizyphus oenoplia*, etc.

Sholas and grasslands.—Hills at the altitude of 4,500-5,000 ft. above sea level are covered with grasslands except the patches of *shola* forests. This type of vegetation was studied at Shamshe and Kudremukh.

The common plants in the *sholas* are:—

Actinodaphne hookeri, *Callicarpa lanata*, *Calamus rotung*, *Calophyllum* spp., *Canarium strictum*, *Chasalia carviflora*, *Cinnamomum zeylanicum*, *Dysoxylum malabaricum*, *Euonymus* spp., *Eugenia* spp., *Elaegnus latifolia*, *Eletteria cardamomum*, *Elaeocarpus tuberculatus*, *Garcinia morella*, *Gnetum ula*, *Hopea parviflora*, *Holigarna grahamii*, *Hypericum mysorense*, *Ixora nigricans*, *Litsaea zeylanica*, *Leea indica*, *Mesua ferrea*, *Mappia foetida*, *Myristica laurifolia*, *Macaranga roxburghii*, *Olea dioica*, *Ochlandra* sp., *Pandanus furcatus*, *Pavetta* spp., *Polyalthia* spp., *Psychotria truncata*, *Rhododendron nilagiricum*, *Senecio tenuifolius*, *Smilax zeylanica*, *Vernonia* sp., etc.

In the open grasslands shrubs like *Wendlandia notoniana*, *Hypericum mysorense* *Phoenix* spp., *Vernonia arborea*, *Symplocos spicata* are common.

COORG—(R. K. ARORA)

The district of Coorg lies between 11° 56' and 12° 56' N, and 75° 22' and 76° 12' E in the western part of the Mysore State and along the western ghats. On the north, north-east of the district, it joins the drier portion of Mysore State, while on its south and west evergreen vegetation with lofty tall trees is met with.

The area is mainly mountainous. The average altitude is 3,500 ft. above sea level along the plateau of Mercara, though some peaks exceed 5,700 ft.

Geologically the area is composed of granite, gneiss and laterite. Alluvial soils are also met with and they support a good growth of teak and/or bamboo. Red soils generally bear an evergreen vegetation. Red and black soil types as described for North Kanara are also met with here.

The climate of the area is monsoonic. The annual rainfall varies from 80 cm. (north-east) to 500 cm. (south Coorg), temperature varies between 50°F—90°F, remaining moderate over central and southern Coorg, and showing extremes along the north.

Vegetation types.—Four vegetation types are met with in the area. The distribution of these types, *i.e.* evergreen, deciduous, scrub, grasslands, is governed chiefly by (a) type of rock and soil, (b) the amount of rainfall, and (c) biotic interferences.

The evergreen forests are developed on red soil, chiefly in the high rainfall areas. Floristic of these forests are yet to be studied. However, the general composition is a mixture of evergreen species with two, three or more co-dominants. These forests are characteristic in showing (a) distinct stratification, (b) dense growth of lianes, (c) rich epiphytic growth, and (d) distinct undergrowth of ferns and tree seedlings with only a few herbs. *Myristica attenuata*, *Calophyllum tomentosum*, *Calophyllum wightianum*, *Canarium strictum*, *Elaeocarpus tuberculatus*, *Garcinia* spp., *Chrysophyllum roxburghii*, *Mesua ferrea*, *Dipterocarpus turbinatus* are the common top storey species. The second storey consists of *Olea dioica*, *Holigarna* spp., *Flacourtia montana*, *Palaquium ellipticum*, *Actinodaphne*, *Litsaea* spp., *Leea indica*, *Psychotria*, *Ixora nigricans*, etc., and the third storey consists of the same species with climbers like *Gnetum ula*. The ground flora is chiefly composed of saplings of top storey species with a few members of *Scytamineae*, *e.g.*, *Costus speciosus* and ferns like *Gymnepterus* and *Pteris*. *Bulbophyllum*, *Pholidota* are the common epiphytes with ferns *e.g.* *Pleopeltis* species.

The climax type in the evergreen forests is perhaps of species like *Mesua*, *Palaquium*, *Calophyllum* and others.

KERALA—(M. Y. ANSARI)

The State of Kerala is situated on the southern most part of the country along the west coast, between latitudes 8° 2' N—13° N and longitudes 75° E—77° E. A large portion of it comprises of the coastal plain areas and the high mountains of the Western Ghats, which rise to 8837' above sea level at certain places.

Geologically, the State has got the following three different types of formations:—

1. *Recent Deposits*.—These are generally formed along the coastal areas of the State.

2. *Older Alluvium/Laterite*.—These are found slightly into the interior side of the State. Here the soils are generally red in colour.
3. *Granite, Gneiss etc.*.—This is the dominant formation in the mountains of the Western Ghats.

The soil type varies considerably from the coastal areas towards the interior of the State. The soil near the coastal regions and the plains are mostly either sandy, sandy-loam or loamy sand in nature. Towards the interior side of the Trivandrum district it tends to assume loamy-clay to clay-loam texture.

The State has a tropical climate, influenced by both the south-west and north-east monsoons with rainfall varying from 150 cm. to 700 cm. at a place like Pettimudi. The temperature in the hot weather often rises to above 100° F.

The following main types of tropical vegetation are met with:—

- (a) Wet evergreen forest.
- (b) Semi-evergreen forest.
- (c) Moist deciduous forest.
- (d) Dry deciduous forest.
- (e) Grasslands (in patches).

The wet evergreen forests which are generally very thick and impenetrable in nature, contain species like *Mesua ferrea*, *Calophyllum tomentosum*, *Artocarpus* sp., *Xanthophyllum flavescens*, *Cinnamomum zeylanicum*, *Mangifera indica*, *Pterospermum acerifolium*, *Pterospermum reticulatum*, *Actinodaphne hookeri*, *Diospyros microphylla*, *Heptapleurum* sp., *Holigarna arnottiana*, *Memecylon edule*, *Mimusops elengi*, *Bischofia javanica*, *Cedrela toona*, *Eugenia jambolana*, *Eugenia arnottiana*, *Hopea parviflora*, *Vateria indica*, *Trewia nudiflora*, *Baccaurea courtallensis*, *Tetrameles nudiflora*, *Sterculia guttata*, *Vitex altissima*, *Carvia* sp., *Psychotria truncata*, *Eupatorium* sp., etc. Besides a number of lianes, climbers, orchids and ferns are also found. These are : *Cocculus macrocarpus*, *Anamirta cocculus*, *Hemidesmus*, *Vitis gigantea*, *Vitis lanceolaria*, *Vitis tenuifolia*, *Smilax zeylanica*. Several species of *Piper*, *Dioscoreas*, *Jasminum* and *Modecca wightiana*, *Passiflora foetida*, *Aerides odoratum*, *Bulbophyllum neilgherrense*, *Dendrobium macraei*, *Eria pauciflora*, *Liparis longipes*, *Pholidota imbricata*, *Aerides maculosum*, *Aerides crispum*, *Dendrobium pierardi*, *Luisia teretifolia*, *Saccolabium viridiflorum*, *Oberonia brunomiana*, *Cymbidium* sp., *Cirrhopetalum* sp., *Drynaria* sp., *Pleopeltis* sp., *Thamnopteris nidus*, *Nephrodium* sp., *Lygodium flexuosum*, *Angiopteris evecta*, *Stenoloma chinensis*, *Pteris* sp., *Blechnum orientale*, *Dayalia* sp., etc. together with canes like *Calamus thawitesii* and *C. rotung*.

The semi-evergreen forests have the elements of both the wet evergreen and moist deciduous vegetation. These are *Adina cordifolia*, *Salmalia malabarica*, *Hopea parviflora*, *Mangifera indica*, *Cedrela toona*, *Lagerstroemia lanceolata*, *Lagerstroemia speciosa*, *Cinnamomum zeylanicum*, *Mallotus philippinensis*, *Xanthophyllum flavescens*, *Terminalia paniculata*, *Dalbergia latifolia*, *Wrightia tinctoria*, *Mitragyna parvifolia*, *Elaegmus latifolia*, *Calycopteris floribunda*, *Mussaenda frondosa*, *Tridax procumbens*, *Solanum xanthocarpum*, *Carrisa macrophylla*, *Tabernaemontana heyneana*, *Leea sambucina* and *Antidesma menasu*.

The vegetation development in different areas shows a general trend of succession towards an evergreen climax under the high rainfall conditions of the humid tropics. The different communities found are either biotic or bioedaphic in origin. The climax vegetation in North Kanara is of *Diospyros-Myristica-Cinnamomum* types.

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REFERENCES

- Ahuja, B. S. 1959 Studies on the vegetation of Sutgatti forest in the western ghats. *Proc. Ind. Sci. Cong.* 1959, p. 308.
- — Studies on the vegetation of Deccan trap country—II. Plants of Belgaum and Kolhapur area. *Ibid.*, p. 309.
- Arora, R. K. 1959 Ecological studies on the evergreen forests, *Ibid.*, p. 304—5.
- Ecological studies of some deciduous forests of north Kanara. *Ibid.*, p. 306-7.
- Champion, H. G. 1936 A preliminary survey of the forest types of India and Burma. *Ind. For. Rec.* (N.S.), Vol. I, p. 1—236.
- Puri, G. S. 1956 Problems in the ecology of the Humid Tropics. *Proc. Kandy Symp.*, UNESCO, p. 19-27.
- 1959 Studies on the vegetation of Humid Tropics of India, *Proc. Bogor Symp.*
- 1960 Forest Ecology (vegetation of India and its environments) Oxford Book Co., (in press).
- Puri, G. S., J. A. Vasvada & M. Y. Ansari. 1959 Botanical exploration of Kerala. *Nat. Acad. Sci.*, 1959.
- Puri, G.S., & R.K. Arora 1959 The flora of North Kanara, Western Ghats, India *Proc. Ind. Sci. Congress* 1959, p. 294-95.
- Studies on the vegetation of Coorg, Western Ghats, India, *Ibid.*, p. 305-6.

TROPICAL EVERGREEN AND SEMI-EVERGREEN FORESTS IN ASSAM AND NORTH EAST FRONTIER AGENCY

BY G. PANIGRAHI

Shillong

Abstract

Although Champion (1936) has dealt comprehensively with the forest types of India and Burma and his classification still serves as the main basis for any discussions on the subject, recent studies undertaken by the Eastern Circle of the Botanical Survey of India over the last four years in parts of Assam and NEFA, have afforded splendid opportunities for looking afresh at the various aspects of the forest types met with in the area.

Regional distribution of the tropical evergreen, semi-evergreen and montane evergreen forests of Assam and NEFA are detailed. Variations both in spatial distribution and in details of floristic compositions, are brought out.

Climate, topography, geology and soil as also biotic influences are primary environmental factors which determine the development and distribution of climax formations. The finest tropical rain forest develops normally a climax on low hills and gentle slopes from the plains upto 1000 m in areas enjoying high temperature, high humidity and high rainfall favourably distributed throughout the year. Similarly, the tropical evergreen, semi-evergreen and montane evergreen forests flourish on a variety of soils including tropical red soils on the outcrops of crystalline rocks and on tertiary red sandstones. These locality factors have been critically examined areawise, with particular reference to NEFA and the prevalence of Bor's (1942) "Forest Climate" over the whole of Assam and the outer ranges of NEFA has been established.

Evergreen and semi-evergreen forests are restricted to inaccessible hills and valleys and along the course of hill streams unsuitable for cultivation or to areas protected as reserved forests or as sacred groves. The forests of Dawki, Umtrua and Sonapur in the Khasi and Jaintia Hills, Upper Dihing R.Fs. near Digboi; Ranga, Cokoi and Dulong R.Fs. in North Lakhimpur; Kocharigaon, Chardwar, Khalingduar and Singri R. Fs. in the Cachar district of Assam are ascribed to tropical evergreen types. Similarly the outer ranges of NEFA, such as the forests between Bhairab kunda and Baha and amidst the triangle formed by Chengi-Warang-Bruckplanchen as also between Foot Hills and Sissini in the Kameng forest division, from Kimin to Hapoli in the Subansiri F.D., from Teju to Hayuliang in the Lohit F.D. and finally the forests south-west of the line joining Pangsupass, Khonsa and Wanu in the Tirap F.D., are covered with primeval evergreen forests with very little evidence of human interference. On the other hand, Chirang R.F. in the Goalpara district, Orang R.F. in the Darrang district and Nambur R.F. in the Sibsagar district and scattered patches in the Motharguri area in the North Kamrup district represent tropical semi-evergreen forests whereas the sacred groves of the Khasis in Shillong Peak, Mawphlong and Cherrapunjee, Pynursla and Nongstoin area, considered as relicts of the once prevalent climax formation on the Shillong Plateau, as also the forests between Sissini and Chakoo in the Kameng F.D. and the forests to the south-east of the line joining Pangsupass, Khonsa and Waun in Tirap F.D. are better classified as montane evergreen forests. The remaining parts of Assam possess either tropical deciduous forests, grassland or riverain vegetation in the Brahmaputra valley, the development of the climax formation in such cases being arrested in different stages of succession conditioned by edaphic, physiographic and/or biotic factors. The vast areas of the Shillong Plateau are now covered by subtropical pine forest or grassland, biotically controlled by fire and 'jhuming'.

The evergreen and semi-evergreen forests over the whole area are characterised by thick impenetrable vegetation comprising of tall tree species up to 20—30 m high, viz., *Ficus*, *Quercus*, members of *Magnoliaceae*, *Lauraceae* etc. forming the top canopy of shrubs comprising of *Myrsinaceae*, *Ternstroemiaceae*, *Rubiaceae*, *Palmae*, *Leea* spp., *Musa* spp. and an evergreen forest floor in which *Cursuma*, *Alpinia*, *Hedychium*, *Piper*, members of *Acanthaceae* etc., are dominant components. Ferns, orchids and mosses are very common as epiphytes.

Dominant species vary from area to area, viz., *Dipterocarpus turbinatus*, *Nephelium longana* and *Palaquium polyanthum* in Katakhar R.F., *Dipterocarpus macrocarpus* and *Shorea assamica* in the Upper Dihing R.F., *Kayea assamica*, *Bridelia* etc., in Dulong R.F.,

Sterculia, *Dysoxylum*, *Pterospermum* and *Elaeocarpus* in the Chirang R.F. and *Canarium* sp., *Stereospermum* sp. and *Terminalia* spp., in the Nambor R.F. of Assam. The evergreen forests of the Kameng F.D. and Subansiri F.D. are dominated by *Quercus*, *Ficus*, *Schima* and *Morus*, the hot river valley of the Lohit and Siang F.D. are featured by *Macaranga*, *Acer*, *Syzygium* sp., *Dipterocarpus*, *Caryota* and *Livistona jenkinsiana*, and the Tirap F.D. by bamboos, *Calamus*, *Daemonorops*, *Stereospermum*, etc.

The finest tropical rain forest develops normally as a climax on low hills and gentle slopes from the plains up to 1,000 m in areas enjoying high temperature, high humidity and high rainfall favourably distributed throughout the year. Similarly, the evergreen and semi-evergreen forest flourishes on a variety of soils including tropical red soils on the outcrops of crystalline rocks and tertiary red sandstones.

The forests of the Upper Assam Hills, Cachar Hills, Naga Hills and parts of Khasi-Jaintia Hills and outer ranges of N.E.F. Agency are characterised by tropical evergreen and semi-evergreen forests, whereas the remaining parts of Assam possess either tropical deciduous forests or sub-tropical pine forests or grasslands the development of the climax vegetation in such cases being arrested in different stages of succession by edaphic, physiographic and/or biotic factors.

Although Champion (1936) had dealt comprehensively with the forest types of this region and his classification serves still as the main basis for any discussion on the subject, recent studies undertaken by Botanical Survey of India over the last four years in parts of Assam and NEFA have afforded opportunities for looking afresh at the various aspects of the forest types met with in this area. These studies show that the vegetational types of the area under study, while conforming broadly to those of Champion, show variations both in spatial distribution and in details of floristic composition.

Topography, Geology and Soil

Geologically speaking the Eastern India, comprising of NEFA, Manipur and parts of Assam, is of recent origin, although Garo, Khasi, Jaintia and Mikir Hills of Assam contain a core of very ancient rock similar to that forming the Indian Peninsula and may thus be ascribed to have formed parts of the old Gondwana continent. Thus the different parts of Assam and NEFA belong to different ages of geological formations. The effects of these can easily be detected in the existing topography which in its turn determines the development and distribution of the present day vegetation.

A. NORTH-EAST FRONTIER AGENCY

Although the geological structures of the NEFA divisions have not been worked out in detail, some of the main outlines are known. The outer ranges from Kameng F.D. in the west to Tirap F.D. in the east comprise of Bhabar and old alluvial deposits in the big river valleys supporting evergreen and semi-evergreen forests whereas the inner ones are of schist, slates, limestones and dolomites of considerable age. The whole area consists of steep hills and deep gorges up to 4,270 m. Hill slopes of the Kameng, Siang and Lohit F.Ds. are often subjected to landslides and soil erosion. Earthquakes and landslides are a constant feature of Lohit F.D. in particular where the soil is predominantly sandy mixed with little alluvium and gravel. The soil is sandy clay at Sissini and sedimentary mica-type at Chakoo, the layer being very distinct and easily separable. Although the general topography of the Tirap F.D. is the same as in other divisions, the highest hill between Raho and Waka attains a height of 1,640 m. These hill ranges consist of brown black alluvium and are perhaps very stable and landslides seldom occur even in heavy rainy season. The forest floor in the foot hills and beyond up to 2,440 m in Kameng F.D., Subansiri and Tirap, is covered over by *debris* often to 60 m in depth arising mainly due to the shedding of leaves from year to year over centuries. It is this humus which forms the soil cover over the bare rock and by preventing evaporation from forest floor, supports the herbaceous and shrubby elements of the flora, including several species of saprophytic fungi.

All the NEFA divisions are cut up by many swift flowing streams and waterfalls joining the main rivers of Kameng, Subansiri, Siang, Lohit and Borab (Tirap). The regions approaching the various streams and river beds, are predominantly sandy mixed with gravel and stony pebbles of different sizes in Lohit and by large and massive rock boulders of gneiss in Tirap, Subansiri and Kameng Frontier divisions.

B. SHILLONG PLATEAU

The Central Shillong Plateau, on the other hand presents a core of very ancient metamorphic rock and is essentially stable in nature with little tertiary foldings. The highest point on the plateau is about 1920 m. The entire plateau consists of flat or rounded hillocks and cut up by many streams and waterfalls and a few rivers of a considerable size. These streams swell up with a heavy shower of rain, but soon get dried up. Large parts of this plateau consist mainly of gneiss with very little mica. The hills of Pynursla and Cherrapunjee are overlain by tertiary beds consisting largely of limestones, coal seams, and sandstone. The hillocks of Nongstoin in border of Khasi and Garo Hills are essentially of red lateritic mass without any hard gneiss or sandstones and have a deposit of black humus of about 60 cm. in depth.

The slopes of Khasi and Jaintia Hills are covered with red earth whereas on the ridges there is a gritty soil derived from disintegration of metamorphic rocks. At Cherrapunjee, no soil cap is at all present. Massive rock boulders stand out prominently in the landscape.

C. BRAHMAPUTRA VALLEY

In between the NEFA ranges of tertiary origin and the Central Shillong Plateau of Gondwana land lies the vast expanse of alluvial plains known as Brahmaputra valley, containing alluvium of several thousand feet in depth.

The valley is broken up by numerous isolated groups of low hillocks such as in Tejpur, Gauhati, Barnihat, Garbhanga and Dhubri and consist mostly of gneiss. The soil is composed of recent alluvium and the subsoil consists of coarse waterborne pebbles with a cover of sandy loam of varying depth. A large number of rivers, viz., Bhoireli, Dhansiri, Brahmaputra, Kapili, Dihing etc. channel their way through this valley. The bed of Bhoireli in Darrang district is full of gravels of varying size, whereas the bed of Dihing river in foothills of Mikir Hills is made up of hard gneiss. The surrounding area, however, is of sandy loam and is replaced by black alluvium at certain places. These rivers help in the creation of large swamps and *Bheels* of which the Kaziranga Game Sanctuary is perhaps the largest. The yearly flood creates swamps and marshes and soil is presumably acidic. Humus cover on the forest floor forms a porous layer. At Barnihat, soil is mostly alluvial attaining black texture and is very fertile. The Hills of Garbhanga are made up of red or brown alluvium and are subjected to land-slides. Near Notharguri in the North Kamrup district, as also at Khaling Duar, the soil is rocky mixed with alluvium and gravel. The upper Dihing R.Fs. (East Block) near Digboi have an uneven topography with a number of cliffs and valleys. The soil in the east block is muddy brown and lateritic whereas in the west block it is alluvial covered by humus. There are a few swampy areas in this region also.

Climates

There is prevalence of moderately high temperature, heavy rainfall and high humidity in different parts of Assam and NEFA. They enjoy a favourable distribution of rainy days throughout the year. Consequently there is no seasonal variation in temperature. 75% of the rain falls down between the months of June to October.

Vegetation

This climax formation of primeval vegetation up to 1000 m although occurs in its virgin state in the outer ranges of NEFA has, however, suffered greatly due to the effect of physiographic, edaphic and biotic factors operating in Assam. Accordingly, evergreen forests are now restricted in the Khasi and Jaintia Hills to inaccessible hills and valleys and find optimal expressions along the course of hill streams unsuitable for cultivation or protected either as sacred groves or as reserved forests. These forests are characterised by thick impenetrable vegetation, comprising of tall tree species up to 20—30 m high. Rank growth of shrubs and epiphytes predominates in the middle storey and of an evergreen forest floor made up of moist humus cover supporting ground vegetation. No climbers or lianes are found in montane forests of Khasi Hills.

The spatial distribution of evergreen and semi-evergreen forests referred to above are presented below together with the details of their floristic compositions.

I. EVERGREEN FOREST OF THE KHASI AND JAINTIA HILLS

(a) The relict vegetation of the Shillong Plateau is preserved as sacred groves by the Pagan Khasis. These groves occur on scattered patches in Shillong Peak, Nawphlang, Land Kyntang and Pynursla. The rest of the plateau at Cherrapunjee is covered by grassy formation

which are burnt in December when only the hardy fronds of *Dicranopteris linearis* var. *montana* provide the green colour to the charred landscape. The forests at Shillong Peak, Mawphlang, Cherrapunjee and Pynursla predominate in *Quercus fenestrata*, *Schima wallichii*, *Rhododendron arboreum*, *Cinnamomum* spp., *Manglietia insignis* and *Pyrus* spp. together with members of *Ternstroemiaceae*, *Myrsinaceae*, *Rubiaceae*, *Thymeliaceae*, etc. Epiphytic orchids, ferns, mosses and lichens cover every branch and twig in the middle canopy, whereas liverworts, mosses, members of *Urticaceae* and ferns infest the moist rock boulders. Ferns, particularly members of *Aspidiaceae* flourish best amidst the leaf litter of the forest floor.

(b) At Dawki, on the Indo-Pakistan border, one meets with evergreen forest dominated by *Heterophragma pinax* and many other tree species which are covered by climbers like *Porina paniculata* and *Gnetum montanum*. *Artocarpus integrifolia*, *Areca catechu* and *Piper betel* flourish well as introductions.

(c) Vegetation of the area between Mawngap, Nongstoin and Nongkhlaw is essentially a grassland type broken up here and there by pockets of evergreen forests. These pockets are found in the shelters of the hill slopes, which are unsuitable for 'jhuming' because of their steep nature or because these are too far away from human habitation. Along the course of the river valley, deep down the gorges, 2 miles west of Nongstoin, primeval evergreen forest is met with. At Nongkhlaw, the subtropical pine forest is abruptly replaced by broad leaved evergreen forest. The Chief tree species are *Schima wallichii*, *Quercus* spp., *Ficus* spp., and members of *Araliaceae*. *Toddales acueata*, *Mussaenda* and *Saurauja* make up the shrub layer. Orchids and ferns are common.

(d) At Umtrue, the dam site, the evergreen forest is dominated by bamboos, *Ficus* spp. and *Quercus* spp., amongst which lianes like *Gnetum montanum* are common. Along the edge of the forest and the bank of the river Barni, grasses grow up to 3—4 m. in height.

(e) Sonapur, near Jowai, presents an evergreen forest in the Nanpoo Reserve, particularly along the Luva river bank. *Dillenia indica*, *Anthocephalus cadamba* and *Ficus* spp., together with *Calamus* and other palms, *Musa*, *Dendrocalamus hamiltoniana* are the dominant components. *Gnetum gnemon* occurs in scattered patches.

II. EVERGREEN FORESTS IN THE BRAHMAPUTRA VALLEY

Although the major parts of the Brahmaputra valley are characterised by preclimax forest type dominated by *Shorea robusta*, or by riverain forest with *Salmalia malabarica*, *Duabanga sonneratioides*, *Acacia catechu*, *Tetrameles nudiflora* or by grassland with *Sclerostichya fusca*, *Saccharum aponsaneum*, *Phragmites* spp., etc., it passes imperceptibly to tropical evergreen forest type in the Upper Dihing R.Fs. near Digboi, in the Ranga, Kakoi and Dulong R.Fs. in the North Lakhimpur district, in the Kocharigaon, Chardwar, Khalingduar, and Singri R.Fs. in the Darrang district in Katakhal and Innerline R.Fs. in the Cachar district of Assam.

The Nambur R.F. in the Sibsagar district, Chirang R.F. in the Goalpara district, Orang R.F. in the Darrang District and scattered patches in the Motharguri area in the North Kamrup district of Assam represent semi-evergreen forests in the valley.

(a) Upper Dihing R.Fs.

These reserve forests near Digboi comprise of 2 blocks, viz. East and West and stretch as a continuous belt from north-east to south-west for more than 12 miles. It is a typical wet evergreen tropical forest dominated by *Dipterocarpus macrocarpus*, *Beilschmiedia* (*Purkayastha*) *pseudomicropora*, *Mesua ferrea*, *Shorea assamica* in the west block and *Terminalia myriocarpa*, *Callicarpa* and bamboos in the east block. *Dipterocarpus* projects high above the general level. *Mallotus philippinensis*, *Saurauja*, *Melastomaceae*, *Cyathea* spp., and *Angiopteris evecta* are the important shrubs. The forest floor is covered by *Calamus*, *Piper*, *Commelinaceae*, *Salaginella* and ferns with orchids and *Asplenium nidus* and *Microsorium punctatum* as common epiphytes. The edge of the forest is fringed by *Hedychium*, *Musa volutile*, *Polliia* and *Cyclosorus paratiticus*.

(b) Dulong, Kakoi and Ranga R.Fs.

These three R. Forests represent a continuous stretch along the foot-hills of the Subansiri Frontier division and the maximum width is about 3 miles. *Kayea assamica*, *Terminalia chebula*, *Castanopsis*, *Bridelia*, *Pterospermum*, *Dysoxylum* and *Mesua ferrea* are the principal trees. *Telloma phellocarpa*, *Abroma augusta*, *Calamus*, *Hydnocarpus*, *Cyathea* and *Angiopteris evecta* together with *Myrsinaceae* constitute the principal shrub layer.

Acanthaceae, very rich in species, is in the ground layer. Epiphytic orchids and *Antrophyllum reticulatum* are common. *Terminalia myriocarpa* plantations are doing well in these reserves.

(c) **Chardwar R.F.**

Dharikheti, Bhalukpung, Kocharigaon and Chardwar R.Fs. border upon the foothills of Kameng F.D. and represent almost continuous blocks of forests and represent similar floristic composition. A very large compact block of Balipara R.Fs. with *Shorea robusta* as most dominant species is nearby Kosharigaon R.F. and includes large plantations of *Morus laevigata* (*bola*), *Phoebe goalparensis* (*bonsum*), *Cedrela toona* (*poma*), and *Amoora wallichii* (*amari*); whereas near Potasali *Mesua ferrea*, *Lagerstroemia parviflora*, *Salmalia malabarica*, etc. are common. These trees are generally very tall but some species are with slender girth. The second storey consists of shrubs with members of *Myrsinaceae*, *Palmae* and tree ferns. *Gnetum gnemon* and *G. montanum* are rather common. *Clerodendrum*, *Eupatorium*, *Coffea bengalensis* and ferns are common in the forest floor. *Stenochlaena palustre* and *Lygodium* are common on forest fringe.

(d) **Khalingduar R.F.**

Khalingduar R.F. with an elevation of 330—488 m. and with an area of 17,372 acres, presents in general an evergreen forest with deciduous elements in the eastern flank of the reserve. The northern side of the reserve gradually changes from deciduous type to semi-evergreen and attains to evergreen type near the innerline bordering upon Bhutan. *Phoebe goalparensis*, *Terminalia myriocarpa* and *Gmelina arborea* together with *Tetramesles nudiflora*, *Duabanga sonneratioides*, etc., form the dominant components in the top canopy and are associated with *Canarium bengalense*, *Chisocheton parviculatus* and *Acacia catechu*—the last one being restricted to the eastern zone. *Gnetum montanum*, *Calamus*, *Dioscorea*, *Cuburbitaceae*, *Vitis* sp., *Pothos*, *Stenochlaena palustre* and *Piper* mixed with epiphytic orchids like *Dendrobium*, *Vanda*, *Rhyncostylis* and *Pholidota* form dense covering in the upper and middle strata of the forests.

(e) **Singri R.F.**

Singri R.F. represents a solitary compact hillock of evergreen forest, surrounded by cultivated rice fields, swamps and grasslands. At its periphery, *Tectona grandis* plantations flourish luxuriantly.

(f) **Katakhal and Innerline R.Fs.**

These reserve forests in the Cachar district, like the Sonapur R.F. nearby represent true evergreen type dominated by *Dipterocarpus turbinatus*, *Canarium resiniforme*, *Nephelium longana*, *Diospyros* spp. and *Cynometra polyandra* in the top canopy; *Podocarpus nerifolia*, *Palaquium polyanthum*, *Melocanna bambusoides* and *Bambusa balcooa* are also very common. *Eupatorium odoratum* forms dense thickets. *Entada scandens* and *Combretum decandrum* are common climbers. Thus, good many species occur here which are absent from upper Assam. *Shorea assamica* of upper Assam is altogether absent.

III. SEMI-EVERGREEN FORESTS IN THE BRAHMAPUTRA VALLEY

(a) **Nambor R.F.**

The Nambor R.F. and its surroundings in the Sibsagar district are dominated by the tree species of *Mesua ferrea*, *Amoora wallichii*, *Stereospermum chelonoides*, *Canarium* spp., *Artocarpus chaplasha*, *Cedrela toona*, *Lagerstroemia flos-reginae*, *Terminalia chebula*, *T. belerica* and *T. tomentosa*. *Zizyphus*, *Croton*, *Ixora*, *Ardesia* and *Gnetum gnemon* are the prominent shrubs. *Dioscorea*, *Coculus*, *Premna*, etc. are common climbers covering shrubs and trunks of many trees. *Lygodium* and *Cyclosorus* form thickets in the sunny forest margins.

(b) **Chirang R.F.**

The mixed evergreen as well as deciduous forests found in parts of the Chirang R.F. occur as large patches between Bismuri and Ultapani and between the two rivers, Samukha and Lo Pani in the Lungsang Block. The forest is composed of tall tree species of *Sterculia*, *Phoebe*, *Gmelina*, *Dysoxylum*, *Pterospermum*, *Dillenia*, *Amoora*, *Salmalia* and others. *Mussaenda havetta*, *Lagerstroemia*, *Bauhinia*, *Ixora*, etc. constitute the shrubs. *Millettia*, *Smilax*, *Ipomea* and *Calamus* are common climbers. *Alpinia*, *Curculigo* and *Clerodendrum* are the important herbaceous plants. Epiphytic orchids, represent by *Dendrobium*, *Cymbidium*, *Vanda*, *Pholidota* cover the high branches of trees. *Tectona grandis* plantations are under experimental cultivation.

There is, however, an amazing change in the nature of vegetation and floristic compositions of the Chirang R.F. (Goalpara East). This is bounded by Champamati river with its tributary Lo Pani on the east and Saralbhangra river with Patgaon and Jharbari forest villages in the west, Haltugaon forest village on the south and Ultapani forest village on the north (26°29'—26°46' N, 90°12'—90°20' E) within about 20 miles distance lying in the same latitude one meets with (1) open deciduous forest with pure sal (*Shorea robusta*) plantations, (2) mixed evergreen forest with variety of tree species, and (3) riverain vegetation with *Acacia catechu* as its dominant species along the Saralbhangra river bank.

(c) **Oranga R.F.**

Oranga R.F. lying on the bank of Brahmaputra and Dhansiri river is largely a plantation where *Cedrela* sp., *Dalbergia sissoo*, *Acacia catechu* and one species of *Urticaceae* are planted in the midst of thick growth of thatch grass. The forest floor comprises of *Piper*, *Hedychium*, *Clerodendrum* and *Rauwolfia serpentina* in scattered groups.

IV. EVERGREEN FORESTS IN N.E.F. AGENCY

The outer ranges of the N.E.F. Agency such as between foot-hills to Chakoo and from Bhairabkund to Baha and again near Warang—Bruckpalanchen in the Kameng F.D., Kimin to Hapoli in the Subansiri F.D., Gazing and Syom valley in the Siang F.D., from Teju to Hayuliang in the Lohit F.D. and almost the whole of Tirap F.D. particularly south of the line joining Pangsupass—Khonsa and Wanu, are covered with primeval evergreen forest with very little evidence of human interference.

(a) **Kameng F.D.**

The foot-hills and beyond upto Chakoo present a continuous belt of tropical and subtropical forest over a long distance of 28 miles. The floristic components at Sissini (1,220 m.) differ a good deal from those of Chakoo (2,400 m.) although both are characterised by the climax evergreen forest. There is hardly any sign of interference by man. The landscape is made up of high hills and deep valleys, all of which are covered up by thick impenetrable canopy of trees, shrubs and herbs: *Ficus*, *Quercus*, *Schima* and others attain gigantic heights (30—35 m.) and their trunks infested with climbers belonging to *Araceae*, *Vitaceae* etc. *Gnetum montanum* is important among the lianes. *Girardiana* and other species of *Urticaceae*, *Musa*, *Zingiberaceae*, *Liliaceae* and many ferns constitute the ground layer. Epiphytic mosses, orchids and ferns are very abundant. Bamboos attain luxuriant growth between Sissini and Chakoo. Mosses cover the bare rock surfaces.

The general feature of the broad-leaved vegetation at Chakoo dominated by *Magnolia cambelli*, *Rhododendron* and others suddenly changes to narrow-leaved pine forest as one crosses Peri La flat (2,800 m.).

The vegetation of the Kalaktang sub-division between Bhairabkund and Baha and between the triangle formed by the villages, Chengi, Bruckpa, Lanchen and Warang represents vast expanse of evergreen forest blocks.

The track between Bhairabkund to Baha lies along the Dhansiri river valley and covers a distance of 16 miles without any trace of human habitations in the area. Although *Sterculia villosa*, *Lagerstroemia parviflora*, *Quercus* sp., and *Ficus* sp., are seen at Bhairabkund. *Michelia*, *Schima*, *Quercus*, *Engelhardtia* among trees; *Murraya exotica*, members of *Annonaceae*, *Lauraceae* and *Meliaceae* are the common shrubs between Bhairabkund to Baha. Similarly, *Entada scandens*, *Gnetum montana*, *Derris* and *Vitis* are the common climbers in this region. Tree ferns are fairly abundant.

The top canopy in the forest lying in the triangular zone between Chengi, Bruckpalanchen and Warang comprises of *Morus*, *Betula*, *Albizia* and bamboos. *Premna*, *Murraya*, *Phyllanthus*, *Saurauja*, *Tabernaemontana*, *Mussaenda* and *Ixora*, together with *Moraceae* and *Araliaceae* constitute the shrub layer. *Leea*, *Alpinia*, *Galenga*, *Curcuma*, Ground orchids, *Impatiens*, *Piper*, *Selaginella* and many ferns cover the forest floor. *Anemone* sp. with its white flowers colour the open hill tops near Chengi. Along the river valley *Artimisia vulgaris* forms extensive perennial thickets.

(b) **Subansiri F.D.**

The forests between Kimin to Hapoli is typical evergreen in nature with many giant trees forming the top canopy. Among them *Quercus* spp., *Sterculiaceae*, *Schima wallichii* and members of *Magnoliaceae* are important in the top canopy. *Pandanus sikkimensis* and *Phoenix* spp., are prominent on all hill slopes with *Cyathea* and *Angiopteris evecta* in the humid valleys and moist corners. Large number of *Leguminosae* form climbers and

cover the shrubby layer comprising of *Saurauja* and *Boehemeria* amongst others. *Acanthaceae*, *Polygonaceae* and *Commelinaceae* are evergreen layers on the ground floor. *Musa* (wild banana) form extensive thickets from foot-hills to Pitepool with no prospect of economic use. Orchids are common epiphytes.

(c) Siang F.D.

The main vegetational types obtainable in the areas of Siang F.D. are humid evergreen tropical forests up to 914 m and wet sub-tropical evergreen forests up to 1,524 m which in its turn gradually merges into humid sub-temperate type of forests over an altitude of 1,829 m. The tropical evergreen type of forests are restricted to isolated parts of the hills round about Gasing 640 m and the regions along the valley of Syom river and further down, due to the human interference and the conversion of the land to cultivable fields. Dominant tree components of such forests are species of *Ficus*, *Dipterocarpus*, *Terminalia* and *Mallotia* mixed with dense growth of bamboos and sparse distribution of *Ageratum* and *Eupatorium* are the most common herbaceous weeds. However, the cleared burnt areas are often completely covered by the luxuriant growth of *Saccharum arundinaceum*. Climbers belonging to *Leguminosae* and *Dioscoreaceae* are met with in profusion. The moist soil surface is completely covered by the members of the *Filicales*. The orchids are rare. *Polyporales* and *Agaricales* are common in forest floor.

Typical wet sub-tropical evergreen forest is the type occurring over the extensive area around Tuting and especially around the valley of the Siang river from Ninguing right up to Kapang La (India-Tibet border) covering an altitude of 1,158 m to 1,524 m. The general vegetation is typical of its kind with a mixture of a few species of sub-tropical and tropical types. *Dipterocarpus*, *Terminalia myriocarpa*, *Ficus*, *Mallotus*, *Macaranga*, *Dillenia*, *Acer* and *Syzygium* mixed with tall and short species of *Musa* form the dominant components of the vegetation. Bamboos do not enjoy a wide distribution. The palms like *Livistona jenkinsiana* and *Caryota* are found here and there. Different species of *Calamus* are found in plenty throughout the tract.

The families of *Melastomaceae*, *Ternstroemiaceae*, *Polygonaceae*, *Rubiaceae*, *Verbenaceae*, *Acanthaceae*, *Gesneraceae* and *Solanaceae* are well represented.

Shrubs like *Hibiscus*, *Glycosmis*, *Citrus*, *Cassia*, *Aralia*, *Rubus*, *Coffea*, *Ixora*, *Saurauja*, *Triumfetta*, *Hydringia*, *Melastoma* sp., *Strobilanthes*, *Clerodendrum* and *Ficus* species mixed with sparse growth of tree ferns such as *Cyathea* and tall species of *Musa* are quite common in the area. Among the climbers, robust species of *Raphidophora* and *Pothos* mixed with tender climbing species of *Piper*, *Dioscorea*, *Vitis*, *Smilax*, *Combretum* and *Strobilanthes* form dominant components covering practically most of the tree trunks and rocks. Epiphytic orchids are common.

(d) Lohit F.D.

In accordance with the altitude of the region under study mostly ranging from 61 m to 610 m except along the region from Senge Dam to Dreyi and Tedding Saddle where it ranges from 1,037 m to 1,731 m. The general vegetation is typically of moist tropical evergreen forest type with considerable change into sub-tropical type along the higher altitudes. Along the banks of Digaru and Lohit rivers up to Badaru foot-hills, *Terminalia myriocarpa* (hollock) forms the dominant component of tree species covering the upper canopy mixed with *Ficus* and other species and the lower canopy is densely covered by species of *Musa*, *Costus* and others. The main components of the vegetation slowly change into dense bamboo thickets mixed with *Calamus* and other species while ascending from foot-hills towards Dreyi (1,464 m) where the vegetation approaches to sub-tropical type with species of *Quercus* as the dominant component. While descending from Tedding Saddle (1,731 m) to an altitude of 610 m, species of *Musa* mixed with *Ficus*, *Caryota*, *Pandanus*, *Bambusa*, *Raphidophora*, *Pothos*, etc. are met with together with climbers and members of *Vaccinaceae*. Epiphytic forms and several species of *Zingiberaceae*, *Labiatae*, *Acanthaceae*, *Gesneraceae* and others form the chief component of the vegetation. Similar vegetation with slight variation here and there has been recorded all along the remaining region under study.

Bryophytes limited to a few species have been recorded to be common all along the region under study although ferns appear to be rather uncommon.

Orchids, both epiphytic and terrestrial are also comparatively rare within this zone

(e) Tirap F.D.

The vegetation of the Tirap F.D. over the whole area to the south of the Margherita-Nampong-Panguspas line, may be ascribed to the tropical evergreen type up to an altitude

of 1000 m and is met with in the foot-hills to the west of the line joining Panguspass, Kheti, Khonsa, Chenglang and Wanu. The chief tree components in these forests are *Stereospermum*, *Anthocephalus cadamba*, *Ficus* sp., *Albizia* and *Callicarpa* associated with shrubs like *Croton* and *Abroma*, together with members of *Urticaceae* and *Melastomaceae*. Climbers like *Mucuna*, *Dioscoreaceae*, *Vitis*, etc. are common. The epiphytic orchids are rather rare in Khela-Khonsa area, although these are profuse in the hills of Rusa—Longhus and Wanu, whereas bamboos and *Calamus* spp., together with *Phragmites* and other tall grasses are the most dominant types.

The vegetation to the east of the line joining Panguspass and Niusa belong to the sub-tropical evergreen type in which *Callicarpa*, *Bambusa*, *Saurauja*, *Schima*, *Quercus* and members of *Magnoliaceae* among trees, *Melastomaceae*, *Vitaceae*, *Liliaceae*, *Araliaceae*, etc. predominate. This vegetation is greatly disturbed by the practice of "Harem" or shifting cultivation in the area practised by native Nagas. This practice has resulted in extensive grassland on the hills and slopes in which two or three sp. of grasses including *Saccharum* predominate.

The hill between Raho and Waka attain a height of about 1840 m (6000') and is covered by a thick primeval forest dominated by tall giant trees. The forest floor is very humid and is covered over by members of *Acanthaceae*, *Liliaceae* and *Melastomaceae*, associated with *Selaginella*. The tree ferns, *Cyathea* and *Angiopteris*, are very common in Tinha and Niusa area together with various palms. *Selaginella* spp. are found very abundantly.

Discussion

Thus, despite the prevalence of 'forest climate' all over Assam, the present distribution of evergreen and semi-evergreen forests in Assam is rather limited and is confined mostly to a peripheral ring bordering upon the outer ranges of NEFA Himalayas. In the rest of the State, scattered patches of evergreen forest occur as relicts of the climax formation in the Shillong Plateau. The vast areas of this plateau are now covered by sub-tropical pine forest or grassland as biotic preclimaxes and the fact that these seral formations are in severe competition with each other as also with the evergreen forest type, has received brilliant exposition in the hands of Bor (1942).

Similarly, the occurrence of a grassy belt and an evergreen forest on the southern fringe of the swampy Kaziranga proves the latter beyond doubt as an edaphic climax. The existence of the evergreen-cum-semi-evergreen Garchanga R.F. bordering upon the sal forest belt of the south Kamrup district (*viz.* Jarasal, Rani, Barduar etc.) shows that the former climax formation has given way to the existing moist deciduous sal forest, as a sequel to biotic interference purely for economic reasons.

Further, the occurrence of large number of species in the flora of the evergreen and semi-evergreen forests discussed above, *viz.* *Ficus* spp., *Duabanga*, *Quercus*, *Syzygium*, *Stereospermum*, *Lauraceae*, *Meliaceae* etc., among the trees, *Myrsinaceae*, *Ternstroemiaceae*, *Rubiaceae*, *Palmae*, *Musa* etc., among the shrubs, *Curcuma*, *Alpinia*, *Piper* and almost the same species of orchids and ferns among the herbaceous flora, suggest strongly the prevalence of the climatic climax formation in the past on the whole tract of Assam and outer ranges of NEFA. On the contrary the differences in the floristic compositions, *viz.* *Dipterocarpus turbinatus*, to the Cachar R.F., *Beilschmiedia pseudomicropora* and *Dipterocarpus manii* etc. in the Upper Dihing R.Fs., *Terminalia myriocarpa*, *Caryota*, *Pandanus* etc. in the hot river valleys of the Siang and Lohit F.D., *Daemonorops*, *Calamus* etc. in the Tirap F.D., *Rhododendron arboreum*, *Pyrus*, *Cinnamomum tamala*, *Manglietia insignis*, etc., in the evergreen forests of the Khasi and Jaintia Hills to cite a few, are conditioned by local environment factors and illustrate the well-known relationship between the 'vegetation' and 'flora.'

RESEARCH

(a) Main Problem

The extensive tropical rain forests of India, particularly in the lower part of the eastern Himalayas, the Khasi hills and north-eastern Assam, have received very scant attention despite the fact that the tropical rain forest offers a field of biological research which has no substitute and in it lies the key to a vast amount of scientific knowledge which could not be obtained elsewhere. The rain forest flora with its immense wealth of species belonging to thousands of genera and scores of families has acted in the past as a reservoir of genetical diversity and potential variability. All available evidences, including cytological (Manton 1954), floristics (Goods 1953) and ecological (Richards 1952)

suggest that tropical rain forests have been the main centre of evolutionary activity of the world flora owing to the absence of secular climatic changes such as glacial periods and by the prevalence of high and constant temperature of the rain forest which is specially favourable to the survival mutations.

Yet it must be admitted that this richness of the tropical flora both with regard to the number of species and their frequency has offered the greatest practical handicap for disentangling the role of genotype and environment. All the same, the study of the high complex relationships of the species with each other and with their environment in these floristically rich communities may be highly rewarding in revealing many new principles and laws governing the competition and dominance of species in mixed communities.

Whether a species arised solely due to mutational changes (cf. de Vries 1903) or by effects of the environment (cf. Darwin 1859) or by hybridisation of the fact remains that it is the environment that determines the destiny of the species. In communities such as rain forest, where there are numerous species of varied taxonomic affinity, but similar life form, convergent resemblances between unrelated species are shown far more clearly than in temperate communities.

Yet, there is not a single area of rain forest for which complete information in the life forms (particularly of the herbaceous and similar woody plants) is available.

Accordingly, it is imperative that the phytosociology of the tropical rain forests of India should be studied to throw more light on the comparative rate and pace of evolution of the world flora.

(b) Current Research Programme

The presence of evergreen forests (according to some montane evergreen forests) as relicts of the climatic climax on the Shillong Peak (1920 m), Mawphiang (Land Lyndoh 1830 m) and Cherrapunjee (Land Kuntang 1465 m) discussed earlier, represent, in miniature, the tropical rain forests of the Indo-Malayan region. Accordingly, these forests, which are well delimited in size deserve careful study.

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LITERATURE CITED

- | | | |
|----------------------------|------|---|
| Anderson | 1950 | The selection of tree species. |
| Champion, H. G. | 1936 | Preliminary survey of the forest types in India and Burma. |
| Bor, N. L. | 1942 | Relict vegetation of the Shillong Plateau. |
| Manton, I. & Sledge, W. A. | 1954 | Conservations on the cytology and taxonomy of the Pteridophytic flora of Ceylon. Trans. Roy. Soc. |
| Richards | 1952 | Tropical Rain Forest. |
| Goods | 1953 | Geography of the flowering plants. |
| Du Rietz, G. | 1930 | Handle, der Biol. Arbeit Smith Teil 5 heft 2 abder Halden. |
| Raunkiaer, C. | 1934 | The life forms of Plants and Statistical Plant-Geography, Clarendon Press, Oxford. |

SHORT NOTES ON THE EVERGREEN FORESTS OF MYSORE STATE

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Name, Situation and Area of the Forests

The evergreen forests in Mysore State occupy mostly the slopes of the Western Ghats facing the Arabian sea. They cover a strip approximately 250 miles long and 10 to 15 miles wide, with an approximate area of about 3,000 square miles.

Physical Features of the Region

The country is mountainous, the general drainage being westward to the Arabian sea. The ground generally slopes steeply, often precipitously. The forest streams, a large number of which are perennial, have scoured deep down into their beds forming steep, often nearly vertical walls standing several feet high. Small or large leaps of water, locally called "*Abbulu* or *Abbi*" are found all along the ghats.

The highest altitude is 6000 ft. or more, while the lowest is barely a couple of hundred feet high above mean sea level. The average elevation ranges from about 500 to 2500 feet.

The precipitous slopes are liable to land-slips which occasionally occur during the heavy rains of June to September.

Geology—Rock and Soil

The underlying rock consists principally of granitic gneisses interspersed by bands of horn-blende schist with or without garnet, occasional dolerite dykes and rare patches of basic charnokite and reefs of quartzite. Huge boulders and sheet rocks of granitic gneiss are abundant on the ground surface and these cover some extensive areas on the slopes of hills and form the beds of the leaping streams or crest the hill tops lending to them often fantastic or weird shapes, and causing them to be known by distinctive names. The presence of granite rock or sometimes laterite, near the surface is almost entirely responsible for the absence of tree growth on many hill tops and slopes.

The soil is generally shallow, consisting of loam of poor quality or of laterite capping the sheet rock and boulders, but enriched, in spite of its occasional shallowness, by the humus of the evergreen forest which, as usual, has created its own soil fertility, and this accounts partly for the fact that once the forest cover is removed the soil deteriorates so rapidly that the reconstruction of the evergreen cover is a very slow and laborious process.

The underlying rock crops out frequently at the ground surface. It is superimposed by laterite or lateritic loam which is generally red on the leeward side of the ghat crest of the plateau, but sometimes grey on the wind swept westward steep sloping country in which are found pockets of yellow clay or nearly pure white clay sometimes to a depth of a few feet. On hill tops and ridges pebbly sand-stone which crumbles easily when smashed and generally grey-white in colour is common, and this, probably gives rise by weathering to the finer grey loam found in some of the valleys below. With the exception of the pockets of clay mentioned above, the soils are generally shallow, occasionally filled with rock fragments in places. The humus content is generally high, but the intensity of the surface wash prevents its accumulation except on the floor of the valleys where the general slope is gentle.

Climatology

The temperature is relatively constant and low as compared with that of the low lands of south or north Kanara, but never so low as to make frost possible, and the rainfall is very abundant in the rainy season during the south-west monsoon. The Western Ghat region is, therefore, a *tropical montane evergreen region*, lying above the hot lowlands fringing the coast of the Arabian sea, and mostly not attaining to a sufficient altitude for the temperate and alpine influences to come into play. The dominant vegetation is the evergreen broad-leaved rain forest, which is strongly tropical in its floristic make-up and vegetative characteristics.

The following data on the average climatology of the rain forest region are based on the records kept by the Meteorologist to the Government of old Mysore State at Marnalli and Hanabal and by the Manager of the Kadamane estate.

Rainfall—The following table shows the total monthly rainfall in inches for the localities:—

Month	Place	
	Hanabal (1941)	Marnalli Toll-gate (1941)
January	—	—
February	0.12	—
March	—	—
April	1.47	0.04
May	4.61	7.02
June	39.11	62.85
July	59.89	90.55
August	37.24	75.00
September	9.19	9.52
October	6.29	3.20
November	1.52	—
December	2.87	1.35
TOTAL	162.31	249.53

KADAMANE

	1939	1940	1941	1942	1943	Average
January	—	0.03	0.11	—	0.90	0.20
February	—	—	0.06	—	—	0.01
March	0.64	—	—	—	0.03	0.13
April	2.90	5.51	1.05	2.39	1.46	2.66
May	1.50	4.41	3.88	2.31	15.94	5.60
June	46.38	62.54	59.60	56.16	57.59	56.45
July	105.20	82.42	78.34	118.75	106.59	98.26
August	73.97	74.44	79.09	52.42	—	55.98
September	20.47	9.24	16.95	20.20	—	13.37
October	11.28	10.61	3.29	5.03	—	6.04
November	3.82	5.54	1.25	0.94	—	2.31
December	—	0.52	2.59	0.82	—	0.79
TOTAL	266.16	255.26	246.21	259.02	182.51	241.80

The data for the stations show very abundant rainfall at one season only, but the fall at Hanabal is not so high as at Marnalli toll-gate or Kadamane, because the former is situated fairly inland on the plateaux and not at the crest of the ghat where the forests lie. The forest area enjoys, probably, even heavier rainfall than is indicated by the record at Marnalli toll-gate or Kadamane; and this assumption is justified by the rainfall recorded at other stations situated at the crest of the ghat in Shimoga and Chikmagalur districts. There is very heavy fall between June and August, the peak month being July, and practically no rainfall in the months between January and April, which are consequently very dry, while between September and December there is some, though relatively light fall.

The drought of summer is fairly severe and serious enough to cause most of the hygrophyllous vegetation like algae, liverwort and many ferns to shrivel and disappear, and to make many trees of the evergreen forest to shed a good portion of their leaves, some even their entire leaf cover. Yet, the shedding is not so heavy as to change the essentially evergreen look of the forest, or embrown the leaf canopy as a whole, like what we find in the mixed-deciduous (moist deciduous) zone of forests. This is because, in spite of the great variation of the rainfall from month to month and season to season, the soil retains adequate quantity of moisture throughout the year to enable the plants to carry on photosynthetic activity more or less uninterruptedly. There is, therefore, no wholesale leaf shedding even in the dry, summer months preceding the monsoon.

Air temperature—The record of air temperature for Hassan, a typical locality adjoining the forest is reproduced below (Seshachar, 1941) :

Month					Mean monthly temperature for 1941.
January	..	..	..	..	66·0°
February	..	..	..	..	67·6°
March	..	..	..	..	72·2°
April	..	..	..	..	75·9°
May	..	..	..	..	75·2°
June	..	..	..	..	71·5°
July	..	..	..	..	70·5°
August	..	..	..	..	70·7°
September	..	..	..	..	70·6°
October	..	..	..	..	72·2°
November	..	..	..	..	70·9°
December	..	..	..	..	66·2°

Month					Monthly mean minimum dry temperature and its variation from the average of 45 years.		Monthly mean maximum dry temperature and its variation from the average of 45 years.	
					°F	°F	°F	°F
January	..	..	..	..	59·2	+3·1	81·3	-0·5
February	..	..	..	..	61·6	+3·0	85·2	-0·9
March	..	..	..	..	66·4	+3·9	91·5	+0·9
April	..	..	..	..	69·5	+2·9	93·3	+1·8
May	..	..	..	..	69·6	+2·6	89·6	+1·4
June	..	..	..	..	67·3	+1·5	80·0	+0·2
July	..	..	..	..	66·3	+1·3	78·6	+1·8
August	..	..	..	..	66·7	+2·2	78·7	+0·6
September	..	..	..	..	66·3	+2·3	80·4	·0
October	..	..	..	..	63·2	+1·1	82·4	+1·0
November	..	..	..	..	63·9	+3·2	82·2	+2·3
December	..	..	..	..	58·7	+2·1	80·6	+1·2
				65·1	2·5	Year 83·7	0·9	

A fairly correct record of temperature has been maintained at Kadamane which lies adjoining the forest area.

KADAMANE

Month	1939		1940		1941		1942		1943		Average	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
January	78	62	78	60	78	59	78	61	78	60	78.00	60.4
February	84	62	80	61	82	61	83	62	83	58	82.4	60.8
March	85	64	83	60	89	66	86	64	90	58	86.6	62.4
April	84	66	84	67	90	71	86	71	88	62	86.4	67.4
May	81	71	80	68	82	70	84	71	82	70	81.8	70.0
June	72	64	74	68	73	68	70	66	74	65	72.6	66.2
July	66	64	68	66	72	65	68	66	68	66	68.4	65.4
August	68	66	69	63	70	64	68	65	—	—	68.75	64.5
September	74	72	78	64	74	64	72	66	—	—	74.5	66.5
October	76	68	80	64	82	65	80	66	—	—	79.5	65.75
November	78	64	76	62	80	66	78	62	—	—	78.0	63.5
December	79	60	78	60	78	62	78	63	—	—	78.2	61.25

Cursory observations and readings taken in the forest show that radiation takes place most actively during the early hours of the night, while the minimum temperature is reached just before day-break, and this makes it necessary to derive the lowest temperatures due to radiation by subtracting 8° or thereabouts from the temperatures shown by the records of monthly extremes. Within the forest area the temperature falls very considerably by night, the cold resembling what one would experience on a chilly November night out in the plains of Northern India.

Humidity and Fog—High humidity prevails generally at all times, especially under evergreen cover. Even in the rainless season from January to April there is some precipitation of moisture in the early mornings and just before day-break. This moisture drips from the crowns of trees like a continuous weak shower. During rainy season water trickles down the leaf surface of trees almost continuously, and the humidity of the atmosphere remains throughout the day and night at saturation point. In summer the heat causes sometimes a warm fog to ascend by day from the numerous perennial sources up into the leaf canopy whose top stands in some places over a hundred and fifty feet high, and the water which thus saturates the atmosphere is eliminated during the cool hours of the early morning by precipitation.

Sunshine and Cloudiness—Once the monsoon rains start in June, the percentage of cloud reaches 100 per cent, and this remains so throughout July and August. A dense mist which blurs human vision even at a dozen feet envelopes the whole atmosphere within and around the forests and hill peaks every few minutes and this is followed almost at once by heavy rainfall which lifts this veil of mist, and brings temporary clearness. This is followed again by the misty cloud. Late in August or early in September the weather clears and intermittent sunshine appears.

Wind—The wind blows from the west and south-west, and commonly reaches its highest force at night and in the rainy season, from June to August. Its influence on the vegetation is greatest on the peaks and ridges, and the fact that the lowest humidities

accompany high wind probably makes its desiccating influence considerable. Wind record at Hassan are reproduced below (Seshachar, 1941) :—

Month	Monthly mean wind velocity in miles in 1941	Monthly mean daily wind direction in 1941
	<i>Means for 1941</i>	<i>Means of 1941</i>
January	64	38° S.E.
February	67	21° S.E.
March	93	54° S.W.
April	127	72° S.W.
May	161	87° S.W.
June	240	77° S.W.
July	246	74° S.W.
August	232	W.
September	165	W.
October	107	11° N.E.
November	79	82° S.E.
December	76	81° N.E.

The flora of the Evergreen Forest

Throughout the history of the botanical exploration of India, the flora of the Western Ghats has received little attention from the systematic botanists.

There is no comprehensive systematic work for the region under consideration. Among the systematic works useful for consultation are :—

1. Flora of British India by Sir Joseph Dalton Hooker.
2. Flora of Bombay by Theodore Cooke.
3. Flora of Madras by J. S. Gamble.

No Manual exists for Pteridophytes except the work of Beddome—"Ferns of British India".

I have not been concerned with a complete listing of the flora, but have endeavoured to secure determinations of all species which go to make up the economically useful portion of the crop or govern the characteristic features of the vegetation.

List of Characteristic Plants DICOTYLEDONS—ANGIOSPERMS

Flowering plants	Name of Hassan Ghats	Name of Shimoga and Kadur Ghats
Ranunculaceae		
<i>Clematis gouriana</i> Roxb.	<i>Gori-bilu</i>	
<i>Clematis wightiana</i> Wall.	<i>Sali-maddinahambu</i>	
<i>Naravelia zeylanica</i> DC.		
Dilleniaceae		
<i>Dillenia pentagyna</i> Roxb.	<i>Kanagalu</i>	<i>Kanagalu.</i>
Magnoliaceae		
<i>Michelia nilagirica</i> Zenk.	<i>Kendasampige</i>	
Anonaceae		
<i>Unona pannosa</i> Dal.		<i>Kadu bende.</i>
<i>Unona discolor</i> Vahl.		
<i>Artabotrys zeylanicus</i> Hk. f. & T.	<i>Kadu-kittale bilu.</i>	
Menispermaceae		
<i>Cocculus macrocarpus</i> Wright & Arn.		
<i>Cyclea peltata</i> Hk. f. & T.		
<i>Tinospora cordifolia</i> Miers.		

Flowering plants	Name of Hassan Ghats	Name of Shimoga and Kadur Ghats
Bixaceae		
<i>Flacourtia montana</i> Grah.	<i>kulla-jepalu</i>	<i>sampe.</i>
<i>Hydnocarpus wightiana</i> Bl. (<i>Indian Chalmoogra</i>).	<i>yethina-taradinakayi,</i> <i>kalduvala, chengavara</i>	<i>surati.</i>
Hypericaceae		
<i>Hypericum mysorense</i> Heyne.		
Guttiferae		
<i>Garcinia xanthochymus</i> Hook		<i>jeerakanahuli.</i>
<i>Garcinia cambogia</i> Desrouss	<i>mantahuli</i>	<i>kadagolu-maruga.</i>
<i>Garcinia indica</i> Chois	<i>muruglu</i>	<i>guaragi.</i>
<i>Garcinia morella</i> Desr.	<i>makkalatayimara</i>	<i>arisinagaragi.</i>
<i>Calophyllum elatum</i> Bedd.	<i>bobbi</i>	<i>surahonne.</i>
<i>Calophyllum wightianum</i> Wall.	<i>bobbi</i>	<i>holehonne.</i>
<i>Mesua ferrea</i> , Linn.		<i>nagasampige.</i>
<i>Poeciloneuron indicum</i> Bedd.	<i>balagi</i>	<i>balagi.</i>
Ternstroemiaceae		
<i>Gordonia obtusa</i> Wall.	<i>naganamara</i>	<i>mallanga.</i>
Dipterocarpaceae		
<i>Dipterocarpus indicus</i> Bedd.	<i>halamaddi</i>	<i>dhuma.</i>
<i>Hopea parviflora</i> Bedd.	<i>kiralbhogi, bogi</i>	<i>kiralbhogi, bogi.</i>
<i>Hopea wightiana</i> Wall.	<i>karehagalu bilehagalu</i>	<i>haiga malehaiga.</i>
<i>Vateria indica</i> Linn.	<i>haiga</i>	<i>sal-dhupa.</i>
Malvaceae		
<i>Bombax malabaricum</i> DC.	<i>burulu</i>	<i>buruga.</i>
<i>Hibiscus furcatus</i> Roxb.	<i>gowri-bilu</i>	<i>hulugobri-beelu.</i>
<i>Abutilon polyandrum</i> (Schlecht) G. Don.		
Sterculiaceae		
<i>Sterculia guttata</i> Roxb.	<i>konan-tholdina-mara.</i>	<i>huli-thardina-mara.</i>
<i>Helicteres isora</i> Linn.	<i>kade-harukla</i>	<i>kowri, hedamuri,</i> <i>balamuri.</i>
<i>Pterospermum rubiginosum</i> Heyne.	<i>hunjanmara</i>	
Tiliaceae		
<i>Grewia umbellifera</i> Bedd.		
<i>Grewia tiliaefolia</i> Vahl.	<i>tadasalu</i>	
<i>Elaeocarpus oblongus</i> Gaertn.	<i>nai-tupru</i>	
<i>Elaeocarpus tuberculatus</i> Roxb.	<i>nanal-tare</i>	<i>sataga.</i>
<i>Elaeocarpus munroii</i> Mast.	<i>tupru</i>	
Malpighiaceae		
<i>Hiptage madablota</i> Gaertn.		
Rutaceae		
<i>Evodia roxburghiana</i> Benth.	<i>magali, devadari,</i> <i>kamblimara.</i>	<i>mangappe.</i>
<i>Clausena indica</i> Oliver		
<i>Clausena willdenovii</i> W. & A.		
<i>Zanthoxylum rhetsa</i> DC.	<i>jumma</i>	<i>jummanamara.</i>
<i>Luvunga eleutherandra</i> Dalz.		
<i>Atalantia monophylla</i> Correa.		
<i>Atalantia missionis</i> Oliv.		
<i>Paramigyna monophylla</i> Wight.		
<i>Toddalia aculeata</i> Pers.	<i>cuda menasina bilu</i>	
Simarubaceae		
<i>Ailanthus malabarica</i> DC.	<i>halammaddi</i>	<i>maddi-dhupa.</i>
Burseraceae		
<i>Canarium strictum</i> Roxb.	<i>guggala</i>	<i>kayi-dhupa,</i>

Flowering plants	Name of Hassan Ghats	Name of Shimoga and Kadur Ghats
<i>Garuga pinnata</i> Roxb. Meliaceae	godda	godda.
<i>Heynea trijuga</i> Roxb.	kaggale	
<i>Dysoxylum malabaricum</i> Bedd.	devagare, devagarige	devadari.
<i>Aglaia odorata</i> Lour.	kengavara	kempunola.
<i>Lansium anamalayanum</i> Bedd.		chigatamari.
<i>Cedrela toona</i> Roxb. (Red-Cedar).	nogavara gandhagarige	
Chailletiaceae		
<i>Chailletia gelonioides</i> Hk. f.		kadutengu.
Celastrineae		
<i>Celastrus paniculata</i> Willd.		gangumbe.
<i>Euonymus indicus</i> Heyne.	benne-muthaga	kan-kithulli, kuranthi.
<i>Lophopetalum wightianum</i> Arn.	hebbale	bite-hebbalasu.
Rhamnaceae		
<i>Zizyphus xylopyrus</i> Willd.		bemmaralu.
<i>Zizyphus rugosa</i> Lamk.		
Ampelideae		
<i>Vitis lanceolaris</i> Laws.		norlebilu.
<i>Vitis tomentosa</i> Heyne.		
<i>Leea sambucina</i> Willd.		mitli.
<i>Leea macrophylla</i> Roxb.		
Sapindaceae		
<i>Allophylus cobbe</i> Bl.		
<i>Schleichera trijuga</i> Willd.	sagade, karisagade	kendala keli.
<i>Nephelium longana</i> Camb.	kanu-kendala	sannela-kendala.
Sabiaceae		
<i>Meliosma wightii</i> Planch.		
Anacardiaceae		
<i>Mangifera indica</i> Linn.	mavu	mavu.
<i>Holigarna arnottiana</i> Hook.	kutageri	sannele-hole-gara.
<i>Holigarna grahamii</i> Hook.	tatagiri	doddele-molegarna.
<i>Holigarna</i> sp.	kadu-geru	badacharlu.
<i>Nothopegia colebrookiana</i> Bl.		
Leguminosae		
<i>Mucuna pruriens</i> DC.		nasgunni.
<i>Erythrina stricta</i> Roxb.		keechakanamara.
<i>Spatholobus roxburghii</i> Benth.		ujinabilu.
<i>Butea superba</i> Roxb.	muthugadahambu	muthugada-bilu.
<i>Butea frondosa</i> Roxb.	muthaga	muthaga.
<i>Dalbergia latifolia</i> Roxb.	bite, biti	bite, biti.
<i>Pterocarpus marsupium</i> Roxb.	rakta-honne	honne.
<i>Darris</i> spp.		
<i>Pongamia glabra</i> Vent.	honge-mara	honge-mara.
<i>Caesalpinia sepiaria</i> Roxb.	badabakka	
<i>Acrocarpus fraxinifolius</i> Wight.	havalige	havalige.
<i>Kingiodendron pinnatum</i> Harnis.	yennemara	
<i>Saraca indica</i> Linn.		ashoka.
<i>Cassia fistula</i> Linn.	kakke	kakke.
<i>Humboldtia brunonis</i> Wall.	yesale	asage-kan-asoka.
<i>Bauhinia phoenicea</i> Heyne.	basavanapadada hambu	basavanapadada bilu.
<i>Bauhinia malabarica</i> Roxb.	basavanapada	basavanapada.
<i>Entada scandens</i> Benth.	snemettinahambu	ganape-bilu.

Flowering plants	Name of Hassan Ghats	Name of Shimoga and Kadur Ghats
<i>Xylocarpus xylocarpa</i> Taub.		<i>jambe</i> .
<i>Mimosa pudica</i> Linn.		
<i>Acacia caesia</i> Willd.	<i>kaduseege</i>	<i>kadusigemullu</i> .
<i>Albizzia stipulata</i> Boiv.		<i>chattumbe</i> .
<i>Pithecolobium bigeminum</i> Benth.		<i>korachatte</i> .
Crassulaceae		
<i>Bryophyllum calycinum</i> Salisb.		<i>hele-chigurugida</i> .
Rhizophoraceae		
<i>Carallia lucida</i> Roxb.	<i>tora-halasu</i>	<i>nai-halasu</i> .
Combretaceae		
<i>Terminalia belerica</i> Roxb.	<i>tare-mara</i>	<i>tare-mara</i> .
<i>Terminalia chebula</i> Retz.		<i>alale</i> .
<i>Terminalia tomentosa</i> Bedd.	<i>kare-mathi</i>	<i>karemathi</i> .
<i>Terminalia arjuna</i> W. & A.	<i>bilemathi</i>	<i>bilemathi</i> .
<i>Terminalia paniculata</i> Roth.	<i>huli-saggade</i>	<i>hunalu</i> .
<i>Calycopteris floribunda</i> Lamk.		<i>kumsanballi</i> .
<i>Combretum ovalifolium</i> Roxb.		
Myrtaceae		
<i>Eugenia munronii</i> Wight.		
<i>Eugenia jambolana</i> Lam.	<i>nerlu</i>	<i>nerlu</i> .
<i>Eugenia hemispherica</i> Wight.	<i>mattanerlu</i>	
<i>Eugenia gardneri</i> Bedd.		<i>male-nerlu</i> .
<i>Eugenia zeylanica</i> Wight.		<i>kunnerlu</i> .
<i>Eugenia corymbosa</i> Berg.		
<i>Eugenia laeta</i> Ham.	<i>chappalu</i>	<i>kadu-pannerle</i> .
<i>Eugenia heyneana</i> Duthie		<i>meenangi</i> .
<i>Careya arborea</i> Roxb.	<i>kowlu</i>	<i>kowlu</i> .
Melastomaceae		
<i>Melastoma malabathricum</i> Linn.	<i>nekkarike</i>	<i>dodda-nakkarike</i> .
<i>Obsbeckia truncata</i> D. Don.		<i>sanna-nakkarike</i> .
<i>Memecylon edule</i> Roxb.	<i>udatale-kaddi</i>	<i>hulichappu, adachari</i> .
<i>Memecylon amplexicaule</i> Roxb.		<i>volle-kodi</i> .
<i>Memecylon amabile</i> Bedd.		
Lythraceae		
<i>Lagerstroemia lanceolata</i> Wall.	<i>nandi</i>	<i>nandi</i> .
<i>Lagerstroemia flos-reginae</i> Retz.		<i>hole-dasavana</i> .
Samydaceae		
<i>Casearia rubescens</i> Dalz.		
Datisceae		
<i>Tetrameles nudiflora</i> R. Br.		
Araliaceae		
<i>Heptapleurum wallichianum</i> C.B. Clarke		<i>varekethanaballi</i> .
<i>Heptapleurum</i> sp.	<i>anagalubilu</i>	<i>changaranaballi</i> .
Cornaceae		
<i>Mastixia arborea</i> Clarke	<i>vedare, akka-tangira-mara</i> .	<i>gulle</i> .
Rubiaceae		
<i>Sarcocephalus missionis</i> Haviland		
<i>Hymenodictyon excelsum</i> Wall.		
<i>Wendlandia exserta</i> DC.	<i>kadu-bodalu, talige</i>	<i>kan-uragi</i> .
<i>Wendlandia notoniana</i> Wall.	<i>kadu-bodalu, talige</i>	<i>kan-suragi</i> .
<i>Mussaenda frondosa</i> Linn.		
<i>Webera corymbosa</i> Willd.		
<i>Gardenia latifolia</i> Sol.		<i>mara-bikke</i> .
<i>Randia uliginosa</i> DC.	<i>banagare-kayi</i>	<i>banagare-kayi</i> .
<i>Randia dumetorum</i> Lamk.	<i>kare</i>	<i>kare</i> .

Flowering plants	Name of Hassan Ghats	Name of Shimoga and Kadur Ghats
<i>Plectronia didyma</i> Bedd.	abbalu	bilachi, kan-bilachi.
<i>Pavetta hispidula</i> W. & A.		
<i>Ixora parviflora</i> Vahl.	goravi	goravi.
<i>Ixora nigricans</i> Br.	kadu-kapigida	yelagara.
<i>Psychotria truncata</i> Wall.	hampalu	vettamadike.
<i>Psychotria thwaitesii</i> Hk. f.	hampalu	vattamadike.
<i>Rubia cordifolia</i> Linn.	kai-kuyyana-bilu	manjatte-bilu.
Myrsinaceae		
<i>Embllica ribes</i> Burm.		vayuvilanga.
Sapotaceae		
<i>Chrysophyllum roxburghii</i> G. Don.	ale	alehale.
<i>Palaquium ellipticum</i> Engl.	halganne	hadasale.
<i>Mimusops elengi</i> Linn.	bakula	ranja.
<i>Bassia malabarica</i> Bedd.	kadu-ippe	ippe.
Ebenaceae		
<i>Diospyros paniculata</i> Dalz.		karimarlu.
<i>Diospyros microphylla</i> Bedd.		sannele-marimarlu.
<i>Diospyros montana</i> Roxb.		
<i>Diospyros embryopteris</i> Pess.		hole-tumre.
<i>Diospyros ebenum</i> Koerig. •	bale	bale.
Styraceae		
<i>Symplocos spicata</i> Roxb.	turublu	chunga.
Oleaceae		
<i>Olea glandulifera</i> Wall.		
<i>Olea diocia</i> Roxb.	kal-sandle	madle.
<i>Ligustrum neilgherrense</i> Wight.	gachalu	chandraka, chandxalaka.
<i>Linociera intermedia</i> Wight.	bangara-sadle	botha-madle.
<i>Jasminium rottlerianum</i> Wall.	kadu-mallige	kadu-mallige.
<i>Jasminium arborescens</i> Roxb.	Do.	Do.
Apocynaceae		
<i>Carissa suavissima</i> Bedd.	kavali	karji.
<i>Alstonia scholaris</i> Br.	jantavala, kodiya	madhale.
<i>Tabernaemontana heyneana</i> Wall.		maddarasa.
<i>Ichnocarpus frutescens</i> Br.	kari-humbu.	
Asclepiadaceae		
<i>Hoya wightii</i> Hk. f.		peepiballi.
Loganiaceae		
<i>Strychnos nux-vomica</i> Linn.	kasarka	kasaraka.
<i>Strychnos colubrina</i> Linn.		
Boraginaceae		
<i>Ehretia laevis</i> Roxb.	kapura	
Convolvulaceae		
<i>Lettsomia elliptica</i> Wight.	maribilu.	
<i>Ipomoea campanulata</i> Linn.		
Bignoniaceae		
<i>Stereospermum chelonoides</i> DC.	masivara	padri.
<i>Oroxylum indicum</i> Vent.		anangi.
Acanthaceae		
<i>Thunbergia mysorensis</i> T. Anders.		
<i>Strobilanthes barbatus</i> Nees.	hegguruklu	guragi.
Verbenaceae		
<i>Vitex altissima</i> Linn. f.	halabindige	naviladi.
<i>Vitex negundo</i> Linn.	nakki-rakke-gida	nakki.

Flowering plants	Name of Hassan Ghats	Name of Shimoga and Kadur Ghats
<i>Vitex leucoxydon</i> Linn.	<i>hole-lakki</i>	<i>bile-likki.</i>
<i>Clerodendron serratum</i> Spreng.		<i>taggi.</i>
<i>Clerodendron infortunatum</i> Gaertn.	<i>taggadupranti</i>	<i>tagadata.</i>
<i>Callicarpa lanata</i> Linn.	<i>ibni, tagadupranti</i>	<i>tagadata.</i>
Labiatae		
<i>Colebrookia oppositifolia</i> Smith	<i>ibhani-gida</i>	<i>guragi.</i>
<i>Pogostemon plectranthoides</i> Desf.		
Aristolochiaceae		
<i>Bragantia wallichii</i> Br.		<i>niruvate-bern.</i>
Piperaceae		
<i>Piper nigrum</i> Linn.	<i>kadu-menasina-balli</i>	<i>kadu-menasina-bilu.</i>
<i>Piper argyrophyllum</i> Miq.	Do.	Do.
<i>Peperomia portulacoides</i> A. Dictr.		
Myristicaceae		
<i>Myristica magnifica</i> Bedd.	<i>natwara</i>	<i>ramanadike.</i>
<i>Myristica malabarica</i> Lamk.	Do.	<i>rampathre.</i>
<i>Myristica laurifolia</i> Hk. f. & T.	Do.	<i>rampgotu.</i>
<i>Myristica attenuata</i> Wall.	Do.	<i>sannale-ramagotu.</i>
Lauraceae		
<i>Litsaea wightiana</i> Benth & Hook.	<i>hammadde</i>	<i>sudagenasu.</i>
<i>Litsaea glabrata</i> Hook f.	<i>kirale-hammadde</i>	<i>sannale-sudagenasu.</i>
<i>Litsaea stocksii</i> Hook f.		
<i>Litsaea zeylanica</i> Linn.	<i>nayi-yelaga.</i>	
<i>Actinodaphne hookeri</i> Bedd.	<i>yelele-hammadde</i>	<i>salsvare.</i>
<i>Actinodaphne hirsuta</i> Hook f.	Do.	Do.
<i>Cinnamomum macrocarpum</i> Hook f.	<i>yelaga</i>	<i>kankutla.</i>
<i>Cinnamomum zeylanicum</i> Breyn.	<i>yelaga</i>	<i>dalchinni.</i>
<i>Machilus macrantha</i> Nees.	<i>kulmavu</i>	<i>gulmavu.</i>
Thymelesecae		
<i>Lasiosiphon eriocephalus</i> Decne.		<i>mukkadaka.</i>
Elaeagnaceae		
<i>Elaeagnus latifolia</i> Linn.	<i>hulugaraballi</i>	<i>belli-hembu.</i>
Loranthaceae		
<i>Loranthus wallichianus</i> Schultz.	<i>handare</i>	<i>bandarike.</i>
<i>Loranthus obtusatus</i> Wall.	Do.	Do.
<i>Loranthus lageniferus</i> Wight.	Do.	<i>batlu-bandamike.</i>
<i>Loranthus loniceroides</i> Linn.	Do.	<i>bandanike.</i>
<i>Loranthus capitellatus</i> W. & A.	Do.	Do.
<i>Viscum angulatus</i> Heyne.	Do.	Do.
Euphorbiaceae		
<i>Bischofia javanica</i> Bl.	<i>gobar-nerlu</i>	<i>gobar-neralu.</i>
<i>Bridelia retusa</i> Spreng.	<i>nelagoje, gote</i>	<i>bilkumbe.</i>
<i>Bridelia hamiltoniana</i> Wall.	Do.	Do.
<i>Aporosa lindleyana</i> Baill.		<i>salle.</i>
<i>Breynia patens</i> Benth.	<i>okkane</i>	<i>kunkanake.</i>
<i>Glochidion lanceolarium</i> Dalz.	<i>hanchatte</i>	<i>salle.</i>
<i>Glochidion tomentosum</i> Dalz.	Do.	<i>nirus-alle.</i>
<i>Ostodes zeylanica</i> Muell.	<i>bale</i>	<i>bale.</i>
<i>Sapium insigne</i> Benth.		<i>ganganamara.</i>
<i>Adenochlaena indica</i> Hook f.		
<i>Mallotus philippinensis</i> Muell. Arg.	<i>hullatti</i>	<i>kapila-rangu.</i>
<i>Mallotus</i> sp.	Do.	Do.
<i>Macaranga roxburghii</i> Wight.	<i>upranti</i>	<i>batlu-chandaika.</i>

Flowering plants	Name of Hassan Ghats	Name of Shimoga and Kadur Ghats
<i>Trewia nudiflora</i> Linn.	<i>hole-harivana,</i> <i>niruvana.</i>	
Urticaceae		
<i>Celtis australis</i> Linn.		
<i>Trema orientalis</i> Bl.	<i>gorakallu</i>	<i>gorakallu.</i>
<i>Ficus gibbosa</i> Bl.	<i>goddu-mutli</i>	
<i>Ficus retusa</i> Linn.		
<i>Ficus arnottiana</i> Miq.		
<i>Ficus nervosa</i> Roth.	<i>neer-atti</i>	<i>kan-atti.</i>
<i>Ficus infectoria</i> Roxb.	<i>kari-basari</i>	<i>kari-basari.</i>
<i>Ficus hispida</i> Linn.	<i>kolla</i>	
<i>Ficus tsiela</i> Roxb.	<i>bile-basari</i>	<i>bile-basari.</i>
<i>Ficus glomerata</i> Roxb.	<i>atti</i>	<i>atti.</i>
<i>Ficus asperrima</i> Roxb.		<i>male-gargatti.</i>
<i>Antiaris toxicaria</i> Leschen.	<i>gadda-hasave</i>	<i>ajjanpatte.</i>
<i>Artocarpus hirsuta</i> Lamk.	<i>hasenmara</i>	<i>hebbalasi.</i>
<i>Artocarpus integrifolia</i> Linn. f.	<i>halasu</i>	<i>halasu.</i>
<i>Artocarpus lakoocha</i> Roxb.	<i>vate, vante-hull</i>	<i>vate.</i>
<i>Laportea crenulata</i> Gaudich.	<i>nugga</i>	<i>male-maruga.</i>
<i>Streblus asper</i> Lour.	<i>vate-buruklu</i>	<i>matli.</i>
Salicaceae		
<i>Salix tetrasperma</i> Roxb.	<i>niranji</i>	<i>niranji.</i>
<i>Salix ichnostachya</i> Lindl.		
MONOCOTYLEDONS		
Liliaceae		
<i>Dracaena spicata</i> Roxb.		
<i>Smilax aspera</i> Linn.		
<i>Asparagus racemosus</i> Willd.	<i>huli-rayana-kudi</i>	<i>shatavari majjigehambu.</i>
<i>Gloriosa superba</i> Linn.		
Orchidaceae		
<i>Oberonia recutya</i> Lindl.		
<i>Oberonia lindleyana</i> Wight.		
<i>Microstylis rheedii</i> Wight.		
<i>Dendrobium herbaceum</i> Lindl.		
<i>Eulophia nuda</i> Lindl.		
<i>Cymbidium bicolor</i> Lindl.		
<i>Rhynchostylis retusa</i> Bl.		
<i>Saccolabium wightianum</i> Hook f.		
<i>Vanda roxburghii</i> Br.		
Scitamineae		
<i>Clobba bulbifera</i> Roxb.		
<i>Curcuma aromatica</i> Salisb.		
<i>Alpinia galanga</i> Sw.		
<i>Musa superba</i> Roxb.	<i>kadu-bale</i>	<i>kadu-bale.</i>
Amaryllideae		
<i>Curculigo orchioides</i> Gaertn.		<i>nela-tengu.</i>
<i>Crinum ensifolium</i> Roxb.		
Dioscoreaceae		
<i>Dioscorea pentaphylla</i> Linn.		
<i>Dioscorea oppositifolia</i> Linn.		
Palmae		
<i>Pinanga dicksonii</i> Bl.	<i>geraddlu</i>	<i>janjarigi.</i>
<i>Caryota urens</i> Linn.	<i>bagani</i>	<i>bagani.</i>
<i>Phoenix humilis</i> Royle	<i>kirichalu</i>	<i>kirichalu.</i>

Flowering plants	Name of Hassan Ghats	Name of Shimoga and Kadur Ghats
<i>Arenga wightii</i> Griff.	<i>nepalu</i>	<i>dadasalu</i> .
<i>Calamus pseudotenius</i> Becc.	<i>halubetta</i>	<i>halubetta</i> .
<i>Calamus thwaitesii</i> Becc.	<i>kaman-betta</i>	<i>handi-betta</i> .
<i>Calamus</i> sp.	<i>simbe-betha</i>	<i>sanna-betha</i> .
<i>Calamus rheedei</i> Griff.		
<i>Calamus</i> sp.	<i>nagabetta</i>	(not present).
<i>Caryota urens</i> Linn.	<i>bagani</i>	<i>bagani</i> .
Pandanaeae		
<i>Pandanus furcatus</i> Roxb.		
<i>Pandanus canaranus</i> Warb.		
<i>Pandanus tectorius</i> Sal.		<i>kyadige</i> .
Aroidae		
<i>Amorphophallus campanulatus</i> Bl.		
<i>Pothos scandens</i> Linn.		
Gramineae		
<i>Bambusa arundinacea</i> Willd.		(not found).
<i>Ochlandra talbotii</i> Brandis		
<i>Ochlandra rheedii</i> Benth.		
GYMNOSPERMS		
Gnetaceae		
<i>Gnetum scandens</i> Roxb.	<i>kambli-bilu</i>	<i>kule-bilu</i> .

The Vegetation of the Evergreen Forests

General—The peaks and eroded slopes of the Ghats, owing to the presence of cliffs and rock out-crops often of considerable size, have meagre forests covering or are entirely here, in spite of the lack of any disturbance by man. The colour tone of the landscape here is a dull grey whose continuity is occasionally broken by vein of dark green shade where forest growth intervenes.

The precipitous tops have frequently sheet-rock which excludes tree growth and even grass, and elsewhere, where the rock is very near the surface, grass is abundant amidst which stand occasional shrubs of *Wendlandia notoniana* and the Bracken Fern (*Pteris aquilina*) while the grass cover itself is occasionally littered with the yellow, starlike flowers of *Curculigo orchoides*. The valleys and slopes (*Sholas*) are the home of evergreen forests of a magnificent type in whose interior there is not much evidence of colours other than green. The condition, along with the general paucity of showy birds and insects gives the forest interior an air of gloom to which its frequent fogginess only adds. The varying tinge of barks of a few trees sometimes serve to relieve the monotony of the tint; among such trees *Calophyllum elatum* is the commonest.

When, however, the evergreen forest canopy is seen from an opposite vantage point in summer, many differences between it and the forest interior strike the eye. The upper surface forms a richly varied mosaic in which every shade of green and often variegated colours are noticeable, the most frequent being the dark-green. By the mere tint of the foliage and the shape of the crowns an experienced forestman can recognise some of the valuable trees of the forests. Among trees so recognisable are : *Schleichera trijuga* with its bright copper coloured foliage, *Canarium strictum* with its long shoots of dark copper colour and tall round-headed crowns, *Dichopsis ellipticum* with its tall, round-headed crowns with light-coloured young foliage and *Dipterocarpus indicus* with its towering canopy which stands far above the rest of the forests.

Several gigantic trees tower over the general level of the forest, and the stature of the trees is surprisingly varied in spite of the favourableness of rainfall and temperature; the largest ones attain in sheltered valleys a height of 150 feet and over. But on ridges, particularly those at high altitudes directly facing the western wind, the largest individuals seldom exceed 30 to 50 feet in height. The combined influence of wind and seasonal desiccation caused by the shallowness and low water content of the soil contributes to the low stature of the trees on the open ridges but, in general, the phenomenon is probably also due to the high wind increasing the evaporation which makes its desiccating influence on the forest growth considerable. A good number of trees directly exposed to the western wind on the ridges often exhibit nearly fan-shaped crowns caused by the more prominent growth of the branches in the leeward direction,

The forests of the Western Ghats exhibit pronounced tropical characteristics both in their composition and general ecology. There is not a single species of the temperate type, and no gymnosperm except the gigantic climber *Gnetum scandens*. There are generally considerable peculiarities of form. The larger trees, especially species of the genera *Elaeocarpus*, *Alstonia* and *Ficus* and, to a lesser extent, *Myristica*, *Artocarpus*, *Lophopetalum* and some others exhibit conspicuous plank buttresses. The low trees at the top-ends of the *sholas*, which usually belong to the genera *Eugenia*, *Symplocos*, *Canthium*, *Olea* etc. have round compact heads of foliage, while those standing on wind exposed tops and ridges have dwarf boles capped by irregularly extending one-sided crowns.

In narrow, sheltered valleys there is a lofty closed canopy with very tall, clean, cylindrical stems, and as one proceeds into wider valleys and from them to the slopes and finally on to the ridges and hill-tops the stems become less and less clean and tall, and the canopy more and more open, until on the hill-tops and peaks tree growth is altogether absent. The general level of the top canopy is, however, more uniform on the ridges than in the ravines. On ridges, especially when we approach the limit of tree growth of a *shola*, the canopy has sometimes no line of demarcation from the foliage of the under trees and shrubs, and this results in an irregular and more or less solid mass of foliage from the tree tops down nearly to the level of the terrestrial herbaceous plants.

The leaf varies within very wide extremes as regards both size and form, but those of the same species become smaller as the upper limit of tree growth at the top ends of the *shola* are approached. The great majority of the leaves are simple, large in size, and those of the top layers of the canopy are firm, coriaceous and highly cutinised, and contain several layers of palisade cells with little mesenchyma; they contrast with the extremely hygrophilous character of the leaves of the ferns and other herbaceous plants of the forest floor.

The floor of the forest is converted with a litter of leaves, twigs and branchlets of trees the decay of which proceeds very rapidly in the season immediately following the rains, *i.e.* between September and December, while the rate of decay is slower both in the dry and in the wet seasons, in the former owing to the litter getting too dry and in the latter to the extreme witness maintained at relatively low temperatures. White ants do a small amount of destruction of the dead trees before they fall, but it is the abundant discomycetous and other fungi which hasten the disintegration of the stems and branches. The soil is extremely rich in organic matter but, except in valley, it is usually shallow and sometime full of fragments of rock; occasionally rocky boulders cut up its continuity.

The terrestrial herbaceous vegetation varies from extreme wealth in the ravines to almost complete absence in places on the ridges and tops, where, in the absence of sheet rock, grass covers the ground along with masses of the bracken fern—*Pteris aquilina* and thickets of the scrambling fern—*Cleichenia dichotoma*. In the ravines caused by the cutting into the steep ground by forest streams, tree-ferns of the genera *Alsophyle* and *Angiopteris* occasionally figure along with species of *Blechnum*, *Nephrodium*, *Pteris*, *Peperomia* and others. Terrestrial orchids are usually absent, but the most conspicuous members in some of the valleys are the palms, both erect and climbing; among them are *Pinanga dicksonii*, *Arenga wightii*, *Caryota urens* and two or more species of *Calamus*. The large-leaved *Musa*—wild plantain—is also sometimes seen. The abundance of the palms both erect and climbing, and the musaceous type of large leaved phanerogams taken together with the paucity of ferns, filmy ferns and bryophytes stamps upon the vegetation its general tropical character.

Climbers and lianes are not common under the closed canopy but are abundant along the banks of forest streams scouring the bottom of valleys or in places where the upper leaf canopy is relatively open owing to a temporary swampiness, or has been broken and remained so far a long time. Along water courses *Entada scandens* is the commonest climber, while in other places *Gnetum scandens* is prominent. In flat, not very rapidly drained localities cane-brakes of varying density are found, while elsewhere a host of climbing species are present whose systematic identity has been meagrely established.

The vegetation is very varying from north to south although the main characteristic of these forests remain almost identical. The trees of the various canopies are indicated below :—

Top canopy:

- | | |
|--------------|------------------------------|
| 1. Dhuma | <i>Dipterocarpus indicus</i> |
| 2. Yennemara | <i>Hardwickia pinnata</i> |
| 3. Saldhup | <i>Vateria indica</i> |
| 4. Kaidhup | <i>Canarium strictum</i> |

- | | |
|------------------|---------------------------------|
| 5. Hebbalasu | <i>Artocarpus hirsuta</i> |
| 6. Nagasampige | <i>Mesua ferrea</i> |
| 7. Halasu | <i>Artocarpus integrifolia</i> |
| 8. Havalige | <i>Acrocarpus fraxinifolius</i> |
| 9. Hadasale | <i>Palaquium ellipticum</i> |
| 10. Gandhagarige | <i>Cedrela toona</i> |
| 11. Neerulli | <i>Bischofia javanica</i> |
| 12. Ajanpatte | <i>Antiaris toxicaria</i> |
| 13. Kadukumbala | <i>Trewia nudiflora</i> |

The middle storey generally consists of the following species :—

- | | |
|------------------------------|-----------------------------------|
| 1. Chattumbe | <i>Albizia julibrissin</i> |
| 2. Nai-halasu | <i>Carallia integerrima</i> |
| 3. Sampuhannu | <i>Hemicyclia elata</i> |
| 4. Staga | <i>Elaeocarpus tuberculatus</i> |
| 5. Dalchinni | <i>Cinnamomum zeylanicum</i> |
| 6. Ebony | <i>Diospyros ebenum</i> |
| 7. Karimarlu | <i>Diospyros nilagirica</i> |
| 8. Gauri | <i>Polyalthia fragrans</i> |
| 9. Surati | <i>Hydnocarpus wightiana</i> |
| 10. Naviladi | <i>Vitex altissima</i> |
| 11. Jambe | <i>Xylia xylocarpa</i> |
| 12. Jummana | <i>Zanthoxylum rhetsa</i> |
| 13. Halemara | <i>Chrysophyllum roxburghii</i> |
| 14. Sannele kendale | <i>Nephelium longana</i> |
| 15. Kanagalu | <i>Dillenia pentagyna</i> |
| 16. Natwara, Ramanadike etc. | <i>Myristicas</i> (four species). |

The under storey consists of the following species ;—

- | | |
|---------------------|---------------------------------|
| 1. Basavanapada | <i>Bauhinia racemosa</i> |
| 2. Kadunimbe | <i>Limonia acidissima</i> |
| 3. Chigatamari | <i>Lansium anamalayanum</i> |
| 4. Karivokkichelape | <i>Zanthophyllum flavescens</i> |
| 5. Salle | <i>Aporosa lindleyana</i> |
| 6. Lavatepannu | <i>Allophylus phoebe</i> |
| 7. Julichappu | <i>Memecylon angustifolium</i> |

So far as undergrowth is concerned, canes, reeds and creepers dominate. The following species are found to form the undergrowth :—

- | | |
|----------------------------------|--|
| 1. Canes | <i>Calamus</i> species |
| 2. Reeds | <i>Ochlandra rheedii, travancorica</i> |
| 3. Kurunji | <i>Strobilanthes</i> species |
| 4. Webera | <i>Webera corymbosa</i> |
| 5. Karotai | <i>Leea sambucina</i> |
| 6. Mundachekke | <i>Pandanus tectorius</i> |
| 7. Grasses of different species. | |
| 8. Creepers | |
| 9. Kolakachi | |
| 10. Upparanti | <i>Macaranga roxburghii</i> |
| 11. Taggi | <i>Clerodendron infortunatum</i> |
| 12. Tagadate | <i>Callicarpa lanata</i> |
| 13. Maleangara | <i>Laportea crenulata</i> (or nettle) |
| 14. Koovali | <i>Clinegyna virgates</i> |
| 15. Nettiapai | <i>Arenga wightii</i> |
| 16. Kowri | <i>Helicteres isora</i> |

All these species do not occur in every portion of the evergreen strip for example, *Palaquium ellipticum*, *Evodia*, *Poeciloneuron* etc., are absent in the extreme north, while *Calophyllum tomentosum* is very common in Coorg area, *Hopea parviflora* is plentiful in South Kanara and portions of Coorg while it is found here and there in patches in North Kanara,

The Progress of Natural Regeneration

This, of all the important tree species which dominate the top canopy, is generally adequate to replace the loss by natural death or uprooted by wind. Except in the very dark portions where little sunlight reaches the forest floor, the soil is generally covered with a mixture of young growth of the tree species in all stages of development, which owing to the abundance of undergrowth, is not readily visible. Even at spots where owing to sudden influx of light, a host of fast growing and light demanding weeds are found crowned together. Careful observation reveals underneath them a good number of seedlings and saplings of the larger tree species. In places where the canopy has been disturbed by forest exploitation, promiscuous natural regeneration comes up and replaces the light loving weeds which first set foot on the soil.

A judiciously worked evergreen forest is, therefore, better regenerated by nature than one in its virgin state. In other words, it is only necessary to exploit an evergreen forest to obtain abundant natural regeneration. In the evergreen zone the problem is not one of obtaining but of securing and tending the regeneration of the right kind of the desired species.

The evergreen forests of the State are formed out at four different units which have been integrated in the present State. Naturally the working of these evergreens in those four different units differed according to their prevailing circumstances. In North Kanara district of the erstwhile Bombay State no working was prescribed. During the second World War, however, a few of the species such as *garjan* and *poon* along with some softwoods were exploited to meet the war demands. In 1948, 100 *garjan* trees were removed to meet the requirements of the railways. At about the same time some more working was carried out along the western slopes of these Ghat forests. In the former case the gaps created were cleared and planted with species such as teak, *Machilus macrantha*, *Artocarpus* spp., *Mangifera indica*, etc. When these patches were inspected subsequently in 1955 it was observed that all these plants were completely smothered by profuse natural regeneration of *garjan*. Another area where *poon* was also exploited, young regeneration of the same was also coming up. This emboldened the officers and regular exploitation of *poon* and *garjan* of 7' and up in girth was undertaken on an increasing scale since 1957.

In the Agumbe forests of the old Mysore State exploitation of the species like *Mesua*, *garjan*, *poon* and *Vateria indica* has been going on with a view to supply sleepers to railways.

The exploitation of timber from the Ghat forests of Coorg was taken up from about 1867. This was by issue of permits to the West Coast merchants and extraction was confined mostly to *poon*. A few other species were also in demand but to very small extent. Even though attempts were made to control the fellings, they were a failure. In 1916 working plan was drawn up. As per this working plan, forests were exploited on selection method and improvement fellings. The girth limit for felling fixed under this system was 6' in the case of ebony and 7' for all other saleable species. The area included in this working circle was 30,000 acres and the area of the annual coupe was about 3,000 acres with an estimated outturn of 4½ lakhs of cubic feet of timber for each coupe at the rate of 150 cubic feet per acre. Blanks created by these fellings were dibbled with seeds of more valuable species and the results were successful. Bamboo (*Dendrocalamus brandisii* and *Dendrocalamus giganteus*) were also planted along the river margins. In 1920 and 1924 regeneration fellings in a valley was done. Fellings were also done in this valley from 1926 onwards which were stopped in 1929 as per the resolution of the Third Silvicultural Conference held at Dehra Dun. The fellings of evergreen forests were again taken up in 1934 and all marketable timber above 4' girth at B.H. were felled. The girth limit subsequently was raised to 6' in 1936 except for *Palaquium ellipticum* and *poon* for which girth of 4½' was fixed. This system continued till 1938. In 1938 another working plan was drawn up covering an area of 32,000 acres by Mr. Van Haeften. This had two working circles (1) Irregular shelter wood system in which all saleable timber above 4½' was felled. The yield was regulated by area. Tending operation in third and sixth year was taken up. (2) The other Working Circle was of selection working. This working circle prescribed the felling of all species of 6' and above girth except *pali* and *poon*. This method was followed by tending operation in the 3rd and 6th year and regeneration by dibbling seeds of more valuable species.

Cardamom was also cultivated in these forests by both 'Plot method' and 'Plantation method' by giving certain areas on lease.

REFERENCES

Seschachar, C. (1941)—Meteorology in Mysore.

THE SILVICULTURE AND MANAGEMENT OF EVERGREEN FORESTS OF KERALA STATE

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The evergreen forests are distributed all over the State of Kerala and are confined mostly up to 4,500 feet elevation on the Western Ghats. A major part of these forests may be classed as the tropical wet evergreens. At lower elevations, however, this type merges imperceptibly into the tropical semi-evergreen forests, which is an intermediate type between the wet evergreen and the moist deciduous forests. Exact delimitation of wet evergreens is rather difficult because very often the patches groups of moist deciduous forests are interspersed. At higher elevations the wet evergreens merge into so called *shola* or stunted evergreens. They may also be designated as high range *shola* evergreens. *Shola* forests in turn pass on to montane grassy lands. Roughly speaking, about 900 square miles of the reserved forests of the State are evergreens. Some of the evergreens have been retrogressed due to biotic influence like shifting cultivation, burning, cutting, etc. This is patently visible in some of the badly degraded private forests and areas opened out for cultivation.

Site Factors

A. *Rock and Soil*—The nature of rock and soil varies considerably from place to place. The underlying rock formation consists mainly of gneiss of granitic nature and at places has produced laterite. The gneiss is often composed of felspar, quartz and mica.

The soil of the lower slopes and valleys is considerably deeper and finer in texture. Typical soil in such situations is dark-coloured loam with a good mixture of sand. Alluvial soils are usually deep and rich, particularly along the water courses. Over the crest of the main *ghats* and ridges, the soil is usually shallow, rocky and poor.

The deposition of humus in these forests is usually of appreciable depth which often inhibits the establishment of regeneration. The absence of fires and sunlight coupled with high humidity and heavy rainfall usually keeps the forest floor moist. The type is relatively little governed by the kind of rock and soil on which it occurs having evolved a system of living largely on the products of its own decay. But the condition of the soil, in as much as its capacity to retain moisture, considerably influences the type of forests it supports. This explains to some extent the occurrence of a mosaic of evergreen, semi-evergreen and deciduous forests.

A few representative soils in which evergreens and seeds grow, have been analysed by the Agricultural Chemist, Vellayani, Trivandrum. The samples were taken from two important evergreen areas in the State—Malayattur and Thenmalai divisions.

Sample 1	Malayattur Reserve.
Sample 2	Sendurney N.R.
Sample 3	Sendurney S.R.
Sample 4	Sangali Reserve.

The results of analysis are given below :—

	S1	S2	S3	S4
1. N	0.187%	0.109%	0.070%	0.130%
2. Available P ₂ O ₅ , Phosphoric acid	0.001%	0.001%	0.001%	0.001%
3. Available Potash K ₂ O	0.019%	0.026%	0.008%	0.027%
4. pH	4.6	5.5	5.6	5.2
5. Conductivity	0.39	0.12	0.16	0.60

The above data indicates that the wet tropical soils are acidic to a large extent.

B. Climate.

(a) *Temperature and Humidity*—The mean annual temperature fluctuates between 70°F to 90°F, mostly depending on elevation. The warmest months are February to May. Humidity per cent does not fall below 80 and during monsoon months it reaches

saturation point. Winter season does not occur though the nights in December and January may be fairly cool and may precipitate.

(b) *Rainfall*—The major of the annual precipitation is received from the south-west monsoons during the months of June to August. The north-east retreating monsoons bring light showers during October and November. The average annual rainfall ranges between 120" to 150", while in places like Anamudi is it recorded as 380". There is no prolonged drought.

(c) *Natural succession*—The undisturbed evergreen forests form a climatic climax in the ecological succession. Intensive working, shifting cultivation and repeated fires, have at places, resulted in the formation of retrogressional types. These types are characterised by tall grasses, *Eupatorium*, reeds, etc.

Depending upon the degree of disturbance caused the retrogressional stages are very varied. This variation is further complicated by the development of secondary succession. These changes are noticeable in abandoned old estates and the intensively worked forests. On the abandoned sites grasses are the first to invade and they are followed by ferns, ground orchids and *Eupatorium*. These are followed by species like *Wendlandia*, *Moesa*, *Glochidion*, *Hypericum*, *Symplocos* etc. which form a sort of canopy under which further succession of species like *Achronychia*, *Elaeocarpus*, *Meliosma*, *Litsaea*, *Olea*, *Linocera* etc., takes place. This gives way finally to any of the evergreen associations in which species like *Calophyllum elatum*, *Mesua ferrea*, *Cullenia excelsa* etc., may dominate.

In the heavily worked *sholas* like those of the private forests where almost all saleable species are ruthlessly extracted, the cleared area is first invaded by weeds and is followed up in the course of few years by fast growing species like *Leea*, *Trema*, *Macaranga* etc. Under the shade of these species, evergreen plants like *Calophyllum*, *Artocarpus hirsuta*, *Mesua*, *Palaquium* etc., come up. Where the depletion of stock is gradual in a series of years, the conditions caused favour growth of *Macaranga*, *Leea*, *Cardamom*, etc. These continuing partial cuttings also facilitate the natural regeneration of species like *Palaquium*, owing to the availability of light.

Even under the selection system, if the gaps opened out are large and numerous, profuse regeneration of *Palaquium* appears. If these fellings are, however, light say causing removal of about 3 trees to an acre, the size of gaps formed varies from 40' × 30' to 100' × 60'. In the former type of gaps, reproduction of *Mesua* and *Palaquium* establishes very well. In large-sized gaps, weed competition is too heavy and only inferior species like *Macaranga*, *Laportea*, *Leea*, grasses etc. appear, unless cultural operations are carried out to favour the economically important species. In such gaps, however, artificial regeneration can be tried and has come out very successfully with *Hopea* at Shendurne.

The incidence of fire plays a very important role in diverting the course of succession. In places where reeds already exist, recolonisation after deforestation is by *Macaranga peltata* and reeds. These two species come up simultaneously but due to the fast growing nature of *Macaranga*, it takes a lead. The colonising behaviour of reeds is also doubted because they flower once in 20 years. Extensive colonisation, therefore, can occur only at long intervals. In places where reeds established the chances of regeneration of the evergreen species are very remote.

Ecological status

Out of the three types of evergreen forests mentioned the Tropical Moist Evergreens and the High Range *Shola* Evergreens are the climatic climax. But biotic factors like shifting cultivation, excessive fellings, opening of estates etc., have modified the characteristic appearance at several places. In virgin evergreen forests only occasionally a few associations are met with in which only one or two species dominate.

In this connection, it is not out of place to discuss the association of reeds (*Ochlandra travancorica* and *O. rheedii*) with evergreens, Champion has suggested that such associations should be considered as edaphic variants only, such as E. 9—South Wet Bamboo brakes. This view is unquestionable so far as the occurrence of *Ochlandra rheedii* is concerned. In the case of *Ochlandra travancorica*, two major local sub-types are met with, viz. (i) almost pure patches with scattered or no overhead trees and (ii) reeds existing as an understorey in evergreens. The first type of areas are usually more accessible and consequently heavily worked. They are subject to severe fires which kill regeneration of evergreen species. However, the rhizomes escape this damage and resprout during heavy rains. This sub-type is, therefore, conditioned with biotic influences. In the second type of areas, which are mostly inaccessible lofty scattered trees of *Calophyllum* and *Poeciloneuron* occur. The age of these trees may be easily reckoned as 100 or 150 years and

during this period the reeds must have flowered at least four or five times. Since the flowering cycle of reeds is about 20 years and the big and heavy tree seeds are incapable of dispersion to any great distance, the reeds are perpetuating as a stable undergrowth for long time. Fires are unknown in these tracts but the thick reed growth inhibits multiplicity of tree species. The sporadic nature of tree is, therefore, maintained. This type is eminently conditioned with edaphic influences. The soil is more suitable for the perpetuation of reeds.

Composition of the Crop

The Moist Tropical Evergreen forests of Kerala State may be broadly divided into three main types :

- (A) 1 a C2 Western Tropical Evergreen,
- (B) 2 a C2 West Coast Tropical Semi-Evergreen,
- (C) 7 a High Range *Shola* Evergreen (Montane Wet sub-tropical forest).

(A) The majority of the evergreen forests of the State fall within the main type of Western Tropical Evergreens. These forests are characterised by a luxuriant growth of evergreen trees of different sizes and shapes arranged in several tiers of storeys. Though distinct stratification of crowns is not marked three tiers may be conveniently distinguished.

The trees of the dominant storey or top canopy attain a height of hundred to hundred and fifty feet with a clean cylindrical bole of about 80 to 90 feet. The constituent species are *Acrocarpus fraxinifolius*, *Aglaiia roxburghiana*, *Ailanthus malabarica*, *Anacolosa densiflora*, *Antiaris toxicaria*, *Artocarpus hirsuta*, *Bischofia javanica*, *Calophyllum tomentosum*, *Carallia integerrima*, *Cedrela toona*, *Cullenia excelsa*, *Dipterocarpus bourdillonii*, *Dipterocarpus indicus*, *Diospyros assimilis*, *Dysoxylum malabaricum*, *Elaeocarpus tuberculatus*, *Eugenia arnotiana*, *Eugenia chavaran*, *Eugenia jambolana*, *Filicium decipiens*, *Hopea parviflora*, *Hopea racophloea*, *Lophopetalum wightianum*, *Machilus macrantha*, *Mangifera indica*, *Mesua ferrea*, *Myristica attenuata*, *Myristica malabarica*, *Palaquium ellipticum*, *Polyalthia fragrans*, *Pterospermum reticulatum*, *Pterospermum rubiginosum*, *Sterculia alata*, *Tetrameles nudiflora* and *Vateria indica*.

The chief species of the lower canopy of second storey are *Achronychia laurifolia*, *Actinodaphne hookeri*, *Amoora rohituka*, *Aporosa lindleyana*, *Baccaurea courtallensis*, *Bocagea dalzelli*, *Canarium strictum*, *Cinnamomum zeylancium*, *Diospyros microphylla*, *Elaeocarpus serratus*, *Evodia roxburghiana*, *Ficus* spp., *Garcinia morella*, *Holigarna arnotiana*, *Hopea glabra*, *Hydnocarpus wightiana*, *Litsaea* spp., *Macaranga roxburghii*, *Mallotus philippiensis*, *Memecylon edule*, *Mimusops elengi*, *Myristica beddomei*, *Nephelium longana*, *Pithecolobium bigeminum*, *Pygeum wightianum*, *Vernonia travancorica*, *Xanthophyllum flavescens* and *Zanthoxylum rhetsa*.

The third storey consists mostly of shrubby species such as *Euonymus angulatus*, *Agrostistachys indica*, *A. longifolia*, *Eugenia munroii*, *E. loeta*, *Paramignya armata*, *Sauropus albicans*, *Leea sambucina*, *Saprosma fragrans*, *Webera* sp., *Clerodendron infortunatum*, *Macaranga roxburghii*, *Strobilanthes* sp., *Laportea crenulata*, *Olea dioca*, *Linocera malabarica*, *Callicarpa lanata*, *Pavetta zeylanica*, *Vernonia arborea*, *Lepisanthes deficiens*, *Turpinia malabarica*, *Orophea uniflora*, *Apama siliquosa*, *Sarcococca brevifolia* and *Croton scabiosus*.

The ground flora consists of cardamom, *Curcuma*, *Strobilanthes*, *Selaginella* etc.

Species of *Calamus*, *Pandanus*, *Pinanga* reeds etc., are often met with. Climbers are abundant, mainly of *Entada scandens*, *Dioscorea* sp., *Derris*, *Smilax macrophylla*, etc. Epiphytes are numerous; mosses, ferns, Orchids and lichens occur almost everywhere. Buttressed base of trunks are conspicuous in species like *Tetrameles*, *Lophopetalum*, *Poeciloneuron*, *Cullenia* etc. Cauliflory and brilliantly coloured juvenile foliage are striking and attractive features of the evergreen forests; the innumerable leaches and the 'Elephant nettle' are equally repulsive and one cannot fail to have acquaintance with these in an evergreen forest.

Sri T. V. Venkateswara Iyer distinguished 8 sub-types in this main type:

1. The *Cullenia-Palaquium* association,
2. The *Palaquium-Mesua* association,
3. The *Poeciloneuron-Palaquium* association,
4. The *Mesua-Calophyllum* association,
5. The *Vateria-Cullenia* association,
6. The *Mesua-Cullenia* association,
7. The Reed-*Calophyllum* association, and
8. The Reed-*Poeciloneuron* association,

(B) C₂ West Coast Tropical Semi-Evergreen forest.—Semi-Evergreen forests lie as a transitional zone between the Wet Evergreen and Moist Deciduous forests. The average rainfall may be taken as 80" to 100", though at places it may be more. These Semi-Evergreen forests may occur from plains upto an elevation of over 3000'. The status of the Semi-Evergreen cannot be precisely defined. They are probably the secondary seral stages towards an evergreen climax.

The general floristics of the type are as follows:

TOP CANOPY : *Adina cordifolia*, *Anthocephalus cadamba*, *Artocarpus hirsuta*, *Calophyllum tomentosum*, *Cedrela toona*, *Eugenia chavaran*, *Eugenia jambolana*, *Holoptelea integrifolia*, *Hopea parviflora*, *Lagerstroemia lanceolata*, *Lagerstroemia flos-reginae*, *Mangifera indica*, *Melia dubia*, *Milusa velutina*, *Mitragyna parviflora*, *Polyalthia fragrans*, *Pterospermum reticulatum*, *Pterospermum rubiginosum*, *Spondias mangifera*, *Sterculia alata*, *Terminalia paniculata*, *Tetrameles nudiflora*, *Vateria indica*, *Vitex altissima*.

LOWER CANOPY : *Anacolosia densiflora*, *Aporosa lindleyana*, *Baccaurea courtallensi*, *Bocagea dalzellii*, *Canarium strictum*, *Cinnamomum zeylanicum*, *Evodia roxburghiana*, *Mallotus philippensis*, *Pygeum wightianum*, *Xanthophyllum flavescens*.

BAMBOOS AND REEDS : *Bambusa arundinacea* is the commonest bamboo. *Ochlandra travancorica* occurs in large patches in certain localities, especially in areas subjected to shifting cultivation.

UNDERGROWTH : *Antidesma diandrum*, *Calamus rotang*, *Calamus travancoricus*, *Clerodendron infortunatum*, *Clausena wildenovii*, *Croton malabaricum*, *Eleagnus latifolia*, *Glycosmis pentaphylla*, *Ixora notoniana*, *Leea sambucina*, *Limonia acidissima*, *Murraya exotica*, *Strobilanthes* sp., etc.

CLIMBERS : *Entada scandens*, *Spatholobus roxburghii*, *Dioscorea* spp. etc.

(C) High Range *shola* Evergreens (Montane Wet Subtropical Evergreens).—This type of forest occurs on elevation of over 4500' in sheltered valleys. The exposed situations carry only grass formations. The rainfall varies from 75" to over 300". The climate in general is temperate. The general appearance of these forests is distinctly different from the Wet-Evergreen forests. Size of the trees does not exceed 80 ft. Boles are short and branchy and copiously covered with mosses, ferns, lichens and epiphytes. Canopy differentiation in various tiers is not possible. Floristic composition is as follows :

THE TOP AND LOWER CANOPIES : The chief species are *Actinodaphne hookeri*, *Alseodaphne semecarpifolia*, *Bauhinia racemosa*, *Clausena* sp., *Cinnamomum sulphuratum*, *C. wightii*, *C. zeylanicum*, *Daphniphyllum glaucescens*, *Eugenia arnottiana*, *Eugenia gardneri*, *Eurya japonica*, *Euonymus* sp., *Ficus* sp., *Humboldtia* sp., *Ixora* sp., *Ilex denticulata*, *Litsaea* spp., *Neolitsaea* sp., *Meliosma wightii*, *Michelia* sp., *Nothopegia dalzelli*, *Photinia notoniana* and *Rhododendron arboreum*.

Lower down species like *Beilschmiedia wightii*, *Diospyros* sp., *Elaeocarpus* sp., *Myristica* sp., *Nephelium longana*, *Xanthophyllum* sp., etc. also occur.

UNDERGROWTH : (i) *Arundinaria wightiana* and *Teinostachyum beddomei* are common, of which the former is more conspicuous.

(ii) *Ardisia*, *Ligustrum*, *Rhamnus*, *Strobilanthes*, *Viburnum* etc.

(iii) (In the open) *Berberis nepalensis*, *Dodonaea viscosa*, *Eupatorium* sp., *Gaultheria fragrantissima*, *Hypericum* sp.

CLIMBERS : *Rosa* sp., *Clematis*, *Rubus*, *Elaeagnus latifolia*.

Several species of *Strobilanthes* forming extensive thickets of undergrowth are often met with.

The occurrence of this type has not been mentioned specially in the Champion's types and so a convenient name is given as the High Range *Shola* Evergreens.

Silviculture and Management

(a) *Seeding habits of principal species*.—Though the leafing, flowering and fruiting habits of the main species varies to some extent, generally speaking it may be said that the leaf-shedding commences with the approach of winter, flowering is conspicuous from January to March and seeding is mainly during May to June. Every year may not be a good seed year for all the species. In the case of some species like *Dysoxylum malabaricum*, seeding is delayed to as late as August. The fruits on the whole are heavy and the dispersion is limited. Usually bats and birds help in the dispersal of seeds to longer distances.

Growth habits.—Most of the seeds fall at a time when there is sufficient moisture and they start germinating as soon as they reach the ground. Considerable quantities of seeds of species like *Mesua* are destroyed by rats, porcupine, mouse, deer, squirrels etc. But under favourable conditions natural regeneration of most of the species comes up adequately. Dense undergrowth may be inimical for the establishment and growth of seedlings. In species like *Palaquium*, *Vateria* etc. the germination might commence even when the fruits are still on the trees.

The natural regeneration of the most important species comes up easily. But their establishment and development is mainly decided by the amount of overhead light, they get. The seedlings have to compete for light and space and the roots struggle a good deal to reach the mineral soil. Of course, there is no paucity of moisture. But when the moisture is in excess, e.g., during the monsoon months, the seeds falling on the ground do not germinate or if they germinate, make little progress, till the wettest period is over. In case of *Mesua*, seeds fall before the monsoon, in May or June but they commonly do not germinate till September and *Palaquium* drops its seeds during the monsoon and they germinate immediately, though the seedlings make little progress till the wet weather is over. Under favourable conditions most of the seedlings after germination, get an initial establishment. Establishment process is hindered in localities where gaps are not created in the overhead canopy to admit light on forest floor. If the openings are inordinately large the forest floor is swamped with grasses and weeds, inimical to the existence of tree seedlings. Only a judicious and careful working of evergreens is, therefore, essential to obtain adequate natural regeneration. Obtaining of recruitment must be supplemented with cultural operations to shorten the period of establishment. Under natural condition established saplings are not noticeable.

The silvicultural requirements of the various important species vary considerably. *Calophyllum* and *Mesua* are tolerant to shade when young, while *Palaquium* is one of the strongest shade-bearers. *Acrocarpus fraxinifolius* is a strong light demander while *Dysoxylum* is only a moderate shade-bearer. Most of the seedlings are capable of persisting in shade for a considerably long period. But their further development depends upon availability of light. The struggle for existence is the keenest when the seedlings are young. A large proportion of seedlings succumb during this struggle.

On closer examination of some of the Wet Evergreen forests, it is seen that there is a general paucity of established regeneration of the merchantable species while some species like *Vateria*, *Hopea* and *Tetrameles* regenerate profusely in gaps created under selection fellings. Continued selection fellings also deplete the forest of merchantable species.

Improvement works done for Natural Regeneration.—Various attempts have been made to manipulate the overhead canopies to achieve regeneration of species like *Mesua*, *Calophyllum*, *Hopea*, etc. The effect of removing the undergrowth and soil working before felling were also tried in the Chenai Nair Reserve. Usually regeneration comes up satisfactorily, but the proportion of the best species is inadequate. Cultural operations of freeing the natural regeneration from competing weeds have always been fruitful. Such intensive cultural operations, however, are not possible on a large scale due to remoteness of the evergreens and the usual unhealthy conditions prevailing. Also, most of the evergreen species are not marketable. These facts have hitherto hindered the progress in obtaining natural regeneration in evergreen forests.

Artificial regeneration

Artificial methods of regeneration have also been tried since 1920 and the results are encouraging. Experiments on sowing of *Hopea*, *Artocarpus*, *Mangifera* and *Palaquium* were tried under different canopy conditions. Best results were obtained where the lower canopy was removed. Particularly, the sowings of *Mesua* and *Calophyllum* responded the best.

Dibbling of seeds, transplanting of one year old seedlings of species like *Mesua*, *Calophyllum*, *Hopea*, *Dysoxylum*, *Acrocarpus*, etc. have given fairly good results. Constant weeding and tending operations are of paramount importance. Experimental strip planting was started in Shendurney (Thenmalai division). Strips 11' wide are cut one chain apart and along the strip planting or dibbling at 11' along the centre of the strip was carried out. Species tried were mahogany, *Artocarpus*, *Dipterocarpus* and *Vateria*. The latter two species were tried where conditions were comparatively more moist. Along the strips all undergrowth and poles of inferior species were removed. Mahogany came up well, but had a set-back due to abandoning of cultural operations.

Planting of *Hopea* seedlings in gaps created during selection fellings were also tried at Shendurney. The results are hopeful.

The old practice of gap regeneration practised in the Kannothe and Begur ranges of Wynaad division included planting of *Artocarpus hirsuta*, *Mesua*, *Dysoxylum*, *Cedrela*, *Hardwickia* and *Diospyros* in prepared pits 6 feet apart in gaps 30' across and weeding was done for two years. But there was heavy damage from wild animals like bison and so this practice was revised to planting in pits 12' x 12' after the removal of lower canopy trees and shrubs. Tending of natural regeneration was also attended to together with manipulation of canopy.

In this connection special mention has to be made of the very successful artificial regeneration works with *Hopea parviflora* started by Tireman from 1921 onwards at Parappa (Wynaad division). Pits of varying size (4' x 12' x 10", 12' x 12' x 10" etc.) were prepared and dibbled with *Hopea* seeds. The patches were 27' x 27', 13½' x 13½', 19' x 19' etc. Seeds were sown broadcast in certain areas in 1923 and 1924. The results are very encouraging. Manipulation of canopy was regularly done to admit light and the poles developed adequately. All interfering trees except teak and *Terminalia tomentosa* were either felled or girdled. Some of the poles have grown 20" to 22" in girth and the top height is about 60'. The physiognomy of these forests is more like semi-evergreen or some transitional stage of evergreens.

In the Palghat division restocking of larger gaps where natural regeneration was inadequate, artificial introduction of *Artocarpus*, *Acrocarpus*, *Dysoxylum* and *Gluta travancorica* was prescribed. A suitable size of gaps which can regenerate satisfactorily is about 200 square yards and on successful completion of the operation they carry 12 to 15 established seedlings.

The general prescriptions for the artificial regeneration of evergreen forests of the erstwhile Travancore-Cochin State consist mainly in strip regeneration to be done on an experimental scale in smaller areas only 2 to 8 strips 11' wide and one chain apart (centre to centre) are cleared of all undergrowth and understorey, retaining only advance growth of useful species. Germinating seeds of *Dipterocarpus* and *Vateria* may be dibbled, 11' apart along the centre of the strip. Dibbling or transplanting of species like *Artocarpus*, *Machilus*, *Vateria*, *Gluta*, *Dysoxylum*, mahogany, *Canarium*, etc. are preferred. Timely and frequent weedings and opening of canopy are done according to requirements.

In most cases the artificial regeneration operations in evergreens were either neglected or not continued to be pursued due to reasons more than one. It was often difficult to follow the patches, the areas were inaccessible and often the results were not proportionate to the pains or expenses involved in the operation.

In this connection special mention must be made of the excellent regeneration works done in some of the private forests belonging to the Western India Plywood, Baliapatam (Tellicherry district). Six feet strips were cut 30' apart and broadcast sowing of seeds of species like mango, *Vateria*, *Artocarpus hirsuta* etc., was tried after soil working. The area is strictly protected from fires and grazing. Necessary tending operations are carried out and the results are excellent.

In recent years some of the semi-evergreen forests and even to a small extent low level evergreen forests have been clearfelled and planted up artificially with softwood species like *Salmalia*, *Evodia*, *Ailanthus malabarica*, *Sterculia campanulata* etc., under the *taungya* system. The areas were burnt thoroughly and planted up. The plants have come up very well.

The usual silvicultural system employed in the working of the evergreen forests is the Selection system under which selection girth limits are fixed for removal. The girth limit varies with different species—the usual girth limit being 6" to 8" and above. On an average about 3 mature trees are expected to be available for felling per acre. The annual yield is regulated on area basis. The rotation is tentatively fixed at 100 years and the felling cycle is fixed as 30 years. In a few cases when demand for a particular species like *Vateria*, *Machilus*, *Palaquium* etc., occurred some concentrated fellings were also done.

Volume and Yield

The rate of growth of most of the species in the evergreens are not completely known at present. Standard volume tables for most of the species are also not available. Local volume tables had been prepared for *Mesua* and *Palaquium*. The standing volume of timber varies a good deal from place to place. The enumeration figures for the clearfelling area of the Sholiar lake area give a utilisable volume equivalent to about 50 tons of timber per acre. Of these, species like *Palaquium*, *Vateria*, *Machilus*, *Lophopetalum* and *Canarium* are supplied to the plywood factories and some others like *Vitex*, *Calophyllum*, *Artocarpus*, *Dysoxylum* and *Mesua* are taken to Chalakudy depot, and these together form about 30% of the bulk production, while the rest of the species like *Myristica*, *Cullenia*, *Garcinia* etc., are

utilised for packing cases etc. The proportion of species also varies with different localities. The yield of firewood is expected to be about 40 tons per acre. The yield from selection felling areas may be safely taken as about 200 c.ft. of timber.

Injuries and Protection

At present there are no major injuries from which the evergreens suffer. But there are varying intensities of damage from various sources that do damage to the evergreen forests. Of climatic injuries delayed outbreak of monsoon, strong westerly winds which precede the southwest monsoon, long breaks in the monsoon etc., are important factors that do certain amount of damage to regeneration and sometimes to the trees also.

Though fires on the whole are not a menace to these forests, certain amount of damage from fire is experienced where heavy grass and reed growth occurs. These fires even though are light do considerable damage to regeneration and trees.

Of the injurious plants, special mention must be made of *Eupatorium odoratum* and *Lantana camara* which come up when the canopy is opened. *Eupatorium* has become a real menace. Grasses, besides inviting fire prevent regeneration. Also heavy growth of *Strobilanthes*, *Toddalia* etc., hinders regeneration. Damage from fungus is not severe. Many of the species like *Vateria*, *Dipterocarpus*, *Palaquium* etc., suffer from heart rot and become hollow when over-mature. This may be regarded only as an inescapable phenomenon.

Among the insect pests, the larvae of a species of *Phassus* (on *Gmelina*, *Trema* etc.), *Terias sythetana* (on *Acrocarpus*) and grubs of *Trypetid* (on fruits and seeds of *Dysoxylum*) do some damage.

A very serious damage was noticed on living trees of all girth classes belonging to both *Mesua* and *Poeciloneuron* by a *Buprestidae* borer *Chrysochora* sp. in the Nelliampathy range (Trichur division). The trees apparently looked to be sound but when felled and converted they were found to have very serious damage due to irregular and large galleries. In certain of the localities most of the trees of these species were seen attacked.

Human interference, especially in his attempt to establish estates and raise plantations has done considerable damage. Damage from elephants, bison and *sambur* are seen in some localities.

Research

The experiments on artificial regeneration of evergreen species of economic importance reveal that most of them can be introduced successfully in the evergreens and semi-evergreens under different conditions of canopy and shade. In some cases even clearfelling followed by regular planting under *taungya* is found to be successful, particularly after burning. Growth and development of *Calophyllum elatum*, *Gluta travancorica*, *Hopea*, *Artocarpus*, *Dipterocarpus indicus* etc., were studied when planted in shade and open conditions. E.P. 23 of Wynaad division was laid out to find out the best method of inducing natural regeneration of *Dysoxylum* in evergreen forests. The indications are that clearing the undergrowth and soil worked with fork upto a depth of 5" to 6" give significantly the best results. Experiments were also laid out to study the best method of inducing natural regeneration of *Hopea* and the weeding technique to be applied and the effect of heavy opening of the canopy over established and unestablished regeneration of *Hopea*. The indications are that :

- (i) clearing undergrowth just after the seed fall considerably encourages natural regeneration.
- (ii) Regular weedings 3 times a year till the seedlings reach the sapling stage is significantly beneficial.
- (iii) removing the overwood over establish *Hopea* sapling and poles encourages rapid growth.

Experiments done to study the effect of tending natural regeneration of *Mesua* indicate that the clearing of interfering growth is beneficial both for the growth of seedlings and for obtaining more recruitment. Results obtained in studies conducted on natural regeneration of *Palaquium ellipticum* show that clearfelling the top canopy—after obtaining natural regeneration is considerably beneficial to the establishment and growth of this species.

In the past, in the Chenat Nair Reserve—upper felling area, the Creeper Plot, Fischer's Burn etc. many trials were made with *Acrocarpus*, *Artocarpus*, *Hopea*, *Mesua*, *Palaquium*, *Calophyllum*, *Mangifera* etc. Seeds, seedlings (natural and nursery grown), stumps etc. were

used. In the Fischer's Burn (Palaghat division) an area of 9 acres was planted in September 1920 with natural seedlings of *Palaquium* and dibbled with seeds of *Dysoxylum* without success. It was then burned and dibbled with seeds of *Hopea*, *Vateria*, *Palaquium* and *Artocarpus* at 6' x 6' in June 1921 and 1922, under cuttings of *Erythrina lithosperma*. On failure of these, repeated attempts were made in successive years with species like *Terminalia tomentosa*, *Artocarpus hirsuta*, *Vateria*, *Hopea*, etc., without success. However the area has now regenerated naturally with *Acrocarpus fraxinifolius*. In other, areas planting was mostly done in gaps. In most cases the success was not commensurate with the expenses and efforts involved. But tending of regeneration, both natural and artificial, was in most cases essential. Main trend in present day research is centred on study of growth and development of important evergreen species like *Vateria*, *Ailanthus malabarica*, and such other softwoods introduced on plantation scale. Dendrology, distribution and development of species are studied on the Linear Tree Increment Plots.

Future Research

Since most of the species that are available from the evergreens are used at present in one way or other and since the demand on the evergreen species is on the increase, it is likely that more attention will be concentrated on evergreen forests and the utilisation of the various types of timbers that are available from these forests.

Future research may be based on the following lines :—

1. *Dendrology and Ecology*.—Identification and classification of the evergreen species is necessary. The ecological associations related to elevation and moisture conditions should be studied. So also studies on the natural succession in evergreen forests after clearfelling, heavy fellings and light fellings should be undertaken. The relation of natural regeneration to openings, soil condition and moisture are to be studied more closely. The progress of evergreen species in predominantly reed areas is an interesting aspect of study.

2. *Silviculture*.—Regeneration surveys should be conducted and the seeding habits and the nursery technique of the major species be studied in greater detail.

The effects of selection fellings and tendings on the recruitment and establishment of the main species should be undertaken. Investigations are to be conducted with regard to the primary operations that are required prior to fellings to get regeneration either naturally or by artificial means. Various methods to get natural regeneration and the effect of sowing, dibbling etc., under various conditions of removal of the undergrowth and upper canopy layers, with and without soil working are items to be experimented upon. An important item of experiment to be undertaken in this connection is the removal of the subsidiary species of the middle and lower canopy by way of an improvement felling to be done two or three years prior to the main fellings around the probable gaps that may be caused by selection fellings and also around the mother trees selected. Tending of regeneration including thinnings are to be investigated. The possibilities of increasing the number of valuable species in the stand are to be explored.

The possibility of clearfelling evergreens and planting them up with important species like *Vateria*, *Palaquium*, *Machilus*, *Calophyllum*, *Hopea* etc., are to be experimented upon. This may be done with and without *taungya*. The help of cover crops like *Tephrosia* may also be tried.

Protection

Further study on the cause of and remedial measures for the attack of the various insects mainly that of the *Buprestidae* larvae on *Mesua* and *Poeciloneuron* are to be undertaken. The damage caused by fires on evergreens especially on regeneration have to be studied.

Mensuration

More of continuous Inventory Plots and Evergreens Arboreta are to be laid out. The growth and increment rates of the major species should be studied both in the natural conditions and in plantations.

Standard timber volume tables are to be compiled for the major commercial species.

Utilisation

The possibility of converting these heterogenous evergreen forests in suitable localities into almost pure stand of valuable species seems feasible. If such a change becomes possible large quantities of timber from these evergreen forests will be available. At present excluding few species like *Artocarpus*, *Hopea*, *Vateria*, *Palaquium*, *Machilus*, *Mesua* etc., the demand for others is limited. Most of the inferior species are utilised for packing cases. But with

more of research on the properties and uses of the evergreen species and the possibilities of seasoning and preservation of these timbers it is quite likely that many of these so-called inferior species will find more uses into which they can be put to. The use of these species for manufacture of pulp is an item of research that should be taken up without any further delay.

However, the future working of these evergreens has to be guided by an extreme sense of caution and discretion because these forests are very important in consolidation of soil, conservation of moisture and protection of catchment areas. No effort should be spared "to preserve for the future generation adequate areas of this culmination of Nature's plant creation, the Tropical rain forest." The aim of future management of these forests, while taking all aspects of natural and artificial methods of regeneration into account, should particularly consider the climax status of the evergreens and all the effects of altering into ecological status by biotic interference.

REFERENCES

1. Bourdillon, H. The Forest Trees of Travancore.
2. "Calophyllum" Evergreen Forests in British Malabar, *Indian Forester*: January 1929 (pages 20 to 30).
3. Cariappa, B. A. Revised Working Plan for the Wynaad Forest Division—1950 to 1960.
4. Champion, H.G. A preliminary survey of forest types of India and Burma.
5. — The Regeneration of Tropical Evergreen Forests (Rain Forests). *Indian Forester* : August, 1929 (pages 429 to 446) and September, 1929 (pages 480 to 484).
6. Fraser, H. The enumeration of the growing stock in Tropical Forests. *The Empire Forestry Review* 1958 (pages 316-319).
7. Ghani, G. Heterogenous Types of Tropical Forests Chittagong Forests—IV World Forestry Congress—India 1954.
8. Joseph, K. J. Silviculture and Management of *Ochlandra travancorica* with special reference to its exploitation in Kerala State—1959.
9. Kadambi Krishnaswamy The Evergreen Ghat Rain Forest, Agumbe—Kilandur Zone.—*Indian Forester* : April, 1941 (Pages 184 to 203).
10. Kesava Vittal, B. S. Working Plan for South Kanara division—1943 to 1958.
11. London, F. H. Tropical Rain Forest—IV World Forestry Congress—Indian 1954.
12. Menon, N. N. A Working Plan for the forests of Shencottah division—1945—1960.
13. Richards, P. W. The Tropical Rain forest.
14. Stracey, P. D. The Silviculture and Management of Tropical Rain Forests in India—*Indian Forester* : July, 1954 (Pages 385 to 407).
15. Venkiteswara Iyer, T. V. Working Plan for the Ghat forests of the Palghat division—1933 to 1943.
16. Viswanathan, T. P. Working Plan for the Moovattupuzha part of the Malayattur division—1951 to 1967.

THE EVERGREEN FORESTS OF KERALA

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Champion in his monumental work on the classification of the Forest Types of India has included the evergreen forests as one of the six main formations into which he has divided the forests of India. The southern form of this formation either in its climax form or in one or the other of its seral, edaphic or altitudinal variants is found more or less throughout the length of Kerala from Kasargode to Neyyattinkara wherever it has escaped the twin evils of fire and shifting cultivation.

The fact that this type of forests probably extended throughout Kerala at one time is indicated by the floristic composition of some of the ancient "Kavus" which are still extant in the compounds of some old family houses and contain species like *Hopea parviflora*, *Diospyros microphylla*, *Lophopetalum wightianum*, *Cinnamomum zeylanicum*, *Aporosa lindleyana* etc. which are not found elsewhere in the neighbourhood and have to be looked for in the evergreen patches of the reserve forests nearby. This indicates the possibility of the "Kavus" being the remnants of the old forests which being strictly protected and preserved have remained unchanged retaining their old floristic composition.

The climax form of this formation represents at its best, the highest development that can be attained by vegetation under conditions most favourable for its growth, viz., the Tropical Rain Forests.

The southern form of this type (Tropical Rain forests) in India is a closed forest of a hundred fifty feet or more in height consisting of several stories of which two, three or more consist of trees of different heights while shrubs form an understorey under the lower most tier of trees and the ground contains a cover of *Scitamineous* herbs like wild ginger, turmeric, arrow-root, *Alpinia* or some species of *Strobilanthes* or some aroid but never of grass. Lianes are abundant, epiphytic orchids are common. Instead of the handful of species met with in the deciduous forests there is a bewildering variety of species including several species of palms like *Pinanga dicksoni*, *Arenga wightii*, *Caryota urens*, as well as the troublesome canes (*Calamus* sp.) which abound in the more moist hollows. The tree trunks and the rocks on the forest floor are covered by lichens and often moss, while species of ferns like *Lycopodium*, *Adiantum* and *Selaginella* are common among the ground vegetation. Most of the trees have thin bark and large entire leaves which are dark and thick. Trees with finely divided leaves are comparatively few. Many of the trees have well developed plank buttresses which sometimes go upto a height of fifteen feet or more of the stem forming huge partitioned stalls at the bases of the trees each one of them easily capable of accommodating a full grown elephant. The whole appearance of this lofty forest with tall clean boles of sixty feet or more is dark, gloomy, sombre and awe-inspiring in the extreme.

Floristic Composition

As already mentioned floristic composition varies very much on account of the extremely large number of species of which the mature forest consists. At its best gregariousness is absent and the number of species comprising it may number 200 or more of which almost half the number may form the two tiers at the top. It is a remarkable feature that the tallest trees in most places are trees of deciduous species which are the regular inhabitants of this type of forests except where *Dipterocarpus* are present.

The typical composition of one such forest is given below :—

- I. *Dipterocarpus indicus* (O), *Hardwickia pinnata* (O), *Hopea parviflora* (A), *Mangifera indica* (O), *Bombax malabaricum* (O), *Eugenia* sp. (C), *Tetrameles nudiflora* (O), *Antiaris toxicaria* (O), *Artocarpus hirsuta* (O), *Dysoxylum malabaricum* (O), *Diospyros microphylla* (O), *Machilus macrantha* (O), *Bischofia javanica* (O), *Vateria indica* (A), *Chukrasia tabularis* (R), *Holigarna grahamii* (O), *Ficus* sp. (F), *Elaeocarpus tuberculatus* (O), *Vitex altissima* (O), *Terminalia travancorica* (R).

II. *Myristica laurifolia* (F), *Canarium strictum* (O), *Polyalthia fragrans* (A), *Bocagea dalzelli* (O), *Nephelium longana* (A), *Cinnamomum zeylanicum* (A), *Nothopegia colebrookiana* (R), *Ostodes zeylanica* (R), *Carallia lucida* (O), *Pygeum wightianum* (O), *Garcinia cambogia* (O), *Actinodaphne hirsuta* (A), *Evodia roxburghiana* (O), *Hydnocarpus alpina* (R), *Canthium didymum* (R), *Chrysophyllum roxburghii* (O), *Zanthoxylum rhetsa* (O), *Baccaurea courtallensis* (C).

III. *Leea sambucina*, *Psychotria* sp., *Strobilanthes*, *Alpinia* spp., *Pinanga dicksonii*, *Bracantia wallichii*.

III (a). *Gnetum scandens*, *Pothos scandens*, *Entada scandens*, *Calamus* sp., *Bauhinia vahlii*, *Wagatea* sp.

IV. *Lycopodium* sp., *Selaginella* sp.

(Note. —A = abundant, C = common, F = frequent, O = occasional, R = rare).

The foregoing example though a fairly typical one cannot by any means be expected to occur in all localities. The extremely large number of species and their individual preferences of soil moisture and degree of acidity in the soil introduce such great variations that no two localities are likely to have exactly the same floristic composition. However the species comprising the forests would be sure to consist of all or any of the species given below as well as a host of others too numerous to mention :—

Anacolosia densiflora, *Alstonia scholaris*, *Albizia stipulata*, *Alseodaphne semecarpifolia*, *Artocarpus integrifolia*, *A. lakoocha*, *A. chaplasha*, *Beilschmedia bourdillonii*, *Cryptocarya* sp., *Neolitsea zeylanica*, *Actinodaphne* sp., *Litsaea* sp., *Cinnamomum* sp., *Myristica* sp., *Aglaiia roxburghiana*, *A. canarana*, *Lansium anamalayanum*, *Cedrela toona*, *Amoora rohituka*, *Beddomea* sp., *Carapa moluccensis*, *Walsura piscida*, *Eugenia* sp., *Jambosa* sp., *Syzygium* sp., *Elaeocarpus tuberculatus*, *E. serratus*, *Bassia fulva*, *Palaquium ellipticum*, *Mimusops elengi*, *Chrysophyllum roxburghii*, *Sterculia alata*, *Pterospermum heyneanum*, *P. rubiginosum*, *Heritiera papilio*, *Garcinia* sp., *Mesua ferrea*, *Poeciloneuron indicum*, *Calophyllum tomentosum*, *C. wightianum*, *Hopea glabra*, *H. wightiana*, *H. racophloea*, *Vateria indica*, *Vatica roxburghiana*, *Ormosia travancorica*.

Linocacri malabarica, *Ligustrum* sp., *Olea dioica*, *Stephegyne tubulosa*, *Ixora notoniana*, *Ixora nigricans*, *Hymenodictyon obovatum*, *Gluta travancorica*, *Semecarpus travancorica*, *S. auriculata*, *Holigarna arnottiana*, *H. grahamii*, *H. beddomei*, *Spondias mangifera*, *Filicium decipiens*, *Harpulia cupanoides*, *Sapindus laurifolius*, *Nephelium longana*, *N. stipulaceum*, *Achrotychia laurifolia*, *Toddalia bilocularis*, *Zanthoxylum rhetsa*, *Evodia roxburghiana*, *Polyalthia fragrans*, *P. cerasoides*, *P. coffeoides*, *Goniothalamus Thwaitesii*, *Orophea zeylanica*, *Cyathocalyx heyneii*, *Cyclostemon macrophyllus*, *Prosorus indicus*, *Baccaurea courtallensis*, *Croton malabaricum*, *Putranjiva roxburghii*, *Glochidion* sp., *Gelonium* sp., *Ficus* spp., *Diospyros* sp., *Caryota urens*, *Arenga wightii*, etc.

Though the formation as a whole is remarkably similar and uniform in appearance, the composition shows wide variations, certain species showing marked preference for certain types of terrain or situations and forming well marked associations.

(a) Thus the *Myristica magnifica* and *M. canarica* and *Diospyros embryopteris* are characteristic of fresh water swamps at the bottom of some of the valleys in the forests of the Thenmala-Punalur and Trivandrum divisions. This association consists almost exclusively of *Myristica magnifica* and one or two other species of *Myristica* with a few *Lagerstroemia flos-reginae*, *Eugenia montana*, *Diospyros embryopteris*, etc.

(b) *Machilus macrantha*, *Lophopetalum wightianum*, and *Hopea parviflora* are all found in moist localities.

(c) *Bassia malabarica*, *Calophyllum wightianum*, *Hydnocarpus wightianum* and *Humboldtia vahliana* are characteristic of river banks while right in the middle and nodding with the current may be found *Homonioia ripariens*. Occasionally *Marringtonia racemosa* may be found on the river banks with *Pongamia glabra*.

(d) On rocky ravines which form water courses *Arenga wightii* is often found.

(e) Lateritic areas are favoured by *Hopea wightiana*, *Strychnos nux-vomica*, *Ixora coccinea* and *Memecylon* sp., *Artocarpus hirsuta* though quite at home in lateritic soil is commonly found along with *Dysoxylum* on the best soil.

(f) *Poeciloneuron indicum*, *Nephelium stipulaceum*, *Heritiera papilio* and *Palaquium ellipticum* appear to favour localities where the precipitation is particularly heavy as in Palaghat, Rajamalai, Ponnudi, etc.

(g) On the other hand *Filicium decipiens* and *Alseodaphne semecarpifolia* are species which occur either on the main backbone of the ghats or more frequently on the eastern slopes of it or on the eastern edge of the plateau where the rainfall is considerably less than it is on the western edge.

(h) *Hopea parviflora* which is fairly common but not gregarious lower down becomes markedly gregarious on land abandoned after clearing such as abandoned Tea and Coffee estates where crops of young poles may be met with growing so close together that elephants cannot pass between the stems. In fact *Hopea parviflora* and *Poeciloneuron indicum* are the most gregarious among the evergreen species.

(i) *Acrocarpus fraxinifolius*, *Calophyllum tomentosum* and *Hemicyclea elata* are generally met with only above 1000' and very rarely below it.

(j) In the southern parts of Kerala, *Polyalthia fragrans* which is a typical evergreen species is found as a sort of post-climax on the river banks where the soil is of deep well-drained alluvium, in the midst of moist deciduous forests, while in the north the place of this species is taken by another member of the Anonaceae viz., *Saccopetalum tomentosum*. Both these species occur on land which is ideal for the growth of teak.

Endemic Species

There are some species which occur only in the forests of Kerala and have not been reported as occurring elsewhere though allied species are said to occur in the Andamans, Burma and the Indo-Malayan region, which indicate the affinities of the flora of this region; though the giant *Dipterocarps* which are said to dominate the typical Indo-Malayan forests are not so much in evidence here and are altogether absent in some places.

The species of greatest botanical, though not of economic interest, is *Podocarpus latifolia* (Bourdillon) (*neriifolia*) found only near the Augusthiar peak as well as in the hills above Muthukuzhy Vayal (which has now been transferred to the Madras State) This species or one very closely allied to it is reported to occur in the Andamans as well as in Malaya.

Gluta travancorica whose claret red timber is one of the most ornamental woods in India occurs only in a small area on the Choorodemala and Ponmudi ridges and the slopes of the Augusthiar peak as well as the forest of Tinnevely district of Madras adjoining it and nowhere else but curiously enough *Balanocarpus utilis* which is fairly common in the Tinnevely forests adjoining the old Travancore State has not been found anywhere in our forests.

Among other endemic species may be mentioned *Bassia fulva*, *Humboldtia unijuga* and *Hopea racophloea*.

Status of the Forests

The evergreen forests in any given locality may be climax, post-climax or seral. Its status can be known from its composition; though there is no difference observable externally. The climax type can be distinguished by the very much larger number of species composing the forest, the marked absence of gregariousness and the presence in the top canopy of giant *Dipterocarps* and the absence of deciduous species in the topmost canopy.

The presence of reeds in the lower most canopy is a sure indication of the seral nature of the forest. Wherever there is an opening made (due to whatever cause) reeds if at all present in the area occupy it and by their ability to withstand partial shade and the extremely aggressive and vigorous growth of their rhizomes rapidly colonise and occupy the clearing and spread over the forests wherever there is some slight opening in the canopy. They form a remarkably stable association covering vast areas which cannot be easily colonised by tree species owing to the inability of the seedling of most tree species either to reach the soil under the reeds or to grow up through the dense cover of reeds and reach the light. The result is that the reeds form an almost stable sub-climax sort of association till they flower and die.

There is every reason to believe that the large areas of forest containing insolated mature evergreen trees with reeds all round them as well as the vast reed areas adjoining the grassy tops of hill ranges are the result of such a retrogressive change originated by fire,

MYRISTICA SWAMPS IN THE EVERGREEN FORESTS OF TRAVANCORE

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In the valleys of the Shendurney, Kulathupuzha and Anchal ranges of Travancore (Kerala) a distinct plant association is noticeable. It fringes sluggish streams in flat bottomed valleys, the altitude of which is below 1000'. The whole area is subject to more or less complete inundation during the greater part of the year and certainly between the months of June and January.

The association forms a fairly dense forest with a completely closed canopy. There are no distinct storeys among the trees. The height of the forest is usually about 80' to 100' and the trees have clean and comparatively slender boles. The whole association is evergreen in character and occurs in the midst of Tropical Evergreen Rain Forest.

The ground is covered more or less completely by the looped "knee roots" which are very similar in appearance to those of the mangroves found growing in the saline marshes in maritime areas.

There is little doubt that the association is a stable one as long as the edaphic factors which are responsible for its origin and existence remain unchanged.

The floristics of this association are as follows :

I. *Myristica mangifera* (very frequent), *Myristica laurifolia* (occasional), *Myristica canarica* (frequent), *Myristica malabarica* (occasional), *Lagerstroemia flos-reginae* (f), *Lophopetalum wightianum*, *Anthocephalus cadamba*, *Eugenia montana*, *Carallia integerrima* (occasional).

II. Undergrowth is sparse and consists of certain aroids, and sedges growing gregariously where the ground is not covered with the "knee roots" and overhead light penetrates on the floor, as on the margins. On the edges of the swamp *Humboldtia vahliana*, *Machilus macrantha*, *Vateria indica*, and *Hopea parviflora* (occasional) occur and *Strobilanthes* species occur as undergrowth along with various Scitaminae.

The tree composition of the association is remarkably constant and the predominant species is *Myristica magnifica*. Such variation as is observable in the composition of the association in different localities is only with regard to the frequency of the other species occurring on the outer edges of the swamp.

The association occurs in the midst of Tropical Evergreen Rain Forest. Thus the climate is warm, humid and equable without large variation either seasonal or diurnal with the temperature rarely reaching above 85°F in the shade even on the hottest day or below 70°F on the coldest night. Frost and drought being equally unknown, the conditions are ideal for the growth of vegetation helped as it is by a heavy rainfall or more than 100" derived from both the monsoons supplemented by occasional heavy thundershowers during the summer months.

The soil on which the association stands is alluvium brought down from the surrounding slopes and containing a large proportion of humified sand. Kaolin is met with at varying depths below the surface. The underlying rock is gneissic (charnockite).

Due to extremely humid conditions fires do not occur. Grazing is also excluded due to swampy nature of the terrain and abundance of knee-roots.

Though Champion in his "Preliminary Survey of the Forest types of India" (pp.108) has assigned the type of forest where this association occurs as IS/4 "Tropical valley Fresh water swamps" and described some of them, he does not seem to have been aware of the existence of this type of swamp with prominent knee roots of *Myristica magnifica* covering the greater part of the ground and giving it the appearance of a mangrove formation from a distance. It appears to be appropriate to name this the "*Myristica* swamp" association and include it among others of this type.

The following points appear to be worth investigating :—

- (1) The distribution of this association
 - (a) in the west coast;
 - (b) elsewhere in India.
- (2) The factors which determine its occurrence.
- (3) The variations in the composition of the tree species forming the association in the different localities.
- (4) The influence of this association on the maintenance of stream flow and underground water resources.
- (5) Study of the succession leading to this type and determination of its status (whether it is seral or the climax).

It is rather unfortunate that most of these swamps have been destroyed due to the clamour for land for food production.

They can be easily converted into ideal paddy fields by felling the trees and uprooting and removing the roots and stumps.

It remains to be seen how far these paddy fields will offset the serious depletion of ground water resources of which these swamps were evidently the reservoirs.

THE TROPICAL EVERGREEN FORESTS OF MADRAS STATE

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Abstract

General—The evergreen forests of Madras State are small in extent. They cover an area of about 150 sq. miles in scattered patches. Some patches are found even in areas 70" minimum annual rainfall either due to favourable soil moisture conditions or favourable distribution of rainfall. A number of associations of species are recognisable. A characteristic feature of the forests is the total absence of the genus *Dipterocarpus*.

Silviculture—Generally speaking natural regeneration of the principal timber species is plentiful but remains suppressed if timely canopy openings are not made. Also a number of attempts at artificial regeneration of useful species were made in the past. These trials were not planned systematically but have still given some useful indications.

Protection—Protection is of primary importance as they are catchment forests. Large scale clearance of such forests for the establishment of tea, coffee, rubber and cinchona plantations has taken place in the past. Damage by wild game is noticeable.

Management—Systematic exploitation was introduced in 1888 in parts of Tirunelveli district and since 1916 in Coimbatore district. In Madurai and parts of Tirunelveli district these forests are leased for cardamom cultivation. In Nilgiris district they are being preserved to regulate moisture and stream flow. The methods of management followed are described.

Conclusion—In view of the heavy demand for timber a more intensive study and exploitation of the evergreen forests of the State is called for.

General

The evergreen forests of Madras State are small in extent and are situated in the districts of Coimbatore, Tirunelveli, Kanyakumari, Nilgiris and Madurai, mostly in scattered patches and at elevations between 2000' and 5000'. The total area covered by such forests is only about 150 sq. miles. These forests occur on the eastern slopes of the Western Ghats and the easterly spurs off the Western Ghats such as the Nilgiris, the Anamaiais etc.

The average annual rainfall varies from 2000 m.m. to 5000 m.m. (80"—200"). At places even in areas receiving only 70" of annual precipitation a post-climax moist evergreen type of vegetation has developed. These localities are the sheltered pockets with favourable soil moisture throughout the year. In some places like Kanyakumari district, the insufficient rainfall is compensated by its better distribution during the year. Here rainfall occurs both from the S.W. and N.E. monsoons. The driest months are from January to May. Details of rainfall at two typical stations collected over a ten-year period are given below :—

	Jan.	Feb.	March	April	May	June
Station I	0.50	0.61	2.15	5.03	9.17	25.33
Station II	0.94	0.30	10.58	4.36	8.98	25.10
	July	Aug.	Sept.	Oct.	Nov.	Dec.
Station I	33.96	19.57	11.58	10.41	5.77	2.04
Station II	33.58	20.56	10.82	11.40	6.29	2.49

The temperature varies from 70° to 90°F, April and May being the hottest months and December and January the coolest. In the Nilgiris and Madurai districts, frost is commonly experienced on the high level plateau during the months from November to February but do not affect the evergreen zone.

The underlying rock is gneiss belonging to the Archaean group. The gneiss is of varying character, mostly granitoid gneisses, often a pale quartzo-felspathic banded rock containing narrow veins of black mica and intercalated with numerous small pale red or pink garnets. The gneiss disintegrates into a rich loam.

The soils in these areas are not subject to heavy erosion as thick vegetation completely covers the ground. Any large scale clearings are, therefore, undesirable. The role of these forests in the catchment areas is eminent.

While the locality factors as stated above are generally obtainable in all the evergreen forests of the State, the rainfall and temperature conditions, however, are very variable even within short distances and from district to district and this variation expresses itself in the floristic composition of the local moist evergreen forests. A description is, therefore, attempted here district by district.

COIMBATORE DISTRICT

The moist evergreen forests cover an area of about 10 sq. miles in the South West corner of the district in the Anamalais, an easterly spur off the Western Ghats. Besides large areas, a few compact but isolated patches also occur in the Plakadavu, Ulandi and Mount Stuart Blocks, the most accessible being Karianshola (3652 acres), close to the Topslip forest colony. In the latter, a post-climax type of wet evergreen vegetation is found though the annual rainfall is only about 70". Clements⁽¹⁾ has regarded this as post-climax and has described that "Under exceptionally favourable conditions of soil and situation, this development may actually appear to overshoot the climatic climax as commonly seen in the occurrence of evergreen types in sheltered fertile hollows in predominantly deciduous types".

The canopy is extremely dense and there is distinct differentiation into layers or tiers. Of the numerous species composing this type, the dominants attain heights of 150 feet or more. Some species, such as *Poeciloneuron indicum*, exhibit typical plank buttresses. Epiphytes are numerous, especially aroids, ferns, mosses and orchids. The chief species occurring in the top storey are *Mesua ferrea*, *Poeciloneuron indicum*, *Palaquium ellipticum*, *Hopea parviflora*, *Cullenia excelsa*, *Calophyllum elatum*, *Vateria indica*, *Heritiera papilio*, *Aglaia roxburghiana*, *Dysoxylum malabaricum*, *Eugenia* sp., *Cedrela toona*, *Artocarpus integrifolia*, *Bombax malabaricum*, *Canarium strictum*, *Polyalthia* sp., *Amoora canarana* and species of *Elaeocarpus*. In the second storey *Adenochlaena indica*, *Acronychia laurifolia*, *Cyclostemon macrophyllus*, *Gomphandra polymorpha*, *Lansium anamalayanum*, *Macranaga* sp., *Nephelium longanum* and species of *Litsaea* and *Myristica* are prominent. The understorey is characterised by *Laportea crenulata* (the devils' nettle), *Psychotria* sp., *Eugenia* sp., *Calamus* sp., etc. Cardamom reeds (in moist places) and several species of *Strobilanthes* are main shrubs.

Different local associations of the predominating species may be noticed in the top-most tier. Three more or less distinct associations or sub-types may be distinguished :—

(i) The comparatively dry types of Tunacadavu and Ulandi blocks, in which *Hopea parviflora* and *Mesua ferrea* occur in appreciable quantities (which may, therefore, be said to belong to the *Hopea-Mesua* association).

(ii) The intermediate type found in portions of the Punachi range where the annual rainfall is about 120 inches, the preponderate species are *Mesua ferrea* and *Palaquium ellipticum* (the *Palaquium-Mesua* association).

(iii) The wet *sholas* in regions with an annual rainfall of about 200 inches or more, as in the Italar Valley of the Punachi range, where the predominating tree species is mostly *Poeciloneuron indicum* with a small admixture of *Cullenia excelsa* (the *Poeciloneuron-Cullenia* association). This association appears, however, to be conditioned by edaphic factors as it is found in all places where the soil retains a high percentage of moisture for the greater part of the year.

Undergrowth is generally sparse. In some patches a carpet of *Strobilanthes* or ferns may occur; grasses are sparse. Canes, screw-pine, cardamoms and *Curcuma* occur here and there.

An abstract of enumerations of marketable species (for railway sleepers, scantlings etc.) for the whole felling series is given in Appendix I.

TIRUNELVELI DISTRICT

These forests cover an area of about 100 sq. miles of hilly country in the Southern most extension of the Western Ghats.

In localities where the rainfall is over 75" and elevation over 100' and the soil capable of adequate moisture retention, the deciduous forest gives way to a semi-evergreen type.

Small patches of this type of forest are found along streams at elevations below 1000' but the greater portion occurs between 1000' and 2000' elevation. The density of stocking is good. This is probably accounted for by the increased rainfall and consequent increased vegetative activity.

The principal species met with are—

Balanocarpus utilis, *Hopea parviflora*, *Pterospermum rubiginosum* and *P. glabrescens*, *Aglaia courtallensis* and *A. barberii*, *Nephelium longanum*, *Hemicyclia venusta*, *Hardwickia pinnata*, *Stereospermum chelonoides*, *Dalbergia latifolia*, *Chukrasia tabularis*, *Artocarpus integrifolia*, *Bischofia javanica*, *Carallia integerrima*, *Diospyros* sp., together with a host of other less known species. The undergrowth consists of *Strobilanthes*, *Glycosmis pentaphylla*, *Helicteres isora*, *canes*, etc.

The truly evergreen rain forest or *shola* forest commences at an elevation of about 2000' and extends upwards to nearly the crest of the mountains upto 4500', the growth deteriorating rapidly along the windswept ridges, both in quality and volume per acre. The whole of the hillsides above 2000' are not however clothed with such forest. There is much bare and precipitous rock and extensive areas where the soil is shallow or rock is near the surface; and these areas are covered with high grass, *Phoenix sylvestris* and stunted tree growth. Small patches of *shola* nestle in most of the sheltered pockets and extend over the protected faces of the peaks, thus enhancing their scenic value. Much of the true *shola* forest has been destroyed by extensive clearing made by hill tribes—the *Kanis*, and coffee planters in the past. A secondary *shola* growth characterises such areas and consists chiefly of *Macaranga*, *Mangifera*, *Clerodendron*, *Diospyros* sp., *Eugenia* sp., *Myristica* sp., etc., typical examples being the old Kuliratti and Taraganar estates in the Nanguneri hills and the Sembatota on the left bank of the Kariar.

There is a noticeable correlation between rainfall and elevation with reference to the incidence of the evergreen forests. With decreasing rainfall the minimum elevation at which the true *shola* appears increases. Thus in Nanguneri range where the rainfall is comparatively less, the *shola* forest starts only at about 3000' elevation and is at its best at 3500' to 4000' deteriorating further higher up. Similarly in the Srivilliputtur range where the rainfall is even below that obtaining in the Nanguneri *sholas*, the true *shola* appears only at about 3500' to 4000'. The characteristic *shola* type of forest occurs principally in Ambasamudram range where it forms a three-storeyed high forest, from elevations of 2000' to 4000'.

In the topmost canopy occur principally *Mesua ferrea*, *Cullenia excelsa*, *Gluta travancorica*, *Palaquium ellipticum*, *Hopea parviflora*, *Heritiera papilio*, *Dysoxylum malabaricum* and *D. beddomei*, *Myristica beddomei*, *Eugenia* sp., *Litsaea* sp., *Pygeum wightianum*, *Filicium decipiens*, *Garcinia* sp., etc. In the lower tier, besides sapling growth of the species mentioned above, are found *Agrostistachys longifolia*, *Mallotus* sp., *Cinnamomum gracile*, *Aporosa acuminata*, *Hydnocarpus alpina* and the bright crimson fruited *Baccaurea courtallensis*. The undergrowth consists principally of rattan cane, wild cardamoms, *Pandanus* sp., *Solanum* sp., and the dreaded but comparatively rare devil's nettle, *Laportea crenulata*. Picturesque ferns and palms, *Pinanga dicksonii* and *Caryota urens* are also scattered all over the forest.

The Nanguneri *sholas* are characterised by the total absence of *Gluta travancorica*, the comparative rareness of *Mesua ferrea* and the greater preponderance of *Palaquium ellipticum* and *Mangifera indica*. The dominant association is the *Palaquium-Mangifera* type. Around Nettekall a few big sized *Podocarpus latifolia* occur, but beyond the botanical interest centred in the fact that it is the only indigenous conifer in South India, the tree is not of importance as it is not present in exploitable quantities.

The Kuttalam *sholas* are all very deficient in exploitable species, and are generally poor, all the best *shola* areas having been acquired by coffee planters in the past and partially destroyed.

The Srivilliputtur range contains a number of patches of *shola* varying in size from 100 acres to 350 acres, which are surrounded by grassland. These *sholas* are neither so dense nor so luxuriant as in the Ambasamudram range and owing to the fact that the Travancore high ranges and the upper Palnis keep off much of the rain which would otherwise fall on these hills, the locality is far less moist. The principal species are *Acrocarpus fraxinifolius*, *Cedrela toona*, *Mesua ferrea*, *Eugenia* sp., *Palaquium ellipticum*, *Bischofia javanica* and *Mangifera indica*.

The results of a 33½ per cent strip enumeration carried out in 1923 in a typical exploitable evergreen area of 983 acres are tabulated in Appendix II.

KANYAKUMARI DISTRICT

The evergreen forests in this district are confined to the higher slopes of the hills and plateaus. The density of the tree crop is very high and an extraordinary variety of species is noticeable. Not only do the trees grow close together and form a complete canopy at a great height, but on the ground also there is a dense tangled and almost impenetrable mass of undergrowth through which were it not for the paths made by elephants and bisons, locomotion would be well nigh impossible for anything except the smaller quadrupeds. These forests are, however, much less valuable than the deciduous forests at lower elevations, on account of the small percentage of valuable species and the high cost involved in extracting them.

The dominants attain heights of 150 feet or more. There is a certain differentiation of the canopy into layers or tiers. Some of the species like *Cullenia excelsa* exhibit typical plank buttresses. Epiphytes are common. The chief species occurring in the top storey are *Mesua ferrea*, *Cullenia excelsa*, *Palaquium ellipticum*, *Gluta travancorica*, *Hopea parviflora*, *Calophyllum trapezifolium*, *Aglaia roxburgiana*, *Artocarpus integrifolia*, *Myristica* sp., *Eugenia* sp., *Canarium strictum*, *Salmalia malabarica*, *Dysoxylum malabaricum*, *Acrocarpus fraxinifolius*, *Polyalthia* sp., and many species of *Diospyros* and *Elaeocarpus*. In the second storey *Anacolosia densiflora*, *Cinnamomum* sp., *Hydnocarpus alpina*, *Mallotus* sp., *Agrostistachys longifolia*, *Baccaurea courtallensis* are more prominent. The understorey is composed of canes, cardamoms, reeds, *Pandanus* species, ferns and palms like *Pinanga dicksonii*, *Caryota urens* and several species of *Strobilanthes*. Six or seven species of canes (*Calamus*) which are all saleable grow in these areas.

Different associations of the predominant species may be noticed in the topmost tier :—

- (i) A comparatively dry type (around Sengalteri and Mahendragiri) in which *Hopea parviflora* and *Mesua ferrea* occur in appreciable quantities (which may therefore be said to belong to the *Hopea-Mesua* association).
- (ii) An intermediate type (found in mid portions of Sengalteri and Singampatti sholas) where the rainfall is about 100 inches, in which *Palaquium ellipticum* and *Mangifera indica* preponderate (*Palaquium-Mangifera* association).
- (iii) The wet sholas in the region with annual rainfall over 100" like Muthukuzhivayal, where the predominating species are *Cullenia excelsa* and *Calophyllum* spp., (*Cullenia-Calophyllum* association).

The undergrowth is usually dense and impenetrable and consists of canes, thorny creepers and a large variety of evergreen shrubs. A few species of reeds also form the dense undergrowth. Climbers are very common, the chief being *Entada scandens*, *Calicopteris floribunda*, *Dioscorea* species and *Caesalpinia bonducella*.

The results of an enumeration of the stock giving the incidence of saleable timber species are shown in the Table at Appendix III.

NILGIRIS DISTRICT

Several small patches of typical evergreen forest occur in the vicinity of Benine in Gudalur division. The rainfall is about 80" and the elevation 2000'. The largest of these is about 25 acres. The species met with are *Palaquium ellipticum*, *Artocarpus hirsuta*, *Michelia champaca*, *Hydnocarpus wightiana*, *Schleichera trijuga*, *Calophyllum tomentosum*, *Evodia roxburgiana*, *Cullenia excelsa* and *Acrocarpus fraxinifolius*.

In the Nilgiris, the temperate forests often found in sheltered or damp locations on the high level (6000' and above) plateau are of a dense low evergreen type and may be considered ecologically as an upward projection by gradual stages of the tropical evergreen forests found in the lower tracts. The tropical wet evergreen forest falls off in height and general luxuriance with ascending elevation till in the transitional stages the sub-tropical wet hill forests and the tropical evergreen forests found in the lower tracts look more or less alike.

MADURAI DISTRICT

In moist protected valleys between 3000' and 5000' above sea-level, an evergreen type of forest prevails in the Cumbum valley and on the Palni hills. It is surrounded by

forests of a mixed deciduous type. It is not of any vast extent being confined to moist protected valleys. Transition stages between the two types may often be observed at the margins. The chief species that prevail are *Bischofia javanica*, *Cedrela toona*, *Chukrasia tabularis*, *Elaeocarpus tuberculatus*, *E. serratus* and *E. oblongus*, *Canarium strictum*, *Myristica* sp., *Lagerstroemia lanceolata* and *Eugenia* sp., with a sprinkling of *Michelia champaca* and *Acrocarpus fraxinifolius*. Large trees of *Mesua ferrea* (upto six feet in girth) sometimes occur along streams.

There is usually a second storey of smaller trees, such as *Nephelium longanum*, *Agrostistachys longifolia*, *A. indica*, *Euonymus quadrangularis*, etc. The margins of the *sholas* have invariably been eaten into by fires; they must have been more extensive in the past.

From the above account of the floristic composition of evergreen forests in Madras State, it will be observed that a characteristic feature is the absence of the genus *Dipterocarpus*.

SILVICULTURE

In the evergreen forests of Coimbatore district natural regeneration of the important timber species is generally plentiful but usually remains suppressed for lack of opening of the canopy and proper tending. In the *Hopea-Mesua* association, natural regeneration of *Hopea parviflora* is dense, though *Mesua ferrea* also regenerates freely. Such natural regeneration even if remained in a suppressed condition for a long period, responds quickly if sufficient light reaches it through any canopy openings. In the *Palaquium-Mesua* association, natural regeneration of *Palaquium ellipticum* is more prolific than that of *Mesua ferrea*, partly because the former seeds every year and these seeds are less palatable to rodents. Also since *Palaquium ellipticum* is more shade-bearer than *Mesua ferrea*, there is a marked tendency for the former to oust the latter. In the *Poeciloneuron-Cullenia* association there is always a dense mass of natural regeneration of *Poeciloneuron indicum* and all age classes are represented. In fact there is a marked tendency towards the formation of a pure *Poeciloneuron indicum* community.

Attempts at artificial regeneration of these forests started in 1937 when Laurie⁽²⁾ prescribed regeneration of artificial gaps in the Karianshola by sowings and planting of *Hopea parviflora*, *Artocarpus hirsuta*, *Acrocarpus fraxinifolius*, *Mesua ferrea*, *Dysoxylum malabaricum* and *Cedrela toona*, at an espacement of 4' x 4' and the tending of natural regeneration of *Hopea parviflora*. As no fellings were done, the gap regeneration was not carried out but tending of *Hopea parviflora* was done from 1933 to 1937. Then it was discontinued. Sarma⁽³⁾ prescribed the regeneration of gaps exceeding 200 yards in extent in the Kallar Valley with the same species and also *Dipterocarpus bourdilloni* and *Gluta travancorica*. In 1936, 68 gaps were regenerated with seeds of *Acrocarpus fraxinifolius*, *Artocarpus hirsuta*, *Cedrela toona* and *Dipterocarpus bourdilloni* and six months old nursery transplants of *Acrocarpus fraxinifolius* and *Actinodaphne hirsuta*. The transplants were put out late in October (towards the end of the rains) and failed to survive. In 1937/38 and 1938/39 similar work was repeated. The work was subsequently abandoned as the results were wholly incommensurate with the expenditure incurred owing to suppression by weeds and less valuable species and damage by game. Venkateswara Iyer⁽⁴⁾ probably influenced by the failure of gap regeneration, prescribed in 1942 experimental five acres plantations annually in the evergreen Karianshola by removing trees and shrubs of the middle and lower canopy and introducing stumps of *Cedrela toona* and *Artocarpus hirsuta* and transplants of *Dipterocarpus indicus*, *Diospyros assimilis*, *Hardwickia pinnata* and other species. *Gluta travancorica* was to be sown direct. The prescription was, however, dropped in 1953 as the one acre experimental plantation raised earlier did not indicate any chances of success.

In the present plan, Bhoja Shetty⁽⁵⁾ has prescribed experimental underplanting of *Artocarpus hirsuta*, *Dipterocarpus indicus* and *Acrocarpus fraxinifolius* with progressive opening of the canopy in worked coupes by girdling (on an average) not less than 3 trees and not more than six trees per acre including those felled in the coupe, to create conditions suitable for development of the seedlings.

Between 1908 and 1912 in the evergreen forests of Tirunelveli district, Latham and Peake⁽⁶⁾ had carried out various small scale experiments in opening up the canopy over young natural regeneration of *Balanocarpus utilis*, *Gluta travancorica* and *Hopea parviflora*.

This work was continued by Barry⁷⁾ who, by judicious cutting or girdling of trees standing over natural regeneration of *Hopea* and *Balanocarpus* and by broadcast sowing of large quantities of seed of these species, was able to raise even-aged crops on small areas scattered over the forest. The so-called "*Balanocarpus* areas" behind the Kodamadi Rest House on the western face of Usipothai ridge, along the bridle path to Cox's Hut, and along the Kariarkannikatty road, were all the results of Barry's enthusiasm in this direction. These results confirmed the belief that large scale operations on similar lines would be equally successful and accordingly it was decided in 1920 that the best method of exploiting the evergreens was to establish a mass of advance growth of the more valuable species about 5 years in advance of felling, so that when the felling of the overwood took place, sufficient even-aged regeneration would remain undamaged to provide a new crop, potentially more valuable than the original crop. The technique adopted was :

- (a) foresting existing valuable natural regeneration and advance growth by a judicious and graduated opening of the canopy by girdling or felling undesirable species.
- (b) cutting all climbers, and
- (c) supplementing natural regeneration where it was absent or insufficient, by sowing or planting.

For this purpose, the species were divided into three classes as shown below :

CLASS

A	B	C
1. <i>Gluta travancorica</i>	1. <i>Vitex altissima</i>	All the remaining species.
2. <i>Hopea parviflora</i>	2. <i>Hardwickia pinnata</i>	
3. <i>Mesua ferrea</i>	3. <i>Cullenia excelsa</i>	
4. <i>Balanocarpus utilis</i>	4. <i>Aglaia roxburghiana</i>	
5. <i>Dysoxylum malabaricum</i>	5. <i>Diospyros</i> sp.	
6. <i>Cedrela toona</i>	6. <i>Eugenia</i> sp.	
7. <i>Artocarpus hirsuta</i>	7. <i>Pygeum wightianum</i>	
8. <i>Filicium decipiens</i>	8. <i>Pterospermum rubiginosum</i>	
9. <i>Palaquium ellipticum</i>	9. <i>Garcinia</i> sp.	
	10. <i>Cinnamomum</i> sp.	
	11. <i>Canarium strictum</i> .	

The work done was as follows:—

In the first year :

- (a) climbers were cut as also C class species below 18 inches in girth; the debris was deposited in lines 6-10 feet apart, to facilitate subsequent burning, sowing and planting operations.
- (b) About 3 months old seedlings of A and B class species (as were readily obtainable) were planted out.
- (c) Such seeds of A and B class species as were readily obtainable were sown broadcast.

In the second year item (a) was repeated and in addition C class trees between 18 inches and 24 inches girth were girdled to let in more light. The latter operation was, however, not carried out over the whole regeneration area as prescribed, because there was not sufficient regeneration on the ground to justify further opening up of the canopy. Sowing and planting were again done over as much of the area as deemed necessary. The results are tabulated in Appendix IV.

From year to year the results were pronounced most unsatisfactory. It is probable that with the limited knowledge of the silviculture of the various species, the light conditions which favoured the growth of a particular species were detrimental to the growth of others. It was probably a mistake to attempt to grow too many species under the same conditions. Large quantities of seed were destroyed by rodents and insects and the little germination which occurred was often adversely affected by dry spells. The heavy expenses on these operations also proved a serious drawback. Excluding overhead and interest charges

which together would amount to a considerable amount the following Table shows the total expenditure incurred.

Locality		Areas in acres	Total expenditure	Expenditure per acre
			Rs. nP.	Rs. nP.
1.	Kannikatty (1921-22)	81	1,435.00	17.69
2.	Kannikatty (1922-23)	89	1,374.00	15.44
3.	Kannikatty (1923-24)	53	793.00	15.00
4.	Kodamadi (1921-22)	97	1,674.00	17.25
5.	Kodamadi (1922-23)	103	1,389.00	13.50
6.	Kodamadi (1923-24)	51	884.00	17.31

Again some of the important species such as *Hardwickia pinnata*, *Vitex altissima*, *Aglaia roxburghiana* were grouped as B class together with less valuable species like *Cullenia excelsa*, *Canarium strictum* and *Cinnamomum* sp., and were consequently girdled or cut to favour A class species. The cutting or girdling of B and C class species upto 18 inches girth and the subsequent girdling of some B and C class species of 18 inches to 24 inches girth opened out the canopy too much with the result that masses of inferior species such as *Cinnamomum*, came in and swamped out the regeneration of the better species. Further, the operations had to be done with labour recruited from the plains: and it is highly probable that these *mazdoors* (owing to their ignorance of the identity of seedlings of evergreen species) destroyed them unwittingly in large numbers during the very operations for tending them.

In 1927, therefore, the hope of securing advance regeneration was abandoned and the policy of removing the exploitable trees first and regenerating the gaps subsequently was inaugurated. Kesava Vittal's(*) work, in this connection, is worth a careful study. His work may be discussed under the following heads :

- (a) nursery practice,
- (b) artificial regeneration,
- (c) natural regeneration.

(a) *Nursery practice*.—The following tentative conclusions regarding evergreen nursery practice were arrived at:

1. Fencing of the nursery was essential in order to prevent the destruction of the seed and germinating seedlings by mouse, deer, porcupine, squirrels, rats and other vermins. A fence 4½ feet high made of split reeds tied together almost touching each other was found quite effective and the cost was about Rs. 1.50 nP. per chain length.
2. Care taken in the collection of good seed and dibbling it as soon as possible after collection was amply repaid by a high germination per cent.
3. The depth of sowing should not exceed the thickness of the seed. A thin covering of leaf mould especially over small or light seeds was found to be advantageous.
4. Watering during germination and periods of dry weather was necessary and was best done with a watering can having a fine spray.
5. Seedlings from the open nursery, *i.e.*, not under natural shade, stood transplanting better than from the *shola* nursery although the latter looked more healthy.
6. In the open nursery it was found advantageous, (in order to prevent wilting of the seedlings) to shade the beds with reed screens, during, the hottest part of the day.

Natural regeneration.—When a tree was felled a lot of damage was inevitably done to the surrounding trees; and a gap was caused of varying dimensions, according to the height of the tree and the size of its crown. The sawyer cut out all saplings in the immediate vicinity of the tree trunk in order to erect the requisite scaffolding for sawing at site. The resulting leaf litter and small branchwood *debris* were generally burnt, especially as its retention was found to attract a species of gadfly (a source of much annoyance to the workers). Thus hardly any regeneration was left in the gaps caused. After the rains some of the cut back saplings and seedlings sent up side shoots which were more in the nature

of pollards than coppice shoots. The gaps thus caused vary in extent from $\frac{1}{4}$ to 1 square chain.

Artificial regeneration was of two kinds, dibbling and transplanting of seedlings from the nursery:—

- (i) *Dibbling*.—The general conclusion arrived at was that the expense was not justified by the results obtained. Seeds of *Mesua ferrea*, *Balanocarpus utilis*, *Eugenia* sp., and *Dysoxylum binectariferum* were readily attacked by vermins or insects and destroyed. Seeds of *Aglaia* sp., *Poeciloneuron indicum*, *Chukrasia tabularis* and *Hopea parviflora* were available only at a time which did not synchronise with rainfall conditions suitable for dibbling. Other species like *Vitex altissima* and *Cedrela toona* with very small seed having a low germination capacity were better raised in a nursery prior to transplanting in the forest. *Heritiera papilio*, *Gluta travancorica* and *Acrocarpus fraxinifolius* were the only species which could be successfully dibbled.
- (ii) *Transplanting*.—The south west monsoon generally bursts in the first week of June and after a short break it comes on again more steadily. It was during this second period of the monsoon that the best results were obtained from transplanting. The results achieved are tabulated below:

TRANSPLANTING

Species	Optimum age	Optimum height	Remarks
<i>Mesua ferrea</i>	1 year	4 inches	Three to four months old seedlings give fair results.
<i>Chukrasia tabularis</i> ..	6 months	6 inches	One year old stump plant were successfully planted out.
<i>Balanocarpus utilis</i> ..	3 months	—	
<i>Cedrela toona</i>	6 months	—	
<i>Dysoxylum malabaricum</i>	9 months	8 inches	
<i>Hardwickia pinnata</i> ..	6 months	—	
<i>Acrocarpus fraxinifolius</i>	6 months	6 inches	
<i>Hopea parviflora</i> ..	1 year	4 inches	One year old seedling 1 foot to 1½ feet high were successfully stump planted.

Owing to the comparatively slow rate of growth of the evergreens in early years, tending by cutting out weeds and grass directly interfering with the seedlings was found essential for a period of 2 years. The following Table shows the results of enumeration (in November 1932) of selected gaps in the various coupes.

COUPE I. KANNIKATTY

Species	Date of dibbling	Date of planting	Average percentage survivals	Average ht. growth in inches in Nov. 1932
1. <i>Acrocarpus fraxinifolius</i>	June 1929	Nov. 1929	58	72
2. <i>Aglaia roxburghiana</i>	May 1930	Nov. 1930	50	9
3. <i>Gluta travancorica</i>	July 1929	—	40	15
4. <i>Chukrasia tabularis</i>	—	Nov. 1929	70	24
5. <i>Cedrela toona</i>	June 1929	Nov. 1929	38	24
6. <i>Mesua ferrea</i>	—	Nov. 1929	40	15
7. <i>Vateria indica</i>	Dec. 1928	Dec. 1928	—	30

COUPE II. KANNIKATTY

Species	Date of dibbling	Date of planting	Average percentage survivals	Average ht. growth in inches in Nov. 1932
1. <i>Acrocarpus fraxinifolius</i>	May 1930	—	61	60
2. <i>Mesua ferrea</i>	—	June 1930	60	14
3. <i>Aglaiia roxburghiana</i>	—	June 1930	61	6
4. <i>Hopea parviflora</i>	—	Nov. 1930	50	6
5. <i>Chukrasia tabularis</i>	—	Oct. 1930	75	42
6. <i>Balanocarpus utilis</i>	—	—	100	6

Depending on the light requirements of seedlings it was found that *Acrocarpus fraxinifolius*, *Chukrasia tabularis* and *Vitex altissima* seedlings behave best in the centre of the gap where they could receive maximum amount of light, and *Mesua ferrea* and *Hopea parviflora* seedlings near the periphery of the gap where there was more of shade. *Gluta travancorica* seedlings did well in the intermediate space. *Hopea parviflora* and *Balanocarpus utilis* did not thrive over an elevation of about 2,500 feet, the two species were usually found in nature flourishing at elevations between 1,000 feet and 2,000 feet. The following Table gives details of actual costs of the gap regeneration :

Coupe No.	Number of gaps	Year of regeneration	Cost of nursery	Cost of seeds	Planting	Dibbling	Weeding
			Rs. nP.	Rs. nP.	Rs. nP.	Rs. nP.	Rs. nP.
I	150	1928	10.00	—	—	1.50	—
		1929	3.00	9.75	15.75	21.62	—
		1930	—	—	—	—	4.37
II	105	1930	27.31	5.00	22.50	14.75	—
		1931	—	—	7.50	5.25	—
		1932	—	—	—	—	—

The total cost for 255 gaps thus amounted to Rs. 148.30 nP. or Re. 0.58 nP. per gap excluding interest charges. It must be borne in mind, however, that much of the work of weeding was done free of cost by local subordinates. Allowing for working on a larger scale and for increased efficiency obtainable due to experience gained, the following charges per gap appear reasonable :

	nP.
FIRST YEAR :	
Nursery charges	16
Dibbling	12
Transplanting	19
Weeding	16
SECOND YEAR :	
Replacing casualties	12
Weeding	19
THIRD YEAR :	
Weeding	25
TOTAL .. Rs.	1.19 nP.

On the basis of an average of 2.5 gaps per acre, the expenditure per acre for the three year period would be Rs. 2.97 nP. or Rs. 3.00. Considering that a revenue of Rs. 16 per acre on the very conservative basis of Rs. 6 per tree is obtained from exploitation, an expenditure of Rs. 3 per acre on regeneration would be reasonable.

Lasrado⁽⁹⁾ in 1934 prescribed that natural regeneration be tended over 25 acres of the annual coupe under personal supervision of the technical staff and further added a proviso to increase this area as more knowledge is gained in identifying the more valuable evergreen species and noting their silvicultural requirements. This prescription was followed till 1942. The discontinuance had to be adopted as adequate natural regeneration was not forthcoming.

He also prescribed gap regeneration in selection felling coupes by dibbling of seeds and transplanting of seedlings. Gaps less than 100 square yards in extent were considered unsuitable as they tended to close up in a couple of years and much before the regeneration could get a chance to establish itself. Only gaps over 100 square yards in extent and not less than 7 to 8 yards in width were prescribed to be regenerated artificially. Owing to the presence of adjacent seed bearers especially of *Acrocarpus fraxinifolius*, *Palaquium* sp., and *Gluta travancorica*, some gaps were filled with sufficient regeneration naturally. Such gaps were not to be further stocked artificially.

He felt that given good seed and timely dibbling there was little to choose between the two methods. Seeds of species like *Hopea parviflora* rapidly lost their germinative capacity in storage, while *Dysoxylum* had too many insect enemies, hence transplanting from a nursery was the safest course. *Gluta travancorica*, *Palaquium ellipticum*, *Acrocarpus fraxinifolius*, *Chukrasia tabularis* and *Aglaiia* sp., could be successfully raised by dibbling.

He prescribed in detail for the gaps to be inspected, classified for natural or artificial regeneration work, accounted for and delineated on a large scale map suitably. All these gaps were to be staked at a rough espacement of 6 feet by 6 feet and regenerated as follows :—

Dibbling—Dibbling should, as far as possible be completed by the 31st May. Seeds that are not then ripe should be sown as soon as ripe and become available. Experiment has shown that (a) *Balanocarpus utilis* seed should be dibbled only in gaps below 1,500 feet elevation. (b) Seeds of *Hopea parviflora* and *Dysoxylum malabaricum* if dibbled must be treated with exceptional care, as the former loses its germinative capacity within a few days, and the latter is easily attacked by insects and vermin. (c) Seeds of *Acrocarpus fraxinifolius*, *Artocarpus hirsuta* and *Cedrela toona* should be dibbled in the centre of the gaps where there is maximum amount of light, while seeds of *Gluta travancorica* and *Palaquium ellipticum* should be dibbled on the periphery of the gap where there is maximum of shade. (d) Seeds of *Mesua ferrea* should not be used in artificial regeneration operations as they are invariably attacked by borers. There was also a sufficiency of natural regeneration of this species, scattered over the forest. (e) Seeds of *Gluta travancorica* and *Palaquium ellipticum* should not be dibbled in gaps below 2,500 feet elevation, especially as these species thrive naturally only above this elevation. (f) In the case of *Artocarpus hirsuta* the ripe fruit should be collected from the tree (there were numerous seed bearers along the upper reaches of the Kalar in the Sivaisalem forests) and the freshly pulped seed sown direct with the minimum of delay. It was, however, preferable to raise seedlings of this species in a nursery as the seed was a favourite food of squirrels, monkeys and rodents. (g) Dibbling was best effected by making a shallow saucer-like depression near each stake and refilling it with the same soil after having removed the undecomposed humus, and then putting 5 to 15 seeds in each such little bed according to the size of the seed and its germinative capacity. The seed should be lightly covered with a layer of humus and soil equal to half the thickness of the seed.

Transplanting—He felt that it was not advisable to experiment with too many species in transplanting operations, due to reasons of heavy cost. Only a few species should be raised in nurseries according to the availability of seed and the elevation of gaps to be regenerated. The following were recommended.

- | | |
|-------------------------------------|---------------------------------|
| 1. <i>Acrocarpus fraxinifolius</i> | 8. <i>Dysoxylum malabaricum</i> |
| 2. <i>Aglaiia roxburghiana</i> | 9. <i>Filichium decipiens</i> |
| 3. <i>Artocarpus hirsuta</i> | 10. <i>Gluta travancorica</i> |
| 4. <i>Balanocarpus utilis</i> | 11. <i>Hardwickia pinnata</i> |
| 5. <i>Cedrela toona</i> | 12. <i>Heritiera papilio</i> |
| 6. <i>Chukrasia tabularis</i> | 13. <i>Hopea parviflora</i> |
| 7. <i>Dipterocarpus bourdilloni</i> | 14. <i>Palaquium ellipticum</i> |

Transplanting was best effected in June, at the beginning of the south-west monsoon and nursery work should be started in the previous July or as early after July as possible,

so that seedlings of sufficient age and size might be available for transplanting. It was indicated that the following rules should be observed :

- (a) *Balanocarpus* seedlings should not be introduced above 1,500 feet, *Hopea parviflora* above 2,500 feet elevation, and *Artocarpus fraxinifolius* and *Filicium decipiens* above 3,000 feet elevation.
- (b) *Acrocarpus fraxinifolius* and *Artocarpus hirsuta* should be introduced in the centre of a gap, *Gluta travancorica*, *Palaquium ellipticum* and *Hopea parviflora* on the periphery of the gap. The other species may be introduced in the intermediate space in the gap.

Nursery practice—It was noticed that the open nurseries were of definite advantage as far as the plant per cent and the success of transplants were concerned, but had the distinct disadvantage of requiring shade over the beds and daily watering during the dry weather. Nurseries in the shade on the other hand required no watering (except in the seed beds to promote germination) but the plants raised were not so healthy and carried either etiolated or leathery leaves. It was, therefore, suggested that a *via media* between the two types be adopted, by having a rectangular open nursery the longer sides running north and south, and the shorter side being not more than a chain wide. Such a nursery would be in direct sun light but for the shortest possible time.

Raised beds of convenient length, but 3 feet wide and running along the contours, were considered best and were sown with one species at a time. The nursery was fenced adequately; a fence with close set hardwood supports closely interlaced with reed was considered the best. In order to save transport charges it was considered preferable to have a nursery in each annual coupe. It was also prescribed that a sufficient number of plants at suitable espacement be retained in the nursery, so that abandoned nursery sites would be automatically afforested with useful species.

First year tending—In the year following dibbling or transplanting operations a light tending was prescribed. It involved cutting out of grass, weeds and other inferior species interfering with the growth of the seedlings. The operation was considered best done in June during the south-west monsoon and again if necessary in October-November during the north-east monsoon.

Second year tending—In the succeeding year a similar tending would be done during the south-west monsoon. No further tending was prescribed. The work did not prove a success.

In other districts neither natural regeneration was studied closely nor were any special artificial regeneration works undertaken. It would generally be stated however, that as was observed in Coimbatore and Tirunelveli districts, natural regeneration was plentiful but remained suppressed if appropriate canopy openings did not take place.

Protection

The evergreen forests of the State occur in the catchments of the main water courses and hence their protection is an important consideration.

There has been large scale clearing of these forests in Kanyakumari, Coimbatore and Nilgiris districts for the opening of tea, coffee, rubber and cinchona plantations.

Damage to young seedlings, saplings and poles by wild animals like elephants is very common. Bison, sambhur and spotted deer browse young *Hopea parviflora*, *Dalbergia latifolia*, *Pterocarpus marsupium* and strip the bark off *Acrocarpus fraxinifolius*. Porcupines, bats, squirrels, monkeys and rats consume large quantities of the seeds and fruits of *shola* trees such as *Mesua ferrea*, *Elaeocarpus munroii* and *Dysoxylum malabaricum*. Wild pig exhibits a great avidity for the cotyledons of *Balanocarpus utilis*. Sometimes all attempts at artificial regeneration are set at nought by such damage.

In Tirunelveli district, *Hopea* poles have been attacked fatally by the borer *Massiscus venustus*. The damage to *Mesua ferrea* done by a Cerambycid borer is sometimes extensive, and almost every tree of over 1' girth is riddled by tunnels making it unfit for sleepers.

The number and variety of fungi in the evergreen forests of Tirunelveli district are enormous. The huge bracket-shaped *Polyporous* fungi are a feature of the tract, many of them, however, being saprophytic. Ground fungi both poisonous and innocuous are found scattered over the forest floor.

In places, heavy grass and *Strobilanthes* suppress the growth of young seedlings. The latter is a menace in Tirunelveli district.

The common climbers met with are *Entada scandens*, *Gnetum scandens*, *Bauhinia* sp., *Calamus* sp., and *Acacia concinna*.

Fires are not a common feature in these forests. At the most they creep up to the edge of the forests and die out.

Management

The earliest proposals for the management of the evergreen forests in Coimbatore district were made by Wood⁽¹⁰⁾ in 1916. The extent of these forests is 3,652 acres and he prescribed them to be maintained as protection forests. In 1926, Laurie⁽²⁾ constituted a Karianshola Working Circle, 2,600 acres of which were to be worked under selection fellings. The girth limits were laid down as—

<i>Mesua ferrea</i>	.. .. .	6 feet
<i>Hopea parviflora</i>	.. .. .	7 "
<i>Calophyllum tomentosum</i>	.. .. .	9 "
All other saleable species	.. .. .	8 "

The rotation was fixed at 150 years and the felling cycle at 25 years. It was also laid down that not more than 3 trees per acre be extracted in order to preserve the evergreen nature of the forest. No appreciable working could, however, be done for want of demand.

In 1941, Venkateswara Iyer⁽⁴⁾ formed a Karianshola Evergreen Working Circle on similar lines, and with an estimated annual yield of 30,000 c.ft., the annual coupe being about 82 acres. Owing to heavy war demand, however, the whole area was gone over during the first three years, with the following outturn:

1941-42	2,650 c.ft.	and	3,261 B.G. sleepers	=	12,433 c.ft.
1942-43	688 "	and	2,808 "	=	9,112 "
1943-44	5,891 "			=	5,891 "

The disappointing yield as compared with the forecast was mainly due to the fact that only a few of the species enumerated as saleable found a market in spite of the general increased demand for timber.

The earliest attempt at marketing evergreen timber from the forests of Punachi range was made in 1903-05 when *Mesua ferrea*, *Calophyllum tomentosum*, *Dysoxylum malabaricum*, *Artocarpus integrifolia* and *Cedrela toona* were felled departmentally in Andiparai shola near Iyerpadi and the sawn scantlings transported to Anamalai for sale. The operation resulted in a loss in all probability because it was not realized how rapidly evergreen sawn timber would degrade. In 1896 Government approved of the grant of forest areas for the raising of plantation produce such as coffee, tea and cardamoms and large areas of virgin evergreen forest were rapidly taken up for plantation, the total area so assigned now amounts to 47,232 acres. One of the terms of assignment was that the assignee could use any timber on the area for his own purposes but could not sell it; this resulted in a very large amount of merchantable timber being burnt or allowed to be destroyed by insects and fungi.

In 1927, an area of 23,000 acres of virgin evergreen forests in the Kallar valley was ordered to be set apart for the planting of cinchona by the newly formed Cinchona Department, and by 1951, the total area amounted to 8,823 acres. The initial clearing of forested areas for Cinchona planting drew attention to the possibility of exploiting some of the evergreen timber species at a profit. The Logging Engineering Division accordingly did a cruise of the Kallar valley forests between 1925 and 1928, and extracted some 6,000 broad gauge sleepers of *Mesua ferrea*. The operation was discontinued in 1933 as owing to a reduction in sleeper prices by the Railway, extraction could not be done at a profit. Between 1926 and 1933, 3,750 acres of the Kallar valley sholas were thus gone over and a total of 79,298 broad gauge and 18,221 metre gauge sleepers were extracted, earning a revenue of Rs. 758,199. Besides some 10,366 cubic feet of *Palaquium ellipticum*, *Calophyllum tomentosum*, *Dysoxylum malabaricum* and *Cedrela toona* timber scantlings were also extracted and sold at a small profit.

Under Sarma's Working Plan (1935-36 to 1940-41)⁽³⁾ the Kallar valley (4,885 acres) was constituted into a Selection Felling Series and coupes I to V were worked between 1935-36 and 1939-40 for sleepers, some red cedar scantlings were extracted

for the cigar box industry. Charcoal (from top ends) was manufactured in 1939-40 but the operation resulted in a loss. A total of 55,799 broad guage units were extracted.

Coupes VII to X were worked between 1941-42 and 1947-48 the yield being :

Coupe No.	Year of working	Estimated yield c.ft.	Actual yield c.ft.
VII	1941-42 } 1942-43 }	36,783	38,851
VIII	1945-46	35,925	20,461
IX	1943-44 } 1944-45 } 1945-46 }	38,841	40,902
X	1942-43 } to 1947-48 }	43,860	91,004

The whole area was then handed over to the Cinchona Department.

At present the exploitable evergreen areas of the district are worked under Bhoja Shetty's Plan (?) (1954-55 to 1968-69). The Evergreen Selection Working Circle covers an area of 5,927 acres, and is divided into two Felling Series—the Karianshola Felling Series (2060 acres) and the Punachi Felling Series (3,807 acres). No working has been prescribed in the former as it is primarily a protection forest.

In the Punachi Felling Series a 10% enumeration of the growing stock by the "Systematic Strip Sampling" method was carried out. The volume was calculated by the quarter-girth formula, based on breast height girth, the estimated length of utilizable bole and a form factor of 0.66. Trees of over 12' girth were ignored as they were considered unsound. The total number of trees of 7'—12' girth in the felling series was 23,992 or an average of six trees per acre of the following species: *Mesua ferrea*, *Palaquium ellipticum*, *Calophyllum tomentosum*, *Artocarpus integrifolia*, *Vateria indica*, *Cedrela toona* and *Dysoxylum malabaricum*. The girth limit prescribed was 7' for all species. The felling of more than six trees per acre was not permitted. The District Forest Officer, could exploit any other than these seven species if a demand existed subject to the restriction of not more than six trees per acre. A rotation of 150 years was tentatively adopted in view of inadequate knowledge of the silviculture of these species. The felling cycle was fixed at 30 years which gave an average annual coupe of about 125 acres.

Though a maximum of 6 trees per acre could be felled, it was desired that this limit should not usually exceed four. On the basis of an average volume of converted timber per tree of 125 c.ft., an outturn of 500 c.ft. per acre or an estimated total of 64,500 c.ft. was anticipated.

The following marking rules were prescribed :

- (a) Only sound trees of saleable species of a girth of 7 feet and above would be marked.
- (b) Total number of trees to be marked should not exceed 6 on any one acre.
- (c) No two trees within a chain distance from each other should be marked, but if two trees were so close to each other as to form only one gap both might be marked.
- (d) As far as possible the largest trees should be preferred to trees of lower girth provided they were sound.
- (e) All climbers on trees marked as well as on neighbouring trees should be cut at the time of marking, so that when felling took place damage to neighbouring trees would be minimized.
- (f) The marking should be done by the Range Officer or an experienced Forester who could identify the evergreen species and had sufficient experience in enumeration and estimation of lengths of exploitable boles.

The yield obtained so far (mostly as sleepers) has been as follows:—

Year	Species	B.G. Units	M.G. Units	N.G. Units
(1)	(2)	(3)	(4)	(5)
1954-55	<i>Mesua ferrea</i>	7124	2606	—
	<i>Calophyllum elatum</i>	1685	343	—
		8809	2949	—
1955-56	<i>Mesua ferrea</i>	3335	1763	—
	<i>Calophyllum elatum</i>	369	126	—
		3704	1889	—
1956-57	<i>Mesua ferrea</i>	2360	3987	486
	<i>Calophyllum elatum</i>	688	161	191
		3048	4148	687
1957-58	<i>Mesua ferrea</i>	1848	2523	1679
	<i>Calophyllum elatum</i>	3904	2076	979
		5752	4599	2658
1958-59	<i>Mesua ferrea</i>	1616	3410	757
	<i>Calophyllum elatum</i>	1273	1066	2199
	<i>Cullenia excelsa</i>	6088	919	1160
	<i>Canarium strictum</i>	262	42	91
		9239	5437	4207

The earliest working of the evergreen forests in the Tirunelveli division seems to have occurred between 1888 and 1896 in the *Sholas* of Srivilliputtur range. They were mainly unorganised fellings by contractors who felled principally *Vitex altissima*, *Filicium decipiens*, *Litsaea zeylanica* and *Mesua ferrea* in the *shola* forests in the Chittar valley and converted them into small sizes (spokes, plough shares, poles, etc.) which could be carried in head loads down to the plains. Similar work was carried on in the *sholas* in Nanguneri range from 1897 to 1901; *Palaquium ellipticum*, *Mesua ferrea* and *Bischofia javanica* being extracted. The contractor paid on the quantity of timber that he actually removed to the depot in the plains. In the absence of supervision of fellings and owing to the fact that conversion was affected by the axe, much wastage was involved and the system was abandoned. Richmond⁽¹⁾ remarked in 1903 that under the system "a contract for a certain number of cubic feet was given to a contractor who was at liberty to take them from *anywhere* he liked, and moreover if he cut down a tree and found it not quite suitable for him, he worked on and cut down another and so on. It did not matter to him how many trees he destroyed as he only paid on the number of cubic feet he removed. Anything more wasteful it would be difficult to imagine."

The next attempt was to sell marked trees standing in small areas. The following working circles were constituted :

Range	Total area Acres	Felling cycle in years	Girth limit at breast height (ft.)	Average annual possibility in trees	Year of Starting
Srivilliputtur Range :					
Mylai Working Circle ..	705	6	6	50	1903
Vellakalteri Working Circle.	1810	6	4½	20	1903
Nanguneri Range :					
Karumandiamman Working Circle	2235	6	7	200	1903

The trees were to be selected and marked prior to felling and sold standing. The following Table for the Karumandiamman Working Circle shows the results of workings :

	Area in acres	Possibility in trees	Actually extracted trees	Revenue Rs.
Coupes I and II	438	400	210	436
Coupe III	280	200	141	426
Coupe IV	561	200	43	160
Coupe V	410	200	83	314
Coupe VI	499	200	60	536

It is evident that the possibility was fixed high, as sufficient trees above the prescribed girth limit could not be found on the area. The revenue works out to Re. 0.84 nP. per acre or Rs. 3.47 nP. per tree felled. As early as 1904, Richmond⁽¹¹⁾ had remarked, "I do not think the system is a good one as it tends to favour bad species which are not cut unless the greatest care is taken in the selection of the trees to be felled, none being marked except those surrounded by, or standing over a well established advance growth of the same or other valuable species". Again the prescription that as little damage as possible should be done to the surrounding forest during felling could not be successfully carried out. In view of the importance of these *sholas* as affording protective cover in the catchments of the more important streams, the possibility of destroying them by exploitation could not be contemplated, and in their Proceedings of 1913, the Madras Revenue Board directed that all *shola* exploitation in this area be stopped. Considering that these *sholas* were fairly accessible and moderately stocked with saleable species of large dimensions, the discouraging financial results of working doubtless also influenced the above decision.

In Ambasamudram range valuation surveys (over representative areas) had been carried out in the *shola* forest at Kannikatty and Kodamady as early as 1883, with a view to ascertain the possibility from these forests. From 1886 to about 1896, an average of 6,000 cubic feet of *Hopea parviflora* and *Balanocarpus utilis* were extracted annually from Ullar, Upper Serviar and Kaduvarai valleys, all extraction being done departmentally, the cost of extraction averaging 0.78 nP. per cubic foot. The operations, however, were wasteful and as an instance, out of 152 trees felled in the Kaduvarai valley in 1899 only 28 were converted. Hooper⁽¹²⁾ accordingly ordered the stoppage of operations until the forest were rendered accessible and demand stimulated, particularly as he was also convinced that a considerable amount of over-felling had been done in the past. After the construction of the Kodamady-Kuttalam-Kaluruvi road in 1909-1910, extraction in the area west of the Usipothai saddle was attempted departmentally, but was soon abandoned as it did not prove lucrative. In 1910-11, 50 trees, principally *Vitex altissima*, were sold standing in this locality to a contractor at Rs. 5.50 nP. per tree. In 1911-12 this system was again tried, and 50 trees were sold at Rs. 6.50 nP. per tree. In the succeeding years, contractors refrained from offering reasonable prices and departmental working was decided upon but could not be implemented due to several reasons. All extraction was, therefore, suspended pending the preparation of a working plan. From 1915 till 1934 no regular plan was drawn up. In 1934, Lasrado⁽⁹⁾ drew up a ten year plan which constituted an Evergreen Timber Working Circle. A 33½ per cent strip enumeration was carried out in the evergreen forests of the division. The working circle was divided into three felling series— one regular and two reserve (to be worked when there was a demand):

The exploitable size was fixed as below :—

<i>Aglaia roxburghiana</i>	}	5 ft.
<i>A. courtallensis</i>		
<i>Nephelium longanum</i>		
<i>Anacolsa densiflora</i>	}	6 ft.
<i>Balanocarpus utilis</i>		
<i>Calophyllum trapezifolium</i>		
<i>Chukrasia tabularis</i>		
<i>Diospyros</i> sp.		
<i>Heritiera papilio</i>		

<i>Mangifera indica</i>	}	6 ft.
<i>Mesua ferrea</i>		
<i>Palaquium ellipticum</i>		
<i>Pterospermum rubiginosum</i>		
<i>Stereospermum chelonoides</i>		
<i>Vitex altissima</i>		
<i>Acrocarpus fraxinifolius</i>	}	7 ft.
<i>Artocarpus integrifolia</i>		
<i>Artocarpus hirsuta</i>		
<i>Bischofia javanica</i>		
<i>Cedrela toona</i>		
<i>Dysoxylum malabaricum</i>		
<i>Eugenia</i> sp.		
<i>Elaeodendron</i> sp.		
<i>Filicium decipiens</i>		
<i>Hardwickia pinnata</i>		
<i>Hopea parviflora</i>		
<i>Gluta travancorica</i>		

A modified "Selection System" was adopted under which trees of exploitable girth were to be marked uniformly over the entire coupe and the gaps were to be regenerated artificially. Yield was regulated by area.

A ten year felling cycle was prescribed. Marking rules included :

- The trees marked for felling would be (as far as possible) evenly distributed over the annual coupe.
- Not more than three trees were to be marked on *any one acre*, i.e., one marked tree should be not less than 120 feet away from its nearest neighbour. This rule may, however, be relaxed in cases where two exploitable trees standing close together are likely to cause only one gap on being felled, when both trees may be marked for felling.
- No tree incapable of yielding at least 25 cubic feet of timber should be marked for felling; subject to this proviso partially unsound trees were to be marked.
- All large climbers met within the annual coupe in the course of marking operations should be cut.

Working through the agency of contractors was advocated on annual leases.

With a view to increase the revenue, and provide a clean forest floor for regeneration operations, charcoal burning using top ends and rejects was prescribed over a maximum of 25% of the gaps caused by felling. This prescription, however, was soon abandoned.

In 1949, the plan was revised by Cariappa⁽¹³⁾. So far as the Evergreen Timber Working Circle of Lasrado's Working Plan was concerned all the coupes prescribed for felling had been worked in the past. Actually felling had by no means been restricted either to the girth classes prescribed by Lasrado or even to the areas specified by him, as it became necessary to meet the demand of the defence services for timber. There were, therefore, very few trees available for extraction for some years to come. In the circumstances, the Evergreen Timber Working Circle was given rest for the period of the plan.

As a result of States Reorganisation four Tamil taluks of Travancore State (Vilavankod, Kalkulam, Agastheeswaram and Thovala) were transferred in November 1956 to Madras State to form Kanyakumari district. The forests in these taluks occur in important catchment areas. In 1844, *Dalbergia latifolia* and *Artocarpus hirsuta* were declared State monopolies in addition to teak. Later ebony was added on. In 1918, Jacob⁽¹⁴⁾ prepared a Working Scheme for the tract to meet the demands of the Nagercoil market. This scheme came into force in 1921 but was followed in a most haphazard manner, exploiting was easily accessible. This resulted in large gaps in the forests. In 1953 Devassy⁽¹⁵⁾ drew up a Working Plan which was neither approved nor enforced. This was the position till the areas were handed over to Madras State in 1956.

In 1957, Rahmatullah⁽¹⁶⁾ was entrusted the revision of Cariappa's Plan for the areas included in Tirunelveli South division and the new areas in Kanyakumari district. A Timber Selection Working Circle was constituted to include moist deciduous forests in Kulasegaram and Azhagiapandiyapuram ranges and tropical wet evergreen forests in Nanguneri range (1799 acres). Partial enumerations were carried out in 1 chain

wide strips at random, to see if a sufficient stand of exploitable size had resulted from the rest period prescribed by Cariappa. A study of these enumerations indicated the irregular nature of the crop. In the Kanyakumari forests there was a great deficiency in the mature stock. However, the presence of a fair number of middle aged stock indicated that if further exploitation were made with sufficient safeguards, the distribution could be normalised.

Selection system has been adopted. The girth limit fixed is 6 feet (except in Sengalteri Series where it is 7'), for the following species:

Acrocarpus fraxinifolius

Artocarpus hirsuta

A. integrifolia

Bischofia javanica

Cedrela toona

Hopea parviflora

Filicium decipiens

Eugenia sp.

Elaeodendron sp.

A felling cycle of 15 years is prescribed in order to increase the area of the annual coupe and thus to make the extraction more economical. Not more than 2 trees would be removed per acre. The yield is regulated by area. An annual approximate yield of 100,000 c.ft. is anticipated. Usual marking rules have been adopted and artificial stocking is *not* prescribed.

Preliminary reconnaissance in the Ambasamudram and Kuttalam ranges and the new Shencottah Forests and Ex-zamindari forests, indicates that the evergreen areas which were under rest during Cariappa's Plan can now be worked. In addition a few more areas can also be exploited. Tentatively a Selection Working Circle has been constituted of all such wet evergreen forests (2000 acres) in Ambasamudram range. A 10-year felling cycle and exploitable girths of 6' to 7' are proposed.

In the Nilgiris district the small patches of tropical evergreen forests have not been worked so far due to financial reasons. Also their preservation is of paramount importance to the regulation of moisture and stream flow in these hills.

In the Madurai and Tirunelveli district 4851 acres of evergreen forests have been leased out in scattered patches for cardamom cultivation. The cardamom is introduced as a shrubby ground cover without interfering at all with the tree canopy.

Research

In the evergreen forests of Tirunelveli district natural regeneration of the important timber species is generally plentiful but usually remains suppressed for lack of opening of the canopy and proper tending. In the *Hopea-Mesua* associations often found on stream banks, natural regeneration of *Hopea parviflora* is dense. Such natural regeneration remains suppressed for a long period owing to uninterrupted canopy and dense undergrowth, but responds quickly if sufficient light is allowed to reach through the top canopy. In the *Palaquium-Mangifera* association, natural regeneration of both the species is prolific. In the *Cullenia-Calophyllum* association, natural regeneration of *Cullenia excelsa* is more prolific. The desirability of tending the existing natural regeneration by making light cuttings, so as to free the more valuable species has been thought over but not prescribed, because:

- (a) the most favourable light conditions for the growth of evergreen species are not yet known,
- (b) identification of seedlings is difficult and they are liable to be cut by mazdoors during tending operations,
- (c) the cost of tending operation is considerable and the advantages gained are doubtful.

In these evergreen forests there is a considerable amount of young natural regeneration of both desirable and undesirable species. Such regeneration stagnates for varying periods, until a gap in the canopy admits sufficient light to enable it to shoot up. Little is known as regards the light requirements of such seedlings except that a light opening of the canopy immediately above such regeneration is definitely beneficial. The extent of opening required to assist the desired species or the stage at which such opening should be made are still matters of conjecture. Artificial regeneration of useful species either by

dibbling of seeds or transplanting of nursery or natural seedlings present similar problems regarding the amount of light and shade to be afforded. The main problems in the evergreen forests that require research are, therefore :—

- (i) the nature, extent and time of opening of the canopy required for encouraging natural regeneration of useful species and successfully establishing it,
- (ii) the tending necessary for establishing both artificial and natural regeneration,
- (iii) the best method of artificial regeneration of the different species, including nursery techniques.

While much work has been attempted in the evergreen forests of Coimbatore and Tirunelveli districts, these problems are yet to be solved. Past efforts have resulted in but little guidance though a mass of useful knowledge has been accumulated.

In the evergreen Karianshola of Coimbatore South division, a linear tree increment plot was laid out for phenological studies. Experiments were started in 1941 to find out whether it is possible to introduce valuable species artificially.

So far the following results have been obtained :

After clearing all the undergrowth (growth upto 10 feet in height except the seedlings and saplings of useful species such as *Calophyllum elatum*, *Hopea parviflora*, *Dysoxylum malabaricum*, *Canarium strictum*, etc.) the following hardwood species were introduced by direct sowings, entire transplants and stump plants :

1. *Acrocarpus fraxinifolius*
2. *Aglaiia roxburghiana*
3. *Artocarpus hirsuta*
4. *Bischofia javanica*
5. *Cedrela toona*
6. *Chukrasia tabularis*
7. *Hopea parviflora*
8. *Swietenia macrophylla*.

Of the three methods tried, transplanting nursery raised seedlings between the 15th June and the 15th July was found to be significantly the best method. In the case of *Hopea parviflora*, three weedings gave significantly good results. *Artocarpus hirsuta* failed completely due to constant browsing by sambhur, bison and elephants. All other species succeeded. Of these, mahogany and *Hopea parviflora* proved most promising. By retaining the top canopy, it was also seen that the damage caused to mahogany by the shoot and collar borers could be controlled to a significant extent. But *Cedrela toona* suffered badly from the shoot and collar borers even with the retention of top and intermediate canopies and what was more, its growth was slower than that of mahogany. *Hopea parviflora* and *Gluta travancorica* appeared to be very promising. *Hopea parviflora* grew to an average height of about 15 feet within 10 years, while *Gluta travancorica* reached about 20 feet. Mahogany, during the same period, grew to a height of 35 to 40 feet and a girth of 24 to 30 inches. It might, therefore, be concluded that these three hardwood species could be introduced in this area. It was also seen that for proper growth and development of these species it is necessary to remove not only the undergrowth but also the middle canopy. This could be done by girdling all useless species up to four feet in girth besides clearing the undergrowth.

The following softwood species were tried under the above technique:

1. *Alstonia scholaris*
2. *Ailanthus excelsa*
3. *Evodia roxburghiana*
4. *Ailanthus malabarica*
5. *Lophopetalum wightianum*
6. *Machilus macrantha*
7. *Samadera indica*
8. *Sterculia alata*
9. *Vateria indica*

All the above species were introduced by transplanting nine months to one year old nursery seedlings between June 15 and July 15. Three weedings are necessary till the end of second year. While it was impossible to raise *Alstonia scholaris* due to constant damage from bison and sambhur, it was more or less easy to establish the others. *Vateria indica* and *Ailanthus excelsa* appeared to be most promising. In about 10 years, *Vateria*

indica grew to an average height of about 20 feet even though the top and intermediate canopies were left untouched. *Evodia roxburghiana* seemed to grow fairly well but like *Vateria indica* this species also requires more light and this could be given by the removal of the trees forming the intermediate canopy.

The following exotic species were tried :—

1. *Sterculia campanulata*
2. *Broussonetia papyrifera*
3. *Ochroma lagopus (balsa)*.

1. *Sterculia campanulata* (a good matchwood) was successfully raised from one year old transplants, even with the retention of the top canopy. The growth appeared to be fairly rapid. The species will be further tried along with *Vateria indica* in the coming years.

2. *Broussonetia papyrifera* was at first tried as a suitable wood for manufacture of newsprint. But since last year the wood has been found to be quite suitable for the manufacture of match splints. This species could be raised by transplanting seedlings or stump planting and its growth proved very rapid. In about 8 years a girth of 2 feet was obtained and it was expected that on a rotation of 20 years it may be possible to get trees of 3 to 4 feet in girth. When once introduced this species spreads fast by natural regeneration. As a suitable species for the match industry this would deserve special attention.

3. *Ochroma lagopus (balsa)*.—Experiments with *balsa* were started in 1942 and the silvicultural characteristics and requirements of the species have been more or less fully understood. The species could be raised from seedlings and its rate of growth appeared to be most promising in Topslip. The tree attains a girth of more than 4 feet in 4 to 6 years. But the timber when tested in the Forest Research Institute at Dehra Dun proved to be more dense than the imported *balsa* from South America. Unless a special market for this heavier wood could be assured it would not be advantageous to extend this species.

The following other species were also tried :

1. *Tung oil*.—Both *Aleurites fordii* and *Aleurites montana* have been tried during the last eight years. The growth of *Aleurites fordii* was not satisfactory but *Aleurites montana* appeared to grow well. The trees started flowering when they were about six years old. They have also fruited. The growth and development appeared to be satisfactory.
2. *Rauwolfia serpentina* could be successfully grown both under a top canopy and in the open, using nursery raised seedlings, 3 to 4 months old or cuttings.

Conclusions

Since the States Reorganisation, the timber forests of Madras State have dwindled considerably in extent. On the other hand, the demand for timber to meet the requirements of hydro-electric projects, railway sleepers and structural works, is increasing by leaps and bounds and this would call urgently for a more intensive study and exploitation of our evergreen forests, however, limited they might be in extent and however difficult or remote they might be in location.

APPENDIX I

Enumeration (1953) of marketable species : Evergreen forests of Coimbatore district

Serial number and name of species.	GIRTH CLASSES					
	7 feet to 8 feet		8 feet to 9 feet		9 feet to 10 feet	
	Number of trees	Volume	Number of trees	Volume	Number of trees	Volume
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1. <i>Mesua ferrea</i>	4238	485549	3596	531905	1936	366450
2. <i>Palaquium ellipticum</i>	4324	536167	2016	324607	1212	241738
3. <i>Calophyllum tomentosum</i>	332	44999	282	48234	188	39475
4. <i>Artocarpus integrifolia</i>	300	23946	190	17633	112	16509
5. <i>Vateria indica</i>	748	90445	492	79984	324	66756
6. <i>Cedrela toona</i>	26	3580	26	4063	10	1913
7. <i>Dysoxylum malabaricum</i>	48	5306	110	15411	68	12119
TOTAL	10016	1180992	6712	1021837	3850	744960

	10 feet to 11 feet		11 feet to 12 feet		Total	
	Number of trees	Volume	Number of trees	Volume	Number of trees	Volume
1. <i>Mesua ferrea</i>	1234	274106	788	211206	11792	1896216
2. <i>Palaquium ellipticum</i>	394	93481	176	54737	8122	1250730
3. <i>Calophyllum tomentosum</i>	198	52280	56	15977	1056	200965
4. <i>Artocarpus integrifolia</i>	46	5481	26	5337	674	68906
5. <i>Vateria indica</i>	230	53059	160	45401	1954	335645
6. <i>Cedrela toona</i>	10	1532	—	—	72	11088
7. <i>Dysoxylum malabaricum</i>	66	13928	30	9009	322	55773
TOTAL	2178	493867	1236	341667	23992	3792323

APPENDIX II

Enumeration of marketable species : Evergreen Forests of Tirunelveli district.

	Girth at breast height in Feet							Over 10
	1-3	3-5	5-6	6-7	7-8	8-9	9-10	
A Class species								
<i>Acrocarpus fraxinifolius</i>	326	238	84	57	55	48	38	27
<i>Aglaia roxburghiana</i>	2380	1642	388	142	35	13	11	1
<i>Amoora rohituka</i>	3524	1679	540	146	81	61	24	18
<i>Anacolosia densiflora</i>	1347	1405	446	250	82	36	28	14
<i>Artocarpus</i> sp.	522	563	176	130	45	18	15	8
<i>Bischofia javanica</i>	190	233	106	99	64	34	37	24
<i>Balanocarpus utilis</i>	616	321	128	63	40	20	7	16
<i>Calophyllum trapezifolium</i>	68	94	46	31	31	25	7	2
<i>Chukrasia tubularis</i>	149	117	54	27	16	21	19	7
<i>Cullenia excelsa</i>	3833	3444	1854	1555	949	566	322	—
<i>Eugenia gardneri</i>	211	81	29	4	4	2	1	200
<i>Filicium decipiens</i>	183	134	66	45	25	2	2	—
<i>Garcinia echioocarpa</i>	1861	952	208	110	55	23	12	—
<i>Gordonia obtusa</i>	279	143	38	17	7	3	—	—
<i>Gluta travancorica</i>	1708	1805	922	806	463	328	181	103
<i>Hardwickia pinnata</i>	947	865	449	277	128	47	46	36
<i>Hopea parviflora</i>	1635	817	126	128	79	31	18	34
<i>Lansium anamalayanum</i>	786	381	51	9	6	—	—	—
<i>Mesua ferrea</i>	2806	2181	804	582	365	196	105	70
<i>Mimusops elengi</i>	652	443	164	109	48	22	13	13
<i>Pterospermum</i> sp.	829	718	280	179	121	56	44	40
<i>Palaquium ellipticum</i>	4552	4940	2645	1967	969	439	934	108
<i>Pygeum wightianum</i>	286	253	82	63	37	19	15	2
<i>Vitex altissima</i>	282	413	194	236	136	48	21	30
B Class species								
<i>Agrostistachys longifolia</i>	6749	1601	102	14	3	—	—	—
<i>Alstonia scholaris</i>	175	62	20	12	8	4	1	11
<i>Canarium strictum</i>	664	608	182	253	160	106	81	6
<i>Cinnamomum</i> sp.	1284	984	253	169	111	49	14	3
<i>Diospyros</i> sp.	14349	6854	1225	565	151	52	8	3
<i>Elaeocarpus</i> sp.	1642	1110	412	287	172	110	63	71
<i>Eugenia</i> sp. (excluding <i>Eugenia gardneri</i>)	3431	2304	647	486	310	168	69	79
<i>Hydnocarpus</i> sp.	1430	304	30	18	1	—	—	—
<i>Holigarna arnottiana</i>	475	292	89	38	20	6	1	3
<i>Machilus macrantha</i>	254	137	42	20	13	4	1	—
<i>Mangifera indica</i>	309	155	39	26	20	9	7	9
<i>Myristica</i> sp.	1881	1005	279	107	31	24	2	1
<i>Nephelium longanum</i>	2445	1621	392	131	47	17	5	1
<i>Nothopogon colebrookiana</i>	1160	422	77	30	7	2	6	3
<i>Stereospermum chelonoides</i>	115	87	20	12	7	7	2	—
<i>Terminalia belerica</i>	142	122	66	79	48	31	42	42
C Class species	12111	4302	743	233	105	61	32	36

APPENDIX III

Enumeration of marketable species : Evergreen forests of Kanyakumari district.

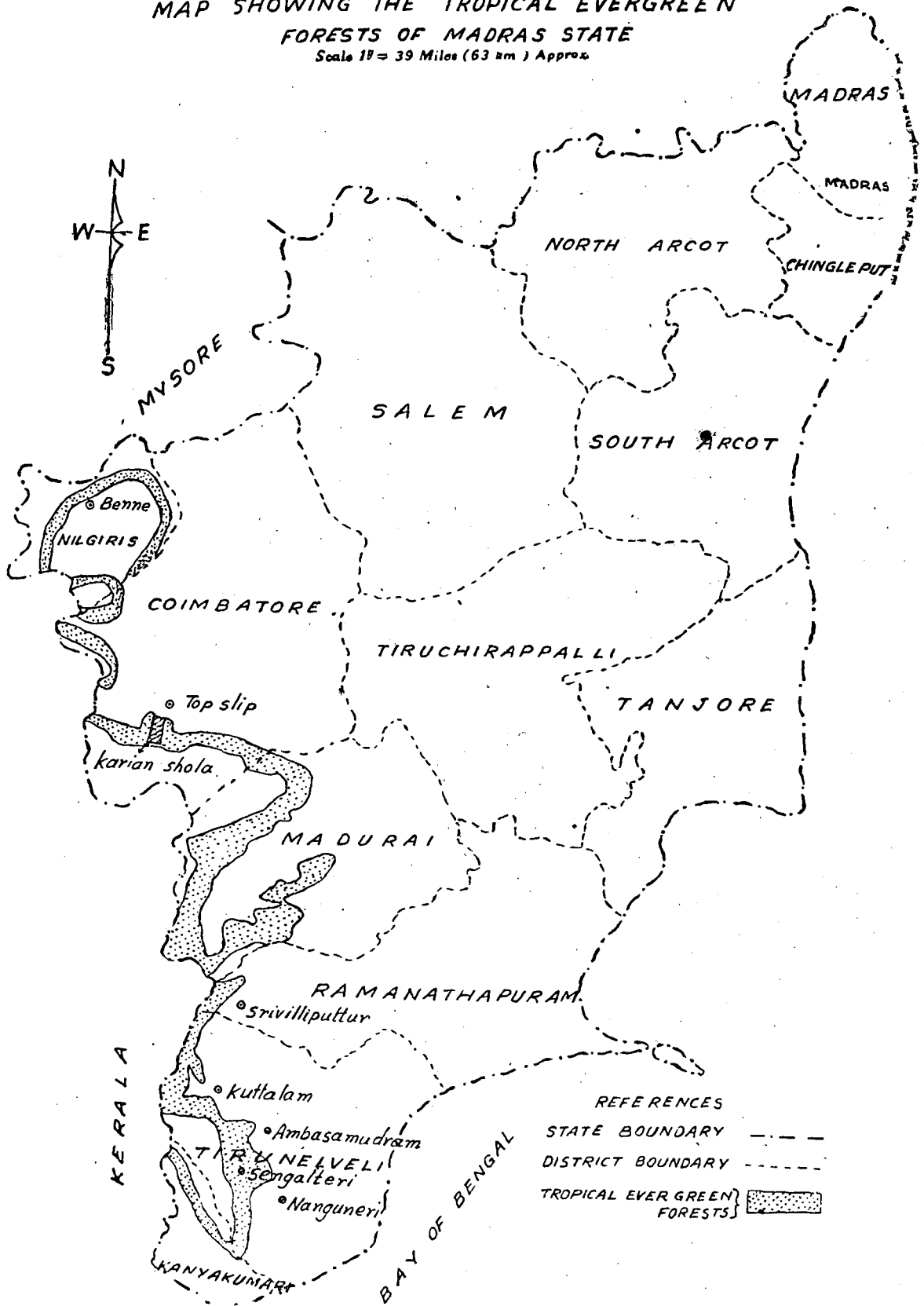
Species	Girth at breast height						7' and above
	2'-3'	3'-4'	4'-5'	5'-6'	6'-7'		
<i>Acrocarpus fraxinifolius</i>	2	1	1	2	—	—	1
<i>Artocarpus</i> species	8	10	9	—	3	—	2
<i>Bischofia javanica</i>	4	4	6	4	2	—	—
<i>Canarium strictum</i>	4	1	—	1	2	—	3
<i>Diospyros</i> species	23	17	9	1	2	—	3
<i>Cullenia excelsa</i>	31	18	16	13	14	—	13
<i>Chukrasia tubularis</i>	5	2	1	—	1	—	—
<i>Dysoxylum malabaricum</i>	2	1	—	—	—	—	—
<i>Eugenia</i> sp.	3	5	3	3	2	—	7
<i>Dipterocarpus</i> sp.	25	25	35	11	2	—	4
<i>Hemicyclia venusta</i>	3	1	1	—	—	—	—
<i>Aglaia</i> sp.	2	1	—	1	—	—	—
<i>Mesua ferrea</i>	1	2	2	—	1	—	2
<i>Mangifera indica</i>	4	3	3	3	1	—	5
<i>Myristica</i> sp.	4	3	—	—	—	—	—
<i>Nephelium longanum</i>	18	13	6	1	2	—	1
<i>Palaquium ellipticum</i>	22	11	9	3	2	—	2
<i>Podocarpus latifolia</i>	1	1	—	—	—	—	1
<i>Vitex altissima</i>	3	3	—	1	—	—	—

REFERENCES

1. Clements, P. E. .. Plant Succession.
 2. Laurie, M. V. .. Working Plan for the South Coimbatore Division: 1927-28 to 1936-37.
 3. Sarma, A. N. .. Working Plan for the South Coimbatore Division: 1933-34 to 1942-43.
 4. Venkateswara Iyer, T. V. Working Plan for the South Coimbatore Division: 1941-42 to 1950-51.
 5. Bhoja Shetty, K. A. Working Plan for the South Coimbatore Division: 1954-55 to 1968-69.
 6. Latham, H. A. & Peake. Inspection Note of the Tirunelveli-cum-Ramnad Forest Division : 1908 to 1912.
 7. Barry, D. T. .. Inspection Note of the Tirunelveli-cum-Ramnad Forest Division : 1913.
 8. Kesava Vittal, B. S. Report of the Special Officer on Evergreens 1927.
 9. Lasrado, E. A. .. Working Plan for the Tirunelveli-cum-Ramnad Forest Division : 1934-35 to 1943-44.
 10. Wood, H. F. A. .. Working Plan for the South Coimbatore Division: 1919-20 to 1930-31 .
 11. Richmond, R. D. .. Inspection Note of the Tirunelveli-cum-Ramnad Forest Division : 1903.
Inspection Note of the Tirunelveli-cum-Ramnad Forest Division. : 1904.
 12. Hooper .. Inspection Note of the Tirunelveli-cum-Ramnad Forest Division : 1900.
 13. Cariappa, B. A. .. Working Plan for the Tirunelveli-cum-Ramnad Forest Division : 1949-50 to 1963-64.
 14. Jacob Working scheme for the Evergreen Forests of Azhagiapandipuram : 1918.
 15. Devassy, P. T. .. Working Plan for the Evergreen Forests of Padmanabhapuram : 1953.
 16. Rahmattullah, S. A. Preliminary Working Plan for the Tirunelveli South Division: 1959-60 to 1968-69.
Reconnaissance report for the Tirunelveli North Division: 1959.
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MAP SHOWING THE TROPICAL EVERGREEN
FORESTS OF MADRAS STATE

Scale 1" = 39 Miles (63 km.) Approx.



TROPICAL RAIN FORESTS OF MADRAS STATE
PLANT COMMUNITIES, WITH SPECIAL REFERENCE TO SUCCESSIONAL
RELATIONS AND FIELD CHARACTERS

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Abstract

The climatic conditions, nature of terrain, and features of the soils on which the Tropical rain forests are dependent in the Madras State are described. Similarly the evergreen subtypes as found in each of the districts from Coimbatore to Kanyakumari are detailed. The ecological status, floristic composition and constituent plant communities of the primary forest are dealt with. The theory of climatic climax, polyclimax or monocl原因 (as far as it relates to these forests) is referred to. Secondary and deflected succession and biotic climax in such of the evergreen forests which were clear-felled or disturbed for *Kumra*, (taungya) cultivation, plantation, agriculture or by heavy selection fellings are described, giving the general features of secondary communities. The heterogeneous composition in dominant species and the varying degree of mixture of one and the same species in different height or diameter classes are briefly mentioned. Some salient observations made in the evergreen forests of this State are presented. Cases of adaptive mechanism of evergreen species like plank buttress, leaf structure, cauliflory etc., are enumerated. Economic importance and future possibility of the evergreen forests without changing its evergreen nature are discussed. Botanical importance of the Tropical rain forest as a reservoir of genetical diversity is stressed. The necessity for a more detailed and close study of various aspects of our Tropical rain forests on the same lines as that of Amazon, Nigeria and Congo forests is suggested.

Introduction—The tropical moist evergreen forests of Madras State are comparatively limited in extent. All the same, the important role they play in protecting the soil and water sources of the rain-sodden slopes where they occur, cannot be over-estimated. Though the earliest forests to attract the attention of forest officers (since 1882), they still remain the least understood.

These forests occur in the hilly terrain of Coimbatore, Madurai, Ramanathapuram, Tirunelveli and Kanyakumari districts in localities favoured with a rainfall of over 200 cm. They are confined to the upper slopes of the Western Ghats in a more or less contiguous stretch from north to south. The width of this belt is variable. These primary rain forests are extremely complex plant communities and exist in a delicate but stable equilibrium with the other components of the ecosystem, the climate, soil and fauna. Extremely little is known of the past history of the rain forest formation but there is reason to believe that they have persisted unchanged or changing exceedingly slowly, from a very remote past. Until the middle of the last century man has had little effect on these rain forests; large areas have been altogether uninhabited or inhabited only by food gathering people with no more influence on the vegetation than any of the other animal inhabitants.

Climate—Climatologically, the Tropical rain forests of this State fall within the monsoon belt with rainfall varying from 200 cm to 500 cm (or more at some places). The average is well over 300 cm for all the areas. Temperature seldom exceeds 37°C. The mean annual humidity is as high as 70%, often reaching saturation point during the south-west and north-east monsoon periods. Frost is unknown. The forests receive the bulk of the rainfall from the south-west monsoon, while certain parts of these forests in Ramnad and Tirunelveli districts get an equal amount of precipitation during the north-east monsoon also.

Soil—The principal underlying rock in most of these forest areas is a granitoid gneiss belonging to Archaean group. It is a pale quartz-felspar banded rock containing narrow veins of black mica and intercalated with numerous small pale red or pink garnets. The soil formed by the weathering of gneiss is generally a sandy loam and the disintegration is comparatively rapid. If the soil cover present is disturbed (for plantation purposes), potash and phosphoric contents tend to diminish by leaching. The rain forest thrives

best where the soil is fairly deep and well drained. But in localised depressions where a clayey loam accumulates from rain wash, marshy conditions arise and in such places tree vegetation is usually poor.

Mechanical and Chemical Analysis of Soil

The results of the mechanical and chemical analysis of the soil from a typical locality in Ambasamudram range of Tirunelveli district are given below :

Mechanical Analysis.

Moisture	Coarse sand	Fine sand	Silt	Clay
4.66%	48.54%	10.29%	7.99%	21.70%

Chemical Analysis.

pH	Organic matter %	Water soluble manganese p.p.m.	Exchangeable manganese p.p.m.
5.50	5.60	0.20	36.00
Reduceable manganese p.p.m.	Total P ₂ O ₅	Base exchange capacity m.e. %	Exchangeable hydrogen m.e. %
270.00	0.106	16.81	7.87
Exchangeable calcium m.e. %		Exchangeable magnesium m.e. %	
7.81		1.95	

Description—The forest formation is characterised by a luxuriance of vegetation, consisting of several tiers. The highest canopy contains lofty trees (often with plank buttresses at the base) reaching fifty metres or more in height; and the lowest consists of dense evergreen shrubby undergrowth. A heavy rainfall, high atmospheric humidity, a short dry season, striking absence of gregariousness, trees with smooth bark sparingly branched, leaves often firm, leathery or glossy, thick stemmed or woody climbers, and woody epiphytes are the characteristic features (Warming).

The characteristic species are *Mesua ferrea*, *Palaquium ellipticum*, *Calophyllum elatum*, *Hardwickia pinnata*, *Hopea parviflora*, *Gluta travancorica*, *Dysoxylum malabaricum*, etc. By and large, this type of forest is situated between the altitude of 500 to 1500 metres.

The growth deteriorates rapidly both in quality and bulk along the wind-swept ridges. The whole of the hill sides above 500 metres are not, however, clothed with dense tree growth. There is much bare and precipitous rock and extensive areas with shallow soils are covered with grass and stunted tree growth. Small patches of *shola* growth cap most of the sheltered faces of the peaks.

Though the plant communities in the evergreens of different districts have many species in common, there are, however, minor variations from locality to locality. A brief description of the forests in each district is given below :

A. COIMBATORE

The evergreen forests are mainly confined to Punachi range. A few isolated patches in Tunakadavu range adjacent to the Kerala State boundary are also found and these are in Palakadavu, Ulandi and Mt. Stuart blocks, the most accessible being the Karian-shola. In Bolampatty range also, narrow strips of evergreen can be seen along the State's western boundary. These evergreen forests once occupied a compact area of about 40,000 hectares, but about half of this has been cleared for plantations of tea etc. Usually this type of forest occurs in region over 600 metres in elevation and with annual rainfall of above 200 cm. The Karian-shola near Top-Slip is an exception where although the rainfall is only 175 cm, soil moisture condition are more favourable. Perhaps this is an instance of a post-climax development because the general climax vegetations to be expected and usually found in such localities is the tropical moist deciduous, but owing to the more favourable moisture conditions in the sheltered situation, these pockets bear a more evergreen vegetation.

Structure and Composition: Emergent layer—The constituent species are numerous. The canopy is extremely dense and there is a certain differentiation into layers or tiers. The top storey of the emergent layer consists of dominants reaching a height

of 45 metres or more. The principal species are *Mesua ferrea*, *Poeciloneuron excelsa*, *Palaquium ellipticum*, *Hopea parviflora*, *Cullenia excelsa*, *Calophyllum elatum*, *Vateria indica*, *Heritiera papilio*, *Aglaia roxburghiana*, *Dysoxylum malabaricum*, *Eugenia* species, *Cedrela toona*, *Canarium strictum* and *Elaeocarpus* species. Many of these species exhibit plank buttresses. The main trunk of the trees are mottled with black patches. Epiphytes are numerous.

Co-dominant layer or second storey—This tier comprises of meso-micro-and macrophyllous species. The crown is dark red in colour. The main species constituting this stratum are *Artocarpus lakoocha*, *Nephelium longanum*, *Diospyros microphylla*, *Mangifera indica*, *Adenochlaena indica*, *Drypetes macrophylla* and species of *Litsaea* and *Myristica*. These species like the emergents have clean smooth but mottled cylindrical boles and fluted or plank buttresses at the base. Epiphytes are not uncommon.

The Sub-canopy or Understorey—Immediately below the co-dominant layer the sub-canopy is seen. The trees are more slender and more branched. The principal species are *Canthium didymum*, *Mallotus philippensis*, *Cinnamomum gracile*, *Sapindus emarginatus*, *Hydnocarpus wightiana*, *Spermum heyneanum*, *Mimusops elengi*, *Myristica laurifolia*, *Casearia esculenta*, etc.

Undergrowth—The undergrowth, although sparse, includes *Calamus pseudo-tenuis*, *Curcuma pseudo-montana*, *Strobilanthes* species and *Oplismenus burmanii*. In moist localities, gregarious patches of *Ochlandra travancorica* exist. Notable climbers met with are *Elaeagnus conferta* and *Entada scandens*. *Lobelia excelsa* is not uncommon near water courses along with species of *Polygonum*. There is a heavy layer of leaf litter with plenty of leeches.

Three plant associations may be distinguished in the forests of Coimbatore :—

1. *Hopea-Mesua* association.
2. *Mesua-Palaquium* association.
3. *Poeciloneuron-Cullenia* association.

In Karian-shola the crop is predominantly a *Hopea-Mesua* association, *Hopea parviflora* and *Mesua efrrea* forming a considerable proportion of the tree crop. This association occurs in comparatively dry sites. Other common species occurring are *Calophyllum tomentosum*, *Dysoxylum malabaricum*, *Canarium strictum*, *Bischofia javanica*, *Vitex altissima* and *Alstonia scholaris*. Natural regeneration in this sub-type is marked by prolific occurrence of *Hopea* seedlings and much less of *Mesua* seedlings. The young plants, however, remain suppressed for a long period, and respond quickly if sufficient overhead light is provided.

The intermediate *Mesua-Palaquium* associations found in Punachi range where the rainfall is over 300 cm. The percentage of each of these two species is about 40, other species met with being *Calophyllum tomentosum*, *Artocarpus integrifolia*, *Cedrela toona*, *Vateria indica* and *Dysoxylum malabaricum*. The natural regeneration in this sub-type consists of profuse *Palaquium ellipticum* seedling and less of *Mesua ferrea*. This is so because *Palaquium* seed almost every year while *Mesua* does not; and the seeds of the former are also less palatable to rodents and insects; and further *Palaquium* is more tolerant to shade. In the lower girth classes there is predominance of *Palaquium*, which, however, does not persist in the more mature stages of the stand.

The Poeciloneuron-Cullenia association is restricted to places where the rainfall is as high as 750 cm., e.g., in Italiar block of Punachi range. The predominant tree species is *Poeciloneuron indicum* with comparatively low incidence of *Cullenia excelsa*. There is always a dense mass of natural regeneration of *Poeciloneuron indicum* and all age classes are well represented. In fact there is a marked tendency towards the crop ultimately becoming almost pure *Poeciloneuron indicum*. Some of the typical *Poeciloneuron* associations are to be found in South Kanara and Palghat divisions of the former Madras State in Tombettu and Agumbe forests and also in Sispara in Silent Valley reserve.

B. MADURAI DISTRICT

In Madurai district, the evergreen forests are not so typical as in Coimbatore or Tirunelveli. This is due to comparatively less rainfall and a longer dry season. They are found in the protected valley of Cumbum in Bodinayakanur and in the lower Palnis between 900 and 1500 metres above sea level. Small patches of evergreen forests are surrounded by deciduous vegetation. The chief species are *Bischofia javanica*, *Cedrela toona*, *Chukrasia tabularis*, *Elaeocarpus* species and *Canarium strictum* with a sprinkling of *Michelia champaca*

and *Acrocarpus fraxinifolius*. Along stream banks *Mesua ferrea* occurs. The *sholas* have gradually been eaten into by fires spreading into their margins from the surrounding deciduous forests.

C. RAMANATHAPURAM DISTRICT

Evergreen forests occur in Srivilliputtur range. But these can be classified as semi-evergreen, because the locality where they occur is far less moist than the adjoining Tirunelveli evergreen areas. The precipitation is less because the Travancore high range and the Upper Palnis keep off much of the rains which would otherwise fall on these hills. The principal species are *Acrocarpus fraxinifolius*, *Cedrela toona*, *Mesua ferrea*, *Eugenia* spp., *Palaquium ellipticum*, *Bischofia javanica* and *Mangifera indica*.

D. TIRUNELVELI DISTRICT

This is a more southerly district adjoining the Kerala State, being separated from it by the crest of the Western Ghats. The forests are situated on the leeward side of the Western Ghats, the evergreen rain forests being found between 500 metres and 1300 metres with semi-evergreen type occurring upto 500 metres elevation. The area of these forests is about 20,000 hectares. The principal species in the evergreen forests are *Mesua ferrea*, *Palaquium ellipticum*, *Hopea parviflora*, *Elaeocarpus tuberculatus*, *Canarium strictum*, *Cullenia excelsa*, *Gluta travancorica*, *Vateria indica*, *Myristica beddomei*, *Nephelium longanum*, *Lansium* sp., *Litsaea* sp. etc. The principal species in the semi-evergreen forest type are *Hopea parviflora*, *Balanocarpus utilis*, *Hardwickia pinnata*, *Vitex altissima*, *Bischofia javanica*, *Diospyros* species etc. Much of the evergreen forests have been destroyed towards the end of the last century by extensive clearings made by hill tribes and coffee planters. The secondary *shola* growth consisting chiefly of *Macaranga*, *Mangifera*, *Clerodendron*, *Diospyros* sp., is met with in abandoned coffee estates. With decreasing rainfall, the minimum elevation at which the true evergreens appear increases. Thus in Kalakad reserve with less rainfall than Papanasam or Kuttalam forests, the evergreens start at about 900 metres elevation and is at its best in the region of 1,000 to 1,200 metres. Around Netterikkal and Murungamottai in Kalakad, and near Kalivelipil and Martins Hut in Papanasam reserve patches of *Podocarpus latifolia* occur. This is the only indigenous conifer of South India.

The following associations are met with in the evergreen forests of Tirunelveli :

1. *Mesua-Palaquium* association.
2. *Gluta-Palaquium* association.
3. *Palaquium-Mangifera* association.

The first two sub-types are not easily recognisable as the distinction is only local. *Gluta* occurs where the moisture conditions are more favourable. In Kalakad reserve with a marked fall in rainfall, the sub-type changes to one of *Palaquium-Mangifera* with total absence of *Gluta travancorica*.

Reed areas—Nearer the summit of the hills (above the belt of *shola* forests) and along the higher slopes of various mountain ranges from Sivagiri to Kanyakumari border, above 900 metres elevation, extensive areas are covered with reed. *Ochlandra brandisii* and *travancorica* form an impenetrable thicket 10 to 15 feet high, from which stand out scattered trees of *Vernonia*, *Monosis*, *Eugenia* sp. etc. These reeds not only occur to the exclusion of all other vegetation but also encroach into *shola* gradually. A picturesque feature of the reed areas is the gregarious growth of the palm, *Bentinckia coddapanna* which usually thrives on the steepest portions and rocky peaks. Reed, of late, has become an important raw material for paper pulp.

E. KANYAKUMARI DISTRICT

The evergreen forests of Kanyakumari district (at higher elevation of 900 to 1300 metres) are more or less similar to those in the adjoining Tirunelveli forests. But their occurrence extends down to lower elevation as the rainfall in these areas is high, being located on the windward side of the main ridge. Narrow belts of evergreen forests are noticed down to 100 metres elevation, especially along stream banks. The species are practically the same as in Tirunelveli but associations or sub-types are not so well marked. Large areas of evergreen forest have been clear-felled in the last century and so the virgin forest is much interspersed by secondary growth on the abandoned clearings. The more accessible forests have also been subject to heavy selection fellings resulting in deflected secondary succession. At high elevation as in Muthukuzhi valley, subject to heavy rain-

fall and fierce winds, the height growth is poor. Pure reed areas occur in this valley. Due to repeated fires certain areas have attained a biotic climax in the form of grassland.

Ecological status—Ecologically these forests are mature and can be classified as climatic climax. They conform generally to Richards' definition of mixed rain forests. Also some of Richards' observations can be empirically applied with suitable modifications to these forests.

A. Primary Rain forests—The most important single characteristic of the Tropical rain forest is its astonishing wealth of species. This floristic abundance is achieved by a very congenial climate (favourable to a high rate of speciation) and also by the great age of this South Indian land mass. It is unfortunate that we do not have sufficient scientific data to study the different stages and gradual development of the primary forest communities of the evergreens in this tract. Nor do we possess enough information about the relation of mixed and single dominant primary communities, about primary succession etc. It is desirable that study of this aspect is immediately taken up on the lines indicated by Richards in his 'Tropical Rain Forests'.

Theory of Climax of Rain forests—The climatic climax is regarded as a final stage of stability in the development of vegetation. There are two views about the climatic climax, viz., (1) the *Mono-Climax* theory and (2) *Poly-Climax* theory. According to the former all vegetation under a given climatic region tends to develop towards one and the same climax except where special conditions of soil or topography hinder normal development and lead to sub-climax. The poly-climax theory on the other hand considers the development of vegetation as leading to a series of climax types, all equally stable but suited to different conditions of soil, topography and drainage. A study of the floristic composition of the forests of this State shows that these can be conveniently harmonised within poly-climax theory. But it should be recognised that factors other than climate, for instance the parent rock, topography, etc., do play an important part in the soil development; and this can result in more than one type of mature soils within the same climatic region. The vast reed forests and also patches of stunted tree growth within the evergreen tract, can be classified as edaphic or bio-edaphic climaxes. So also pure patches of *Balanocarpus utilis*.

B. Secondary Succession—After existing for millions of years with little or no disturbance, the evergreen forests have been mainly disturbed in the middle of 19th Century. This involved widespread destruction of the forest to make way for agriculture, coffee, tea and rubber plantations. Such destruction has affected large areas of virgin or primary forest in Kanyakumari and Coimbatore districts and to a lesser extent in Tirunelveli. Of such cleared areas, much has been subsequently abandoned, before the beginning of this century. Thus, at present, the secondary growth in these abandoned clearings varies from stands of herbs and grasses (upper slope of Veerapuli reserves in Kanyakumari) to dense forests not very dissimilar in appearance to the original primary vegetation. Vast areas of grasslands resulting from deflected succession are not an uncommon feature. Secondary communities derived from these evergreen forests, have the aspect of forest, scrub, savannah (as is often the case) of a chaotic wilderness of trees, shrubs, herbs and climbers. They are always more or less unstable and thus from distinct stages in secondary succession. Given absolute rest, without fires, grazing and fellings, these areas can be gradually colonized by primary forest species and there is no doubt that the climatic climax would re-establish itself in the long run. Some of the abandoned estate in Kuttalam, Kalakad and Papanasam reserves are example of such complete recovery. On the other hand if subjected to fire, grazing or periodical shifting cultivation by hill tribes, deflected succession sets in, leading to stable biotic climaxes. The above observations are mere based on the sketchy and fragmentary data available, whereas the study of secondary and deflected succession is complex subject for which the details can be fully obtained only by carefully quantitative observations made over a long period. Such observation should be undertaken soon.

Virgin forests have given place to secondary succession for different reasons. One important cause is *Kumri* cultivation by hill tribes. This is still common in Kanyakumari and Singampatty forests. A patch of forest is felled, though very often bigger trees are spared. The felled growth is burnt and crops such as tapioca, maize, hill rice and plantains are cultivated. Humus is rapidly destroyed by exposure to sun and rain; the ground generally receives little tilling and no manure; and the soil soon becomes infertile. After 2 or 3 years as soon as the soil is impoverished, the plot is abandoned to be overtaken by natural second growth or by *Eupatorium*, grass etc. Plantations of tea, rubber and coffee are generally established on permanent basis but often the story is otherwise. Either due to

pests or disease or uneconomic expenditure many a clearfelled area has been abandoned to be followed by a secondary succession, but very different from abandoned areas of shifting cultivation. Examples of such abandoned estates are to be seen about Balamore in Kanyakumari. The third cause for the destruction of the primary forests is fire. However, fires can occur only in exceptional weather conditions.

Areas of primary rain forest subjected to selective exploitation of timber (selection felling) or to selective removal of overhead shade in order to underplant cardamom (in leased areas). The gaps left by the removal of timber trees become colonised by secondary species and the community thus becomes a mixture of primary and secondary forests of irregular structure. Some of the cardamom lease areas and the old timber coupes in Papanasam and Singampatty forests are typical examples of such depleted forests. The gaps are colonized by *Trema* sp., *Macaranga* sp. etc.

General features of Secondary Rain forest—The course that a secondary succession takes, depends on the size of the cleared area; its distance from uncleared areas, the local conditions of climate, topography, soil type, degree of humus destruction, soil erosion and soil impoverishment. Soil impoverishment in turn depends on how long and in what way the area was utilised (cultivated), whether it was burnt or the slash left to rot on the ground after clearing, the slope of the ground and the amount and intensity of rainfall etc. The course of a secondary succession is to some extent dependent on the intrinsic characteristics of the soil and is different, e.g. in Tirunelveli and Kanyakumari. The history of the site between the clear-felling of original growth and the beginning of secondary growth is also an important factor. If the intervening period under cultivation was long enough to alter the structure of soil and destroy its humus reserve or if there is considerable erosion, the subsequent succession is different from that on an area where the secondary succession sets in soon after clearing of the primary forest.

Some of the general characteristics of secondary forests in their early seral stages are given below :

The secondary forest is lower in height and consists of trees of smaller average dimensions than those of the primary forest. Occasionally trees of much larger dimension (which belong to the primary growth) may occur scattered. Seen from above it has a more level surface than a primary forest. For example the young secondary growth in Kuliratti estate of Kalakad and several abandoned fields in Singampatty and Papanasam forests look like smooth lawns when seen from the neighbouring hill peaks whereas in the more darkly coloured primary forests the crowns of individual species can be distinguished even from a great distance. Very young secondary forest is often remarkably regular and uniform in structure with abundance of small climbers and young saplings. At a later stage, an extremely irregular structure, with tangles of lianes and poor undergrowth, characterise the secondary forest. Later still a two-storeyed forest results, with *Macaranga* sp., *Mallotus* and *Trema* sp., in the upper storey and dense thicket of *Lantana camara*, *Eupatorium* sp. or *Strobilanthes* in the lower storey. As years pass on, these even-aged stands of pioneer species become unable to regenerate under the new conditions they themselves have created. Naturally their proportion reduces abnormally due to increasing casualties. In their place climbers and slow growing and shade tolerant species appear.

Almost all the early secondary forest trees are light demanding. Though they grow well, ultimately they become suppressed by shade-tolerant species of either the primary forest or of the later stages of secondary succession. The early secondary species have efficient means of seed dispersal. This enables them immediately to colonize openings and clearings. Quick growth helps the species of the earlier stages of succession to establish themselves before they are shaded out by the slower growing secondary forest species. For example, *Trema orientalis* has light seeds. Seeds of *Alstonia scholaris* and *Anthocephalus cadamba* are dispersed by wind. *Macaranga*, *Mallotus* and *Trema* seeds are bird dispersed, whereas the dominants of primary species have no such special mechanism for wide dispersal of seeds. The rapid growth of *Macaranga*, *Trema* sp. etc., in cleared patches is a common place observation. Their fast growth is a nuisance to regeneration work undertaken in the tract. It is also observed that species characteristic of drier types of forest occur in the seral stages of evergreens. For example *Kydia calycina*, a tree usually found in dry deciduous forest, is often found in clearings in evergreen forests. After a certain stage, the secondary forest becomes more mixed in age-classes and floristic composition till it approximates to the condition of mature forests. The secondary succession thus differs from the normal regeneration of a primary forest, in which the gaps formed by the death of large old trees are temporarily colonized by the same fast growing, easily dispersed species as

dominate secondary forests. In depleted forests like Singampatty and Papanasam timber series, where larger number of trees has been removed by selection felling, the situation is intermediate between a clear-felled area and a primary forest with naturally formed gaps.

Biotic Climax—"In every part of the Tropical rain forest the tendency of a secondary succession is towards the restoration of the climatic climax, although fire, grazing and soil deterioration due to over-cultivation may deflect the succession and lead to the stabilisation of a biotic climax". Thus, the vast stretches of grassland amidst the evergreen forests in Kanyakumari (between Balamore and Muthizhi) are biotic climaxes resulting from deflection mainly due to annual fires.

And, the natural gaps of cardamom in Papanasam, Kalakad forests are examples of a biotic climax, where by annual tending the secondary succession is inhibited at this stage for cardamom to thrive best. But for the biotic interference primary succession will usurp the gaps.

The Tropical rain forest is an excellent example of an ecosystem in which climate, soil, vegetation and fauna are components in an extremely complex equilibrium. If one of these elements in the primary forest is destroyed, partially or completely, the other elements undergo an equally violent change. During the subsequent secondary succession microclimate, soil and fauna undergo development parallel to that of the vegetation until a balance is once more attained. These changes and development are too many and too complex.

Some Field Observations in the Evergreen Forests of Madras

The following observations are made as a result of numerous visits to the evergreen forests of Madras State including some in the divisions in Malabar and South Kanara which were part of the former composite State of Madras.

A. Gregariousness and Zonation—It is well-known fact that much variation in the distribution of deciduous species is noticed which cannot be satisfactorily accounted for. For instance at Mount Stuart, *Terminalia tomentosa* is one of the common species whereas in Punachi forests, a few miles to the east, it is virtually absent. The same appears to be the case with some evergreen species. At Wynaad near Coorg border *Dipterocarpus indicus* is a common species whereas it is not found in any division of the present Madras State. In Tirunelveli, *Hardwickia pinnata* is common on either sides of the Serviar near Kedumadi. In Kannikathu only a few miles to the south it is absent. *Gluta travancorica* and *Balanocarpus utilis* appears to be confined to Tirunelveli district only in the State.

We are aware of the well-defined species zones in the Himalayas. There are definite *chir* pine zone, the deodor and *kail* zone, the spruce and silver fir zone and the oak zones. Similarly in our evergreen forest differentiation into zones of associations, if not species can be recognized but it is not so obvious with gregarious species. In fact, though evergreen species grow in intimate mixtures, there are some which tend to grow gregariously when condition of elevation and locality are at the optimum for the respective species. Such species are *Hopea parviflora*, *Balanocarous utilis* and *Poeciloneuron indicum*.

Hopea parviflora and *Balanocarpus utilis* are definitely low elevation species occurring between 300 and 500 metres elevation. But when moisture conditions are favourable they may be found even at 200 metres elevation.

Cullenia, *Palaquium* and *Gluta* occupy what may be called middle zone. Generally speaking the zone for these species seem to be narrower than that for *Mesua* which may be seen further up as in Silent Valley and Attapadi reserves of Palghat but below that zone as in Ambasamudram range. In practically the highest tree zone in Kanyakumari and Tirunelveli (beyond Sengalateri, Kannikkatti or on Kuthukuzhi) a species of *poon* (*Calophyllum trapezifolium*) mixed with *Podocarpus latifolia* is common. This occurs in high zone between 1,000 and 1,500 metres. In Silent Valley and Attapady of Palghat, *poon* (*Calophyllum elatum*) is very common in zone above that of *Mesua*; but it also occurs to a small degree in *Mesua* zone itself.

B. Age Class Representation—For lack of distinct annual rings, the age of evergreen species in a natural forest cannot be determined and this renders the study of age class representation very difficult. All the same based on a superficial study, the following observations are made from the enumeration figures available from various tracts. Even

within the same sub-type e.g., *Mesua-Palaquium* all stages of growth from saplings to dominant trees of a particular species do not occur equally abundantly. *Palaquium* which is prolific in seedling and sapling stages ultimately becomes less common than *Mesua* in its incidence at the dominant stage. Therefore, any attempt made to correlate the percentage of a particular main species at different stages (or girths) does not lead to any definite relationship. This, however, is in keeping with the characteristics of these tropical rain forests where all the main species cannot thrive uniformly under the varying conditions of microclimate.

C. Adaptions of Evergreen species—By far a large number of evergreen species have developed certain mechanisms suited to their environmental conditions. These characteristics are buttressed base, thin and smooth bark, deep green, more or less elliptical, entire leaves with a pronounced drip tip, simple cauliflory etc. The leaves become smaller in size as the tree grows up in height.

Economic Possibilities of Evergreen Forest

The revenue through timber and minor forest produce is but limited. The protection of these forests is mainly in order to preserve the catchment areas of important water courses. Without impairing their evergreen nature and their role as regulators of stream-flow, these forests can yield substantial return by under-planting of cardamom or cocoa. Already some suitable patches in Madurai, Ramnad and Tirunelveli districts have been leased out for cardamom cultivation up to elevations of about 900 metres. Cocoa can also be raised as an under-storey. In the semi-evergreen forests, where rainfall conditions are favourable, elevation below 400 metres, rubber can lucratively be raised. Species like cloves, nutmeg and pepper can also be raised in the semi-evergreen forests.

The reed areas which occur mixed or pure, are of value as a source of raw material for paper and rayon industries.

SILVICULTURE AND MANAGEMENT OF THE TROPICAL MOIST EVER-GREEN FORESTS OF MADRAS STATE

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Abstract

The extent of tropical evergreen forests in the State is very limited; typical occurrences have been briefly described. These forests are worked mainly under selection fellings adopting a suitable felling cycle and a minimum but variable girth limit for the different exploitable species. A limit by number of trees that may be felled per acre is also prescribed as a safeguard against any excessive opening of the canopy.

Natural regeneration is generally adequate but there is need to provide optimum conditions of growth and afford preferential treatment for the development or regeneration of the more useful species. The establishment of such regeneration within the shortest possible period would, of course, have a direct bearing on the sustained yield during successive felling cycles.

In the past, artificial regeneration in gaps was attempted but without much success. Results of the experiments concerned are briefly stated.

A feature of the tropical evergreen forests in the State is the cultivation of cardamom as a ground cover.

Necessity for further studies on the regeneration of evergreen species and utilization of their timbers is stressed.

Introduction

Over most of the area of Madras State the rainfall is too low to support anything like tropical wet evergreen forests. This type of forests is confined to comparatively small areas of the western ghats in Tirunelveli district, on the Anamalai hills of Coimbatore district and in small, isolated pockets in Madurai and Ramanathapuram districts. These forests are mainly confined to the hills bordering Kerala State, where the annual rainfall is usually over 100 inches.

The silviculture and management of these forests received but inadequate attention in the past, since the forests are situated in relatively remote localities. Their very location also often renders them uneconomical for exploitation. Another contributory factor was that a majority of the species comprising these forests were considered of but little timber value and hence unsuitable for exploitation. But the position has changed during recent years. The demand for timber in the country has increased tremendously and supply is so short of demand that these forests can no longer be considered uneconomic for valuable timber production. Modern methods of wood preservation and seasoning have helped to increase the durability and utility of many species. New industries such as the plywood, matches, wood pulp, rayon and other undertakings have entered in new uses for wood and have thus pressed into use a number of species which were hitherto considered useless. In this context the tropical evergreen forests have attained the status almost of a valuable store house of wood wealth.

Types of Forests

In Tirunelveli, Ramanathapuram and Kanyakumari districts, the tropical wet evergreen forest is found at elevations from about 2,000 feet and extending upwards to nearly the crest of the mountains, upto 4,500 feet. Some of the more important tree species found are—*Mesua ferrea*, *Cullenia excelsa*, *Gluta travancorica*, *Palaquium ellipticum*, *Cedrela toona*, *Acrocarpus fraxinifolius*, *Hopea parviflora*, *Bischofia javanica*, *Mangifera indica*, *Eugenia* spp., *Elaeodendron glaucum*, *Elaeocarpus tuberculatus*, *Canarium strictum*, *Dysoxylum malabaricum* and *Vateria indica*. The undergrowth consists principally of species of canes, wild cardamom, *Pandanus*, *Solanum* etc.

Along the higher slopes in Tirunelveli district, generally above 3,000 feet in elevation, extensive areas may be locally covered with dense growth of reeds—*Ochlandra brandisii* and *Ochlandra travancorica*. These reeds form vast and impenetrable thickets, 10 feet

to 15 feet high, amidst which stand out scattered trees. A picturesque feature of the reed areas is the gregarious growth of the palm, *Bentinckia coddapanna*, which usually colonises the steepest portions of rocky peaks and knolls above 4,000 feet elevation. It is a generally accepted view that the reed encroaches on the evergreen forest and not *vice versa* and this is borne out by the frequent occurrence of isolated large trees of *Palaquium ellipticum*, *Mesua ferrea*, etc., in a sea of reeds. The area covered by the reeds is estimated as about 35,000 acres.

At lower elevations of about 1,000 ft., where the average annual rainfall is about 75 inches, a semi-evergreen type of forest occurs, the principal species met with being *Balanocarpus utilis*, *Hopea parviflora*, *Pterospermum rubiginosum*, *Pterospermum glabrescens*, *Aglaiia courtallensis*, *A. barberii*, *Nephelium longanum*, *Hardwickia pinnata*, *Stereospermum chelonoides*, *Dalbergia latifolia*, *Chukrasia tabularis*, *Artocarpus integrifolia*, *Diospyros* spp., and *Bischofia javanica*.

The tropical wet evergreen forests in Coimbatore district occur on the Anamalai hills, generally between elevations of 2,000 to 5,000 feet. These forests occupied an extensive area in the past but much of them have been cleared for the planting of tea. The species composing the tropical evergreen type here are as usual numerous, the chief tree species being—*Mesua ferrea*, *Poeciloneuron indicum*, *Palaquium ellipticum*, *Hopea parviflora*, *Cullenia excelsa*, *Calophyllum elatum*, *Vateria indica*, *Heritiera papilio*, *Aglaiia roxburghiana*, *Dysoxylum malabaricum*, *Eugenia* spp., *Cedrela toona*, *Artocarpus integrifolia*, *Canarium strictum* and *Elaeocarpus* spp. Undergrowth is comparatively sparse and includes species of cane, *Pandanus*, cardamom, *Curcuma*, *Strobilanthes* besides *Laportea crenulata*.

Based on associations of the predominating species, the following three sub-types are distinguished in the tropical evergreen forests of Anamalai hills.

- (i) The comparatively dry types of Tunacadavu and Ulandi blocks (70"—100" annual rainfall) in which *Hopea parviflora* and *Mesua ferrea* occur in appreciable quantities (*Hopea-Mesua* association).
- (ii) The intermediate type found in portions of Punachi range where the rainfall is about 120 inches in which preponderate *Mesua ferrea* and *Palaquium ellipticum* (*Palaquium-Mesua* association).
- (iii) In regions where the annual rainfall is 200 inches or more, as in the Italiar valley of Punachi range, the predominating tree species is mostly *Poeciloneuron indicum* with a small admixture of *Cullenia excelsa* (*Poeciloneuron-Cullenia* association).

The tropical evergreen forests in Madurai district are confined to small, sheltered pockets in Cumbum and Palni hills. The chief tree species are *Bischofia javanica*, *Cedrela toona*, *Chukrasia tabularis*, *Elaeocarpus tuberculatus*, *E. serratus*, *E. oblongus*, *Canarium strictum*, *Myristica* spp., *Lagerstroemia lanceolata* and *Eugenia* spp., with a sprinkling of *Michelia champaca* and *Acrocarpus fraxinifolius*. Occasionally *Mesua ferrea* occurs along streams.

Methods of Management

The tropical evergreen forests of the State are worked under a system of selection fellings. A comparatively long felling cycle is adopted and commercially exploitable species are extracted adopting suitable girth limits. The essential principles in the working of these forests are to ensure that their evergreen character is not endangered, that there is no setback in their ecological status on account of excessive exploitation and that the canopy is never permanently disturbed. With a view to ensure all this not only high girth limit is adopted but the number of trees that may be removed from every acre during each felling cycle is limited. The girth limit is generally 7 feet at breast height and the felling cycle is usually 30 years. However, in areas with a preponderance of overmature trees and where it is considered desirable to remove such trees speedily, a shorter felling cycle may be adopted. The maximum number of trees of all species permitted to be removed from any one acre during each felling cycle varies from 3 to 6, depending upon the condition of the crop.

Natural Regeneration

At present reliance is placed entirely on natural regeneration, for restocking areas under working. The observations in the various working plans, based on sample enumerations, indicate that natural regeneration of the desired species is generally adequate.

Experiments have been carried out in Karian-shola forests of Coimbatore South division on natural regeneration of a few of the evergreen species viz., *Hopea parviflora*, *Mesua ferrea* and *Palaquium ellipticum*. Conclusive results are yet to be derived except that it has been ascertained that canopy opening does help in the establishment and subsequent development of natural regeneration, particularly in the case of *Hopea parviflora*. But the number of species that concern us in these forests is very large and the light requirements of one species are often not the optimum for another.

The presence of adequate natural regeneration over most of the areas of tropical evergreen forests in the State tends to give us an optimistic view of the future of these forests under the present method of management. This is evident from the fact that though detailed prescriptions regarding selection fellings are contained in the working plans, it has not been considered equally necessary to prescribe measures for the establishment and tending of the regeneration in the exploited areas. In practice, little else is done apart from executing the selection fellings according to the prescriptions.

It is essential, however, that the yield from a felling series is sustained during successive felling cycles. This can be ensured only if natural regeneration is given the most favourable conditions for its further development and the progress from seedling to pole and from pole to tree accomplished in as short a period as possible. Only then will it be possible for the future crop to keep pace with the progress of fellings and thus permit of a more or less sustained yield being realised during successive felling cycles. What would constitute such favourable conditions is yet to be specifically ascertained. For instance, it is to be determined whether any preparatory operations are necessary before timber fellings, in order to induce natural regeneration where such regeneration is either inadequate or absent. After timber fellings, necessary measures by way of canopy manipulation, weeding, tending and thinning for the establishment and subsequent development of natural regeneration are yet to be standardised.

The selection fellings concentrate in practice on the removal of a few, commercially utilizable species and it is obvious that by such fellings there will be progressive reduction in the proportion of such useful species in the crop. Therefore, in all the regeneration operations, it should be the aim to encourage the reproduction of the more useful species and in cases where natural regeneration cannot be relied upon for this purpose, it is necessary to restore to artificial regeneration.

Artificial regeneration

In the past artificial regeneration in gaps was undertaken in the tropical evergreen forests after the completion of selection fellings, but this did not give results commensurate with the time and money involved in it and hence this method of artificial regeneration was given up.

Subsequently, raising of concentrated plantations of the more useful species under a shelterwood in the most accessible localities was thought of. Experiments have shown that some of the important timber species in the evergreen forests can be raised artificially without difficulty. The best shade conditions are obtainable from a high top canopy only. It is also observed that for most species the best method of introduction is transplanting. Burning before regeneration operation is not considered desirable. Though encouraging results have been obtained in experimental work with the artificial regeneration of the evergreens, large-scale work on these lines has not been carried out to any appreciable extent.

While discussing about the artificial regeneration in evergreen forests, mention may also be made to the attempts of raising teak plantations by clear-felling semi-evergreen forests in Papanasam hills of Tirunelveli district. A total area of about 566 acres was planted with teak between the years 1917 and 1950. Results have been generally satisfactory.

Cardamom cultivation

A feature of the tropical evergreen forests in Madras State is the presence of numerous cardamom leases. The right to farm for cardamom is leased usually for a period of 25 years with a provision for renewal for a further period of 20 years.

For cardamom cultivation shade is essential and hence the cultivator takes care to preserve the trees in the top and middle canopies. However, in the process of weedings and other cultural operations for cardamom plants, seedlings and poles of tree

species are ruthlessly removed. Consequently an area brought under cardamom cultivation may cease to serve for sustained timber production.

Conclusion

Under the present system of working wherein selection fellings are concentrated on a few species, there must result a steady reduction in the proportion of those species and unless special measures are taken for the regeneration of these species, after first fellings the number of exploitable trees per acre must progressively fall off. Measures to achieve such regeneration, as well as subsequent development of the regeneration within the shortest possible period, have to be studied further.

Another equally important subject that requires investigation is the utilization of the numerous species comprising these forests. No doubt, in recent years, owing to the acute shortage of timber, many of these species have been brought into use but many more species still remain unknown in the market. The best uses to which these timbers can be put are to be investigated on priority basis.

FEATURES OF PROTECTION IN THE TROPICAL MOIST EVERGREEN FORESTS IN THE MADRAS STATE

BY K. ANDIAPPAN,

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In Madras State, the characteristic tropical rain forest is confined to the eastern slopes of the Western Ghats. The location, type and composition can be broadly accounted for as follows :—

- (1) **High altitude (temperate) sholas**—They are studded amidst a vast sea of grass on the Nilgiris, and are commercially non-remunerative. The growth is stunted. The main species found represent the natural orders *Myrtaceae*, *Styraceae* and *Lauraceae*. Ferns and mosses cover the ground abundantly. The annual rainfall varies from 80 to 300 inches.
- (2) **Typical rain forests**—They occur at altitudes ranging from 2000' to 5000'. They are floristically luxuriant and commercially valuable. Stratification may be distinguished into 3 to 5 tiers. They are found on the Anamalais of Coimbatore district, the Palnis of the Madurai district and the Western Ghats of Tirunelveli and Kanyakumari districts. The rainfall ranges from 100 to 250 inches per annum. Trees are lofty with a fair proportion of useful species like *Mesua ferrea*, *Hopea parviflora*, *Calophyllum* sp., and *Poeciloneuron indicum*. In this type, distinct associations are recognised.
- (3) **The semi-evergreen type**—It occurs below 2000' and down to 1000'. This is characterised by species like *Balanocarpus utilis*, *Hopea parviflora*, *Hardwickia pinnata*, *Bischofia javanica*, *Diospyros* sp., *Mangifera indica*, *Lagerstroemia lanceolata*, *Dalbergia latifolia* etc. This type occurs in parts of Gudalur taluk of the Nilgiris and in Tirunelveli and Kanyakumari districts.

A large part of this commercially valuable evergreen forests was the target of early European settlers for coffee and tea planting. 50% of the 77 sq. miles of the tropical wet evergreen forests of the Anamalais have been replaced by tea, coffee or cinchona. Similarly large areas were cleared and set apart for coffee plantations in the Tirunelveli district and actually assigned in Kanyakumari district. The renowned Karian-shola on the Anamalais which extends over 3 sq. miles, and the accessible portions of similarly useful *sholas*, extending over 200 sq. miles in Tirunelveli district were heavily worked during second World War to meet the ever-increasing defence requirements. Thus the virgin evergreen forests intended by nature to play a protective role in the conservation of moisture, protection of fertile soil, regulation of streams, etc., were encroached into gradually. The following statement shows the extent of encroachments the forests have suffered :

The nature of money crop introduced and other types of encroachment	Areas on the		
	Nilgiris	Anamalais	Tirunelveli & Kanyakumari districts
	Acres	Acres	Acres
Tea, Coffee and Cinchona Cardamom	15,000 —	50,000 10,000	12,000 1,500
Commercial Timber Extraction	Sleeper and war timber		War timber

Injuries

(1) *Man*—Among the injuries to which the *sholas* are susceptible, *man* has been the most potent factor. Vast tracts of evergreen forests have been destroyed for introduction of commercial crops. Even in the so-called selection system of working, when large trees are felled and removed, innumerable poles and saplings of valuable species are damaged. Often, the gaps caused are occupied by prolific growth of persistent and obnoxious weeds and fast growing *Trema orientalis*, *Erythrina* sp., *Maesa perrottetiana* etc. As shade trees for Coffee, Cinchona and Tea, in the place of local species, new, fast growing species like

Grevillea robusta, *Albizzia stipulata*, *Erythrina* sp., are introduced. Even in cardamom areas, all storeys except the top-most one are removed and cardamom alone forms the ground cover. Any attempt at natural regeneration of the tree species is discouraged and where gaps are created in the canopy by a fall or death of over-mature trees, fast growing species like *Macaranga* are introduced. In Tirunelveli, the Marvans of Tenkasi and Sankarankoil taluk, go into the great depths of the *sholas* and collect thousands of *Mesua ferrea* saplings every year for disposal at good prices as sticks and clubs. Shifting cultivation by hill tribes is another adverse factor especially in the *sholas* of Gudalur in the Nilgiris and in Kanyakumari.

(2) *Wind*—Causes great damage in the newly worked coupes and on steep slopes where gaps have been created by fall of over-mature trees or removal of selection trees. The break in the canopy of a *shola* may prove as vulnerable as breaches in a fortress wall and the strong wind during monsoon blows down trees and saplings. The havoc is greater in water-logged soils where tree roots are superficial. On slopes, serious loss of soil due to landslips may follow.

(3) *Landslips*—High winds, when they act on holes and gaps created by clearings in the *sholas*, prove too strong for even deep rooted trees, particularly on rain soaked slopes and soils and cause serious landslips.

(4) *Climbers* like *Entada scandens*, *Bauhinia* sp. also cause not a little damage when they entwine the useful species.

(5) *Animals*—Bison, sambhur and deer browse down young seedlings and saplings of *Hopea*—Porcupine, bats, squirrels, monkeys and rats consume large quantities of seeds and fruits of *Mesua*, *Elaeocarpus*, *Dysoxylum*, etc. Wild pigs dig into the ground and uproot and destroy many seedlings.

(6) *Fire*—Though fires play no specific role as such in evergreen forests, frequent and recurring occurrence of fire around them results in the *shola* being pushed back thus resulting in reduction of its area.

(7) *Insects*—Stem borers in large numbers cause considerable damage to *Hopea parviflora*. A Cerambycid borer riddles longitudinally and radially through the stem of *Mesua ferrea*. This damage is very heavy in some localities e.g., the sleeper coupes in Punachi range. Trypetid grubs riddle the fruits and seeds of *Dysoxylum*.

(8) *Fungi*—The huge bracket shaped polyporous fungi infest trees of *Mesua ferrea*, especially of over-mature size.

(9) *Other injuries*—Twisted fibre is formed in species like *Mesua*. Hollowness is a common feature in mature stems. Rot sets in quite often in the timber of *Calophyllum*.

(4) *Protection*—Evergreen forests require protection mainly from the ravages of man. One of the foremost duties implicit in *shola* management is the care for the health and safety of the crop and of the soil that supports it. Even the Forest Department has to guard against careless and greedy exploitation. That the Forest Officer was conscious of this from early times is evidenced by the fact that Dr. Brandis (in 1882) advised in respect of Tirunelveli and other districts, stoppage forthwith of the alienation of *shola* areas for cultivation. Shifting cultivation should be prevented by tightening up protection. Necessary legislation should be enacted prohibiting encroachment into *shola* areas. In any method of working, every care should be exercised to follow up with systematic and repeated regeneration measures, especially of useful species. Efforts should be made to tackle the silvicultural problems involved in successful regeneration. Inaccessible and far off *shola* areas should not be exploited at all. Care has to be taken against the destruction of seeds by pests and vermin so that the establishment of useful species is ensured. Climber cutting should become a regular operation in the *sholas*. Firing on the fringes of *sholas* should be avoided and prevented. Research on the fungal and borer attacks is indicated.

FORESTS AND FORESTRY IN THE ANDAMAN & NICOBAR ISLANDS

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Location and Climate

A group of 204 big and small islands known as the Great Andamans lies in the South-East of the Bay of Bengal between latitudes of 92°-11' and 93°-7' East and 10°-30' and 13°-41' longitudes North and runs in a North-South line for about 220 miles in length with an average width of about 15 miles, covering about 2,500 sq. miles. Another group of islands known as the Nicobar Group consisting of about 19 islands lies separated from the Andaman Group by 150 miles to the South. As the forests of the former group alone have been studied and worked in the past, this note is confined to these islands.

The configuration of these islands is rough, consisting of a series of mountain peaks which arise abruptly from the level of the sea. The result is that in the Andaman Group there are very few valleys where the level land is found to an appreciable extent.

The characteristic feature of the climate of the Andaman Islands is that it is equable, the temperature varying between 70° F and 90° F with a humidity range of 75% to 90%. The annual rainfall varies from 100" to 130" of which about 80% is derived from the South-West monsoon and the balance from the North-East monsoon. Cyclonic weather prevails in July-August during the peak period of the South-West monsoon, and December-January during the peak period of North-East monsoon.

General History of Forestry in the Andamans

The primeval forests which exist in these islands were for the first time disturbed in 1857 when the settlement was started. The earlier operations were confined to clearances for roads, buildings etc. It was gradually realised that the dense forests of these islands may yield valuable timber and the first Forest Officer was deputed to the Andamans in 1883. The early forest operations consisted in the removal of padauk from the more accessible localities. Mr. Ferrard the first Divisional Forest Officer explored the South Andamans in 1886 and submitted a report for the exploitation of the forests. Although fellings were irregular, it goes to his credit for starting the earliest of the teak and padauk plantations. However, this attempt at artificial regeneration was abandoned after a few years.

In the subsequent years there were various officers who explored the Andamans but the first exploration which was based on regular lines of survey along the main beds of the streams, was carried out by Mr. C.G. Rogers in 1903-1904. The results of those explorations did not alter the mode of working. It continued to be a selective and irregular working of the forests in the easily accessible areas, in spite of the fact that Todd explored the North Andamans in 1904 and eventually prepared a Working Plan in 1906.

The First World War resulted in a stimulus being given to some of the lesser known species of the Andamans and a new division called the North Andaman division with its headquarters at Steward Sound was opened in 1918. In 1921 felling of selected species with a girth limit was discontinued and clear-felling system was introduced. Soon after, however, having failed to regenerate the clear-felled areas, the previous system was again introduced and continued to be in vogue up to even after the Second World War. Thus, the history of forestry operations in the Andamans indicates importance of logging operations which were concentrated on the easier areas and more particularly round about the harbours. The result was that in the greater part of the South Andamans and Middle Andamans the forest in the most accessible areas had been creamed of the best timber, leaving the more remote forests to be worked in the future.

The next Working Plan prepared by Deans in 1936 was not followed. The Working Plan prepared by B. S. Chengappa in 1951, which although could not be adhered to strictly on account of the colonisation schemes being put into operation, for the first time laid down regular exploitation of the forest with natural regeneration in the clear-felling areas.

Several Inspector Generals of Forests have pointed out about the rather loose nature of the working of the Andaman Forest Department. This prevailed even after the last World War and as late as 1947 the then I.G.F., Mr. Hamilton has remarked

"There does not appear to me to be a sanctioned and properly organised cadre in the Andamans. The organisation gives me the impression that it has always been based on a temporary and changing requirement of a series of lumbering camps. There does not appear to be a framework for proper management". It was only as late as 1951 that the need for some sort of territorial jurisdiction was felt and three divisions namely, South Andaman, Middle Andaman and North Andaman were constituted. But even here it must be recalled that the officers-in-charge of the divisions were practically without power and without a well defined plan of operations to execute. It was only as late as 1958 that the three divisions mentioned above were formed to function as normal divisions as on the mainland. Even now, due to the effect of the long standing practice it is feared that it will take some time for these divisions to function in a normal way.

The Forests and their Classification

Except for about 150 sq. miles of level land and undulating areas which have been cleared for settlement and agricultural needs of the settlers, the rest of the area of these islands from water's edge to the summit of the highest hills is covered with luxuriant growth of dense forests, tangled by climbers, canes, bamboos, etc. Along the water's edge in sheltered places and in creeks which penetrate deep into the islands extend the mangrove forests. Large sized commercially valuable species are present in these forests almost throughout their range except the uppermost parts of high hills and steep slopes where growth becomes very stunted and scrubby. The vegetation of these islands has been divided into different types or classes depending upon the nature of the soil, tidal influence, moisture retentivity and floristic composition. Climatically these islands are more or less uniform since altitudinal variation is small and aspect is a factor which has little influence in such low latitude. The two major categories into which the forests can be divided are the group where the forest is mostly a function of the edaphic factor and the group where the climate holds away, as follows :—

- (a) Edaphic pre-climax forests where the forests are influenced by site factors in addition to climatic factors :
 - (i) Tidal forests (Mangrove forests)
 - (ii) Beach forests
 - (iii) Riverain forests (Low level)
- (b) Tropical and climatic forests :
 - (i) Moist deciduous forests
 - (ii) Wet evergreen forests.

A detailed classification of the above according to Champion's classification of forest types, has not been yet attempted. The following 14 types exist in the Andamans. Quite a few of these merge into each other imperceptibly and are difficult to identify whereas others offer a distinct contrast and can be made out without any difficulty.

- | | | |
|----------------|----|---|
| 1. M.Tr/IS/2a | .. | Low Mangrove Forest |
| 2. M.Tr/IS/2b | .. | High Mangrove Forest |
| 3. M.Tr/IS/1 | .. | Beach Forest |
| 4. M.Tr/IS/7a | .. | Southern Tropical Moist Deciduous Riverain Forest |
| 5. M.Tr/IS/8a | .. | Southern Tropical Semi-Evergreen Riverain Forest |
| 6. M.Tr/2S/8 | .. | Secondary Moist Bamboo Brakes |
| 7. M.Tr/E.3 | .. | Andamans Moist Deciduous Forest |
| 8. M.Tr/E.8 | .. | Cane Brakes |
| 9. M.Tr/E.9 | .. | Southern Wet Bamboo Brakes |
| 10. M.Tr/E.10a | .. | Southern Moist Bamboo Brakes |
| 11. 2a | .. | Southern Tropical Semi-Evergreen Forest |
| 12. 1a/C.4 | .. | Southern Low Tropical Evergreen Forest |
| 13. 1a/C.2 | .. | Eastern Tropical Evergreen Forest |
| 14. 1a/C.1 | .. | Evergreen Dipterocarp Forest. |

A brief description of the above is given below :—

1. & 2. *M. Tr/IS/2a & 2b. Low Mangrove Forest and High Mangrove Forest*

Both these types fall under the category of Tidal Forests occupying the marshy alluvium and stiff clays inundated by salt water. They extend as far as the highest

reach of the tide along the sheltered sea-coast and up the creeks as far as the influence of salt water is felt. The Low Mangrove Forests which form more or less dense, gregarious, evergreen belts of *Rhizophora mucronata* and *Rhizophora conjugata* are those which extend farthest into the sea and take the full blast of the tidal current. The forests do not grow to a height of more than 20 ft. Other gregarious species found in patches are *Carapa granatum*, a species of *Phoenix*, etc. Species growing singly are *Avicennia officinalis*, *Ceriops candolleana* etc.

Just behind this belt along the higher reaches of the tidal creeks and where the influence of fresh water is also felt, extends the belt of High Mangrove Forests. A change in the soil between the former and the latter can clearly be seen in so far as it is rather clayey for the Low Mangrove Forests whereas in the High Mangrove Forests it tends to become loamy. This type which comes next in succession, is typically a High Evergreen Forest with a more or less closed canopy. The gregarious habit still continues and the trees attain a height of 40 ft. to 70 ft. The predominant species are *Bruguiera gymnorhiza* and *Bruguiera parviflora*. Below the more or less continuous crown of *Bruguiera* may be seen *Sonneratia acida*, *Nipa fruticans* etc. At the edges of these forests away from the sea and towards the zone of high forests, *Heritiera littoralis* is found.

3. M.Tr/IS/1. Beach Forest

Though this type forms a narrow belt of a few yards to a few chains in width just above the high tide level it is clearly distinguished from the above. The soil consist of sand, shingles, shell fragments etc., and is poor in mineral content except lime, being coarse, porous and more or less dry at the surface.

This type, which is locally known as "Mohwakhari" presents a completely distinct floristic composition having almost pure stands of Sea mohwa (*Mimusops littoralis*). This species attains a fairly large size with a long clear bole and acts as a very efficient wind belt. Its associates are *Calophyllum inophyllum*, *Terminalia catappa*, *Gyrocarpus americanus*, *Erythrina indica* etc., with an understorey of *Thespesia populnea*, *Pongamia pinnata*, *Guettarda speciosa* etc., In places where loose sand collects and where it is touched by high tide may be found *Ipomea biloba*, *Crinum asiaticum*, *Scaevola koenigii* etc.

4. M.Tr/IS/7a. Southern Tropical Moist Deciduous Riverain Forest

This type forms a very small percentage of the forests of these islands being confined to the well drained alluvium near the banks of the bigger streams. It merges into the next type i.e., the Southern Tropical Evergreen Riverain Forest. It is characterised by gravelly, sandy and very loose textured soil with *pyinma* (*Lagerstroemia hypoleuca*) and *thitkandu* (*Pometia pinnata*) as the predominating species. Also characteristic feature of this type is the complete absence of bamboos, canes and species like *gurjan* (*Dipterocarpus* sp.) and *padauk* (*Petrocarpus dalbergioides*) which are typical associates of the Southern Tropical Semi-Evergreen Forests. The floristic composition of this type consists of *Tetrameles nudiflora* and *Gyrocarpus americanus* in the topmost or emergent layer. Below the emergent layer are found *Lagerstroemia hypoleuca* (*pyinma*), *Dillenia pentagyna* (*zimbyun*), *Anthocephalus cadamba* (*kadam*), *Pometia pinnata* (*thitkandu*), *Sterculia alata* (*letkok*) etc. In the lower storey are *Litsaea chinensis*, *Fagraea morindaefolia*, *Garcinia andamanica*, *Pongamia pinnata* etc. The undergrowth is mainly composed of *Mallotus acuminatus*, *Clerodendron infortunatum* and *Leea* sp., etc. In this type of forest, there are small patches covered with a dense growth of *Saccharum arundinaceum* and sedges and supporting only a few scattered *kadam* (*Anthocephalus cadamba*).

5. M.Tr/IS/8a. Southern Tropical Semi-Evergreen Riverain Forest

These forests are found typically on alluvial soils along the banks of large fresh water streams which are sufficiently raised above the flood level and are, therefore, fairly well drained having a good sub-soil water supply. The soil is more clayey than the preceding type, its characteristic feature being that it is sufficiently old to let vegetation progress to a climatic climax.

The principal species in these forests is *Dipterocarpus alatus* (Syn. *D. incanus*), which grows to the largest size amongst *gurjans* in the Andamans sometimes reaching a girth of 30 ft. at breast height and a clear bole of about 100 ft. Other tree species of importance in these forests are *Sterculia campanulata*, *S. alata*, *Terminalia procera*, *T. bialata*, *Albizia lebbek*, *Bombax insigne*, *Artocarpus chaplasha*,

and very often *Pterocarpus dalbergioides*, *Lagerstroemia hypoleuca*, *Tetrameles nudiflora* etc. The trees are found scattered few and far between and so the ground floor is usually densely covered by shrubs and bamboos, climbers and cane brakes, forming a thick impenetrable tangle of vegetation. Clumps of bamboos (*Oxytenanthera* sp.) occur scattered in large patches and wherever bamboo patches occur, the stand of trees is extremely poor.

6. M.Tr/2S/8. Secondary Moist Bamboo Brakes

This type occurs usually in the upper portions of steep hill slopes particularly on their hotter aspects. It is seen characteristically in parts of North Andaman Island along the higher ridges of the Saddle range. The type consists more or less of a gregarious growth of bamboo brakes with a few scattered trees of *Dipterocarpus turbinatus*, *Terminalia procera*, *Sterculia campanulata*, *Planchonia andamanica* etc., which increase in their frequency in the sheltered hollows and other more favourably located patches.

7. M.Tr/E.3. Andamans Moist Deciduous Forest

This is a subsidiary edaphic type of moist tropical forests locally known as the "Padauk Type", which is found on the undulations and gentle slopes up to about 300 ft. elevation and covers about 45% of the total area of Andamans. Padauk is the most important timber species of these forests and is associated with many other valuable deciduous species such as *Terminalia bialata*, *T. manii*, *T. procera*, *Canarium euphyllum*, *Bombax insigne*, *Albizia lebbek* and a number of species valuable to the match, plywood and packing case industries. This is generally characterised by extremely rapid surface as well as sub-soil drainage and absence of perennial water sources.

8. M.Tr/E.8. Cane Brakes

Cane brakes occur in densely shaded wet hollows where the soil is permanently wet, consisting of fine clay rich in humus. A sharp contrast is offered by the presence of this type, the temperature being cooler than the Moist Deciduous types of forests, where the cane brakes are completely absent. This type is more in association with the evergreen and semi-evergreen climaxes than the deciduous ones. It forms an impenetrable thicket of long trailing stems with a few erect species also.

Cane species present in these brakes are *Calamus andamanicus*, *Calamus pseudo-rivalis*, *Calamus palustris*, *Calamus longisetus*, *Calamus viminalis*, *Daemonorops kurzianus*, *Daemonorops manii*, and *Korthalsia laciniosa*. The creeping bamboo (*Dinochloa andamanica*) is also invariably present. A few palms such as *Licuala peltata* and *Licuala spinosa* are also present. Large trees standing over the area if at all, are invariably *Dipterocarpus incanus*, *Planchonia andamanica*, *Pisonia excelsa* etc.

9. M.Tr/E.9 Southern Wet Bamboo Brakes

This type is also connected with the evergreen and semi-evergreen climaxes along sheltered valleys. Dense clumps of *Oxytenanthera nigrociliata* occur with scattered trees of *Dipterocarpus incanus*, *Planchonia andamanica*, *Pisonia excelsa*, *Artocarpus chaplasha*, *Hopea odorata* etc.

10. M.Tr/E.10a. Southern Moist Bamboo Brakes

This type occurs on the moist, shady and gentle slopes. The species forming such brakes are *Oxytenanthera nigrociliata* and *Bambusa schizostachyoides*, and species forming the standards are *Terminalia bialata*, *Terminalia manii*, *Canarium euphyllum*, *Bombax insigne* etc.

11. 2a. Southern Tropical Semi-Evergreen Forest

This type is more or less an imperceptibly transitional pre-climax form between the Tropical Evergreen and the Moist Deciduous types. It is not as dense as the Southern Tropical Semi-Evergreen Riverain type, though it very much resembles the same in its floristic composition. It has a mixture of both evergreen and deciduous trees, the former predominating.

12. 1a/C.4. Southern Low Tropical Evergreen Forest

This type occurs on steep hill slopes exposed to strong winds and having hard, reddish brown, infertile thin layer of soil. In the region of its occurrence there is usually heavy rainfall of over 100" and very often the atmosphere is cloudy and misty.

It occurs typically on the steep slopes of Saddle hill and its surrounding peaks in the North Andamans, Mt. Farrington in Middle Andamans, etc. The characteristic feature of this type is the presence of stunted trees which rarely exceed 30 ft. in height and 3 ft. in girth. The floristic composition in the overhead canopy is of *Dipterocarpus costatus*, *Mesua ferrea*, *Canarium manii*, *Harpullia eupanioides*, *Hopea andamanica*, *Cratoxylon formosum* etc. The principal shrubs present are *Memecylon caeruleum*, *Cryptocarya ferrarsi* and some small bamboos. A species of *Phoenix* is also present.

13. 1a/C.2. Eastern Tropical Evergreen Forest

This type forms the climax vegetation in areas of heavy rainfall having a more or less shallow soil overlying serpentine intrusions. It is found on the steeper slopes of the higher ridges, the tree growth being less luxuriant than in the Evergreen *Dipterocarp* type (1a/C.1). Floristically the two are more or less identical, there being no sharp line of division between them.

14. 1a/C.1. Evergreen Dipterocarp Forest

The Andaman Forests reach their climatic climax in this type and it constitutes the most luxuriant evergreen forests of the islands. It is found in the high hill slopes and ridges in which outcrops of igneous rocks of the serpentine type predominate. The rainfall here is the heaviest being well over 120" per annum. The soil consists of a deep clayey loam which is always wet, having a thick humus layer. The principal tree species is *Dipterocarpus grandiflorus* (Syn. *D. griffithii*) which attains the biggest size among the trees in the Andamans with enormous height growth and large girth. This species has the largest fruit of all the *gurjans*. The other *Dipterocarpus* which occur in the top canopy are *D. kerii* and *D. turbinatus*. It is of interest to note that whereas *D. kerii* occurs exclusively in the South Andaman Island, the other two have been reported to occur throughout the Andamans in this type of forest. Their associates in the top canopy, are, *Artocarpus chaplasha*, *Artocarpus gomeziana*, *Calophyllum spectabile*, *Planchonia andamanica*, *Hopea odorata*, *Endospermum malaccense*, *Sideroxylon longepetiolatum*, *Bassia butyracea*, *Amoora wallichii*, *Sterculia alata*, *Sterculia campanulata* with occasional and large sized *Pterocarpus dalbergioides*, *Terminalia bialata*, *Canarium euphyllum* etc. In the lower storey can be found *Xanthoxylum andamanicum*, *Myristica andamanica*, *Myristica glauca*, *Mesua ferrea*, *Baccaurea spida*, *Podocarpus neerifolia* (this is found only in certain tracts and is gregarious), *Croton argyratus*, *Pterospermum aceroides*, *Caryota mitis*, *Cryptocarya*, *Memecylon*, *Euphorbia epiphyllodes*, *Mitrephora prainii*, *Actephilla excelsa* etc. The chief climbers are *Dinochloa andamanica*, *Gnetum scandens*, *Ancistrocladus extensus*, and a variety of canes.

Management of the Andaman Forests

As will be seen from the history of the forests, Forestry in Andamans was confined to lumbering in the past, there being no real management. The staff existed mainly in temporary camps, whose only guiding principle was the creaming out of the forests in one accessible area and then moving on to the next.

The last Working Plan which was completed in 1951 laid down regular forestry operations as the key-note of working these forests. The forests were to be worked on a system of clearfelling annual coupes with natural regenerations as the silvicultural system to be followed. In addition to these coupes, certain areas were thrown open for selection fellings with prescribed girth limits. These selection fellings were heavy, and resulted in the degeneration of the forests. It has now become the practice to clearfell the areas completely rather than go for such selection fellings which resulted in the degeneration of the forests. Although much controversy has existed on the subject as to whether clearfelling is suitable for the semi-evergreen forests of the Andamans the problems of management and utilisation make any other system unworkable. With the present high cost of extraction, it has been found by experience that unless an area is completely worked the cost of extraction becomes prohibitive. Besides, the so-called selection fellings of the past hardly constituted any recognised system of working, they being heavy lumbering operations which left the forests poorer than before. The system of clearfelling these forests has, therefore, become inescapable on account of the economic factor.

Silvicultural System

The silvicultural system that had been prescribed in the last Working Plan was clearfelling with natural regeneration in the deciduous areas and a system in which advantage

was to be taken by retaining the advance growth in the case of evergreen forests. In both the cases, however, regeneration operations on an intensive scale were prescribed soon after felling and extracation was completed. As the latter operations were prescribed to be carried out over about 8,500 acres of forests in the North, Middle and South Andaman divisions, regenerating these areas on such a large scale has been found to be a difficult task. This in the context of Andaman Forestry, where labour has to be imported from the mainland and has to be paid high wages, coupled with the lack of adequate supervisory staff that the execution of regeneration operations will require over such wide area, made the task almost impossible.

The natural forests as they exist in the Andamans, have a wide range of stocking of commercial timber per acre. In places, it is as low as 3 tons per acre and in others, as much as 25 or 30 tons per acre. The earlier regeneration areas and plantations which are now about 30 years old give an indication that the regenerated areas will on maturity yield at least 60 tons of timber per acre. As the primary object of management of these forests is to convert the existing irregular forests consisting of a large number of inferior species into regular and well-stocked forests of commercially valuable species, the system which is being prescribed in the Working Plan which is under finalisation at present, will be that of compensatory regeneration both natural and artificial, being mainly natural for evergreen species and artificial for deciduous species. On the basis of this system regeneration operations are proposed to be confined to about 600 acres for each division along with 250 acres of teak plantations annually. The area so regenerated is expected to give an ultimate yield of timber which will be far more than the yield prescribed at present, *i.e.*, about 1 lakh tons per annum. The forests so regenerated will have stocking almost to the extent of 5 times the present timber stocking. This will thus maintain the essential principle of forestry, *viz.* provision of increasing yield for posterity. Since 1956 large scale teak plantations have been regularly raised bringing it up to 750 acres in 1960. The results of these plantations have been extremely encouraging and it is now prescribed that each division will raise 250 acres of teak plantations every year. These plantations in the course of time will prove extremely valuable, compared to the present species that exist in the original forests. The amount of labour and supervisory staff that exist at present in the divisions are expected to suffice in tackling regeneration operations over the areas proposed in the new plan.

Regeneration Technique

Although attempts at regenerating the forests had been made as early as the end of the 19th century, there could not be any appreciable success. In fact all attempts to raise natural regeneration in these forests were more or less abandoned by about 1921 in favour of clear-felling and planting. These failures resulted because either the attempts were confined to small gaps in the natural canopy of the forest where no regeneration could come up on account of the low intensity of light or on account of the error being committed by taking recourse to the other extreme, *i.e.*, creating large gaps which, with increased light stimulated weed growth to exuberance. Enough attention was not being paid to the subsequent cleaning and weeding before the young seedlings died. Attempts made in 1931 by Shri B.S. Chengappa, however, proved successful in getting regeneration of almost all Andaman species and the technique has since then been fairly standardised. As this technique has been fully described by Shri B. S. Chengappa in the *Indian Forester* of September, October, November and December, 1944, it is not being discussed in detail here. This technique briefly consists of the following operations :—

A. For Moist Deciduous Types

- (i) Exploitation fellings which are the initial regeneration fellings should remove all timber available by November leaving 4 to 5 padauk trees per acre and sufficient (*Diospyros marmorata*), marble wood and *chooi* (*Sageraea elliptica*) trees as mother trees which should be freed from the climbers.
- (ii) In December regeneration fellings consisting of the removal of all undergrowth up to 30 ft. height should be done. Trees above 30 ft. height may be girdled to lower the cost.
- (iii) A general burning is beneficial in March but no heaping and burning is necessary.
- (iv) Sowing is unnecessary but if seed bearers are absent broadcast sowings may be done.
- (v) In first year weedings in June-July should be done and in second and third year in August and September.

It has now been experienced that regeneration comes up profusely even if no seed bearers are retained.

B. For Wet Evergreen Types

(i) One year before the forest is due for felling it should be examined for seedlings of valuable species like *gurjan*, *toungpeing*, *lambapatti*, etc. and if seedlings are found the undergrowth up to height of 20 ft. from ground level should be cleared as soon as possible. Evergreen areas without seedlings are rare but if such areas are found the treatment should be modified to the extent that whenever *gurjan* seed profusely and the seedlings appear on the ground (this invariably happens every second or third year) the undergrowth up to 15–20 ft. should be cleared at once. These seedlings then establish themselves.

(ii) *Gurjan* does not seed every year. Seeds also lose their viability soon. Artificial methods of regenerating this species have not been successful. It is, therefore, of utmost importance that advantage should be taken of seed years and brushwood cutting done accordingly. But if the area is devoid of sufficient advance growth it should be left along after clearing brushwood up to a height of 10–15 feet.

(iii) Along with general regeneration felling (if seedlings are one season old) all tree growth should be girdled because felling of unwanted trees in evergreen is definitely harmful as climbers spread over them and form a thick leafy umbrella and kill seedlings.

(iv) No burning should be done.

(v) First year weedings should be done in July with uprooting of climbers even and may continue up to December–January. In the second and third year weedings and climber cutting in July–August and December–January are necessary.

Timber Extraction

Extraction of timber in the Andamans offers unique combination of the integrated use of elephants, tractors, tramline with locomotives, rafting in small creeks and towing of rafts by motor boats. Elephant dragging is confined to short distance haulage from stump site to the tramway head. Tramways lead to the rafting point from where logs are tied in a combination of sinkers and floaters and rafted to the export depot. Where the lead from stump-site to the tramway head is more than about $\frac{3}{4}$ of a mile, it is invariably the practice to use heavy tractors. The operations have to be balanced between short distance haulage by elephants in the rainy season and long distance haulage in the dry season, in which alone the tractors can operate. As elephants have much greater manoeuvrability and are handier than tractors, it is quite usual to have combined tractor and elephant extraction. Besides, the elephant does not suffer from the handicap of shortage of fuel or lubricating oil which confronts the tractors in the out of the way forest camps with the inevitable shipping difficulties that one faces in these islands. Although tractors have been very efficient for long distance haulage in the dry season, they have worked out to be far more expensive than the elephants. The cause for this high cost for working with tractors is the frequency with which they break down and remain out of action either as a result of lack of spare parts or the difficulty of getting quick repairs carried out at site where these tractors operate.

Utilization

On account of the high cost of extraction which prevails in these islands with the use of imported labour and the use of expensive mechanical equipment as also on account of the fact that the freight rates from Andamans to the mainland being excessively high, almost all timber species below 4' girth are economically unextractable and are left in the forests. The bulk of the timber is exported in the round to the Matchwood and Plywood industries on the mainland. The major Sawmill industry is located on Chatham Island. This sawmill is capable of taking in over 100 tons of logs per day. The working of the sawmill, however, is invariably linked up with the market trends. When the market for logs on the mainland is fairly high the sawmill has to be slowed down. When, however, the log market falls, the capacity of the sawmill is accordingly increased to give a higher proportion of processed timber.

The need for a plywood factory in the Andamans has been greatly felt to ensure better utilisation of timber if the factory is sited near the source of the raw material. A plywood factory installed by private enterprise has gone into production recently. This factory is expected to consume about 200 tons of ply-logs per month in the initial stages and about 500 tons per month when it goes into full production. There already exists a Match splint

factory of the Western India Match Company Ltd., which consumes about, 3,500 tons of *papita* (*Sterculia campanulata*) species annually. It is hoped that a chipboard factory will also come up in course of time.

Andaman Forestry thus provides a combination of the most elaborate means of timber extraction operations in the forests that can be seen anywhere in India, along with regeneration technique which has proved successful in raising the second rotation crop of the more commercially valuable species in these forests. Also, these forests are a source of raw material for the plywood Industry, the Matchwood industry, and the Sawmilling industry, the last catering for the demands for constructional timber, general utility timber as well as high class cabinet making and furniture.

MANIPULATION OF UNDERGROWTH FOR AIDING NATURAL REGENERATION OF EVERGREEN AND SEMI-EVERGREEN FORESTS

BY K. B. MOHAN LAL,

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Influence of various plants in acting as nurse to regeneration of valuable tree species is well known. The inhibiting and harmful effects of various plants have also been studied. It is also known that some plants assist natural regeneration when they occur scattered but inhibit it when occurring in dense masses. It is, therefore, important, in the interests of securing natural regeneration, to see if it were possible to manipulate undergrowth effectively. The author took up this study in 1938 in Lakhimpur, particularly in the recently worked over evergreen and semi-evergreen forest areas in Margherita range. The forests belonged to *hollong-nahor* (Champion's IB/C.2) type and miscellaneous evergreen and semi-evergreen (Champion's IIb/C-2) type. In the former, *hollong*, *Dipterocarpus macrocarpus*, formed nearly fifty per cent of the crop with *nahor*, *Mesua ferrea*, as understorey and *Amoora wallichii*, *Artocarpus chaplasha*, *Pachylarnax pleiocarpa*, *Talauma phellocarpa*, *Michelia* species, *Manglietia insignis*, *Magnolia* species, *Litsaea* species, *Chukrasia tabularis*, *Dysoxylum* species, *Cinnamomum cecidodaphne* and *C. glanduliferum*, *Shorea assamica*, *Eugenia* species, *Engelhardtia spicata*, *Sapium baccatum*, *Myristica* species, *Polyalthia* species, *Endospermum chinense*, *Elaeocarpus* species, *Castanopsis* species etc., as associates. In the latter type, *hollong* was not found but other species enumerated above occurred with varying proportions. The middle and lower storeys had *Mesua ferrea*, *Vatica lanceaefolia*, *Magnolia griffithii*, *Talauma hodgsoni*, *Dysoxylum* species, *Amoora rohituka* and *A. chittagonga* etc. with occasional poles of tree species enumerated above and bamboos, *Dendrocalamus hamiltonii*, *Teinostachyum dullooa* and *Pseudostachyum polymorpha*. The undergrowth in forest areas consisted of woody shrubs, e.g. *Saprosma ternatum*, *Amblyanthus multiflora*, *Osbeckia* species, *Ixora* species, *Melastoma* species, *Dracaonna angustifolia*, *Laportea crenulata*, *Leea* species with palms, viz. mostly *Pinanga gracilis* and occasional *Livistonia jenkinsiana*, etc. Canes, viz. *Calamus erectus*, *C. floribundus*, *C. flagellum*, *C. latifolius*, *C. leptospadix*, etc. Non-woody shrubs like *Alpina* species, *Phrynium* species, and ferns formed the ground cover in wooded areas. The open areas had either thick clumps of *Dendrocalamus hamiltonii* and *Teinostachyum dullooa* or *Pseudostachyum polymorphum* would occupy the area along with shrubs and climbers, or dense masses of shrubs covered with creepers or *Eupatorium* species would be found. *Macaranga* species, *Mallotus alba*, *Leea* species, *Marlea begoniaefolia*, *Casearia varica*, *Trema orientalis*, *Anthocephalus cadamba*, *Duabanga sonneratioides*, *Litsaea* species are the tree species that came up, the first three being more common.

These areas had been heavily worked over in the past and there were large openings scattered in the area where a group of large trees had been felled and, apart from damage caused by them, the sawyers had removed the poles and small trees to make sawing platforms. These openings were full of a tangled mass of vegetation covered with creepers. It was thought that even if these areas were planted up artificially they would require yearly three or even four weedings, for the first two or three years. Then the idea of selective weeding with manipulation of undergrowth occurred. It was decided to leave such weeds which did not spread rapidly uncut on the ground to keep down creepers and other obnoxious weeds and to keep ground cover down so that newly germinated seedlings could get some overhead room, if they came up. In areas where there were only scattered trees and too much light the same procedure was followed. It was immaterial what the shrubs were as long as they were not likely to spread or hang down and smother the seedlings. As is well known, the number of species which occur in the evergreen forest as undergrowth is very large and all of them which have erect stems were left as long as they did not interfere with seedlings of valuable species or formed a dense mass, e.g. *Eupatorium* species so that light could not reach the ground. Where they formed a dense mass they were only thinned out but where they were scattered to keep down climbers even those which were near valuable seedlings were left and only pruning of lower and such branches were directly over the valuable seedlings was done. In bamboo areas these were allowed to be worked where possible and where this was not the case they were cut but not pulled down as the cut bamboos helped to keep weeds down. This saved cost and labour of pulling them down also. Where overwood was light and dense mass of bamboos

formed the middle storey bamboos in the middle of the clump which went straight up were retained. The results were found to be excellent. Though only one weeding had been done and that too in the cold weather, the majority of valuable seedlings were found to have remained free and put on good increment and there was adequate recruitment.

The method of selective weeding described above will appear to be difficult and complicated but really this was not so. A batch of 20—30 labourers was put in charge of an intelligent forest guard. These would go ahead cutting down creepers and climbers, clearing ground cover and such weeds as form thick masses, e.g. *Eupatorium odoratum*. They would leave all kinds of seedlings, saplings along with shrubs which were more than 3 feet high. The Forest Guard coming behind looked for seedlings of valuable species and removed such plants as interfered with them and did the other things described in the preceding paragraph. Where necessary he would call one of the labour to assist him, i.e. in cutting low branches, dense shrubs etc. The Naga workers came to recognise the seedlings well and became so efficient at this that they used to take the whole operation on contract basis of Rs. 5 per acre for first year's work.

As far as experience in evergreen forests of Upper Assam is concerned it is seen that the method of selective weeding has the following advantages over the orthodox method where all shrubs and even small poles are removed wholesale in 'Lifting up canopy' operations.

1. Creepers and climbers are kept down. Where orthodox method is followed even small poles are found covered with creepers which smother them in places where there is sufficient light. This is not the case where selective weedings have been done.

2. The shrubs keep down the immediate competitors of new recruits for light and growing space, i.e. grasses, ferns, herbal plants etc.

3. The upper canopy need not be kept intact and the forest can be allowed to be worked before being taken up for regeneration. Actually much better light conditions result by the upper canopy being broken by selection fellings, i.e. patchy light on the forest floor. By providing better ground and light conditions, working of the forests helps in getting recruitment, specially of the more valuable species like *Dipterocarpus macrocarpus*, *Miche- lia* species, *Manglietia insignis*, *Talauma phellocarpa*, *Amoora wallichii*, *Chukrasia tabularis*, *Artocarpus chaplasha* etc. which want some light to show increment. With insufficient light the seedlings of these species do not show appreciable increment and more shade bearing species of which *Mesua ferrea* is the most valuable come up but these also do better in scattered, patchy light.

4. The shrubs left on the ground keep the soil soft and moist and prevent the devastating effects of drip which is extremely serious in these forests which get heavy rain and which have tall big leaved trees in the upper canopy.

5. It has not been investigated but these shrubs must be benefiting the recruits by providing a mixture and minimising insect attack, wild animal damage etc.

6. The regeneration actually shows better progress which is obvious from the reasons given above.

In some of the experimental plots laid under the Silviculturist, Assam, where the orthodox methods of lifting the canopy had been followed, the progress was observed to be extremely slow. Indicator lines laid down in areas where these two methods had been followed showed a vast difference in height growth for either the shade was too dense or the weeds and climbers came up and covered up the seedlings. It was about 4" to 14" in the method described above while under orthodox system it would be hardly half of this.

The seedlings came up profusely in semi-open conditions so it appeared to the writer that uniform system could be easily introduced in those forests. It is the present view of the writer after seeing the result of the work for more than 20 years that uniform system could be introduced with full confidence provided the system of selective weeding with careful manipulation of undergrowth is followed.

It appears the method of selective weeding or manipulation of undergrowth may prove important in other type of forests also. Besides the advantages mentioned above it gives protection from grazing and browsing, means more leaf-fall and humus and gives some shelter to wild life the importance of which for inducing natural regeneration is, perhaps, not sufficiently realized.

THE UPPER ASSAM DIPTEROCARPUS-MESUA FORESTS AND THEIR REGENERATION

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Occurrence

The Upper Assam *Dipterocarpus-Mesua* forests are confined to the low outcrops of the Naga and Patkoi Hills and the high alluvial deposits at the foot hills in the Lakhimpur and the eastern half of the Sibsagar districts, on the south bank of the river Brahmaputra. Champion (1) has included this formation in this type 1 b c₂—"Upper Assam Tropical Evergreen Forest". The type finds its best expression on the undulating old alluvium of the Dehing river, though it is also found at an elevation of as much as 2,000' (610 m) on the foot hills of the Naga and Patkoi ranges.

Climate and Rainfall

The maximum temperature in the area seldom exceeds 100° F (38° C) and the minimum is about 51° F (11° C). The hottest months coincide with the monsoons while the cold months are comparatively dry. The following Table shows the rainfall in inches, month by month, for two stations in this area (3):—

Month	Namsang		Margherita	
	Rainfall (inches)	Number of rainy days	Rainfall (inches)	Number of rainy days
January	1.2	4.0	0.9	2.4
February	4.0	8.0	2.2	4.9
March	6.6	13.0	5.2	9.2
April	15.4	16.0	10.6	12.6
May	17.2	20.0	13.2	14.5
June	23.4	22.0	19.3	18.5
July	28.8	26.0	20.7	17.6
August	21.2	21.0	14.9	13.7
September	20.6	17.0	3.6	5.4
October	8.6	17.0	3.6	5.4
November	1.2	4.0	0.3	0.7
December	1.0	4.0	0.7	1.3
TOTAL	149.2	175.0	104.1	111.8

Structure and Composition

These forests are characterised by a multi-storied structure. The top canopy which is open more often than not, is dominated almost exclusively by *Dipterocarpus macrocarpus* which tower up to above 150 ft. (46 m) height. The middle canopy is dominated by *Mesua ferrea*. Another giant in the top canopy is *Shorea assamica* but its occurrence is confined to only a few definite localities so much so that Mackarness (2) divided this forest type into two sub-types based on the presence or absence of this species.

The important commercially valuable species are *Dipterocarpus macrocarpus* and *Shorea assamica* which yield excellent veneers and railway sleepers, *Michelia* species which are prized for furniture and cabinet making, and *Mesua ferrea*, which is used as bridge piles.

Silvicultural characters of the principal species, seeding and fruiting

All the three important species, viz. *Dipterocarpus*, *Shorea assamica* and *Mesua ferrea* are considered to be shade bearers, at least in the early stages of their growth. *Dipterocarpus macrocarpus*, *Shorea assamica* and *Vatica lanceaefolia* have winged seeds which help in seed dispersal by wind. All the three species produce seeds in February-March and seeding may continue till May, and as pre-monsoon rains start by then, the seeds soon germinate

and under favourable ground conditions, establish themselves. As for *Mesua ferrea*, seeding is in October, and if the seeds escape the ravages of wild pigs, they soon germinate and come up in a mass where the ground cover is comparatively low. Seeds of *Shorea assamica* are taken by parrots and ants, which account for almost all the seeds formed.

Silvicultural system and regeneration operations

The forests have been managed in the past under a selection system with a fairly long felling cycle. Srinivasan prescribed tending operations after the main fellings, concentrated in certain localities (3). The object of these tending operations were to enrich the stocking of *Dipterocarpus macrocarpus* and *Shorea assamica*. Purkayastha (1936) prescribed a shelterwood compartment system for some of these important forest areas covered by this type, but somehow or other, these prescriptions were not carried out.

The earliest attempt at obtaining natural regeneration were made experimentally in Jeypore compartment 206, in the year 1929. The initial fellings consisted in removing all valueless species in the lower canopies to have a clear ground floor and to raise the canopy from below. Subsequent operations, carried out once every three years between 1933-34 to 1941-42 consisted in shrub cutting and removing inferior stems competing with *Mesua ferrea* and *Dipterocarpus macrocarpus*. The total cost involved came to Rs. 20.69, up to 1940-41, at labour rate of Re. 0.37 per man day.

The result of this experiment was that the wholesale removal of lower canopy trees and the repeated shrub cuttings soon resulted in a dense regeneration of *Mesua ferrea* to the detriment of *Dipterocarpus macrocarpus* and *Shorea assamica*. In areas where *Mesua ferrea* was thin or absent due to variations in the soil, seedlings of *Dipterocarpus macrocarpus* pierced through the comparatively thin canopied middle storey species like *Vatica lanceaefolia* and established themselves.

A variation in the tending operations as introduced at Jeypore Compartment 206 was tried in the Powai Block of Upper Dehing Reserve in 1938-39, on 286 acres, in which fellings were carried out in 1937-38. The tending operations have been described in detail by Mohan Lal (5). Briefly, these consisted in cutting climbers and straggling shrubs, and removing inferior species only when suppressing or competing with a seedling, sapling or pole of *Dipterocarpus macrocarpus* or other valuable species in that particular canopy layer, or in other words carrying out thinnings around these 'elite' stems of valuable species. In actual practice tendings were done on the 1st, 2nd, 3rd, 5th, 9th, 12th and 15th years followed by one round of girdling of interfering stems during the 16th, 17th and 18th years.

In the 21st and 22nd years, climber cutting was done. The total cost of all operations carried out came to Rs. 53.62 per acre in 1960, at labour rate of Re. 0.37 in 1937, rising progressively to the present day rate of Re. 2.00 per man day. The cost included seed broadcasting and weedings in a very small proportion of the area in one corner.

Assessment of Results

In order to assess the results of such regeneration operations, and also to get further data on the structure and composition of these forests and the silvicultural behaviour of the main species, four areas were selected for detailed study by the quadrat method. These areas are described briefly below:—

Tinali—In the Jeypore Reserve on a more or less flat ground near a stream. The vegetation was rich in density as well as in composition. Selection fellings were done in this area some twenty years ago. A set of 56 consecutive quadrats of 20 m × 20 m size (about 1 chain × 1 chain) was enumerated.

Hukanjuri—In the Jeypore Reserve on high ground. No fellings have been recorded in this place during the last twenty years or so. A set of 80 quadrats was taken here.

Powai—In upper Dehing Reserve, on undulating ground. Fellings were done in 1937-38. One set of 80 quadrats was studied in the area taken for regeneration tending in 1938, and another set in the untended area close by.

Kherjan—In upper Dehing Reserve. Selection fellings were done in 1943-44 and 1944-45, and part of the area was taken up for regeneration tending in 1948-49. In the tended area, operations were carried out in the first, third, fourth, fifth, seventh and tenth years, at a total cost of Rs. 35 per acre, (1960) at labour rate of Rs. 2.00 per man day.

One set of 33 quadrats was taken in the tended area and another set of 80 quadrats was taken in the untended area.

The structure and composition, as revealed by an analysis of the data are shown in the appendix, where the number of species found in canopy layers I to V and their percentage presence frequency (F) as well as the density in terms of percentage of the total number of stems in the canopy are given for each canopy layer.

In spite of a very large number of species occurring in the area, relatively few species showed a high frequency index. A comparative statement of presence of frequencies of such species is shown in Table II:—

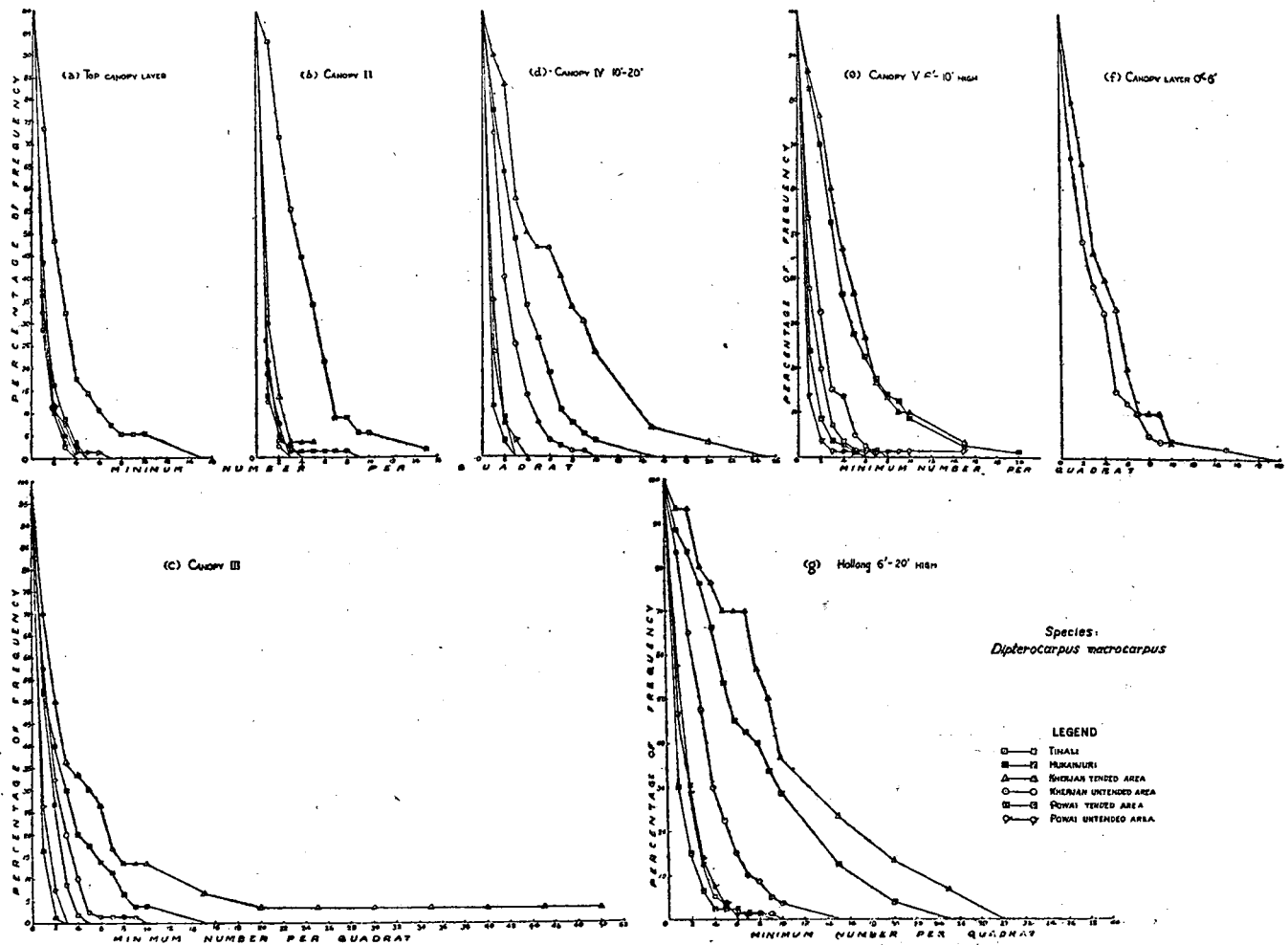
TABLE II

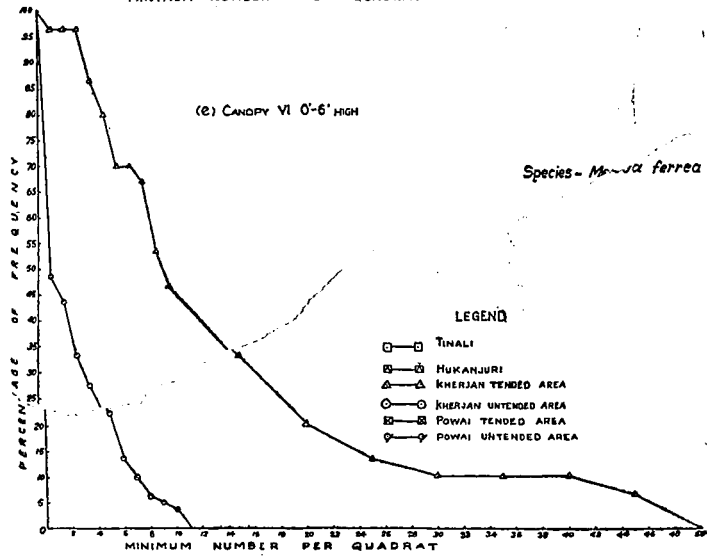
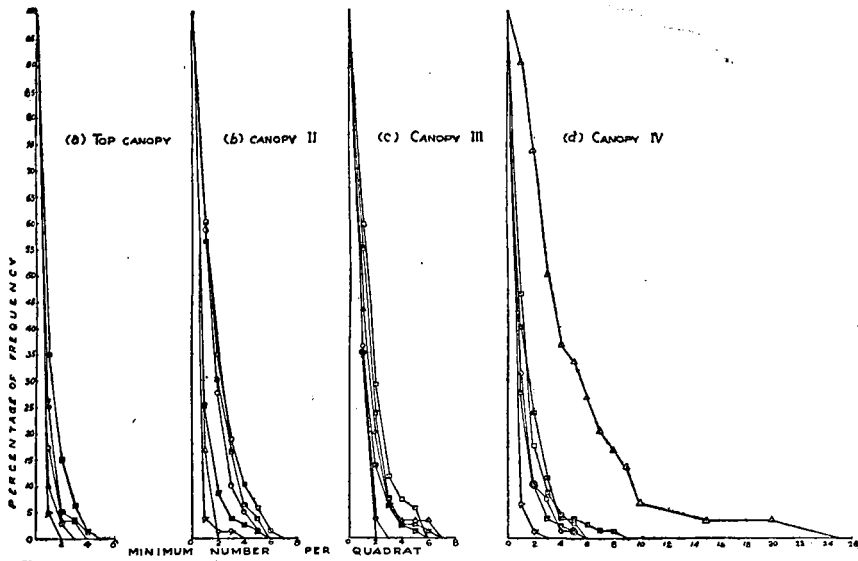
Species	Canopy	Jeypore Reserve		Upper Dehing Reserve			
		Tinali	Hukanjuri	Kherjan		Powai	
				Tended	Un-tended	Tended	Un-tended
<i>Dipterocarpus macrocarpus</i>	I	37.59	42.50	33.75	36.66	30.00	43.75
	II	21.48	17.50	12.50	30.00	21.25	13.75
	III	50.12	16.25	57.50	70.00	26.25	52.50
	IV	93.08	12.50	73.75	90.00	33.75	77.50
	V	73.39	25.00	52.50	86.66	37.50	82.50
<i>Shorea assamica</i> ..	I	44.75	50.00				
	II	17.90	8.75				
	III	41.17	6.25	Nil	Nil	Nil	Nil
	IV	39.38	3.75				
	V	10.74	—				
<i>Vatica lanceaefolia</i> ..	I	1.45	3.75	1.25	0	3.75	82.75
	II	41.17	18.75	0	23.33	8.75	35.00
	III	71.60	46.25	5.00	23.33	47.50	53.75
	IV	84.13	15.00	7.00	16.67	60.00	61.25
	V	32.22	2.50	0	10.00	51.25	40.00
<i>Talauma hodgsoni</i> ..	I	0	0	0	0	0	2.50
	II	3.58	1.25	12.50	0	2.50	1.25
	III	5.31	0	17.50	0	3.75	3.75
	IV	8.95	1.25	11.50	10.00	3.75	3.75
	V	1.79	0	1.25	3.33	2.50	15.00
<i>Mesua ferrea</i> ..	I	23.27	25.00	17.50	10.00	5.00	35.00
	II	51.79	57.50	56.25	16.66	3.75	25.00
	III	57.28	27.50	36.25	43.33	7.50	35.00
	IV	42.98	27.25	30.00	90.00	6.25	40.00
	V	16.11	2.50	15.00	93.33	13.75	41.25
<i>Amoora wallichii</i> ..	I	5.37	0	5.00	0	1.25	0
	II	14.32	11.25	7.50	6.67	3.75	0
	III	16.11	11.25	8.75	3.33	17.50	0
	IV	30.43	0	10.00	6.67	12.50	0
	V	5.37	0	1.25	3.33	11.25	6.25

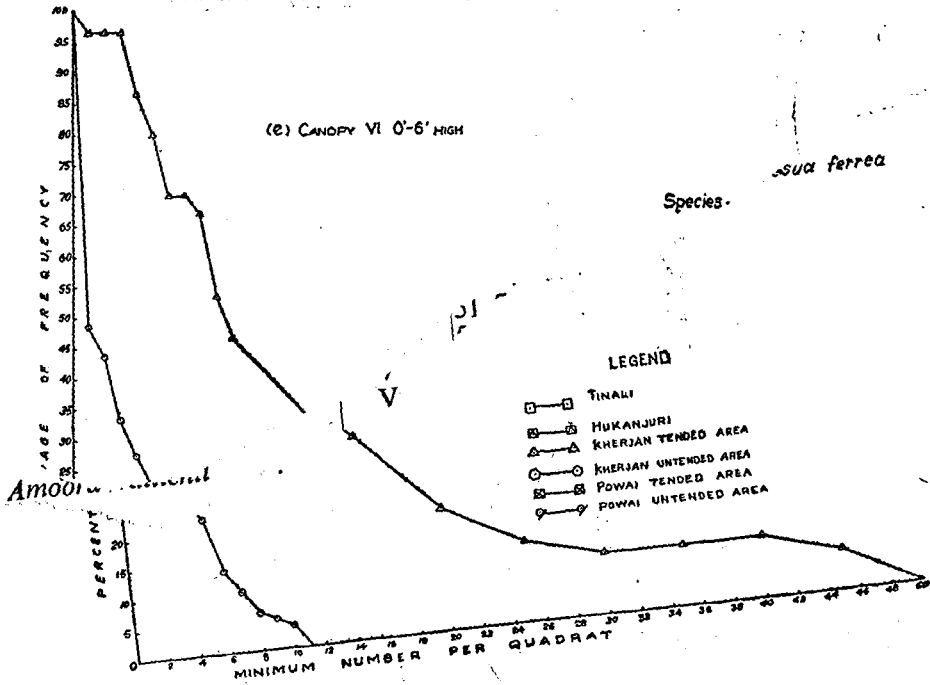
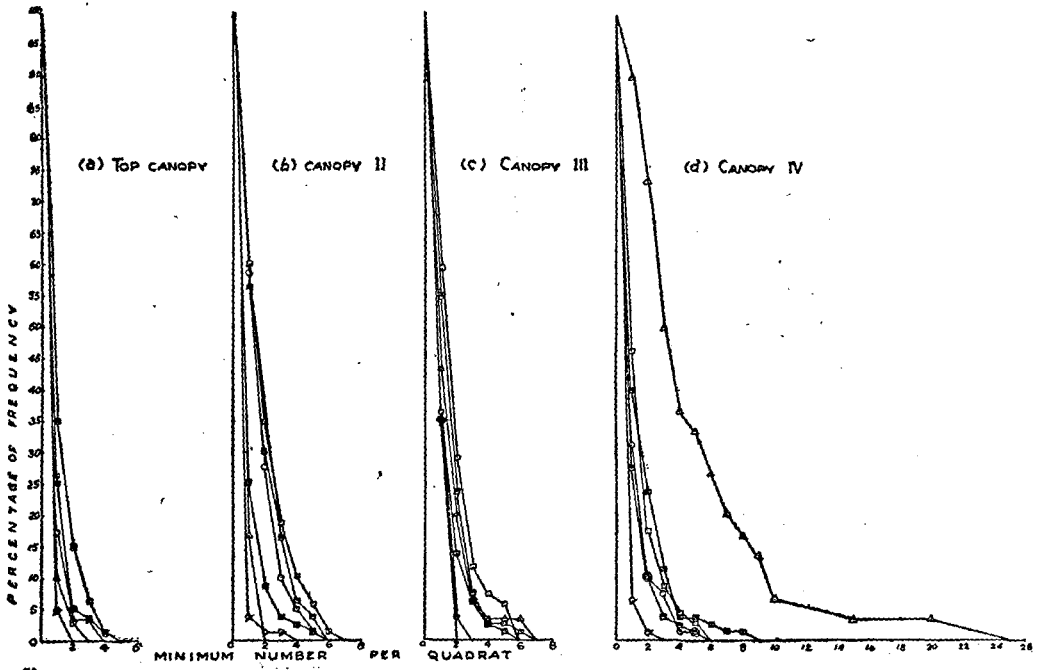
Apart from the above, *Garcinia* species, *Polyalthia simiarum*, *P. jenkinsii*, *Leea sambucina* and *Baccaurea sapida* were found frequently in lower canopy layers, while *Eurya acuminata* had a good representation in the fourth layer in Tinali.

The statement brings out clearly the two sub-types based on the presence or absence of *Shorea assamica*.

As regards the number of stems in different canopy layers, the total number of all species per quadrat varied from 0 to 10 in the top layer. In Tinali, Hukanjuri, Kherjan, untended area, Kherjan tended area, Powai untended area and Powai tended area respectively a minimum of four stems per quadrat was found in 20, 25, 13, 6, 50 and 9 per cent of the quadrats respectively. In the same areas, a minimum of six stems per quadrat in







the second canopy was found in 100, 14, 17, 11, 16 and 0 per cent of the quadrats respectively.

The distributions of the number of stems per quadrat in case of *Dipterocarpus macrocarpus* and *Mesua ferrea* are shown in cumulative frequency curves in the accompanying figures. These show clearly the difference in the stocking of *Mesua ferrea* and *Dipterocarpus macrocarpus* in the lower canopy layers in the tended and untended areas.

Regression analysis brought out the following facts regarding the silvicultural requirements of the main species. The regression equations are given in Table III.

TABLE III
Regression Equations

Sl. No.	Regression equation	F ratio	5% point	1% point
1	$Y = 2.3920 + 0.4778 X$	11.3	4.02	7.12
2	$Y = 1.2393 - .0659 X$	6.17	4.02	7.12
3	$Y = 2.4355 + 0.3613 X$	7.4	3.97	6.97
4	$Y = 2.3805 + 0.4550 X$	110.0	3.97	6.97
5	$Y = 3.4037 - 0.2709 X$	4.07	4.02	7.64
6	$Y = 5.9764 - 0.5438 X$	5.9	4.02	7.64
7	$Y = 4.9883 - 2.6667 X$	25.13	4.02	7.64
8	$Y = 2.1029 + 0.3645 X$	25.4	4.02	7.12

(1) *Indicator species*—The presence of *Leea sambucina* was found to be an indication of conditions suitable for the existence of *Dipterocarp* seedlings and saplings 6'—10' (2.3 m) high. In the tended area of Powai, the quadrats containing *Leea sambucina* contained a greater number of *Dipterocarp* seedlings and the difference was highly significant. There was also a linear increase in the number of *Dipterocarp* stems 6'—10' high with the increase in the number of *Leea* stems per quadrat (Eqn. 1).

(2) *Interaction between associate species*—The presence of *Mesua ferrea* is associated with decrease in the incidence of *Vatica lanceaefolia*. In the Tinali plots, where both these species are well represented in the third canopy, the number of *Vatica lanceaefolia* decreases linearly with the increase in the number of *Mesua ferrea* saplings and poles (Eqn. 2).

(3) *The effect of top canopy*—In tended areas, the presence of top canopy trees appeared to be beneficial to the establishment of *Dipterocarp* trees. In the tended area of Powai which, incidentally, had the highest density in the top canopy, the number of *Dipterocarp* seedlings and saplings 6'—10' (2.3 m) high was found to increase linearly and very significantly not only with the total number of all stems in top canopy including *Dipterocarp*, (Eqn. 3) but also with the total number of stems other than *Dipterocarp* (Eqn. 4). In the untended areas of Tinali, the same trend was seen, but the regression just failed to be significant. In the more open canopied areas elsewhere, *Dipterocarp* regeneration was independent of top canopy.

(4) *The effect of a second canopy*—A dense second canopy was found to inhibit *Dipterocarp* regeneration. The untended areas of Tinali had the densest second canopy and here a significant decrease in the number of *Dipterocarp* saplings 6'—10' (2.3 m) high and the number of stems of all species in the second canopy was found (Eqn. 5). A similar, significant trend was also found in the tended areas of Kherjan (Eqn. 6). In the Tinali plots, it was also found that *Dipterocarp* regeneration decreases significantly with the increase in the number of *Mesua ferrea* trees in the middle canopy. This relationship was found to be highly significant (Eqn. 7).

(5) *The effects of the third and fourth canopies*—The number of stems of all species in these canopies did not appear to make any significant difference in the number of *Dipterocarp* seedlings and saplings 6'—10' (2.3 m) high.

(6) *The effect of the fifth canopy (6'—10') layer*—Competition with stems of other species in this layer did not appear to hamper the growth of *Dipterocarp* seedlings. On the contrary, the number of *Dipterocarp* stems in this layer was found to increase very significantly with the total number of stems of all species in the Tinali quadrats (Eqn. 8).

The effect of tending on *Dipterocarp* and *Mesua* regeneration

The cumulative frequency graphs show clearly that in untended areas, the number of stems of these useful species per quadrat in the lower canopy layers is rather low. Thus in case of *Dipterocarpus macrocarpus*, 0 to 55 per cent of the quadrats have 3 stems per quadrat in canopy II. In the third canopy, 3 stems per quadrat are found in 0 to 20% of the quadrats in the untended areas. A strict statistical comparison was not possible, for tended vs. untended areas of Powai, as the tended areas had a comparatively dense canopy. In case of the pair of sets in Kherjan, however, the mean numbers of stems per quadrat in the top and the second canopy were comparable in respect of *Dipterocarpus macrocarpus* stems, as well as stems of all species taken together.

Since the tendings started in Kherjan in 1948, *Dipterocarp* seedlings recruited then were expected to reach the third canopy by 1960, and this was actually seen to materialise in a very significant rise in the mean number of saplings of *Dipterocarp* in the third, fourth and fifth layers. Another important fact that emerged from an analysis of the number of *Dipterocarp* seedlings in the 0'—6' (0—2 m) height class was that after the stopping of the tending operations in 1957-58, the rate of recruitment of *Dipterocarp* seedlings was not found to be different in the tended and untended areas. All seedlings in the 0'—6' height class would have been recruited since 1957-58, but the mean number per quadrat in tended and untended areas was not different. This highlights the need for continued efforts to get more and more recruits. On the other hand, six tending operations between 1948 and 1957 resulted in a minimum of four stems 6'—20' (2 m—6 m) high, in 77 per cent of the tended quadrats as against the same minimum number found in 30 per cent of the quadrats in untended areas. There was also an increase in *Dipterocarp* stems in the third canopy, i.e. the 20' to 40' layer where, minimum two stems per quadrat was found in 50 per cent of the quadrats, as against the same minimum found in 33 per cent of the quadrats in the untended area.

DISCUSSIONS

It is now possible to summarise the tending requirements of *Dipterocarpus macrocarpus*, which is the main species in these forests. The species requires a clear ground floor for regeneration and up to 6' (2 m) height. At this stage it is not necessary to make any opening in the canopy layers above 6 ft. (2 m) height. After the seedlings reach about 6 ft. (2 m) height, further growth is controlled by the number of stems in the second canopy. At this stage, canopy manipulation is essential to control the rate of growth. Also the effect of cleaning the ground cover is lost after about two years. Early repeated clearing of the ground cover for 3 to 4 years will be necessary to obtain recruitment on the scale shown by the tended areas under consideration. After revenue fellings, the top canopy will have sufficient openings so that no further felling in this layer will be required within the next twenty years or so.

As regards assessment of results obtained after tending, and the adequacy of regeneration obtained, the results are to be judged by the objects of management. In these forests, tending operations aim at obtaining natural regeneration without making drastic changes in the forest composition, as such a state of affairs might upset the ecological balance, bringing in problems of regeneration at a later date. It has been found from general observations that the mortality per cent of seedlings and saplings of *Dipterocarpus macrocarpus* is very low, once they attain about 6' (2 m) height. They have been known to survive in completely suppressed condition under a mid canopy of *Mesua ferrea*. Under the circumstances, 4 stems of 6' to 20' (2-6 m) height per 20 m × 20 m quadrat (about 1 square chain), or in other words, 40 such stems per acre (100 stems per hectare) are considered sufficient and on regeneration sampling, if 75 per cent of the quadrats are fully stocked (to allow for unsuitable sites) the area can be called fully regenerated. On this criterion, the success of the regeneration operations carried out at Powai and Kherjan, as well as the deficiency in the untended areas is shown in the cumulative frequency curves.

Silvicultural system to be adopted

It will be seen from the discussion above and the details of operations found necessary in Powai and Kherjan regeneration areas that initial ground clearing for three or four years, followed by two or three thinnings in the different canopy layers over about 20 years is necessary for obtaining the minimum requirement for having an area fully regenerated. On the other hand, it is not the aim to have a uniform crop of *Dipterocarpus macrocarpus*. These two factors rule out both the uniform system and the selection system as the suitable silvicultural system. The former is unsuitable on ecological considerations, while the latter is impracticable, as in these forests of widely varying density and age classes from area

to area any yield prescription based on sustained yield as well as girth limit will necessarily result in widely varying area of the annual coupe, making tending operation following fellings impracticable. Also, one tending following felling operations, and leaving the area alone till the next felling cycle will not be enough, as there will be no scope for further thinnings in the lower canopy layers to help the recruitment. Thus the Silvicultural system that suggests itself is the Irregular shelterwood system with a 20 year regeneration period. *Dipterocarpus macrocarpus* stems in the lower canopies, (corresponding to about $4\frac{1}{2}$ ft. or 1.35 m. girth at breast height) may be left as seed bearers as well as part of the future crop.

Acknowledgement

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REFERENCES

1. Champion, H. G.—A preliminary survey of forest types of India and Burma. *Ind. Forest Records*. Vol. I, No. 1 (1935).
2. Mackarness, C. G. M.—Working Plan for eleven forest Reserves in the Lakhimpur and Sibsagar Division, Eastern Circle, Assam (1932)—Assam Govt. Press, Shillong.
3. Srinivasan M. M.—Working Plan for the Lakhimpur Forest Division, Assam (1949—59). Assam Govt. Press, Shillong, 1956.
4. Purkayastha, C. S.—Working Plan for the plains Reserves on the South bank of the Brahmaputra river in the Lakhimpur Division (1936). Assam Govt. Press, Shillong.
5. Mohan Lal, K. B.—Manipulation of undergrowth for aided natural regeneration of Evergreen and Semi-evergreen forests. Paper submitted to Tropical Moist Evergreen Forest Symposium, April 1960.

(For Appendix, please see next page).

APPENDIX

Structure and Composition of Upper Assam Mesua-Dipterocarp forest

TOP CANOPY—OVER 70' (21.3 m) ht.

	Tinali		Hukanjuri		Kherjan		Powai	
	F	%	F	%	F	%	F	%
Magnoliaceae								
<i>Manglietia insignis</i>	—	—	—	—	—	—	1.25	1.18
<i>Talauma hodgsoni</i>	—	—	—	—	—	—	1.25	1.18
Other spp.	—	—	—	—	6.25	6.31	3.75	3.53
Anonaceae								
<i>Polyalthia simiarum</i>	—	—	2.50	1.12	—	—	—	—
Guttiferae								
<i>Mesua ferrea</i>	23.27	13.04	25.00	14.61	17.50	18.93	5.00	4.70
Dipterocarpaceae								
<i>Dipterocarpus macrocarpus</i>	37.59	35.67	42.50	34.84	33.75	40.00	30.00	28.23
<i>Shorea assamica</i>	44.75	42.63	50.00	42.15	—	—	—	—
<i>Vatica lanceaefolia</i>	1.45	0.67	3.75	3.37	1.25	1.05	3.75	5.88
Malvaceae								
<i>Kydia calycina</i>	—	—	—	—	1.25	1.05	—	—
Sterculiaceae								
<i>Pterospermum lanceaefolium</i>	—	—	1.25	0.56	—	—	—	—
Elaeocarpaceae								
<i>Elaeocarpus rugosus</i>	—	—	—	—	—	—	1.25	1.18
Burseraceae								
<i>Canarium bengalense</i>	—	—	2.50	1.12	—	—	3.75	3.53
Meliaceae								
<i>Amoorá wallichii</i>	5.37	2.61	—	—	5.00	4.20	1.25	1.18
<i>Cedrela</i> spp.	1.79	0.87	—	—	—	—	—	—
<i>Dysoxylum procerum</i>	—	—	—	—	—	—	1.25	1.18
Lythraceae								
<i>Duabanga sonneratioides</i>	—	—	—	—	1.25	1.05	—	—
Hamamelidaceae								
<i>Altingia excelsa</i>	1.79	0.87	—	2.50	1.12	—	—	—
Combretaceae								
<i>Terminalia belerica</i>	1.79	0.87	—	—	—	—	—	—
<i>T. citrina</i> }	—	—	1.25	0.56	2.50	2.10	1.25	1.08
<i>T. chebula</i> }	—	—	—	—	1.25	1.05	—	—
<i>T. myriocarpa</i>	—	—	—	—	—	—	—	—
Rubiaceae								
<i>Anthocephalus cadamba</i>	—	—	—	—	1.25	1.05	1.25	1.18
Sapotaceae								
<i>Chrysophyllum roxburghii</i>	—	—	—	—	—	—	1.25	1.18
Styracaceae								
<i>Symplocos spicata</i>	—	—	—	—	—	—	1.25	1.18
Bignoniaceae								
<i>Stereospermum chelonoides</i>	—	—	—	—	3.75	6.31	1.25	1.18
Verbenaceae								
<i>Gmelina arborea</i>	—	—	—	—	—	—	3.75	3.53
Datisceae								
<i>Tetrameles nudiflora</i>	—	—	—	—	1.25	1.05	1.25	1.18
Myristicaceae								
<i>Myristica kingii</i>	—	—	—	—	—	—	1.25	1.18
Lauraceae								
<i>Cinnamomum cecidodaphne</i>	—	—	1.25	0.56	—	—	1.25	1.18
<i>Litsaea polyantha</i>	1.79	0.87	—	—	—	—	—	—
<i>Purkayasthaea pseudomicrocarpa</i>	—	—	2.50	2.10	—	—	—	—
Euphorbiaceae								
<i>Endospermum chinense</i>	—	—	—	—	—	—	2.50	2.25
<i>Ficus</i> sp.	—	—	—	—	1.25	1.15	—	—
<i>Macaranga</i> sp.	—	—	—	—	—	—	1.25	2.35
<i>Sapium baccatum</i>	5.37	2.61	—	—	—	—	1.25	1.18
Moraceae								
<i>Artocarpus chaplasha</i>	—	—	—	—	—	—	8.75	8.23
Fagaceae								
<i>Costanopsis indica</i>	—	—	—	—	6.25	5.26	—	—

(Contd.)

APPENDIX—(Contd.)

CANOPY II. 40'—70' (12·2m—21·3m) ht.								
	Tinali		Hukanjuri		Kherjan		Powai	
	F	%	F	%	F	%	F	%
Dilleniaceae								
<i>Dillenia indica</i>	—	—	—	—	2·50	1·00	—	—
Magnoliaceae								
<i>Talauma hodgsoni</i>	3·58	1·20	1·25	0·47	12·50	6·00	2·50	2·15
Other sp.	—	—	1·25	0·47	1·25	0·50	1·25	1·08
Anonaceae								
<i>Polyalthia jenkinsii</i>	5·37	1·80	25·00	15·64	12·50	6·00	—	—
<i>P. simiarum</i>	—	—	—	—	—	—	—	—
Flacourtiaceae								
<i>Taraktogenos kurzii</i>	—	—	—	—	—	—	1·25	1·08
Guttiferae								
<i>Garcinia</i> sp.	1·79	0·60	—	—	1·25	0·50	—	—
<i>Mesua ferrea</i>	51·79	34·80	57·50	46·92	56·25	39·00	3·75	5·38
Ternstroemaceae								
<i>Eurya acuminata</i>	1·79	0·60	—	—	—	—	1·25	1·08
Dipterocarpaceae								
<i>Dipterocarpus macrocarpus</i>	21·48	10·20	17·50	9·48	12·50	6·00	21·25	23·65
<i>Shorea assamica</i>	17·90	6·00	8·75	3·32	—	—	—	—
<i>Vatica lanceaefolia</i>	41·17	29·40	18·75	19·27	—	—	8·75	11·82
Malvaceae								
<i>Kydia calycina</i>	—	—	—	—	1·25	0·50	—	—
Sterculiaceae								
<i>Pterospermum lanceaefolium</i>	1·79	0·60	1·25	0·47	2·50	1·00	1·05	1·08
<i>Sterculia villosa</i>	—	—	1·25	0·47	—	—	—	—
Elaeocarpaceae								
<i>Elaeocarpus ganitrus</i>	3·58	1·20	—	—	—	—	—	—
<i>E. rugosus</i>	—	—	—	—	3·75	1·15	3·75	3·23
Burseraceae								
<i>Canarium bengalense</i>	—	—	—	—	1·25	0·50	3·75	3·23
Meliaceae								
<i>Amoora wallichii</i>	14·32	7·20	11·25	6·10	7·50	3·50	3·75	3·23
<i>Cedrela</i> sp.	1·79	0·60	—	—	—	—	—	—
<i>Chukrasia tabularis</i>	1·79	0·60	—	—	—	—	—	—
<i>Dysoxylum procerum</i>	1·79	0·60	1·25	0·47	—	—	1·25	1·08
Aquifoliaceae								
<i>Ilex godajam</i>	—	—	—	—	—	—	1·25	1·08
Ampelidaceae								
<i>Leea umbraculifera</i>	—	—	—	—	1·25	0·50	2·50	2·15
Leguminosae								
<i>Dalbergia assamica</i>	1·79	0·60	—	—	—	—	—	—
Hamamelidaceae								
<i>Altingia excelsa</i>	—	—	1·25	0·47	1·25	0·50	—	—
Combretaceae								
<i>Terminalia belerica</i>	1·79	0·60	—	—	—	—	—	—
<i>T. chebula</i> }	3·58	1·20	2·50	0·95	3·75	1·50	1·25	1·08
<i>T. citrina</i> }								
<i>T. myriocarpa</i>	1·79	0·60	—	—	—	—	—	—
Myrtaceae								
<i>Syzygium cumini</i>	1·79	0·60	—	—	—	—	—	—
Rubiaceae								
<i>Anthocephalus cadamba</i>	—	—	—	—	1·25	0·05	1·25	3·23
Bignoniaceae								
<i>Stereospermum chelonoides</i>	—	—	—	—	—	—	3·75	3·23
Verbenaceae								
<i>Gmelina arborea</i>	—	—	—	—	—	—	6·25	5·37
<i>Premna bengalensis</i>	—	—	—	—	5·00	2·50	—	—
Myristicaceae								
<i>Myristica kingii</i>	1·79	0·60	—	—	—	—	1·25	1·08
Lauraceae								
<i>Cryptocarya amygdalina</i>	—	—	—	—	—	—	2·50	2·15
<i>Purkayasthaea pseudomicrocarpa</i>	—	—	—	—	2·50	1·00	—	—
Other sp.	1·79	0·60	—	—	—	—	—	—
Euphorbiaceae								
<i>Baccaurea sapida</i>	—	—	—	—	5·00	2·00	—	—
<i>Bischofia javanica</i>	—	—	—	—	1·25	0·50	1·25	1·08
<i>Endospermum chinense</i>	—	—	—	—	—	—	2·50	2·15
<i>Glochidion arborescens</i>	—	—	1·25	0·47	—	—	—	—
<i>Macaranga</i> sp.	—	—	—	—	—	—	3·75	5·37
<i>Mallotus albus</i>	—	—	—	—	8·75	4·50	—	—
<i>Sapium baccatum</i>	1·79	0·60	—	—	—	—	—	—

(Contd.)

APPENDIX—(Contd.)

CANOPY II. 40'—70' (12·2m—21·3m) ht.

	Tinali		Hukanjuri		Kherjan		Powai	
	F	%	F	%	F	%	F	%
Moraceae								
<i>Artocarpus chaplasha</i>	—	—	—	—	—	—	3·75	3·23
<i>A. lakoocha</i>	—	—	—	—	—	—	1·25	1·08
<i>Ficus</i> sp.	1·79	0·60	—	—	1·25	0·50	—	—
Ulmaceae								
<i>Trema orientalis</i>	—	—	—	—	—	—	1·25	3·23
Unknown	—	—	—	0·47	—	6·50	—	7·53

CANOPY III. 20'—40' (6·1m—12·2m) ht.

Dilleniaceae									
<i>Dillenia indica</i>	—	—	—	—	6·25	1·43	—	—	
Magnoliaceae									
<i>Michelia champaca</i>	—	—	—	—	—	—	1·25	2·00	
<i>Talauma hodgsoni</i>	5·31	0·85	—	—	17·50	6·30	3·75	3·00	
<i>T. phellocarpa</i>	—	—	—	—	—	—	1·25	1·00	
Others	12·53	1·87	1·25	0·24	—	—	2·50	2·00	
Anonaceae									
<i>Polyalthia simiarum</i> }	35·80	4·25	27·50	12·08	26·25	6·59	—	—	
<i>P. jenkinsii</i>									
Flacourtiaceae									
<i>Taraktogenos kurzii</i>	—	—	—	—	—	—	3·75	3·00	
Guttiferae									
<i>Garcinia</i> sp.	7·16	0·68	53·75	17·67	11·25	3·44	6·25	7·00	
<i>Mesua ferrea</i>	57·28	9·01	27·50	12·08	36·25	11·75	7·50	6·00	
Ternstroemaceae									
<i>Camellia caudata</i>	—	—	—	—	—	—	2·50	5·00	
<i>Eurya acuminata</i>	7·16	0·85	—	—	—	—	1·25	5·00	
Dipterocarpaceae									
<i>Dipterocarpus macrocarpus</i>	50·12	9·69	16·25	3·39	57·50	29·22	26·25	27·00	
<i>Shorea assamica</i>	41·17	5·10	6·25	1·21	—	—	—	—	
<i>Vatica lanceaefolia</i>	71·60	45·39	46·25	58·68	5·00	1·72	47·50	71·00	
Malvaceae									
<i>Kydia calycina</i>	—	—	—	—	—	—	2·50	2·00	
Sterculiaceae									
<i>Pterospermum lanceaefolium</i>	8·75	0·85	—	—	—	—	1·25	1·00	
<i>Sterculia roxburghii</i>	—	—	—	—	—	—	1·25	1·00	
Elaeocarpaceae									
<i>Elaeocarpus ganitrus</i>	3·58	0·34	—	—	—	—	3·75	7·00	
<i>E. rugosus</i>	0·97	1·02	—	—	3·75	1·43	6·25	6·00	
<i>E. varunna</i>	3·58	0·34	—	—	—	—	—	—	
<i>Elaeocarpus</i> sp.	—	—	1·25	0·24	—	—	—	—	
Rutaceae									
<i>Evodia meliaefolia</i>	8·95	1·36	—	—	—	—	1·25	1·00	
Burseraceae									
<i>Canarium bengalense</i>	—	—	—	—	1·25	0·29	3·75	5·00	
Meliaceae									
<i>Amoora wallichii</i>	16·11	1·70	11·25	2·42	8·75	2·58	17·50	14·00	
<i>Cedrela</i> sp.	21·48	2·21	1·25	0·24	—	—	2·50	3·00	
<i>Chukrasia tabularis</i>	1·79	0·17	—	—	—	—	—	—	
<i>Dysoxylum hamiltoni</i>	5·80	0·68	—	—	—	—	—	—	
<i>D. procerum</i>	19·69	1·87	2·50	1·45	1·25	0·29	11·25	11·00	
Ampelidaceae									
<i>Leca sambucina</i>	1·79	0·17	1·25	0·48	36·25	8·31	12·50	19·00	
Sabiaceae									
<i>Meliosma simplicifolia</i>	1·79	0·17	—	—	—	—	—	—	
Leguminosae									
<i>Albizia lucida</i>	—	—	—	—	1·25	0·29	—	—	
Hamamelidaceae									
<i>Altingia excelsa</i>	5·37	0·51	—	—	—	—	—	—	
Rhizophoraceae									
<i>Caralia lucida</i>	—	—	2·50	0·48	—	—	—	—	
Combretaceae									
<i>Terminalia belerica</i>	14·32	1·53	—	—	1·25	0·29	—	—	
<i>T. chebula</i> & <i>T. citrina</i>	10·74	1·02	—	—	2·50	0·57	—	—	
<i>T. myriocarpa</i>	5·37	0·51	—	—	—	—	—	—	

(Contd.)

APPENDIX—(Contd.)

CANOPY III. 20'—40' (6.1m—12.2m) ht.

	Tinali		Hukanjuri		Kherjan		Powai	
	F	%	F	%	F	%	F	%
Myrtaceae								
<i>Eugenia</i> sp. <i>Syzygium cumini</i> ..	12.53	1.53	—	—	5.00	1.15	2.50	2.00
Datiaceae								
<i>Tetrameles nudiflora</i>	—	—	1.25	0.24	1.25	0.57	—	—
Rubiaceae								
<i>Anthocephalus cadamba</i>	—	—	—	—	—	—	3.75	6.00
Styracaceae								
<i>Symplocos spicata</i>	1.79	0.17	—	—	—	—	—	—
Apocynaceae								
<i>Alstonia scholaris</i>	1.79	0.17	—	—	3.75	0.86	—	—
Bignoniaceae								
<i>Stereospermum chelonoides</i> ..	1.79	0.17	1.25	0.24	1.25	0.29	3.75	3.00
Verbenaceae								
<i>Gmelina arborea</i>	—	—	—	—	—	—	10.00	11.00
<i>Premna bengalensis</i>	—	—	—	—	3.75	1.72	—	—
Myristicaceae								
<i>Myristica kingii</i>	5.37	0.51	—	—	—	—	—	—
Lauraceae								
<i>Cryptocarya amygdalina</i>	—	—	—	—	—	—	2.50	2.00
<i>Cinnamomum obtusifolium</i>	—	—	—	—	5.00	0.15	—	—
<i>C. tamala</i>	—	—	—	—	—	—	6.25	6.00
<i>Litsaea salicifolia</i>	1.79	0.17	—	—	—	—	—	—
<i>L. polyantha</i>	3.58	0.51	—	—	—	—	—	—
<i>Litsaea</i> sp.	—	—	—	—	—	—	1.25	1.99
<i>Purkayasthaea pseudomicrocarpa</i>	3.58	0.34	—	—	7.50	2.00	—	—
Other spp.	12.53	1.19	1.25	0.24	—	—	—	—
Euphorbiaceae								
<i>Baccaurea sapida</i>	30.43	4.25	2.50	0.48	11.25	2.87	3.75	3.00
<i>Croton joufra</i>	1.79	0.17	—	—	1.25	0.57	—	—
<i>Endospermum chinense</i>	—	—	—	—	—	—	8.75	8.00
<i>Macaranga</i> sp.	7.16	0.85	—	—	—	—	16.25	22.00
<i>Mallotus albus</i>	5.37	0.51	—	—	5.00	1.43	—	—
<i>Sapium baccatum</i>	3.58	0.34	—	—	—	—	5.00	5.00
Ulmaceae								
<i>Celtis australis</i>	—	—	—	—	—	—	1.25	1.00
<i>Trema orientalis</i>	—	—	—	—	—	—	1.25	11.00
Moraceae								
<i>Artocarpus chaplasha</i>	—	—	—	—	—	—	1.25	1.00
<i>A. lakoocha</i>	—	—	—	—	—	—	1.25	1.00
<i>Morus laevigata</i>	1.79	0.17	—	—	—	—	1.25	1.00
Jaglandaceae								
<i>Engelhardtia spicata</i>	3.58	0.51	—	—	—	—	—	—
Fagaceae								
<i>Castanopsis indica</i>	21.48	2.39	1.25	0.24	18.75	5.44	1.25	1.00
Unknown	—	—	—	—	—	2.44	—	13.00

CANOPY LAYER IV. 10'—20' (3.0m—6.1m) ht.

Dilleniaceae								
<i>Dillenia indica</i>	—	—	—	—	1.25	0.34	2.50	0.53
Magnoliaceae								
<i>Magnolia griffithii</i>	1.45	0.06	—	—	—	—	—	—
<i>Michelia champaca</i>	—	—	—	—	—	—	1.25	0.26
<i>Talauma hodgsoni</i>	8.95	0.35	1.25	0.98	11.25	4.06	3.75	0.79
<i>T. phellocarpa</i>	—	—	—	—	1.25	0.34	2.50	0.53
Other sp.	42.96	2.38	—	—	7.50	3.04	10.00	4.22
Anonaceae								
<i>Polyalthia jenkinsii</i>	32.22	1.02	7.50	7.84	11.25	5.41	2.50	0.53
<i>P. simiarum</i>	—	—	—	—	—	—	—	—
Flacourtiaceae								
<i>Taraktogenos kurzii</i>	—	—	—	—	—	—	2.50	0.53
Guttiferae								
<i>Garcinia</i> sp.	31.59	2.17	1.25	0.98	17.50	10.14	5.00	1.05
<i>Mesua ferrea</i>	42.96	2.31	27.75	35.28	30.00	14.20	6.25	1.58
Ternstroemaceae								
<i>Camellia caudata</i>	—	—	—	—	—	—	1.25	0.26
<i>Eurya acuminata</i>	18.33	3.92	—	—	—	—	1.25	1.58
<i>E. japonica</i>	—	—	—	—	—	—	—	—

(Contd.)

CANOPY LAYER IV. 10'—20' (3.0m—6.1m) ht.

	Tinali		Hukanjuri		Kherjan		Powai	
	F	%	F	%	F	%	F	%
Dipterocarpaceae								
<i>Dipterocarpus macrocarpus</i> ..	93.08	14.35	12.50	12.74	73.75	45.63	33.75	9.50
<i>Shorea assamica</i>	39.38	2.59	3.75	3.92	—	—	—	—
<i>Vatica lanceaefolia</i>	84.13	37.94	15.00	29.40	7.50	4.06	60.00	28.25
Malvaceae								
<i>Kydia calycina</i>	—	—	—	—	1.25	0.34	—	—
Sterculiaceae								
<i>Pterospermum lanceaefolium</i> ..	3.58	0.14	—	—	—	—	1.25	0.26
Elaeocarpaceae								
<i>Elaeocarpus rugosus</i>	14.32	0.70	—	—	1.25	0.34	—	—
<i>E. varunna</i>	1.79	0.7	—	—	—	—	—	—
Rutaceae								
<i>Evodia meliaefolia</i>	3.85	0.21	—	—	—	—	—	—
Simarubaceae								
<i>Ailanthus grandis</i>	—	—	—	—	—	—	1.25	0.15
Burseraceae								
<i>Canarium bengalense</i>	—	—	—	—	—	—	5.00	1.58
Meliaceae								
<i>Amoora wallichii</i>	30.43	1.47	—	—	10.00	3.88	12.50	2.64
<i>Cedrela</i> sp.	17.90	1.12	—	—	2.50	0.68	—	—
<i>Chukrasia tabularis</i>	1.70	0.07	—	—	—	—	—	—
<i>Dysoxylum hamiltonii</i>	8.70	0.44	—	—	—	—	—	—
<i>Dysoxylum procerum</i>	21.48	1.05	—	—	3.75	1.01	12.75	3.17
Ampelidaceae								
<i>Leea sambucina</i>	21.48	1.26	1.25	0.98	28.75	13.86	21.25	13.46
Anacardiaceae								
<i>Mangifera indica</i>	1.79	0.14	—	—	2.50	0.68	—	—
Leguminosae								
<i>Albizia lucida</i>	—	—	—	—	1.25	0.34	—	—
<i>Dalbergia assamica</i>	1.79	0.14	—	—	—	—	—	—
Hamamelidaceae								
<i>Altingia excelsa</i>	5.30	0.49	—	—	—	—	—	—
Combretaceae								
<i>Terminalia bellerica</i>	21.48	0.91	—	—	—	—	—	—
<i>T. chebula</i> }	32.22	1.47	—	—	6.25	2.03	—	—
<i>T. citrina</i> }			—	—	—	—	—	—
<i>T. myriocarpa</i>	5.37	0.28	—	—	—	—	—	—
Myrtaceae								
<i>Eugenia balsamea</i>	1.79	0.34	—	—	—	—	—	—
<i>E. praecox</i>	1.45	0.11	—	—	—	—	—	—
<i>Syzygium cumini</i>	37.59	2.52	—	—	5.00	1.35	—	—
Melastomaceae								
<i>Blastas cochinchinensis</i>	1.79	0.07	—	—	—	—	—	—
Rubiaceae								
<i>Anthocephalus cadamba</i>	—	—	—	—	1.25	0.34	2.50	0.53
<i>Cephalanthus occidentalis</i>	1.79	0.14	—	—	—	—	—	—
<i>Morinda angustifolia</i>	—	—	—	—	1.25	0.34	1.25	0.34
Styracaceae								
<i>Symplocos spicata</i>	3.58	0.51	—	—	—	—	1.25	0.26
Bignoniaceae								
<i>Stereospermum chelonoides</i>	1.79	0.07	—	—	—	—	—	—
Datisceaeae								
<i>Tetrameles nudiflora</i>	—	—	—	—	2.50	0.68	—	—
Apocynaceae								
<i>Alstonia scholaris</i>	1.79	0.07	—	—	3.75	1.01	—	—
Verbenaceae								
<i>Gmelina arborea</i>	—	—	—	—	—	—	15.00	3.70
<i>Premna bengalensis</i>	3.58	0.14	—	—	—	—	—	—
Myristicaceae								
<i>Myristica kingii</i>	5.37	0.28	—	—	—	—	1.25	0.53
Lauraceae								
<i>Cinnamomum obtusifolium</i>	5.37	0.35	—	—	3.75	1.01	—	—
<i>Litsaea polyantha</i>	5.37	0.21	—	—	—	—	—	—
<i>Litsaea salicifolia</i>	1.79	0.07	—	—	—	—	—	—
<i>Litsaea</i> sp.	4.35	0.22	—	—	—	—	1.25	0.26
<i>Purkayasthaea pseudomicrocarpa</i>	8.95	0.42	—	—	12.50	5.07	—	—
Other spp.	16.11	1.33	—	—	—	—	—	—

(Contd.)

APPENDIX—(Contd.)

CANOPY LAYER IV. 10'—20' (3.0m—6.1m) ht.

	Tinali		Hukanjuri		Kherjan		Powai	
	F	%	F	%	F	%	F	%
Euphorbiaceae								
<i>Baccaurea sapida</i>	59.07	11.06	1.25	0.98	26.25	7.44	7.50	2.11
<i>Endospermum chinense</i>	—	—	—	—	—	—	8.75	5.54
<i>Macaranga</i> sp.	7.16	1.53	—	—	3.75	1.01	10.00	2.10
<i>Mallotus albus</i>	30.43	3.08	—	—	—	—	—	—
<i>Sapium baccatum</i>	1.79	0.07	—	—	*	—	6.25	3.17
Moraceae								
<i>Artocarpus chaplasha</i>	5.37	0.51	—	—	5.00	2.03	1.25	0.26
<i>A. lakoocha</i>	1.79	0.07	—	—	—	—	—	—
<i>Ficus</i> sp.	—	—	—	—	1.25	0.34	—	—
Jaglandaceae								
<i>Engelhardtia spicata</i>	1.79	0.07	—	—	—	—	—	—
Ulmaceae								
<i>Trema orientalis</i>	—	—	—	—	—	—	1.25	0.26
Fagaceae								
<i>Castanopsis indica</i>	44.75	3.92	—	—	6.25	1.69	—	—
Unknown	—	—	—	2.94	—	1.02	—	1.75

CANOPY V. 6'—10' (1.8m—3.0m) ht.

Dilleniaceae								
<i>Dillenia indica</i>	—	—	—	—	—	—	2.50	0.47
Magnoliaceae								
<i>Michelia champaca</i>	—	—	—	—	—	—	2.50	0.47
<i>Talauma hodgsoni</i>	1.79	0.29	—	—	1.25	0.99	2.50	0.47
<i>T. phellocarpa</i>	—	—	—	—	—	—	1.25	0.24
Other species	17.90	4.04	—	—	—	—	11.25	2.60
Anonaceae								
<i>Polyalthia jenkinsii</i>	7.16	1.16	3.75	5.56	3.75	1.49	—	—
Guttiferae								
<i>Garcinia xanthochymus</i>	—	—	—	—	—	—	1.25	0.24
<i>Garcinia</i> sp.	17.90	4.04	—	—	15.00	14.36	3.75	0.94
<i>Mesua ferrea</i>	16.11	3.77	2.50	3.70	15.00	11.38	13.75	6.84
Ternstroemaceae								
<i>Eurya acuminata</i>	14.32	2.90	—	—	—	—	—	—
Dipterocarpaceae								
<i>Dipterocarpus macrocarpus</i>	73.30	35.67	25.00	68.52	52.50	48.51	37.50	15.34
<i>Shorea assamica</i>	10.74	2.61	—	—	—	—	—	—
<i>Vatica lanceaefolia</i>	32.22	15.37	2.50	3.70	—	—	51.25	28.09
Sterculiaceae								
<i>Pterospermum lanceaefolium</i>	—	—	—	—	—	—	1.25	0.47
<i>Sterculia villosa</i>	—	—	2.50	5.41	—	—	1.25	0.47
Elaeocarpaceae								
<i>Elaeocarpus rugosus</i>	7.16	1.16	—	—	1.25	0.99	2.50	0.47
Rutaceae								
<i>Evodia meliaefolia</i>	1.79	0.29	—	—	—	—	—	—
Burseraceae								
<i>Canarium bengalense</i>	—	—	—	—	—	—	6.25	1.18
Meliaceae								
<i>Amoora wallichii</i>	5.37	0.87	—	—	1.25	0.50	11.25	4.25
<i>Cedrela</i> sp.	5.37	1.45	2.50	3.70	1.25	0.50	2.50	0.71
<i>Dysoxylum procerum</i>	—	—	1.25	1.85	—	—	11.25	2.60
Ampelidaceae								
<i>Leea samburira</i>	5.37	0.87	—	—	1.25	0.50	—	—
Anacardiaceae								
<i>Mangifera indica</i>	5.37	0.87	—	—	1.25	0.50	—	—
<i>Spondias mangifera</i>	—	—	—	—	—	—	1.25	0.71
Leguminosae								
<i>Albizia lucida</i>	1.79	0.29	—	—	—	—	—	—
<i>Dalbergia assamica</i>	1.79	0.29	—	—	—	—	—	—
Hamamelidaceae								
<i>Altingia excelsa</i>	1.79	0.29	—	—	—	—	—	—
Combretaceae								
<i>Terminalia belerica</i>	5.37	1.45	—	—	—	—	—	—
<i>T. chebula</i> }	5.37	0.87	—	—	7.50	3.96	1.25	0.24
<i>T. citrina</i> }								

(Contd.)

APPENDIX—(Concl'd.)

CANOPY V. 6'—10' (1.8m—3.0m) ht.								
	Tinali		Hukanjuri		Kherjan		Powai	
	F	%	F	%	F	%	F	%
Combretaceae								
<i>Terminalia myriocarpa</i>	1.79	0.29	—	—	—	—	—	—
Myrtaceae								
<i>Eugenia</i> sp. <i>Syzygium cumini</i> ..	8.95	2.03	—	—	—	—	6.25	8.73
Rubiaceae								
<i>Morinda tinctoria</i>	—	—	—	—	1.25	0.50	2.50	0.71
<i>Randia dumetorum</i>	1.79	0.29	—	—	—	—	—	—
Apocynaceae								
<i>Alstonia scholaris</i>	—	—	—	—	1.25	0.50	—	—
Bignoniaceae								
<i>Stereospermum chelonoides</i> ..	—	—	—	—	—	—	10.00	2.60
Verbenaceae								
<i>Gmelina arborea</i>	—	—	—	—	—	—	11.25	2.83
Lauraceae								
<i>Alseodaphne petiolaris</i>	—	—	—	—	—	—	1.25	0.24
<i>Cinnamomum obtusifolium</i> ..	—	—	—	—	1.25	0.99	—	—
<i>C. tamala</i>	1.79	0.29	—	—	—	—	3.75	0.71
<i>Cryptocarya amygdalina</i> ..	—	—	—	—	—	—	2.50	0.71
<i>Litsaea</i> sp.	—	—	—	—	—	—	3.75	1.98
Other spp.	5.37	0.87	—	—	—	—	—	—
Euphorbiaceae								
<i>Baccaurea sapida</i>	26.85	11.60	—	—	10.00	4.46	5.00	0.94
<i>Croton joufra</i>	—	—	—	—	1.25	0.50	—	—
<i>Endospermum chinense</i>	—	—	—	—	—	—	1.25	0.24
<i>Macaranga</i> sp.	—	—	—	—	—	—	6.25	1.18
<i>Mallotus albus</i>	12.53	2.32	—	—	—	—	1.25	0.24
<i>Sapium baccatum</i>	1.79	0.29	—	—	1.25	0.99	1.25	0.24
Moraceae								
<i>Artocarpus chaplasha</i>	—	—	—	—	10.00	3.96	16.25	4.01
<i>Ficus</i> sp.	—	—	—	—	1.25	0.50	1.25	0.47
Ulmaceae								
<i>Trema orientalis</i>	—	—	—	—	—	—	1.25	0.24
Fagaceae								
<i>Castanopsis indica</i>	10.74	2.61	—	—	—	—	5.00	2.21
Unknown	—	—	—	1.85	—	0.50	—	0.24

As regards the ground cover, the Tinali area had cane brakes as the characteristic ground cover, while in the Hukanjuri area, *Alpinia*, aroids, ferns, *Laportea crenulata* and *Clerodendron* sp. and other shrubs formed the characteristic ground cover. In Kherjan area, cane brakes, the dwarf bamboo *Pseudostachyum polymorphum* and the dwarf palm *Pinanga gracilis* formed the undergrowth. In the Powai area, *Pseudostachyum polymorphum*, *Pinanga gracilis*, *Phrynium* sp., *Calamus erectus*, were common.

In all the areas, climbers were found in abundance, where no tending operation had been done. The chief climbers were *Derris oblonga*, *Tapiria hirsuta*, *Mezoneurum cucullatum*, etc.

FOREST TYPES OF ASSAM, WITH SPECIAL REFERENCE TO THE EVERGREEN AND SEMI-EVERGREEN FORESTS

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Introduction

Champion (1) has divided the Evergreen and Semi-evergreen forests of Assam into some thirteen different types. Admittedly, these types were defined and named on very meagre information then available. This has resulted in relegating several important forest types into one broad group, the floristic heterogeneity of which is misleading. In some other cases, there is also a confusion in naming associations or in denoting their ecological significations. As for example, Champion's type lb/C2—Upper Assam tropical evergreen, embraces two distinct types, viz., the *Mesua-Dipterocarp* formation to the exclusion of *Kayea assamica* and a *Kayea assamica* formation, which practically excludes *Dipterocarpus* species. Also, the extent of this area is not correctly shown. In the Abor, Aka hills, the type is more akin to a submontane type, while in Manipur and Lushai hills, the affinity is more towards Champion's type lb/C3—Cachar tropical evergreen. In case of Champion's type M.Tr./1 S/5,—Moist riparian, a very distinct type which is characterised by the presence of *Dillenia indica* and *Lagerstroemia flos-reginae*, has been grouped together with a riverain *Terminalia* formation. These two forms are distinct, as *Terminalia myriocarpa* is never found in riverain areas west of the Lakhimpur district, except on stream banks of some foot-hills, whereas the other formation is much widely distributed. As a matter of fact, tagging this very localised high level riverain *Terminalia myriocarpa* formation to other formations has resulted in Champion's types M.Tr./1 S/7 (c)—Upper Assam moist deciduous riverain, and M.Tr./1 S/8b—northern tropical semi-evergreen—riverain (*Terminalia-Phoebe* and *Terminalia-Morus* associations).

It may also be mentioned here that *Phoebe goalparensis* is an important constituent of high level semi-evergreen forests of the Assam valley and this species avoids riverain tracts. On the other hand, Champion's type 2b/cl—Upper Assam semi-evergreen forest should include these high level semi-evergreen forests which are found not only in Upper Assam, but up to the western limit of the State and should exclude any reference to an *Altingia-Magnolia-Cinnamomum* association, as a typical example. *Altingia excelsa* occurs in small pure patches in silted up areas in some semi-evergreen forests and a *Dillenia-Mesua-Altingia* association can be distinguished. In the early days, *Altingia excelsa*, *Cinnamomum cecidodaphne* and *Michelia champaca* were about the only useful species in these forests, though their occurrence is very scanty.

In order that the evergreen and semi-evergreen forests of Assam (excluding NEFA and Manipur) can be reclassified on a more rational basis, an attempt has now been made to show the different forest types recognised by the working plans and to indicate their composition as well as their relationship with climate and soil.

In Assam, two main climatic formations can be recognised. These are :

- A.—Evergreen, including semi-evergreen, and
- B.—Deciduous, including what may be termed as semi-deciduous forests.

The two main formations appear to be determined not so much by the total annual precipitation as the length of the dry period, greatly modified by biotic influences, as illustrated in the Table given below :—

Locality	Temperature		Rainfall in inches	Length of dry period with 1" rainfall or less	Forest type
	Mean max. (July)	Mean min. (January)			
Kochugaon	83·1° F.	52·3° F.	179·4"	Nov.-Feb.	Sal, Misc. Semi-deciduous and Assam valley semi-evergreen.
Mazbat ..	88° F.	59 F.	88·01"	Dec.-Jan.	Semi-evergreen forests.

Locality	Temperature		Rainfall in inches	Length of dry period with 1" rainfall or less	Forest type
	Mean max. (July)	Mean min. (January)			
Dimapur ..	?	45° F.	62.7"	Dec.-Jan. (92 rainy days)	Semi-evergreen forests.
Amguri ..	89.6° F.	53.1° F.	83.2"	Nov.-Jan. (124 rainy days)	Evergreen <i>Dipte- rocarp</i> forests.
Namsang (near Jeypore)	84.8° F.	47.6° F.	149.2"	December (175 rainy days)	Evergreen <i>Dipte- rocarp</i> forests.

The true deciduous (including semi-deciduous) formations are in the Kamrup and Nowgong districts, while the evergreen formations are typical of all the other districts.

The two main climatic formations, as above, are further modified by elevation, topography and soil factors.

On the basis of elevation, the evergreen formation is sub-divided into two broad classes, viz., sub-montane evergreen formation, and tropical evergreen formation. The sub-montane formation represents : (a) The Oak-*Rhododendron* formation (Champion's 10 b/c 2) found in the Khasi and Jaintia Hills and the Naga Hills at elevations of about 5000 feet, and (b) an oak formation,* growing almost pure in North Cachar Hills at 2000 feet. Bor (2) describes the first type as seen in Khasi and Jaintia Hills. From the point of view of economic utility as well as extent, these forests are not very important. Shifting cultivation in the past has replaced much of these types in the Khasi Hills by a sub-tropical pine forest, and in North Cachar Hills, by a grassland formation.

The tropical evergreen formation can be classified further into the following types :—

- (1) Evergreen *Mesua-Dipterocarp* formation
 - (2) Evergreen *Kayea assamica* formation
 - (3) Assam valley semi-evergreen formation—This should replace Champion's type 2b/C1.
- } included in Champion's type
} 1b/C 2.

Other bio-edaphic formations occur in between these main formations. Amongst biotic formations may be recognised the following :—

- (4) Secondary bamboo formations—Champion's type M.Tr/E 10(b).
- (5) Secondary semi-evergreen formations—differs from Champion's type M.Tr/2 S/2b.
- (6) Sub-montane savannah formation—not mentioned by Champion.
- (7) Sub-tropical pine formation—Champion's type 11/2C(c).

Amongst edaphic types, the following are distinctly recognisable :—

- (8) High level riverain type—included in Champion's M.Tr./1S/5, Mr.Tr./1S/7(c), M.Tr./2S/2b and 2b/C1.
- (9) Sub-Himalayan sandy alluvium semi-evergreen type—Champion's M.Tr./2S/4.
- (10) High Savannah (*Salmalia-Albizzia* type)—Champion's M.Tr./2S/7.
- (11) Inundated type.
- (12) Fresh water swamp type—Champion's M.Tr./1S/4.
- (13) Riverain *Khair-Sissoo* type—Champion's M.Tr./1S/6.
- (14) Cane brakes—Champion's M.Tr./E 8.

In case of the deciduous forests, two main types can be recognised, viz. sal forests and mixed deciduous forests.

1. The evergreen *Mesua-Dipterocarp* formation

There are two distinct sub-types. These are :

(a) *Cachar Mesua-Dipterocarp-Palaquium* formation.—This has been described by Champion in his Preliminary Survey of Forest types of India and Burma as type 1b c3 "Cachar tropical evergreen forest". Typical forests representing this type may be seen in the Inner Line Reserve of the Cachar division. Rowbotham (3) calls this type "A mixed

* (Not described by Champion).

largely evergreen type' and Mohanlal (4) calls it "Mixed evergreen type". The type is characterised by the presence of *Dipterocarpus turbinatus*, *Mesua ferrea*, *Kayea floribunda*, *Cynometra polyandra*, *Palaquium polyanthum*, *Nephelium longana*, *Heritiera acuminata*, *Alseodaphne owdenii*, *Diospyros* species and *Vatica lanceaefolia*. Moreover, with the exception of *Mesua ferrea*, the first few species are not known to occur in the Brahmaputra Valley.

Shifting cultivation and heavy exploitation for *Dipterocarpus turbinatus* in the past have destroyed much of this formation, so that the type is found in localised patches only.

In a typical formation of this type, *Dipterocarpus turbinatus* forms a very small percentage of the total number of stems per unit area. The most noticeable species are *Palaquium polyanthum* (which produces a lot of seedlings every year), *Kayea floribunda* and *Cynometra polyandra*. In the absence of an emergent canopy of *Dipterocarpus*, *Mesua ferrea* attains good height and is to be recognised as a top canopy species.

The Table below shows the composition of this type. The figures show the percentage density of stems above 3' girth (partial enumeration figures reduced to percentage basis).

Cachar Mesua-Dipterocarp-Palaquium formation

Species	Density per cent
<i>Alseodaphne owdenii</i>	1.13
<i>Amoora</i> spp.	1.13
<i>Artocarpus chaplasha</i>	1.02
<i>Albizzia procera</i>	0.06
<i>Aquilaria agallocha</i>	0.73
<i>Alphonsea ventricosa</i>	0.06
<i>Cinnamomum cecidodaphne</i>	0.17
<i>Calophyllum polyanthum</i>	0.40
<i>Canarium</i> spp.	3.11
<i>Cynometra polyandra</i>	8.19
<i>Dipterocarpus turbinatus</i>	7.29
<i>Dysoxylum reticulatum</i>	0.40
<i>Dysoxylum binectariferum</i>	
<i>Diospyros toposia</i>	9.10
<i>Diospyros lanceaefolia</i>	0.45
<i>Eugenia</i> spp.	7.86
<i>Echinocarpus assamicus</i>	0.06
<i>Elaeocarpus</i> spp.	0.06
<i>Ficus bengalensis</i>	0.23
<i>Garcinia</i> spp.	0.17
<i>Heritiera acuminata</i>	0.10
<i>Ixonanthes khasiana</i>	0.06
<i>Kayea floribunda</i>	0.06
Other Lauraceae and Magnoliaceae spp.	0.79
<i>Lophopetalum fimbriatum</i>	0.28
<i>Morus laevigata</i>	0.23
<i>Michelia champaca</i>	0.11
<i>Michelia montana</i>	0.11
<i>Mesua ferrea</i>	7.63
<i>Mangifera indica</i>	0.80
<i>Myristica kingii</i>	0.06
<i>Nephelium longana</i>	8.53
<i>Podocarpus neriifolia</i>	1.30
<i>Palaquium polyanthum</i>	20.00
<i>Premna bengalensis</i>	0.06
<i>Sterculia alata</i>	0.62
<i>Sterculia villosa</i>	0.28
<i>Sapium baccatum</i>	3.41
<i>Stereospermum chelonoides</i>	0.06
<i>Taraktogenos kurzii</i>	2.43
<i>Terminalia chebula</i>	0.56
<i>Vatica lanceaefolia</i>	2.82
<i>Zanthoxylum budrunga</i>	0.11
Others	5.57

(b) *The Upper Assam Mesua-Dipterocarp forests.*—Rowbotham (3) splits it up into "High evergreen forest consisting chiefly of *Shorea assamica* and *Mesua ferrea*" and "High evergreen forest consisting chiefly of *Dipterocarpus pilosus** and *Mesua ferrea*, but without *Shorea assamica*". Purkayastha, in his working plan (5) calls it the *Hollong-Nahor* type and Srinivasan (6) in his working plan calls it simply "Evergreen forest".

The following figures, taken from Srinivasan's Working Plan (6) show the composition of well stocked areas in certain forests Reserves carrying this type of forest. The figures show the number of stems above 3' girth, per 100 acres, and density per cent (*i.e.* enumeration figures reduced to percentage of total number of stems enumerated).

Species	Upper Dehing Reserve		Dirak Reserve		Jeypore Reserve		Abhoypur Reserve	
	No. per 100 acres	%	No. per 100 acres	%	No. per 100 acres	%	No. per 100 acres	%
<i>Amoora wallichii</i> ..	39.48	1.31	40.74	1.02	42.37	2.30	79.29	4.89
<i>Artocarpus chaplasha</i> ..	25.38	0.84	22.28	0.55	24.26	1.32	35.00	2.17
<i>Altingia excelsa</i> ..	19.74	0.56	9.78	0.24	9.60	0.48	13.71	0.85
<i>Artocarpus lakoocha</i> ..	11.28	0.37	2.71	0.07	—	—	+	—
<i>Alphonsea ventricosa</i> ..	—	—	—	—	—	—	+	—
<i>Ailanthus grandis</i> ..	8.46	0.28	0.5	0.01	—	—	7.14	0.1
<i>Anthocephalus cadamba</i>	2.82	0.09	18.48	1.56	—	—	+	—
<i>Adina cordifolia</i> ..	+	—	—	—	1.43	0.07	+	—
<i>Aquilaria agallocha</i> ..	—	—	—	—	—	—	12.43	0.77
<i>Albizia odoratissima</i> ..	—	—	—	—	0.78	0.03	+	—
<i>Albizia lucida</i> ..	—	—	—	—	—	—	10.43	0.65
<i>Alstonia scholaris</i> ..	—	—	—	—	—	—	4.86	0.30
<i>Bridelia retusa</i> ..	2.82	0.09	—	—	—	—	—	—
<i>Bischofia javanica</i> ..	*	—	—	—	1.44	0.07	10.00	0.62
<i>Cinnamomum glanduliferum</i> ..	19.74	0.65	29.34	0.73	21.64	1.20	98.57	6.10
<i>Cinnamomum tamala</i> ..	+	—	—	—	3.19	0.16	+	—
<i>Canarium</i> spp. ..	16.92	0.56	58.13	1.45	—	—	36.57	2.26
<i>Chukrasia tabularis</i> ..	+	—	40.74	1.02	2.22	0.11	4.44	0.28
<i>Cedrela</i> spp. ..	—	—	2.17	0.54	—	—	6.71	0.41
<i>Castanopsis indica</i> ..	+	—	50.48	0.12	—	—	92.57	5.73
<i>Celtis australis</i> } ..	*	—	6.52	0.62	—	—	+	—
<i>Celtis tetrandra</i> }								
<i>Dipterocarpus macrocarpus</i> ..	1291.56	41.66	1032.28	28.68	629.34	34.56	211.00	13.07
<i>Dysoxylum procerum</i> } ..								
<i>Chisocheton paniculatus</i> }	64.86	2.16	86.91	2.17	—	—	64.00	3.96
<i>Dillenia indica</i> ..	—	—	+	—	—	—	13.57	0.84
<i>Duabanga sonneratioides</i> ..	+	—	1.09	0.02	4.74	0.23	2.29	0.14
<i>Eugenia jambolana</i> ..	—	—	11.40	0.25	—	—	23.00	1.42
<i>Eugenia praecox</i> ..	+	—	16.30	0.41	—	—	+	—
<i>Endospermum chinense</i>	+	—	21.18	0.53	—	—	87.43	5.42
<i>Echinocarpus assamicus</i>	11.28	0.37	—	—	—	—	+	—
<i>Engelhardtia spicata</i> ..	—	—	+	—	—	—	57.43	3.56
<i>Gynocardia odorata</i> ..	—	—	—	—	—	—	11.29	0.70
<i>Garcinia</i> spp. ..	+	—	43.45	0.11	—	—	0.55	0.04
<i>Holigarna</i> spp. ..	5.64	0.18	1.09	0.02	—	—	+	—
<i>Lagerstroemia flos-reginae</i>	+	—	—	—	0.37	0.01	—	—
<i>Lannea grandis</i> ..	+	—	—	—	1.15	0.61	+	—
<i>Mesua ferrea</i> ..	634.50	20.46	636.26	16.67	576.29	31.52	66.14	4.10
Magnoliaceae spp. ..	163.56	5.45	350.62	9.74	85.71	4.70	125.43	7.78
<i>Michelia champaca</i> ..	2.82	0.09	—	—	11.73	0.58	11.29	0.70
<i>Morus laevigata</i> ..	2.82	0.09	21.74	0.54	—	—	0.14	0.01

* *Dipterocarpus macrocarpus*.

Species	Upper Dehing Reserve		Dirak Reserve		Jeypore Reserve		Abhoypur Reserve	
	No. per 100 acres	%	No. per 100 acres	%	No. per 100 acres	%	No. per 100 acres	%
<i>Nyssa sessiliflora</i>	14.10	0.47	—	—	0.56	0.02	9.85	0.61
<i>Magnolia griffithii</i>			—	—	—	—	11.90	0.73
<i>Magnolia pterocarpa</i>			—	—	—	—	18.71	1.61
<i>Myristica kingii</i> ..	+	—	8.14	—	—	—	+	—
<i>Meliosma simplicifolia</i> ..	—	—	2.17	0.05	1.25	0.62	+	—
<i>Podocarpus neriifolia</i> ..	+	—	—	—	—	—	+	—
<i>Pterospermum lanceaefolium</i> ..	+	—	10.87	0.27	—	—	+	—
<i>Phoebe cooperiana</i> ..	+	—	—	—	5.23	0.26	4.29	0.27
<i>Phoebe goalparensis</i> ..	—	—	—	—	—	—	0.55	0.04
<i>Shorea assamica</i> ..	169.20	5.64	294.13	8.17	314.87	17.09	9.71	0.09
<i>Sterculia villosa</i> ..	5.64	0.18	1.08	0.02	—	—	+	—
<i>Sterculia alata</i> ..	2.82	0.09	—	—	1.43	0.71	+	—
<i>Sapium baccatum</i> ..	5.64	0.18	62.47	1.56	—	—	9.85	0.61
<i>Schima wallichii</i> ..	—	—	1.62	0.40	0.27	0.01	7.43	0.46
<i>Spondias mangifera</i> ..	—	—	0.54	0.13	—	—	+	—
<i>Salmalia malabarica</i> ..	—	—	—	—	0.78	0.03	+	—
<i>Stereospermum chelonoides</i> ..	2.82	2.09	2.71	0.09	—	—	85.71	5.31
<i>Terminalia chebula</i> ..	36.66	1.22	33.70	0.84	36.77	2.01	37.86	2.34
<i>Terminalia myriocarpa</i> ..	+	+	9.22	0.23	22.89	1.14	1.43	0.09
<i>Terminalia belerica</i> ..	2.82	10.09	5.97	0.15	—	—	66.00	4.09
<i>Vatica lanceaefolia</i> ..	+++	—	599.5	15.00	+++	—	60.14	3.73
Others	535.80	16.64	684.01	22.75	1.02	.05	103.43	6.40
Unknown	—	—	—	—	—	—	100.43	6.20

+++ indicates species abundant in lower canopy layers in all the reserves, but often excluded from the statement due to small girth.

Besides the above, the following species are also found occasionally and sporadically in the Abhoypur Reserve, and also in parts of the other ones :

Albizia procera, *A. stipulata*, *Aglaia* spp., *Azadirachta indica*, *Antidesma* spp., *Alphonsea ventricosa*, *Cryptocarya amygdalina*, *Cyclostemon* spp., *Dysoxylum hamiltonii*, *Diospyros* spp., *Evodia meliaefolia*, *Elaeocarpus rugosus*, *Elaeocarpus ganitrus*, *Ficus* spp., *Garcinia* spp., *Hydnocarpus kurzii*, *Ilex godajam*, *Kydia calycina*, *Litsaea* spp., *Mangifera indica*, *Machilus bombycina*, *Myristica erratica*, *Myristica gibbosa*, *Olea* spp., *Premna bengalensis*, *Pterospermum acerifolium*, *Polyalthia* spp., *Symplocos racemosa*, *Trewia nudiflora*, *Zanthoxylum budrunga*.

A comparison of the species present and their density is illuminating. Dirak Reserve is near the Sub-Himalayan Frontier tracts, and the eastern-most reserve of those mentioned in the list, and Abhoypur Reserve is very near the western limit of this type of forests.

In the Dirak Reserve, a large number of shallow *nullahs* which remain dry in winter, come to life with the rains and sweep over the forest floor. The soil is devoid of humus (the same being washed away every rain), and contains a percentage of silt. *Terminalia myriocarpa* is generally present near the streams or in areas where surface streams spring up during the rains, and also as pioneer species in fresh silt deposits. The presence of other pioneer species such as *Duabanga sonneratioides* and *Chukrasia tabularis* also indicates the effect of past shifting cultivation. Species like *Eugenia* sp., *Pterospermum lanceaefolium*, *Celtis* sp., *Endospermum chinense*, are more characteristic of the flat ground with recent alluvium, rather than of the red earth of the old alluvium on undulating ground which is more characteristic of the *Mesua-Dipterocarp* formation.

The change of the forest type is clearly noticeable in the Abhoypur Reserve, where the percentage of *Mesua ferrea* and *Dipterocarpus macrocarpus* decreases and a large number of species more characteristic of some other forest type come in. The same is seen in the hilly portion of the Hilika block in Jeypore Reserve. Perhaps its sandy loam soil as opposed

to old alluvium looking almost like tropical red earth in well stocked *nahor-hollong* forests is mainly responsible for this change in composition. Champion classifies this as a secondary formation (Type M.Tr./2s/2b) but geological formation may also have a prominent part to play in its formation.

In all the reserves of the forest type under discussion, *Vatica lanceaefolia* is the commonest species in the lower canopies, so much so that *Mesua-Dipterocarpus-Vatica* association seems to be the more correct name for the type.

The characteristic species in the underground are canes of several species, and the palm, *Pinanga gracilis*.

2. Evergreen Kayea assamica formation

This type occurs in the extreme east on the north bank of the Brahmaputra. A typical area is in the Dulong Reserve. Here, *Dipterocarpus macrocarpus* is practically absent, and *Mesua ferrea* gives way to *Kayea assamica* which comprises about 70% of the stock. The following figures taken from Islam's plan (under preparation) show the floristic composition and percentage density* of stems above 3' girth.

Evergreen Kayea assamica formation, Dulong Reserve

Species	Density per cent
<i>Artocarpus chaplasha</i>	0.31
<i>Aquilaria agallocha</i>	0.01
<i>Amoora wallichii</i>	1.50
<i>Altingia excelsa</i>	0.19
<i>Adina</i> spp.	0.06
<i>Bridelia retusa</i>	0.01
<i>Bischofia javanica</i>	0.14
<i>Cinnamomum cecidodaphne</i>	0.16
<i>Cedrela toona</i>	0.02
<i>Cinnamomum obtusifolium</i>	0.08
<i>Canarium</i> spp.	4.31
<i>Dipterocarpus macrocarpus</i>	0.17
<i>Duabanga sonneratioides</i>	0.01
<i>Dysoxylum</i> spp.	6.33
<i>Dysoxylum hamiltonii</i>	0.30
<i>Eugenia praecox</i>	0.25
<i>Echinocarpus assamicus</i>	3.70
<i>Eugenia</i> spp.	0.13
<i>Gmelina arborea</i>	0.01
<i>Kayea assamica</i>	68.89
<i>Michelia champaca</i>	0.10
<i>Manglietia insignis</i>	0.06
<i>Mesua ferrea</i>	2.69
<i>Michelia montana</i>	0.10
Magnoliaceae spp.	0.09
<i>Mansonia dipikae</i>	0.13
<i>Mangifera indica</i>	0.10
<i>Premna bengalensis</i>	0.02
<i>Pterospermum acerifolium</i>	0.40
<i>Pterospermum lanceaefolium</i>	6.25
<i>Salmalia malabarica</i>	0.07
<i>Terminalia chebula</i>	2.57
<i>Terminalia belerica</i>	0.29
<i>Vitex peduncularis</i>	0.01
<i>Zanthoxylum budrunga</i>	0.32
Others	0.02

*Total enumeration figures reduced to percentage basis.

3. The Assam Valley semi-evergreen formation

On the south bank of the Brahmaputra, this type starts just west of the upper Assam *Mesua-Dipterocarp* type, and extends as far west as Lumding, where it is replaced by a semi-deciduous forest. On the north bank of the Brahmaputra, this type extends from

Naduar reserve of the Darrang district in the east, running along the Sub-Himalayan plains to the western limit of Assam, in the Ripu Reserve of the Goalpara West division (9) with a break in the North Kamrup division where it is replaced by Savannah and other formations characterised by *Salmalia*, *Terminalia myriocarpa*, *Acacia catechu* and *Albizia procera*. This type prefers the well drained, high level areas, giving place to one of the edaphic formations in the inundated low lying areas.

The floristic composition as well as density per cent¹ of stems above 3' girth, taken from working plan figures, are shown below :

Assam Valley semi-evergreen type on the south bank of the Brahmaputra.

Species	Geleki Block I. %	Doyang Reserve %	Nambor Reserve %	Intanki Reserve %	Dhansiri Reserve %
<i>Aglaiia</i> spp.	—	—	+	0.61	1.63
<i>Bischofia javanica</i>	0.20	12.26	1.20	0.21	0.09
<i>Beilschmiedia brandisii</i>	—	0.17	—	—	—
<i>Amoora wallichii</i>	4.11	5.86	5.39	1.82	2.92
<i>Albizia odoratissima</i>	—	0.07	+	0.06	—
<i>Albizia procera</i>	—	0.60	0.22	0.09	—
<i>Albizia</i> spp.	0.24	0.03	—	—	—
<i>Alstonia scholaris</i>	1.12	0.05	0.87	—	0.16
<i>Altingia excelsa</i>	—	0.02	—	—	—
<i>Anthocephalus cadamba</i>	0.72	0.30	+	0.12	0.10
<i>Artocarpus chaplasha</i>	0.60	0.76	1.95	0.70	0.71
<i>Azadirachta indica</i>	—	0.05	—	0.12	0.11
<i>Artocarpus lakoocha</i>	+	—	+	0.21	0.02
<i>Alphonsea ventricosa</i>	—	4.60	1.21	2.93	1.64
<i>Aquilaria agallocha</i>	—	0.11	—	0.41	—
<i>Ailanthus grandis</i>	—	—	0.97	0.40	0.77
<i>Adina cordifolia</i>	—	—	+	0.08	0.20
<i>Bambax insigne</i>	—	—	+	0.17	0.01
<i>Cassia fistula</i>	—	—	—	+	0.01
<i>Castanopsis indica</i>	3.90	6.46	3.87	0.39	0.02
<i>Canarium</i> spp.	3.71	0.67	4.77	0.60	1.36
<i>Chukrasia tabularis</i>	0.72	—	0.53	1.11	2.56
<i>Cinnamomum glanduliferum</i> }	0.92	0.06	0.59	0.31	—
<i>Cinnamomum cecidodaphne</i> }	—	—	—	—	—
<i>Cedrela</i> spp.	0.24	3.63	1.66	0.38	0.04
<i>Cryptocarya amygdalina</i>	—	—	—	—	1.56
<i>Crypteronia paniculata</i>	+	—	—	—	—
<i>Celtis</i> spp.	—	0.13	—	—	0.22
<i>Cinnamomum obtusifolium</i>	0.20	—	+	—	0.22
<i>Cyclostemon ellipticus</i>	—	—	—	18.26	—
<i>Cyclostemon assamicus</i> }	+	+	+	10.01	12.03
<i>Polyalthia</i> spp. }	+	+	+	0.57	4.63
<i>Diospyros</i> spp. }	+	+	+	—	—
<i>Dillenia indica</i>	+	6.45	3.58	1.48	1.09
<i>Dillenia scabrella</i>	—	—	1.07	2.33	1.50
<i>Dillenia pentagyna</i> }	—	—	—	—	—
<i>Dipterocarpus macrocarpus</i>	8.74	—	—	—	—
<i>Dysoxylum procerum</i>	3.11	2.28	3.52	1.58	1.45
<i>Dysoxylum hamiltonii</i>	—	—	—	0.14	0.64
<i>Duabanga sonneratioides</i>	0.49	3.80	0.54	0.28	0.40
<i>Endospermum chinense</i>	4.49	—	0.59	—	—
<i>Eugenia</i> spp.	3.56	0.18	1.80	4.70	—
<i>Engelhardtia spicata</i>	2.92	—	—	—	—
<i>Evodia meliaefolia</i>	—	0.01	—	—	—

¹ Partial enumeration figures expressed as percentage of total number of stems enumerated.

(Contd.)

Assam Valley semi-evergreen type on the south bank of the Brahmaputra—(Concl'd.)

Species	Geleki Block I. %	Doyang Reserve %	Nambor Reserve %	Intanki Reserve %	Dhansiri Reserve %
<i>Erythrina suberosa</i>	—	0.34	—	—	—
<i>Elaeocarpus ganitrus</i>	+	—	—	—	—
<i>Elaeocarpus rugosus</i>	—	0.77	—	—	0.69
<i>Ficus</i> spp.	+	0.08	—	—	—
<i>Gmelina arborea</i>	0.20	0.11	1.49	0.81	1.84
<i>Garcinia</i> spp.	+	—	—	—	—
<i>Heteropanax fragrans</i>	—	0.36	—	—	1.62
<i>Hydnocarpus kurzii</i>	+	—	1.44	0.97	4.85
<i>Lagerstroemia flos-reginae</i>	—	3.42	1.54	0.03	—
<i>Lagerstroemia parviflora</i>	—	—	—	—	0.04
<i>Litsaea polyantha</i>	+	+ } 0.12	—	—	—
<i>Litsaea sebifera</i>	+		—	—	—
<i>Lannea grandis</i>	—	—	+	5.29	7.06
<i>Magnolia</i> spp.	10.61	0.22	3.06	1.32	1.46
<i>Mansonia dipikae</i>	—	—	—	3.68	14.45
<i>Mesua ferrea</i>	0.92	0.09	6.61	0.27	—
<i>Michelia champaca</i>	0.69	—	—	0.13	—
<i>Mangifera indica</i>	0.09	0.19	1.13	2.77	0.78
<i>Morus laevigata</i>	—	0.03	0.15	0.04	0.38
<i>Mallotus albus</i>	+	0.85	—	—	—
<i>Machilus bombycina</i>	+	—	—	0.09	—
<i>Myristica erratica</i>	+	—	—	—	—
<i>Myristica kingii</i>	+	0.36	—	—	1.63
<i>Myristica gibbosa</i>	+	—	—	—	—
<i>Nyssa sessiliflora</i>	1.16	0.85	+	—	—
<i>Nephelium longana</i>	—	—	—	3.19	1.69
<i>Oroxylum indicum</i>	—	0.05	—	—	—
<i>Phoebe goalparensis</i>	—	5.57	0.34	0.75	1.36
<i>Phoebe cooperiana</i>	—	—	—	0.10	0.21
<i>Pterospermum lanceaefolium</i>	0.60	0.19	0.56	0.39	0.70
<i>Premna bengalensis</i>	0.29	0.44	—	0.68	0.61
<i>Podocarpus neriifolia</i>	+	0.02	—	—	—
<i>Parkia roxburghii</i>	—	—	+	0.15	0.39
<i>Stereospermum chelonoides</i>	7.03	8.36	7.33	11.20	10.43
<i>Sapium baccatum</i>	4.69	—	0.88	—	0.12
<i>Sterculia alata</i>	—	5.91	1.93	0.32	0.58
<i>Schima wallichii</i>	2.56	—	+	0.02	0.02
<i>Shorea assamica</i>	1.17	—	—	—	—
<i>Sterculia guttata</i>	—	—	—	0.29	0.77
<i>Spondias mangifera</i>	+	0.41	0.85	0.15	0.13
<i>Sterculia villosa</i>	+	0.45	+	1.32	1.03
<i>Symplocos spicata</i>	+	0.08	—	—	—
<i>Saracca indica</i>	—	0.03	—	—	—
<i>Salmalia malabarica</i>	+	2.09	0.28	0.13	0.40
<i>Terminalia belerica</i>	3.83	1.09	1.00	0.39	0.36
<i>Terminalia chebula</i>	1.10	1.20	3.01	1.20	—
<i>Terminalia myriocarpa</i>	0.12	11.12	0.94	0.85	0.31
<i>Tetrameles nudiflora</i>	+	4.46	5.73	4.02	5.21
<i>Ulmus lanceaefolia</i>	—	—	—	0.49	—
<i>Vatica lanceaefolia</i>	5.63	—	—	—	—
<i>Vitex peduncularis</i>	—	—	—	0.43	0.20
<i>Vitex canescens</i>	—	—	—	0.49	—
<i>Wrightia tomentosa</i>	—	—	—	—	0.72
<i>Zanthoxylum budrunga</i>	+	0.06	0.53	0.13	0.15
Unknown	—	—	11.16	1.97	—
Others*	5.15	—	13.76	3.26	3.51

*Others include species whose scattered presence is shown by +.

Assam Valley Semi-evergreen type—North bank areas

Species	Charduar Panchnoi Block	Charduar Sopai Block	Charduar Belsiri Block	Ripu Bamba Block
<i>Acrocarpus fraxinifolius</i>	—	—	—	0.50
<i>Artocarpus chaplasha</i>	0.25	0.40	0.56	—
<i>Altingia excelsa</i>	0.33	0.44	0.60	—
<i>Amoora wallichii</i>	5.65	0.35	6.41	5.50
<i>Adina oligocephala</i>	0.45	0.76	0.19	+
<i>Artocarpus lakoocha</i>	0.02	—	—	—
<i>Ailanthus grandis</i>	0.90	0.31	0.57	1.00
<i>Alstonia scholaris</i>	0.50	0.46	—	—
<i>Anthocephalus cadamba</i>	0.10	1.37	—	+
<i>Albizia odoratissima</i>	0.30	0.05	0.22	—
<i>Albizia lucida</i>	0.80	0.17	0.66	4.50
<i>Aquilaria agallocha</i>	0.01	—	0.04	—
<i>Bridelia retusa</i>	—	—	0.96	+
<i>Bischofia javanica</i>	0.40	0.86	1.84	—
<i>Bauhinia</i> spp.	0.15	—	0.04	+
<i>Castanopsis</i> spp.	2.80	2.80	2.24	6.00
<i>Cinnamomum cecidodaphne</i>	0.60	0.80	13.35	3.50
<i>Cinnamomum obtusifolium</i>	0.02	1.70	0.04	—
<i>Chukrasia tabularis</i>	0.95	0.66	0.80	+
<i>Cedrela toona</i>	0.50	0.01	—	0.05
<i>Canarium</i> spp.	2.00	2.40	1.35	+
<i>Crypteronia paniculata</i>	0.02	—	—	—
<i>Cinnamomum tamala</i>	—	—	—	—
<i>Celtis australis</i>	0.04	0.02	0.21	—
<i>Crataeva</i> spp.	0.01	0.01	0.04	—
<i>Cordia myxa</i>	0.01	0.08	0.48	—
<i>Callicarpa arborea</i>	—	—	0.17	+
<i>Careya arborea</i>	0.09	0.01	0.02	—
<i>Dysoxylum procerum</i>	7.05	7.71	5.12	+
<i>Dysoxylum hamiltonii</i>	0.35	0.10	0.16	0.50
<i>Dillenia indica</i>	—	4.67	11.34	+
<i>Dillenia scabrella</i>	2.05	—	—	0.50
<i>Dillenia pentagyna</i>	0.02	0.03	—	—
<i>Drimycarpus racemosus</i>	—	0.07	—	—
<i>Duabanga sonneratioides</i>	2.30	0.86	1.24	+
<i>Eugenia</i> spp.	2.00	1.30	1.59	2.50
<i>Echinocarpus assamicus</i>	0.15	0.01	0.64	—
<i>Emblica officinalis</i>	0.05	—	—	—
<i>Endospermum chinense</i>	0.10	0.19	0.06	—
<i>Elaeocarpus ganitrus</i>	—	0.03	0.02	—
<i>Gmelina arborea</i>	1.30	1.10	2.58	+
<i>Gynocardia odorata</i>	0.01	—	—	—
<i>Garcinia xanthochymus</i>	—	0.03	—	—
<i>Heteropanax fragrans</i>	0.01	0.03	—	—
<i>Kayea assamica</i>	—	+	—	—
<i>Kydia calycina</i>	0.05	1.82	3.10	—
<i>Lophopetalum fimbriatum</i>	—	—	—	1.00
<i>Lagerstroemia flos-reginae</i>	—	—	—	—
<i>Lagerstroemia parviflora</i>	0.55	—	—	—
<i>Lannea grandis</i>	4.60	2.85	1.91	—
<i>Garuga pinnata</i>				
<i>Litsaea polyantha</i>	0.15	—	—	+
<i>Litsaea sebifera</i>	0.04	0.04	0.08	+
<i>Litsaea citrata</i>	—	—	—	+
<i>Litsaea elongata</i>	—	1.10	0.16	—
<i>Laportea crenulata</i>	—	1.34	1.12	—
<i>Mesua ferrea</i>	0.60	1.40	3.00	3.00

Assam Valley Semi-evergreen type—North bank areas—(Concl'd.)

Species	Charduar Panchnoi Block	Charduar Sopai Block	Charduar Belsiri Block	Ripu Bamba Block
<i>Michelia champaca</i>	0.08	—	—	1.00
<i>Michelia manii</i>	—	2.70	0.01	—
<i>Michelia oblonga</i>	—	2.70	0.01	—
<i>Michelia montana</i>	0.35	5.38	3.70	—
<i>Manglietia insignis</i>	—	—	—	—
<i>Pachylarnax pleiocarpa</i>	4.80	3.30	3.19	—
<i>Mansonia dipikae</i>	—	—	—	—
<i>Sterculia alata</i>	0.20	—	0.26	13.5
<i>Mangifera indica</i>	0.05	1.09	0.01	—
<i>Magnolia griffithii</i>	—	—	—	—
<i>Nyssa sessiliflora</i>	0.03	0.04	0.10	10.00
<i>Machilus bombycina</i>	—	0.03	0.42	17.50
<i>Machilus globosa</i>	2.85	1.10	1.12	—
<i>Meliosma simplicifolia</i>	—	0.69	0.07	—
<i>Morus laevigata</i>	0.40	0.28	0.07	—
<i>Myristica angustifolia</i>	—	0.74	0.59	—
<i>Oroxylum indicum</i>	0.02	0.02	0.06	—
<i>Olea dioica</i>	—	—	—	—
<i>Elaeocarpus rugosus</i>	—	2.39	1.50	—
<i>Phoebe goalparensis</i>	13.22	7.92	5.87	9.50
<i>Phoebe cooperiana</i>	2.00	1.00	0.32	—
<i>Pterospermum acerifolium</i>	1.47	0.16	—	+
<i>Podocarpus neriifolia</i>	0.01	0.01	—	—
<i>Pterospermum lanceaeifolium</i>	4.85	0.58	—	—
<i>Premna bengalensis</i>	0.45	1.20	0.87	+
<i>Premna latifolia</i>	0.05	—	0.12	+
<i>Polyalthia simiarum</i>	0.67	0.55	0.36	1.50
<i>Salmalia malabarica</i>	1.18	0.20	1.32	+
<i>Schima wallichii</i>	0.01	—	—	3.50
<i>Sapium baccatum</i>	0.35	0.38	0.11	+
<i>Sterculia villosa</i>	1.20	1.20	0.12	+
<i>Spondias mangifera</i>	0.02	—	0.05	—
<i>Symplocos oxyphylla</i>	—	0.02	—	—
<i>Sapium insigne</i>	0.75	0.19	0.28	—
<i>Stereospermum chelonoides</i>	—	0.99	0.52	1.50
<i>Talauma phellocarpa</i>	2.20	4.08	8.10	—
<i>Talauma hodgsoni</i>	—	2.71	0.01	—
<i>Taraktogenos kurzii</i>	1.25	2.16	1.05	—
<i>Terminalia myriocarpa</i>	0.25	0.09	—	0.50
<i>Terminalia belerica</i>	+	1.33	0.01	—
<i>Terminalia arjuna</i>	0.01	—	—	—
<i>Terminalia chebula</i>	0.01	—	0.32	0.50
<i>Tetrameles nudiflora</i>	2.35	2.10	2.10	7.00
<i>Vitex peduncularis</i>	1.70	0.44	0.16	+
<i>Zanthoxylum budrunga</i>	0.60	1.40	0.56	—
Others	3.81	3.31	4.41	6.00

4. Secondary bamboo formations

The most characteristic feature of secondary growths in both the evergreen and semi-evergreen types is the presence of bamboos, either as an understorey, or mainly bamboos, with a few scattered trees standing over them. The characteristic species of bamboos in loamy soil are *Pseudostachyum polymorpha* and *Dendrocalamus hamiltonii*, and that in lateritic soils, *Malocanna bambusoides*. *Dendrocalamus hamiltonii* occurs largely in the low hills of upper Assam, while *Melocanna* is found in Cachar and in Garo hills. In drier regions of North Cachar district, *Bambusa tulda* is the dominating species.

The bamboo forests tend to become more and more pure as the intensity of shifting cultivation increases, and especially in lateritic soils (e.g. in Badshahi tilla reserve of the

present Cachar district) a stage is reached when it becomes difficult to maintain plantations, as these are soon swamped by bamboos.

The characteristic tree species in the hilly areas is *Duabanga sonneratioides*, which often forms pure young crops soon after clearance, where bamboo growth is not prolific. *Tetrameles nudiflora* also occurs along stream banks. These, together with some of the trees of the original formation left standing, form an open tree canopy, where the number of trees may be as small as 2 trees per seven acres or so.

5. Secondary Semi-evergreen formation

This type occurs in sandy loam soil and on low-lying areas of the main formations. On account of the presence of fast growing pioneer species like *Duabanga sonneratioides*, *Pterospermum acerifolium*, *Salmalia malabarica*, the type as a whole tends more towards the deciduous. The following Table, taken from working plan figures (8) of Naduar Reserve exemplify this type. The figures show the percentage density of stems above 3' girth.

Species	Density %
<i>Artocarpus chaplasha</i>	1.70
<i>Amoora wallichii</i>	0.56
<i>Adina</i> spp.	1.70
<i>Artocarpus lakoocha</i>	0.56
<i>Ailanthus grandis</i>	0.56
<i>Albizia lucida</i>	0.63
<i>Bischofia javanica</i>	1.70
<i>Bauhinia</i> spp.	6.23
<i>Chukrasia tabularis</i>	1.13
<i>Cedrela toona</i>	0.56
<i>Castanopsis</i> spp.	0.56
<i>Duabanga sonneratioides</i>	2.26
<i>Dysoxylum procerum</i>	5.66
<i>Diospyros</i> spp.	0.56
<i>Dillenia indica</i>	25.50
<i>Eugenia</i> spp.	1.70
<i>Echinocarpus assamicus</i>	0.56
<i>Ficus</i> spp.	1.70
<i>Gmelina arborea</i>	1.13
<i>Garuga pinnata</i>	1.13
<i>Lannea grandis</i>	
<i>Kydia calycina</i>	
<i>Litsaea sebifera</i>	2.26
<i>Litsaea</i> spp.	0.56
<i>Premna bengalensis</i>	0.56
<i>Pterospermum acerifolium</i>	7.93
<i>Premna latifolia</i>	7.93
<i>Salmalia malabarica</i>	4.53
<i>Stereospermum chelonoides</i>	1.13
<i>Terminalia chebula</i>	0.56
<i>Terminalia belerica</i>	0.56
<i>Trewia nudiflora</i>	1.70
<i>Talauma hodgsoni</i>	0.56
<i>Taraktogenos kurzii</i>	0.56
Unknown	2.17

In the example described, almost all the trees, with the exception of *Dillenia indica*, are below 5' girth, and *Dillenia indica* alone is found up to 10' girth size. It may be noted that the original formation which gave rise to this secondary formation was one of the inundated formations described hereinafter.

6. Sub-montane Savannah formation

This formation is seen in different soil formations, at an elevation above the bamboo zone. The type seems to be separated from the tree forests and bamboo forests by a distinct line. It is seen in the United Khasi and Jaintia hills above 3000 ft. elevation, side by side with pine forests, at 2000 ft. elevation in North Cachar hills near the oak formation, and

on the western side of the Naga hills above 3000 ft. where hill tops are often covered with grass, with timber forests lower down.

These grasslands owe their existence to intensive shifting cultivation and burning, and there are practically no trees in them.

7. Sub-tropical pine formation

This type is seen in Khasi and Jaintia hills and in Naga hills above 3000 ft. elevation. *Pinus insularis* forms pure even aged stands wherever shifting cultivation is prevalent.

8. Edaphic formations

High level riverain type (Terminalia myriocarpa):—This type is found in the Sub-Himalayan tracts as well as in the foot hills of the Naga, and Patkoi hills. The most prominent species is *Terminalia myriocarpa* which is a pioneer species appearing in silt deposits. In the area where this type occurs, a large number of shallow surface streams and springs come to life with the advent of the rains, and carry with them silt washed down from higher areas and clearances for shifting cultivation. The soil is devoid of humus, the latter being washed down every rains.

This type also occurs in the riverain tracts along the Brahmaputra and the Dehing rivers, and often merge with one of the inundated types, as in Dibru Reserve. In the Assam valley semi-evergreen forests, this type occurs to the north of the main formation, as seen in Khalinduar Reserve of the Darrang division, and Chirang Reserve of Goalpara east division. The most clear cut formation, however, occurs in the old Sadiya division (now merged with the Lakhimpur division). The following enumeration figures of 1932, given by Purkayastha (10) for Pasihat Reserve show the best example of this type.

High level riverain type

Species	Percentage density of trees about 3' girth
<i>Amoora wallichii</i>	0.76
<i>Albizzia procera</i>	0.38
<i>Albizzia lucida</i>	1.01
<i>Ailanthus grandis</i>	2.80
<i>Anthocephalus cadamba</i>	0.12
<i>Alstonia scholaris</i>	1.01
<i>Bischofia javanica</i>	1.40
<i>Baccaurea sapida</i>	1.27
<i>Cinnamomum cecidodaphne</i>	0.30
<i>Castanopsis</i> spp.	0.25
<i>Cedrela toona</i>	0.50
<i>Cordia obliqua</i>	0.12
<i>Canarium</i> spp.	0.63
<i>Crataeva</i> spp.	1.52
<i>Dysoxylum binectariferum</i>	0.12
<i>Duabanga sonneratioides</i>	4.33
<i>Dalbergia assamica</i>	1.14
<i>Derris robusta</i>	
<i>Echinocarpus assamicus</i>	1.27
<i>Eugenia</i> spp.	0.38
<i>Elaeocarpus rugosus</i>	2.93
<i>Morus laevigata</i>	0.38
<i>Mesua ferrea</i>	0.50
<i>Premna bengalensis</i>	0.38
<i>Phoebe cooperiana</i>	0.12
<i>Pterospermum acerifolium</i>	7.51
<i>Salmalia malabarica</i>	0.38
<i>Terminalia belerica</i>	0.63
<i>Terminalia myriocarpa</i>	42.24
<i>Terminalia chebula</i>	0.63
<i>Taraktogenos kurzii</i>	1.01

(Contd.)

High level riverain type—(Concl'd.)

Species	Percentage density of trees about 3' girth
<i>Talauma hodgsoni</i>	1.27
<i>Turpinia pomifera</i>	0.25
<i>Vitex peduncularis</i>	3.43
<i>Vatica lanceaeifolia</i>	4.62
Unknown	13.12

9. Sub-Himalayan sandy alluvium semi-evergreen type

This type is found in the Sub-Himalayan tracts to the north of the Assam valley semi-evergreen type where, due to stream action, the soil is composed mainly of loamy sand and pebbles, and where fire is unknown, due to the area being surrounded by a semi-evergreen type. This type is perhaps a forerunner of the Assam valley semi-evergreen type. Here, *Phoebe goalparensis* is either absent, or constitutes a very small percentage of the total number of stems. The top canopy, which is actually an emergent layer over a general canopy level of about 60' height, is very open and consists mostly of deciduous and semi-deciduous trees like *Tetrameles nudiflora*, *Acrocarpus fraxinifolius*, *Ailanthus grandis*, *Terminalia myriocarpa* etc. The middle canopy is composed of evergreens like *Machilus bombycina*, *Amoora wallichii*, *Lagerstroemia parviflora* etc. Rajkhowa (9) in his working plan for Goalpara West division (1956) splits this up into two sub-types depending on the percentage density of *Tetrameles nudiflora* in the emergent layer and the presence of *Michelia champaca*. The following figures taken from his working plan illustrate these two sub-types. The figures show the percentage of stems above 3' girth.

Sub-Himalayan sandy alluvium semi-evergreen type

Species	<i>Michelia</i> sub-type	<i>Eugenia-Tetrameles-Machilus</i> sub-type
<i>Amoora wallichii</i>	7	5.0
<i>Ailanthus grandis</i>	1	0
<i>Alstonia scholaris</i>	1	0
<i>Anthocephalus cadamba</i>	below 1	0
<i>Albizia procera</i>	below 1	0
<i>Albizia lebbek</i>	below 1	3.0
<i>Aporosa roxburghii</i>	0	1.0
<i>Acrocarpus fraxinifolius</i>	below 1	0
<i>Artocarpus lakoocha</i>	below 1	0
<i>Amoora rohituka</i>	below 1	below 1
<i>Bauhinia</i> spp.	below 1	below 1
<i>Castanopsis</i> spp.	5	0
<i>Cedrela toona</i>	1	below 1
<i>Cordia myxa</i>	1	below 1
<i>Careya arborea</i>	below 1	0
<i>Cinnamomum cecidodaphne</i>	below 1	below 1
<i>Chukrasia tabularis</i>	below 1	0
<i>Callicarpa arborea</i>	0	3.0
<i>Duabanga sonneratioides</i>	2	below 1
<i>Dysoxylum hamiltonii</i>	below 1	below 1
<i>Dillenia pentagyna</i>	below 1	below 1
<i>Eugenia</i> spp.	9	24.6
<i>Gmelina arborea</i>	below 1	below 1
<i>Garuga pinnata</i>	below 1	2.0
<i>Ilex godajam</i>	below 1	0
<i>Lagerstroemia parviflora</i>	3	4.6
<i>Lophopetalum fimbriatum</i>	below 1	0
<i>Lannea grandis</i>	below 1	0

(Contd.)

Sub-Himalayan sandy alluvium semi-evergreen type—(Concl'd.)

Species	Michelia sub-type	Eugenia-Tetrameles-Machilus sub-type
<i>Litsea</i> spp.	below 1	below 1
<i>Machilus bombycina</i>	8	15.0
<i>Michelia champaca</i>	6	0
<i>Mansonia dipikae</i>	0	below 1
<i>Mesua ferrea</i>	below 1	0
<i>Premna bengalensis</i>	4	3.00
<i>Polyalthia simiarum</i>	2	below 1
<i>Pterospermum acerifolium</i>	below 1	0
<i>Phoebe attenuata</i>	below 1	0
<i>Schima wallichii</i>	6	2.0
<i>Stereospermum chelonoides</i>	9	4.2
<i>Sterculia alata</i>	3	0
<i>Salmalia malabarica</i>	below 1	below 1
<i>Sapium baccatum</i>	0	2.0
<i>Sterculia villosa</i>	below 1	below 1
<i>Tetrameles nudiflora</i>	10	17.5
<i>Trewia nudiflora</i>	below 1	0
<i>Terminalia belerica</i>	below 1	below 1
<i>Terminalia myriocarpa</i>	below 1	below 1
<i>Vitex</i> spp.	0	below 1
<i>Zanthoxylum budrunga</i>	below 1	below 1

10. High Savannah, *Salmalia-Albizzia* type

This type is found over extensive areas in the Sub-Himalayan tracts of the Goalpara and Kamrup districts, and in some parts of the Darrang district. It is an open formation in high grassland, subject to annual fire. The soil is loamy sand of about a foot or two in depth overlying gravel and boulder deposits. This type seems to follow the *khair-sissoo* type and is in turn followed by the Sub-Himalayan sandy alluvium semi-evergreen type described before.

The following Table, taken from working plan figures (8, 11) shows the composition of this type. The figures indicate the percentage of stems above 3' girth.

High Savannah, *Salmalia-Albizzia* type

Species	Naduar Reserve	Monas Reserve
<i>Adina</i> spp.	0.86	—
<i>Amoora wallichii</i>	0.03	—
<i>Albizzia procera</i>	8.91	5.03
<i>Albizzia lebbek</i>	—	2.67
<i>Artocarpus lakoocha</i>	0.43	—
<i>Ailanthus grandis</i>	1.30	0.36
<i>Anthocephalus cadamba</i>	0.43	0.04
<i>Albizzia lucida</i>	3.35	—
<i>Alstonia scholaris</i>	0.35	0.29
<i>Bridelia retusa</i>	0.76	4.41
<i>Bischofia javanica</i>	5.61	1.27
<i>Bauhinia</i> spp.	2.12	2.70
<i>Cedrela toona</i>	0.08	0.26
<i>Chukrasia tabularis</i>	0.26	—
<i>Canarium</i> spp.	0.21	—
<i>Cryptocarya amygdalina</i>	—	1.58
<i>Celtis</i> spp.	0.51	—
<i>Callicarpa arborea</i>	—	0.82
<i>Careya arborea</i>	—	1.06
<i>Castanopsis</i> spp.	0.21	0.21

(Contd.)

High Savannah, *Salmalia-Albizzia* type—(Concl'd.)

Species	Naduar Reserve	Monas Reserve
<i>Cordia myxa</i>	7.86	4.25
<i>Dalbergia sissoo</i>	—	0.15
<i>Duabanga sonneratioides</i>	1.17	1.92
<i>Dysoxylum</i> spp.	0.43	0.96
<i>Derris robusta</i>	—	0.24
<i>Dillenia indica</i>	5.00	0.11
<i>Dillenia pentagyna</i>	2.80	1.57
<i>Eugenia</i> spp.	1.80	5.15
<i>Echinocarpus assamicus</i>	0.21	—
<i>Emblica officinalis</i>	0.08	0.05
<i>Ficus</i> spp.	0.86	—
<i>Gmelina arborea</i>	2.08	1.96
<i>Garuga pinnata</i>	2.91	—
<i>Hymenodictyon excelsum</i>	—	0.23
<i>Ilex godajam</i>	—	0.07
<i>Kydia calycina</i>	1.08	1.01
<i>Lagerstroemia flos-reginae</i>	1.32	—
<i>Lagerstroemia parviflora</i>	1.26	7.47
<i>Lanea grandis</i>	1.42	0.33
<i>Litsaea</i> spp.	0.08	1.11
<i>Morus laevigata</i>	0.21	0.10
Magnoliaceae spp.	1.08	0.08
<i>Machilus bombycina</i>	0.21	0.28
<i>Phoebe goalparensis</i>	—	0.21
<i>Premna bengalensis</i>	3.90	1.76
<i>Pterospermum acerifolium</i>	1.48	3.96
<i>Pterospermum lanceaefolium</i>	—	0.11
<i>Premna latifolia</i>	—	6.86
<i>Polyalthia simiarum</i>	0.22	0.42
<i>Salmalia malabarica</i>	20.01	9.05
<i>Schima wallichii</i>	—	0.75
<i>Sterculia alata</i>	—	0.02
<i>Sapium baccatum</i>	—	0.38
<i>Spondias mangifera</i>	0.59	—
<i>Sterculia villosa</i>	3.61	4.70
<i>Stereospermum chelonoides</i>	1.02	11.39
<i>Talauma phellocarpa</i>	0.21	—
<i>Tetrameles nudiflora</i>	0.15	0.13
<i>Terminalia belerica</i>	0.22	0.02
<i>Terminalia myriocarpa</i>	0.03	—
<i>Trewia nudiflora</i>	4.12	6.37
<i>Vitex peduncularis</i>	0.29	—
<i>Wrightia tomentosa</i>	—	0.23
<i>Zanthoxylum budrunga</i>	0.23	—
Others	4.02	3.20

11. Inundated type

This type occurs all over the evergreen and semi-evergreen zone in Assam valley along river banks and extending up to several miles inland. The soil is clayey loam to loam, and the topography may be flat or more generally cut up by a large number of small *nallahs*, so that the land appears as a series of ridges and mounds in a low-lying water-logged base. Water stagnates in these areas for a short or long period during the monsoons, depending on the height of the land relative to flood level. These areas are, however, dry for several months in winter, so that the type cannot be called fresh water swamp type. In the working plans this type is often called the "Kurkani" type.

Depending on the topography, several sub-types can be recognised in this formation. In the low-lying areas, *Dillenia indica*, *Echinocarpus*, *Bischofia javanica* are the species most frequently met with, along with *Taraktogenos kurzii* in certain areas (e.g. Dibru Reserve). On slightly higher ground, *Mesua ferrea* appears and often forms pure patches. In loamy

soil an intermediate stage which may be called *Dillenia-Mesua-Altingia* sub-type, is seen.

The following Tables show the composition of the different sub-types with percentages of stems above 3' in girth.

11. (a) Dillenia-Bischofia sub-type

Species	LOCALITY		
	Jokai Reserve	Telpani Reserve	Dehingmukh Reserve
<i>Altingia excelsa</i>	2.23	—	—
<i>Albizzia lucida</i>	3.65	1.77	1.87
<i>Artocarpus chaplasha</i>	0.30	—	—
<i>Artocarpus lakoocha</i>	—	—	0.07
<i>Anthocephalus cadamba</i>	0.51	0.13	0.22
<i>Alstonia scholaris</i>	1.12	0.13	0.90
<i>Bischofia javanica</i>	13.89	25.92	13.14
<i>Beilschmiedia brandisii</i>	—	1.14	4.11
<i>Cedrela toona</i>	0.20	—	—
<i>Castanopsis indica</i>	2.13	—	0.15
<i>Crataeva</i> spp.	0.10	0.18	—
<i>Cryptocarya amygdalina</i>	0.10	—	—
<i>Cryptocarya floribunda</i>	—	2.91	—
<i>Celtis australis</i>	0.51	—	—
<i>Carallia integerrima</i>	—	0.25	0.37
<i>Dalbergia assamica</i>	0.71	—	0.07
<i>Dillenia indica</i>	22.45	23.26	25.77
<i>Duabanga sonneratioides</i>	—	—	0.07
<i>Eugenia</i> spp.	2.23	3.03	1.27
<i>Elaeocarpus rugosus</i>	8.11	—	2.09
<i>Elaeocarpus obtusus</i>	4.16	—	5.75
<i>Echinocarpus assamicus</i>	—	16.56	9.93
<i>Lagerstroemia flos-reginae</i>	8.52	2.91	3.96
<i>Mesua ferrea</i>	0.10	—	0.52
<i>Magnoliceae</i> spp.	0.41	—	—
<i>Premna latifolia</i>	0.30	4.93	0.30
<i>Salmalia malabarica</i>	0.51	0.25	0.30
<i>Turpinia pomifera</i>	4.87	—	0.15
<i>Terminalia chebula</i>	1.82	1.90	2.24
<i>Vatica lanceaeifolia</i>	5.89	8.47	18.67
Other species	15.01	6.32	7.62

11. (b) Dillenia-Mesua-Altingia sub-type

Species	Namdang Reserve	Balipara Reserve
<i>Altingia excelsa</i>	21.90	3.08
<i>Albizzia lucida</i>	0.32	0.41
<i>Ailanthus grandis</i>	—	0.74
<i>Albizzia procera</i>	—	0.12
<i>Artocarpus lakoocha</i>	—	0.47
<i>Artocarpus chaplasha</i>	0.63	0.95
<i>Anthocephalus cadamba</i>	0.32	0.40
<i>Alstonia scholaris</i>	1.27	—
<i>Amoora wallichii</i>	—	5.10
<i>Bischofia javanica</i>	4.92	0.27
<i>Beilschmiedia brandisii</i>	0.32	—

(Contd.)

Species	Namdang Reserve	Balipara Reserve
<i>Cinnamomum cecidodaphne</i>	0.48	1.16
<i>Cedrela toona</i>	0.32	0.91
<i>Carallia integerrima</i>	0.16	—
<i>Castanopsis indica</i>	0.63	3.88
<i>Cryptocarya amygdalina</i>	—	0.02
<i>Canarium</i> spp.	0.79	4.13
<i>Chukrasia tabularis</i>	—	2.39
<i>Celtis australis</i>	—	0.01
<i>Dillenia indica</i>	5.08	8.66
<i>Dalbergia assamica</i>	0.32	—
<i>Duabanga sonneratioides</i>	—	0.27
<i>Dysoxylum</i> spp.	—	5.30
<i>Eugenia</i> spp.	1.75	4.01
<i>Eleaocarpus assamicus</i>	0.08	1.60
<i>Echinocarpus assamicus</i>	1.43	—
<i>Gmelina arborea</i>	—	2.23
<i>Kydia calycina</i>	—	0.40
<i>Lagerstroemia flos-reginae</i>	1.59	0.07
<i>Lanea grandis</i>	—	0.94
<i>Mesua ferrea</i>	31.27	13.30
<i>Magnoliaceae</i> spp.	1.27	3.03
<i>Morus laevigata</i>	—	0.54
<i>Premna bengalensis</i>	1.70	0.72
<i>Phoebe cooperiana</i>	—	0.14
<i>Phoebe goalparensis</i>	—	0.91
<i>Pterospermum lanceaefolium</i>	—	2.44
<i>Pterospermum acerifolium</i>	—	1.13
<i>Quercus xylocarpa</i>	0.79	—
<i>Sterculia villosa</i>	—	0.98
<i>Salmalia malabarica</i>	0.16	0.02
<i>Stereospermum chelonoides</i>	—	1.74
<i>Sterculia alata</i>	—	1.40
<i>Schima wallichii</i>	—	0.02
<i>Sapium baccatum</i>	—	0.18
<i>Terminalia chebula</i>	1.59	0.02
<i>Turpinia pomifera</i>	7.62	—
<i>Terminalia myriocarpa</i>	—	0.64
<i>Terminalia belerica</i>	—	1.86
<i>Talauma hodgsoni</i>	—	2.56
<i>Tetrameles nudiflora</i>	—	0.60
<i>Taraktogenos kurzii</i>	—	1.14
<i>Vatica lanceaefolia</i>	2.70	1.24
<i>Zanthoxylum budrunga</i>	—	0.51
Other species	9.52	19.59

12. Fresh water swamp type

This type is seen in areas where water stagnates almost throughout the year. It is often seen in roadsides and in other swampy areas throughout the State. In this type, *Barringtonia acutangula* forms a pure crop, and sometimes a closed canopy, as seen in Sonebeel areas of Cachar district.

The other edaphic types are (13) **Riverain Khair-Sissoo type**, and (14) **Cane brakes**. These are well known types and will not be described here.

DISCUSSIONS

It will be seen from the detailed description given above, that Champion's classifications of the different evergreen and semi-evergreen types found in Assam will require modifications.

REFERENCES

1. Champion, H. G.—A preliminary survey of the forest types of India and Burma, Indian Forest Records, New Series, Vol. I, No. 1 (1935).
 2. Bor, N. L.—The relict vegetation of the Shillong Plateau, Assam, Indian Forest Research (Botany), Vol. 6.
 3. Rowbotham, C. J.—Proceedings of the Third Silvicultural Conference, 1929.
 4. Mohanlal, K.—Working Plan for the Reserves of the Cachar Division, Assam Govt. Press, 1938.
 5. Purkayastha, C.—Working Plan for the plain reserves on the South bank of the Brahmaputra River in the Lakhimpur Division, Assam—Assam Govt. Press, 1936.
 6. Srinivasan, M. M.—Working Plan for the Lakhimpur Forest Division, Assam—1949—1959. Assam Govt. Press, 1956.
 7. —————Working Plan for the Sibsagar Division, 1951-52 to 1965-66. Assam Govt. Press.
 8. Islam, M. M.—Working Plan for the Darrang Division (under preparation).
 9. Rajkhowa, S.—Working Plan for the Reserved forests of Goalpara West Division (1956)—Unpublished.
 10. Purkayastha, C.—Working Plan for the Sadiya Division.
 11. Islam, M. M.—Working Plan for the North Kamrup Division, 1958-59 to 1972-73. Assam Govt. Press (1959).
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ASSAM VALLEY SEMI-EVERGREEN FORESTS AND THEIR REGENERATION

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Occurrence

The Assam Valley semi-evergreen forests occur all over the alluvial soil in the Assam Valley (Brahmaputra Valley), ranging from 94°—30' E. long. in the east to 89°—50' E. long. in the west, and between 26—40' N and 26° N. latitudes, wherever the rainfall exceeds about 62 inches annually, spread over about 9 months of the year and where it is not replaced by other edaphic or biotic communities.

On the north bank of the Brahmaputra, it is found in the sub-Himalayan "Bhabar" tracts of the Goalpara district, to the north of the sal (*Shorea robusta*) belt, where the main factor preventing this type from invading the sal forests is the annual ground fires that run through the latter. Further east, the type is interrupted by bio-edaphic communities such as the *khair-sissoo* forests, and the High Savannah formation in the North Kamrup division, but patches of this type are also found in places where the soil depth is good and fire is absent. East of the North Kamrup division, and in the sub-Himalayan Bhabar belts of the Darrang district, this type finds its best expression, and continues eastwards, interrupted here and there by other bio-edaphic formations, until it is replaced by the Evergreen *Kayea assamica* formation.

On the south bank of the Brahmaputra, the type occurs sporadically in the foot-hills of the Khasi and Jaintia hills on old alluvium and in Garo hills where the rainfall is favourable, and where such areas are remote from fire. On areas of lesser rainfall in this region, this type is replaced by the Kamrup Alluvial Sub-type of sal.

East of the Kamrup district, the type is absent in the Nowgong Forest division, which is the low rainfall zone of Assam, the rainfall in the dry parts varying from 56" to 60". Further east of this dry zone, the Assam Valley semi-evergreen forests extend continually from near Diphu railway Station to its eastern limit where it is replaced by the Upper Assam *Mesua-Dipterocarp* forests. In the Nambor Reserve, where the rainfall is 62", the change of type towards the semi-deciduous is clearly evident. The type, however, attains its fullest expression in the Panchnoi and Sopai blocks of the Charduar Reserve of the Darrang district, where it is locally known as Bonsum-Amari forest (*Phoebe goalparensis-Amoora wallichii* association) on account of the predominance of these two commercially valuable timber species.

Champion (1) has not mentioned the type, though this covers the major portion of the forest areas of Assam Valley. His type, 2bC1, Assam Tropical Semi-Evergreen forest—described as *Altingia-Magnolia-Cinnamomum* association is, in fact, not seen anywhere.

Climate and rainfall

The following Table shows the mean monthly rainfall in stations at different parts of the area where this type occurs (Kachugaon is in Ripu Reserve, Barpothar is near Nambor Reserve of Sibsagar district and Majbat is near Charduar Reserve in Darrang district).

TABLE I
Rainfall data

	Kachugaon	Barpothar	Majbat
	Rainfall in inches	Rainfall in inches	Rainfall in inches
January	0.57	0.6	0.36
February	0.62	1.2	0.59
March	0.03	2.9	2.92
April	8.68	5.7	6.67

Rainfall data—(Concl'd.)

	Kachugaon	Barpothar	Majbat
	Rainfall in inches	Rainfall in inches	Rainfall in inches
May	24.51	9.1	13.43
June	40.78	10.4	15.88
July	39.17	9.1	14.54
August	25.18	10.0	12.47
September	27.92	8.0	10.24
October	8.25	4.3	5.17
November	0.66	0.6	1.20
December	0.13	0.2	0.39
TOTAL ..	179.50	62.1	83.36

The maximum summer temperature seldom reaches 100°F (37.8°C) in these localities while the minimum winter temperature is about 50°F (10 C).

The elevation above mean sea level varies from about 300 ft. (91 m) to about 900 ft. (274 m).

Structure and composition

Structurally, the Assam Valley semi-evergreen forest is a multi-storeyed forest composed of a large number of species belonging to a number of families and genera. Most of the tree species are evergreen, with a sprinkling of deciduous or semi-deciduous trees in the top canopy. The height of the top canopy layer is over 120 ft. (36.6 m). At the height of its expression, this forest type shows a high percentage of *Phoebe goalparensis* and *Amoora wallichii*.

In order to study the structure and composition of such a well-formed sample, a set 80 consecutive quadrats, each 20 m × 20 m in size, were enumerated in the Sopai block of the Charduar Reserve, in what is locally called a well stocked Bonsum-Amari (*Phoebe-Amoora*) forest. The field work consisted in counting the number of stems of each species in each quadrat and recording them in five height classes, viz., 6'-10' (1.8 m-3.0 m), 10'-20' (3.0 m-6.1 m), 20'-40' (6.1 m-12.2 m), 40'-70' (12.2 m-21.3 m), and over 70' (over 21.3 m) height classes. No attempt was done to enumerate the 0'-6' (0-1.8 m) height class on account of the thick under growth consisting of a large number of species, and cane brakes. The species found in the different canopy layers, their presence frequency (expressed as a percentage of the total number of quadrats enumerated), and the percentage of stems of a species relative to the total number of stems in the height class are shown in this appendix height class by height class.

The commonest ground cover was of cane brakes in somewhat low areas and in other areas, the palm *Pinanga gracilis* and the monocot, *Forrestia hookerii*, were common.

It was found that there was no correlation between the number of trees per quadrat in any canopy layer and that in any lower canopy layer. Table II shows the frequency of the number of trees per quadrat in the top and second canopy layers, where the number of quadrats (out of total 80) which contained 1, 2, etc., trees of one layer has been plotted against the corresponding number of trees found in the quadrats.

Table III shows, for the different canopy layers, the number of species whose occurrence has been confined to 1, 2, and of the 80 quadrats examined. It will be seen that in the top canopy, only three species occur in 8 quadrats or more (i.e. 10% of the quadrats), while in the 2nd, 3rd, 4th and 5th layers, the number of species with a frequency index of 10 or more are 9, 13, 14 and 17.

Table V shows the presence frequency of the top canopy species in different canopy layers. The figures here show the number of quadrats (out of total of 80) in which at least one stem of the species has been found. It will be seen from the table that the representation of *Phoebe goalparensis* which was the highest in the top canopy, falls off in the lower canopy layers and about the same fate has overtaken the next important timber species, *Amoora wallichii*. Considering Bonsum (*Phoebe goalparensis*) the most important timber

species, the frequency of occurrence of 0, 1, 2, etc. numbers of stems per quadrat is shown in Table IV, wherein the number of quadrats is shown against the number of stem per quadrat.

TABLE II

Showing frequency (Number of quadrats) of different numbers of stems of all species per quadrat, in different canopy layers.

Number per quadrat	Number of quadrats	
	Top canopy	Second canopy
0	14	14
1	15	16
2	15	18
3	15	11
4	7	10
5	5	11
6	2	3
7	2	4
8	0	0

TABLE III

Number of species whose occurrence is confined to 1, 2, 3, etc., quadrats (out of 80) in different canopy layers.

Number of quadrats represented	Number of species in canopy layers.				
	I	II	III	IV	V
1	23	15	12	22	26
2	9	5	4	6	5
3	3	5	4	4	4
4	4	3	8	1	0
5	1	3	8	2	5
6	4	0	0	1	1
7	2	3	1	2	1
8	0	2	2	1	3
9	0	1	1	1	3
10	0	1	1	0	0
11	1	1	2	1	0
12	0	2	1	0	1
13	0	1	2	1	2
14	0	0	0	1	1
15	0	1	1	1	1
16	0	0	1	1	0
17	0	0	0	1	1
18	0	0	0	1	1
19	0	0	0	0	0
20	1	0	0	0	0
Over 21	1	0	2	5	4

TABLE IV

Number of quadrats in which *Phoebe goalparensis* occurs in 0, 1, 2 etc., number (in 80 quadrats) in canopy.

Number of plants	Number of quadrats in canopy layers				
	I	II	III	IV	V
0	55	69	75	69	75
1	15	10	5	11	4
2	8	1	0	0	1
3	2	0	0	0	0

TABLE V

Showing presence (out of 80 quadrats) of the top canopy species in different canopy layers (figures show the number of quadrats in which the species was found).

<i>Amoora wallichii</i> ..	23	10	10	15	15
<i>Amoora</i> sp. ..	3	5	5	9	3
<i>Altingia excelsa</i> ..	1	0	3	2	0
<i>Albizzia lucida</i> ..	1	0	0	0	0
<i>Adina oligocephala</i> ..	1	1	0	0	0
<i>Alstonia scholaris</i> ..	0	2	0	0	0
<i>Artocarpus chaplasha</i> ..	0	0	0	0	1
<i>Beilschmiedia assamica</i> ..	10	13	12	17	18
<i>Beilschmiedia</i> sp. ..	8	8	5	5	5
<i>Bischofia javanica</i> ..	0	2	0	0	2
<i>Castanopsis indica</i> ..	8	2	9	7	9
<i>Canarium bengalense</i> ..	6	5	3	8	6
<i>Chukrasia tabularis</i> ..	4	0	1	0	1
<i>Cryptocarya amygdalina</i> ..	2	3	8	5	2
<i>Cedrela</i> sp. ..	1	0	0	0	0
<i>Cedrela toona</i> ..	0	0	0	1	0
<i>Dillenia indica</i> ..	7	9	5	1	3
<i>Diospyros variegata</i> ..	1	0	2	0	0
<i>Duabanga sonneratioides</i> ..	0	1	0	0	0
<i>Evodia meliaefolia</i> ..	2	0	5	0	0
<i>Elaeocarpus floribundus</i> ..	1	0	0	0	0
<i>Ficus elastica</i> ..	2	0	1	0	0
<i>Ficus</i> sp. ..	1	0	1	2	2
<i>Garcinia xanthochymus</i> ..	1	1	0	0	0
<i>Kydia calycina</i> ..	1	2	2	1	3
<i>Litsaea polyantha</i> ..	1	2	3	11	14
<i>Laportea ptergostigma</i> ..	1	4	8	4	9
<i>Lanea grandis</i> ..	1	7	11	16	13
<i>Myristica kingii</i> ..	3	7	5	6	2
<i>Magnolia griffithii</i> ..	2	3	3	2	1
<i>Manglietia insignis</i> ..	8	15	21	14	8
<i>Myristica angustifolia</i> ..	1	0	4	7	12
<i>Michelia champaca</i> ..	4	0	1	0	0
<i>Morus laevigata</i> ..	1	0	0	0	1
<i>Mangifera indica</i> ..	0	0	0	0	1
<i>Phoebe goalparensis</i> ..	37	11	5	11	5
<i>Pterospermum lanceaefolium</i> ..	12	8	11	14	7
<i>Pterospermum acerifolium</i> ..	2	2	0	0	0
<i>Premna bengalensis</i> ..	1	0	0	0	0
<i>Sarcosperma arboreum</i> ..	5	3	4	2	6
<i>Sterculia alata</i> ..	2	0	0	3	6
<i>Sterculia villosa</i> ..	1	1	1	1	1
<i>Sapium baccatum</i> ..	0	0	0	0	1
<i>Stereospermum chelonoides</i> ..	3	1	0	1	2
<i>Taraktogenos kurzii</i> ..	2	1	5	3	1
<i>Talauma hodgsoni</i> ..	22	12	29	29	26
<i>Tetrameles nudiflora</i> ..	1	0	0	0	3
<i>Terminalia chebula</i> ..	0	0	0	0	1
<i>Zanthoxylum budrunga</i> ..	2	0	0	1	5

Silvicultural characters of the dominant species

Except for a few species in the top canopy, trees occurring in this region are evergreen.

The most important Silvicultural characters that have a bearing on the possible methods of regeneration of these forests are that these species are shade bearers, and seeds produced by these species depend on birds and animals for their dispersal. Of the commonest species of importance, *Phoebe goalparensis*, which seeds in Autumn, produces berries

of size about 15 mm by 5 mm, covered by a fleshy pulp of dark colour when ripe. This fruit is a great favourite of birds. It has been specially noticed that regeneration of *Phoebe goalparensis* springs up in patches under *Ficus* trees which are favourite haunts of hornbills. These birds gore themselves with ripe fruits of *Phoebe goalparensis*, and the regeneration of this species springs up from the birds' droppings under *Ficus* trees. As a matter of fact, it is often possible to collect good quantities of viable seeds of this species from the droppings.

Of the other species, *Amoora wallichii* has heavy seeds which do not travel far from the mother trees, except for fortuitous circumstances, when some animals carry them elsewhere. Similarly, seeds of *Manglietia insignis* and *Talauma hodgsoni* depend on rodents and animals for dispersal. This fact accounts for the failure of early attempts at attaining natural regeneration of the commercially valuable species with any degree of uniformity over large areas and at distances from the mother trees.

Seeding habits of the commercially important species

Most of the important tree species produce seed during monsoons or in autumn. Good seed years of *Phoebe goalparensis* and *Michelia champaca* come about every three year, and apart from a good seed year, there may be little or no seed in a particular year.

Method of management

All the forest reserves in the different Forest divisions falling under this type are being managed under the selection system under girth limit. Attempts at cultural operations with a view to obtaining natural regeneration were made on experimental basis in Chilonijan centre of the Nambor Reserve of the Sibsagar division, with indifferent success. In the Charduar Reserve of the Darrang Forest division, from where the transact data were taken, Jacob (1942) prescribed regeneration operations, concentrated in certain localities, wherein regeneration of *Phoebe goalparensis*, *Amoora wallichii* and other commercially important species was sought to be established by keeping mother trees of *Phoebe goalparensis* at least 120 ft. (36.6 m) apart, so that gaps of 30' to 40' (9 m-12 m) were created in the top canopy, leaving alone the low middle canopy unless standing over advance growth of valuable species, till recruitment in sufficient number was obtained on the ground. Simultaneously, cold weather clearance of the undergrowth and cane brakes was prescribed. He also prescribed weeding once before the rains and one cold weather weeding every year, in strips 6 ft. (1.8 m) wide, leaving an unweeded inter space of same width. The removal of all the seed bearers above the girth limit, hitherto left unfelled in order to maintain a spacing of 120 ft. (36.6 m) from one *Phoebe goalparensis* tree to another was prescribed when seedlings of *Phoebe goalparensis* were 6 ft. (1.8 m) high in the weeded lines (2).

As for the results of such operations, it was found by and by that while regeneration of *Phoebe goalparensis* was obtained in fairly good numbers in the vicinity of the mother trees, a uniform distribution of regeneration was not found possible, without resorting to artificial notching of seeds, or transplanting under forest canopy. Also, clearances done for tending regeneration brought in light grass and other vegetations which attracted elephants and bisons to these cleared areas, with consequent damages to the seedlings (3).

It will be seen from the transact data taken from a typical well-stocked Bonsum-Amari (*Phoebe goalparensis*-*Amoora wallichii*) association that the mother trees of this species are not uniformly spaced, in any appreciable area. Also, subsequent experiments started in 1951 by the State Silviculturist to pin-point the factors responsible for the failure of the technique (4, 5) show that seedlings are always concentrated under the mother trees, and the mortality of the new recruits is rather heavy. In this experiment, which was laid out in a well-stocked area a few miles away from the area where the transact data were collected, three canopy manipulations were tried, viz., in the first set (a) only the top canopy trees were retained, in the second set (b) the top canopy trees and some middle canopy trees were left well spaced out, while in the third set (c) the above two canopies, and some lower canopy trees were left. Each of these three sets was further divided into two halves, (i) in one half, clean weeding was done in 6' (1.8 m) wide parallel strips, each 3 chains (60 m) long at 15' (4.6 m) distances from centre to centre while in the other half, (ii) these 6' (1.8 m) wide lines of same length were also hoed lightly initially, besides being weeded annually. There were thus six plots in all, of 1.5 acres (0.61 hectares) each. Subsequent cultural operation consisted in one shrub cutting annually just before seed fall, and one before rains. Assessment of regeneration was made by counting the seedlings found in the weeded lines. The following figures show the number of lines carrying different numbers of seedlings, as found in 1957, after six annual tendings.

Number of seedling	Number of lines					
	Ai	Aii	Bi	Bii	Ci	Cii
0-4	8	8	2	3	26	17
5-9	9	6	4	5	3	10
10-14	2	12	4	1	0	1
15-19	0	1	6	3	0	0
20-24	0	1	6	2	0	0
25-29	0	2	0	2	0	2
30-34	0	2	3	3	0	0
35-39	0	0	2	2	0	0
40-44	0	0	0	1	0	0
45-49	0	0	0	1	0	0
50-54	0	0	0	2	0	0
55-59	0	0	0	1	0	0
60-64	0	0	0	0	0	0
65-69	0	0	0	0	0	0
70-74	0	0	0	0	0	0
75-79	0	0	0	0	0	0
80-84	0	0	1	0	0	0
85-89	0	0	0	1	0	0
Number of mother trees—	11	14	8	8	13	8

Even as an one dimensional picture the above figures show the paucity of seedlings in each line [Considering that the length of each line is 3 chains (60 m)] except for a very few lines where a large number of seedling was found. None of these seedlings grew to be above 6' (1.8 m) height by 1957 when the experiment was finally closed.

In natural forest, however, seedlings above 6' (1.8 m) height are found scattered here and there, even in the well-stocked areas as shown by the transect data.

The following figures show the relationships between the number of Bonsum (*Phoebe goalparensis*) trees in the top canopy and those found in the lower canopy layers. The figures stand for number of quadrats.

		Top canopy Bonsum		
		Present	Absent	Total
Bonsum seedlings and saplings	Present	10	17	27
	Absent	15	38	53
	Total	25	55	80

The values of X^2 for 1 degree of freedom, after applying Yate's correction, is 0.312 showing that no correlation exists between the number of poles, saplings or seedlings above 6' (1.8 m) height and the number of top canopy trees of this species in the quadrat.

The experiment above did not bring out the effect of different canopy conditions and soil working on the survival of *Phoebe goalparensis* seedlings. Hence, in 1957, plots, each 1 chain \times $\frac{1}{2}$ chain (20 m \times 10 m) were laid out in the same old plots as well as in other areas, wherein seeds were sown in patches of different sizes. Judging from survival in 1959, it was found that the highest mortality was seen in plots where, due to the removal of lower canopy layers, thatch was coming in and at the same time, where no soil working was done in the patches (6).

It was also found that when no soil working was done, a light shade of top canopy trees alone, and an evergreen ground cover presented the best condition for the survival of seedlings, and an open canopy or a dense low canopy proved equally the worst, under similar evergreen ground cover and one winter shrub cutting. As regards the effects of hoeing, there seemed to be no difference between survival in hoed patches of 30cm \times 30 cm

size and unhoed patches, so long as the seed was dibbled in, but bigger patches of 61 cm × 61 cm size showed distinctly better survival than in case of the hoed ones of 30 cm × 30 cm size or unhoed patches. It was also seen that canopy and ground cover conditions had a significant effect on the mean height attained by the seedlings in 21 months. It was found that when no soil working was done, a tall light canopy, or an open canopy induced better height growth than when dense low canopy layers were retained. Under tall light canopy, soil working without the addition of any wood ash to the soil did not make any difference as regards height growth, but it was seen that addition of wood ash to the 61 m × 61 m hoed patches made a significant difference in height growth. The best average height attained in 21 months was 4.15' (10.54 cm) and the worst was 1.29' (3.28 cm).

The experiments, described somewhat in detail, show the indifferent success obtainable when natural regeneration of the principal species of these forests is attempted even in areas well stocked as regards *Phoebe goalparensis*. The patchy regeneration, and the slowness of growth of seedlings require shrub cutting operations to be carried out for many years, even in the vicinity of mother trees. On the other hand, it was found that if seedlings of *Phoebe goalparensis* were raised in the nursery and maintained there for two or three years, and then transplanted under forest canopy when they were 4' to 6' high, these seedlings showed a high percentage of survival and required little attention afterwards. The idea in using 6' high seedlings was to put the leading shoots above the level of the shrubby cover once for all, so that they had only to compete with the 6'—10' (1.8 m—3 m), and up canopy layers.

When the technique of underplanting *Phoebe goalparensis* was first started, the plants were removed carefully with ball of earth, after all the leaves except one or two at the tip were stripped off in order to reduce transpiration loss. The tap root had to be cut at a depth of about 18" (46 cm) for practical reasons, but this did not induce any mortality. Later on it was found that these plants could survive fairly well without ball of earth, and also, the survival percentage was even higher when root and shoot cuttings were planted under tall forest canopy, though the last method was not recommended because of slow height growth in the succeeding years. When transplanted with ball of earth, the seedling showed about 80% survival, and without ball of earth, the survival was 77% (5, 6).

When underplantings were done initially, the spacing adopted was 6' × 6' (1.8 m × 1.8 m) which was later extended to 9' × 9' (2.7 m × 2.7 m) and still at a later date to 18' × 18' (5.5 m × 5.5 m) and 24' × 24' (7.3 m × 7.3 m). With closer spacings adopted initially, it was the practice to clear the lower canopy levels completely up to a height of about 40' (12.2 m) with the result that after some 10 years, the crop grew up to be a pure plantation of *Phoebe goalparensis*. The modern tendency is not to have a pure crop of one species, but to introduce a certain number of seedlings of other valuable species in the area and let them grow up in competition with the lower canopy layers as they would have grown in natural forest, and do the minimum cultural operations necessary, so that finally at the time of harvesting, some 30 trees of these valuable species survive in each acre, along with other species which grow up without any assistance. The present technique is thus to clear "tunnels" some 6' (1.8 m) wide, in the lower canopy layers, spaced 24 ft. (7.3 m) apart, and transplant the seedlings there. Research is being directed towards finding out if it is possible to arrive at a minimum figure for the number of *Phoebe goalparensis*, and *Amoora wallichii* seedling to be introduced artificially, well spaced in each acre, so that without any subsequent tending except for periodic climber cutting and thinning around these "elites" the stipulated number of plants per acre at maturity can be obtained.

REFERENCES

- (1) Champion, H. G. —A preliminary survey of the forest type of India and Burma, Indian Forest Records, New Series Vol. I. No. 1 (1935).
- (2) Jacob, M. C. —Working Plan for the Forest Reserves of the Darrang Division (1942).
- (3) Jacob, M. C. —Regeneration of the Bonsum—*Amari* forest of Assam—Proceedings of 8th Silvicultural Conference, Dehra Dun, 1951.
- (4) Annual Research Report, Assam, for 1955-56.
- (5) Annual Research Report, Assam, for 1956-57.
- (6) Annual Research Report, Assam, for 1957-58.
- (7) Annual Research Report, Assam, for 1958-59.

APPENDIX

Structure and Composition of the Laurus-Melia association found in the Assam Valley Semi-evergreen forests, as revealed by quadrat studies in Sopai Block of Charduar Reserve.

Top Canopy over 70' (21.3 m) tall

	F.	%
Dilleniaceae		
<i>Dillenia indica</i>	7.50	3.57
Magnoliaceae		
<i>Manglietia insignis</i>	8.75	4.08
<i>Magnolia griffithii</i>	2.50	1.02
<i>Michelia champaca</i>	5.00	2.04
<i>Talauma hodgsoni</i>	2.50	1.02
Anonaceae		
<i>Polyalthia simiarum</i>	10.00	4.08
Flacourtiaceae		
<i>Taraktogenos kurzii</i>	2.50	1.02
Guttiferae		
<i>Garcinia xanthochymus</i>	1.25	0.51
Malvaceae		
<i>Kydia calycina</i>	1.25	0.51
Sterculiaceae		
<i>Pterospermum acerifolium</i>	1.50	1.02
<i>P. lanceaefolium</i>	13.75	6.12
<i>Sterculia alata</i>	1.25	1.02
<i>S. villosa</i>	1.25	0.51
Elaeocarpaceae		
<i>Elaeocarpus floribundus</i>	1.25	0.51
Rutaceae		
<i>Evodia meliaefolia</i>	2.50	1.02
<i>Zanthoxylum budrunga</i>	2.50	1.02
Burseraceae		
<i>Canarium bengalense</i>	7.50	3.06
Meliaceae		
<i>Amoora wallichii</i>	25.00	11.73
<i>Amoora</i> sp.	3.75	1.53
<i>Cedrela</i> sp.	1.25	0.51
<i>Chukrasia tabularis</i>	5.00	2.04
<i>Dysoxylum procerum</i>	1.25	0.51
Anacardiaceae		
<i>Lannea grandis</i>	1.25	0.51
Leguminosae		
<i>Albizzia lucida</i>	1.25	0.51
Hamamelidaceae		
<i>Altingia excelsa</i>	1.25	0.51
Myrtaceae		
<i>Syzygium cumini</i>	2.50	1.02
Datisceae		
<i>Tetrameles nudiflora</i>	1.25	0.51
Rubiaceae		
<i>Adina oligocephala</i>	1.25	0.51
Sapotaceae		
<i>Sarcosperma arboreum</i>	6.25	2.55
Ebinaceae		
<i>Diospyros variegata</i>	1.25	0.51

Top Canopy over 70' (21.3 m) tall—contd.

	F.	%
Bignoniaceae		
<i>Stereospermum chelonoides</i>	3.75	1.53
Verbenaceae		
<i>Premna bengalensis</i>	1.25	0.51
Myristicaceae		
<i>Myristica angustifolia</i>	1.25	0.51
<i>M. kingii</i>	3.75	1.53
Lauraceae		
<i>Beilschmiedia assamica</i>	12.50	5.10
<i>Beilschmiedia</i> sp.	10.00	4.80
<i>Cryptocarya amygdalina</i>	2.50	1.02
<i>Machilus bombycina</i>	2.50	1.02
<i>Phoebe goalparensis</i>	32.50	19.21
Moraceae		
<i>Ficus elastica</i>	2.50	1.02
<i>Ficus</i> sp.	1.25	0.51
<i>Morus laevigata</i>	1.25	0.51
Urticaceae		
<i>Laportea pterygostigma</i>	1.25	0.51
Fagaceae		
<i>Castanopsis indica</i>	8.75	4.08
Unknown spp.		4.08
		100.00

Canopy II. 40'—70' (12.2 m—21.3 m) height

	F.	%
Dilleniaceae		
<i>Dillenia indica</i>	12.50	5.10
Magnoliaceae		
<i>Manglietia insignis</i>	18.75	7.65
<i>Magnolia griffithii</i>	3.75	1.53
<i>Talauma hodgsoni</i>	15.00	6.12
Anonaceae		
<i>Polyalthia simiarum</i>	15.00	7.14
Flacourtiaceae		
<i>Taraktogenos kurzii</i>	1.25	0.51
Guttiferae		
<i>Garcinia morella</i>	1.25	0.51
Malvaceae		
<i>Kydia calycina</i>	2.50	1.02
Sterculiaceae		
<i>Pterospermum acerifolium</i>	2.50	1.02
<i>P. lanceaefolium</i>	10.00	4.08
<i>Sterculia villosa</i>	1.25	0.51
Burseraceae		
<i>Canarium bengalense</i>	6.25	3.06
Meliaceae		
<i>Amoora wallichii</i>	12.50	5.10
<i>Amoora</i> sp.	6.25	2.55
<i>Chukrasia tabularis</i>	16.25	8.67
<i>Dysoxylum binectariferum</i>	8.75	3.57
<i>D. procerum</i>		
Ampelidaceae		
<i>Leea umbraculifera</i>	1.25	0.51

Canopy II. 40'—70' (12.2 m—21.3 m) height—*contd.*

	F.	%
Anacardiaceae		
<i>Lannea grandis</i>	1.25	0.51
Lythraceae		
<i>Duabanga sonneratioides</i>	1.25	0.51
Myrtaceae		
<i>Syzygium cumini</i>	6.25	3.57
Rubiaceae		
<i>Adina oligocephala</i>	1.25	0.51
Sapotaceae		
<i>Sarcosperma arboreum</i>	3.75	1.53
Styraceae		
<i>Symplocos</i> sp.	3.75	1.53
Apocynaceae		
<i>Alstonia scholaris</i>	1.25	0.51
Bignoniaceae		
<i>Stereospermum chelonoides</i>	1.25	0.51
Myristicaceae		
<i>Myristica kingii</i>	8.75	4.08
Lauraceae		
<i>Beilschmiedia</i> sp.	10.00	5.10
<i>Cryptocarya amygdalina</i>	2.75	1.53
<i>Machilus bombycina</i>	2.50	1.02
<i>Phoebe goalparensis</i>	13.75	6.12
Euphorbiaceae		
<i>Bischofia javanica</i>	2.50	1.02
<i>Croton</i> sp.	1.25	0.51
Urticaceae		
<i>Laportea pterygostigma</i>	5.00	3.57
Fagaceae		
<i>Castanopsis indica</i>	2.50	1.02
Unknown spp.		5.63
		100.00

Canopy layer III. 20'—40' (6.1 m—12.2 m) height

	F.	%
Dilleniaceae		
<i>Dillenia indica</i>	6.25	1.55
Magnoliaceae		
<i>Manglietia insignis</i>	26.25	8.06
<i>Magnolia griffithii</i>	3.75	1.55
<i>Michelia champaca</i>	1.25	0.31
<i>Talauma hodgsoni</i>	36.25	11.16
Anonaceae		
<i>Polyalthia simiarum</i>	16.25	4.03
<i>P. jenkinsii</i>		
Flacourtiaceae		
<i>Gynocardia odorata</i>	1.25	0.31
<i>Taraktogenos kurzii</i>	6.25	1.55
Guttiferae		
<i>Garcinia xanthochymus</i>	1.25	0.31
Malvaceae		
<i>Kydia calycina</i>	2.50	0.62
Sterculiaceae		
<i>Pterospermum lanceaefolium</i>	13.75	3.72
<i>Sterculia alata</i>	6.25	1.25
<i>S. villosa</i>	1.25	0.31

Canopy layer III. 20'—40' (6.1 m—12.2 m) height—contd.

	F.	%
Burseraceae		
<i>Canarium bengalense</i>	3.75	1.24
Meliaceae		
<i>Amoora wallichii</i>	12.50	3.51
<i>Amoora</i> sp.	6.25	1.55
<i>Cedrela</i> sp.	1.25	0.31
<i>Chukrasia tabularis</i>	1.25	0.31
<i>Dysoxylum binectariferum</i>	18.75	6.82
<i>D. procerum</i>		
Ampelidaceae		
<i>Leea sambucina</i>	16.25	4.96
Anacardiaceae		
<i>Lannea grandis</i>	13.75	3.72
Hamamelidaceae		
<i>Altingia excelsa</i>	6.25	1.24
Myrtaceae		
<i>Syzygium cumini</i>	6.25	1.86
<i>Eugenia</i> sp.		
Rubiaceae		
<i>Anthocephalus cadamba</i>	1.25	0.31
Sapotaceae		
<i>Sarcosperma arboreum</i>	5.00	1.24
Ebinaceae		
<i>Diospyros variegata</i>	2.50	0.62
Myristicaceae		
<i>Myristica amygdalina</i>	5.00	1.24
<i>M. kingii</i>	6.25	2.17
Lauraceae		
<i>Beilschmiedia assamica</i>	11.25	3.72
<i>Beilschmiedia</i> sp.	6.25	2.17
<i>Cinnamomum tamala</i>	3.75	0.93
<i>Cryptocarya amygdalina</i>	10.00	3.10
<i>Lindera reticulata</i>	1.25	0.31
<i>Machilus bombycina</i>	3.75	0.93
<i>Phoebe goalparensis</i>	6.25	1.55
Euphorbiaceae		
<i>Baccaurea sapida</i>	1.25	0.31
Moraceae		
<i>Ficus elastica</i>	1.25	0.31
<i>Ficus</i> sp.	1.25	0.31
<i>Morus laevigata</i>	1.25	0.31
Urticaceae		
<i>Laportea pterygostigma</i>	10.00	1.24
Fagaceae		
<i>Castanopsis indica</i>	11.25	2.79
Unknown spp.		16.49
		100.00

Canopy IV. 10'—20' (3 m—6 m) height

	F.	%
Dilleniaceae		
<i>Dillenia indica</i>	1.25	0.17
Magnoliaceae		
<i>Manglietia insignis</i>	17.50	2.64
<i>Magnolia griffithii</i>	2.50	0.33
<i>Talauma hodgsoni</i>	36.25	6.45

Canopy IV. 10'—20' (3 m—6 m) height—contd.

	F.	%
Anonaceae		
<i>Polyalthia jenkinsii</i>	17.50	3.63
<i>P. simiarum</i>		
Flacourtiaceae		
<i>Taraktogenos kurzii</i>	3.75	0.66
Guttiferae		
<i>Garcinia kydia</i>	2.50	0.33
<i>Garcinia</i> sp.	2.50	0.33
Malvaceae		
<i>Kydia calycina</i>	1.25	0.17
Sterculiaceae		
<i>Pterospermum lanceaefolium</i>	17.50	2.97
<i>Sterculia alata</i>	3.75	0.50
<i>S. villosa</i>	1.25	0.17
Rutaceae		
<i>Zanthoxylum budrunga</i>	1.25	0.17
Burseraceae		
<i>Canarium bengalense</i>	10.00	1.49
Meliaceae		
<i>Amoora wallichii</i>	18.75	2.14
<i>Amoora</i> sp.	12.50	1.65
<i>Cedrela toona</i>	1.25	0.17
<i>Cedrela</i> sp.	2.50	0.33
<i>Dysoxylum binectariferum</i>	7.50	9.24
<i>D. procerum</i>		
Ampelidaceae		
<i>Leea sambucina</i>	43.75	11.06
Anacardiaceae		
<i>Lannea grandis</i>	20.00	3.80
<i>Mangifera indica</i>	3.75	0.50
Leguminosae		
<i>Bauhinia sanguinea</i>	1.25	0.17
Hamamelidaceae		
<i>Altingia excelsa</i>	2.50	0.33
Combretaceae		
<i>Terminalia chebula</i>	1.25	0.17
Myrtaceae		
<i>Syzygium cumini</i>	16.25	2.97
<i>Eugenia</i> sp.		
Sapotaceae		
<i>Sarcosperma arboreum</i>	2.50	0.33
Styraceae		
<i>Symplocos</i> sp.	1.25	0.17
Bignoniaceae		
<i>Stereospermum chelonoides</i>	1.25	0.17
Verbenaceae		
<i>Vitex heterophylla</i>	2.50	0.33
Myristicaceae		
<i>Myristica angustifolia</i>	8.75	1.16
<i>M. kingii</i>	7.50	1.16
Lauraceae		
<i>Beilschmiedia assamica</i>	21.25	3.14
<i>Beilschmiedia</i> sp.	6.50	1.49
<i>Cinnamomum tamala</i>	3.75	0.50
<i>Cryptocarya amygdalina</i>	6.50	0.99
<i>Litsaea laeta</i>	1.25	0.17
<i>Litsaea</i> sp.	1.25	0.17
<i>Machilus bombycina</i>	13.75	1.98
<i>Phoebe goalparensis</i>	13.75	1.82

Canopy IV. 10'—20' (3 m—6 m) height—*contd.*

	F.	%
Euphorbiaceae		
<i>Antidesma bunius</i>	1.25	0.17
<i>Baccaurea sapida</i>	22.50	3.80
<i>Macaranga</i> sp.	1.25	0.17
Moraceae		
<i>Ficus</i> sp.	2.50	0.33
Urticaceae		
<i>Boehmeria</i> sp.	31.25	7.92
<i>Laportea pterygostigma</i>	5.00	0.66
Fagaceae		
<i>Castanopsis indica</i>	8.75	1.16
Unknown spp.		19.69
		100.00

Canopy V. 6'—10' (1.8 m—3.0 m) height

	F.	%
Dilleniaceae		
<i>Dillenia indica</i>	3.75	0.60
Magnoliaceae		
<i>Manglietia insignis</i>	10.00	1.20
<i>Magnolia griffithii</i>	1.25	0.15
<i>Talauma hodgsoni</i>	32.50	9.05
Anonaceae		
<i>Polyalthia simiarum</i>	11.25	1.95
<i>P. jenkinsii</i>		
Flacourtiaceae		
<i>Taraktogenos kurzii</i>	1.25	0.15
Guttiferae		
<i>Garcinia xanthochymus</i>	1.25	0.15
Malvaceae		
<i>Kydia calycina</i>	3.75	0.75
Sterculiaceae		
<i>Pterospermum lanceaefolium</i>	11.25	1.60
<i>Sterculia alata</i>	6.25	1.25
<i>S. villosa</i>	1.25	0.15
Rutaceae		
<i>Citrus documana</i>	1.25	0.30
<i>Zanthoxylum budrunga</i>	6.25	1.80
Burseraceae		
<i>Canarium bengalense</i>	7.50	1.05
Meliaceae		
<i>Amoora wallichii</i>	18.75	2.85
<i>Amoora</i> sp.	3.75	0.60
<i>Chukrasia tabularis</i>	1.25	0.15
<i>Dysoxylum binectariferum</i>	35.00	6.83
<i>D. procerum</i>		
Ampelidaceae		
<i>Leea sambucina</i>	47.50	13.70
Anacardiaceae		
<i>Lannea grandis</i>	16.25	2.10
<i>Mangifera indica</i>	1.25	0.15
Moringaceae		
<i>Moringa pterygosperma</i>	1.25	0.15
Leguminosae		
<i>Albizzia procera</i>	1.25	0.15
Combretaceae		
<i>Terminalia chebula</i>	1.25	0.15

Canopy V. 6'—10' (1.8 m—3.0 m) height—*contd.*

	F.	%
Myrtaceae		
<i>Syzygium cumini</i> } <i>Eugenia</i> sp. }	10.00	1.50
Dastiscaceae		
<i>Tetrameles nudiflora</i>	3.75	0.45
Sapotaceae		
<i>Sarcosperma arboreum</i>	6.25	2.55
Apocynaceae		
<i>Tabernaemontana coronaria</i>	1.25	0.15
Verbenaceae		
<i>Clerodendron hestatum</i>	1.25	0.15
<i>Premna bengalensis</i>	1.25	0.15
Myristicaceae		
<i>Myristica angustifolia</i>	15.00	2.40
<i>M. kingii</i>	2.50	0.30
Lauraceae		
<i>Beilschmiedia assamica</i>	22.50	2.70
<i>Beilschmiedia</i> sp.	6.25	1.50
<i>Cinnamomum tamala</i>	6.15	0.90
<i>Cryptocarya amygdalina</i>	2.50	0.30
<i>Litsaea polyantha</i>	17.50	3.25
<i>Litsaea</i> sp.	8.75	1.35
<i>Phoebe goalparensis</i>	6.25	0.90
Euphorbiaceae		
<i>Bridelia stipularis</i>	1.25	0.15
<i>Baccaurea sapida</i>	16.25	2.70
<i>Macaranga</i> sp.	6.25	0.75
<i>Sapium baccatum</i>	1.25	0.15
Moraceae		
<i>Ficus</i> sp.	1.25	0.15
<i>Morus laevigata</i>	3.75	0.45
Urticaceae		
<i>Laportea pterygostigma</i>	11.25	2.40
Fagaceae		
<i>Castanopsis indica</i>	11.25	1.50
Unknown spp.		25.90
		<hr/> 100.00 <hr/>

THE SEMI-EVERGREEN FORESTS OF THE CHANDGAD RANGE, KOLHAPUR DIVISION, BOMBAY

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Abstract

The semi-evergreen forests of the Chandgad range are described. The past history of management and its results are summarised. Attempts made to introduce artificial regeneration in recent years and the silvicultural and management problems are discussed. Items of investigation necessary to be undertaken are indicated.

Introduction—Area Distribution

The semi-evergreen forests of Chandgad lie approximately between latitudes 15° 44' and 15° 58' North and longitudes 74° 1' and 74° 4' East, and occupy the hills in the south-western part of the Kolhapur division of the Bombay State. Topographically the site is located on the Deccan tableland near its edge over-looking the coastal plains of South Konkan. The total area of these forests is about 33,000 acres. These were constituted Reserves under the Indian Forest Act between the years 1880 and 1909. There are no adverse rights but a number of concessions are given to the residents in respect of forest produce. These concessions permit, *inter alia*, the free grazing of cattle and rotational cultivation on steep hill slopes over an area of about 4,600 acres. An area of about 650 acres is also given out for patch cultivation.

Locality Factors

Except for a small portion in the southwest which reaches down almost to sea-level along the western slopes of the Sâhyadris, the general elevation varies from about 2,400' to 3,000' above mean sea level. The highest point is 3,435 ft. Most of the forest exists only on the rugged hills. The hill ranges mostly extend in a south-west to north-east direction. The slopes are steep to precipitous. The tract forms the catchment of the Ghata-prabha river, an important tributary of the Krishna. Most of the smaller streams are heavily flooded in the rainy season but dry soon after the cessation of the monsoon, but there are also a few perennial streams wherein water persists in the hot weather in pools or small trickles.

The geological formation is Deccan trap. The prevailing rock is basalt, which produces red tropical soil varying considerably in depth, texture and fertility.

Climate

The recorded annual rainfall during the years 1950–58 at Chandgad which is on the drier limit of this tract averages 118", though during recent years a relatively much higher rainfall from 150 to nearly 200 inches is recorded. The edge of the plateau which gets the full blast of the south-west monsoon experiences the highest precipitation. Waghotra, where a rain gauge station has been established recently recorded 222 inches in 1957 and 386 inches in 1958. Also, very dense fog constantly persists during the four monsoon months. From this region, the rainfall decreases rapidly towards the leeward side, the gradient being roughly about 20" for every five miles. More than 80% of the rain falls during the months of June to September and the number of months with less than 2" of rainfall is six. The mean monthly minimum and maximum temperatures of the years 1950–1958 at Chandgad average to 63°F in December and 93°F in May. There is no frost.

Composition and Condition of the Forest

The semi-evergreen climatic climax in this tract is represented by the hithertofore unworked parts of forests mostly in the upper reaches and pockets difficult for timber extraction and in two fair-sized groves at an elevation of about 2,400' m.s.l. the latter occurring nearer the drier limits of the region. Here the dominants attain a height of about 100' and the growth is luxuriant. The vegetation corresponds to Champion's type 2a C2— "West Coast semi-evergreens". *Syzygium cumini*, *Memecylon edule*, *Mangifera indica*, *Artocarpus hirsuta*, *Terminalia paniculata*, *Terminalia tomentosa*, *Lagerstroemia microcarpa*, *Terminalia chebula*, *Garcinia indica*, *Albizia lebbek*, *Diospyros montana*, *Ficus*

spp. usually occur in the top canopy while *Dalbergia paniculata*, *Mimusops elingii*, *Cinnamomum tamala*, *Mallotus philippiensis*, *Dalbergia latifolia*, *Alstonia scholaris*, *Trewia nudiflora*, *Careya arborea* occur in the lower canopy. There is a dense undergrowth of shrubs and annuals in which *Strobilanthes* spp., *Carissa carandas*, *Murraya koenigii*, *Murraya paniculata*, *Atlantia monophylla*, *Lasiosiphon eriocephalus*, *Calycarpa lantana* and *Lantana camara* are predominant. The main climbers which grow luxuriantly are *Waghatia spicata*, *Acacia concinna*, *Acacia pinnata* and *Smilax macrophylla*.

Regeneration

Under natural conditions most of the tree species regenerate freely. In particular *Memecylon edule* and *Syzygium cumini* are very prolific. Where the tree canopy has been injudiciously opened, the soil deteriorates rapidly and the ground is overrun chiefly by *Strobilanthes* spp. (mainly *sessiles*)—*Lasiosiphon eriocephalus*, *Carissa carandus* and *Lantana camara*. The only regeneration of tree species persisting through the mass of these weeds is *Syzygium cumini* and *Memecylon edule*. Vast stretches of abandoned shifting cultivation on the slopes often carry only masses of *Strobilanthes sessiles* to the total exclusion of all others.

Management

These forests lying in a remote place were neglected in the past and so far no working plan has been drawn up. From 1913-14 onwards the forests are being worked under what is known as a "Felling list" under which 8 'Blocks' or Felling Series have been formed and each divided into 40 annual coupes. There were no definite prescriptions for working or felling rules. In most coupes, the working has left about 20-25 trees per acre in the coupes causing wide gaps in the canopy which have failed to fill up. Large areas were clearfelled and given out for "agri-silvi" cultivation ostensibly under the Grow More Food Campaign, but the conditions pertaining to the growing of the tree species were never properly enforced and on the plea that the 'forest crop' has not come up well, leases were often extended after the expiry of the original period with no better results. These areas have been virtually rendered barren. In 1953-54, fellings continued in the second cycle after the issue of a "correction slip" to the "felling list" under which felling rules were framed. These laid down, reservation of 15 to 20 trees per acre, preservation of all growth to a width of 33' on either side of *nalas*, planting of denuded areas, blanks, and charcoal kiln sites and preparing burnt *rabs* and planting about 2,500 seedlings of "suitable species" by the staff in the annual coupes. The coupes which have been worked over twice carry practically nothing but a dense growth of weeds with a few climber-infested *Eugenia*s and *Terminalia*s. A teak plantation was raised some 20 years back at Bhing Mal near Parle. Plantations on "agri-silvi" lines continued to be attempted and failed. Such of the tree species as persisted are either smothered by weeds and climbers or otherwise suffered for want of tending.

A working plan is now under compilation for these forests. For the first time the area has been divided into compartments and stock-mapped. These stock-maps indicate the extent of retrogression of these forests in acreage. Out of the total area of 33,329 acres, an area of 4,647 acres is occupied by shifting cultivation and 644 acres by patch cultivation. The stocking in the remaining forest area of 28,038 acres is as follows :

overwood density over 0.6	10,295 acres.
overwood density 0.3 to 0.6	7,809 acres.
overwood density below 0.3	9,934 acres.

Artificial Regeneration

During the last two years, viz. 1958 and 1959 earnest efforts are being made to reboise these areas and to increase the value of the forests by planting various species. Though not of a striking magnitude, these provide valuable information and indications useful for future management. Owing to the difficulty of obtaining adequate labour, paucity of staff and high initial costs, all these plantations are being raised by agri-silvicultural method. In contrast with the earlier attempts at agri-silvicultural plantations, the recent attempts show that with rigid control on lessees' work through proper vigilance and strict enforcement of conditions, the method can be employed successfully.

Teak—This has been attempted at 12'×6' and 6'×6' spacement. The burning, aligning and staking are done departmentally and the planting stock is also provided by the department. The lessee is allowed to plough the land before staking is done, and *nachani* (an inferior millet) is grown in 8' wide strips in the case of plantations with 12'×6'

spacing and 4' wide strips in case of 6'×6' spacing, respectively, thus leaving a clear strip for the teak seedlings, raised mainly from stump planting or from four months old *dona* or polythene-bag transplants, and in rare cases from seeds dibbled in crow-bar holes. The growth is very poor during the first year presumably because of the low temperatures prevailing during the incessant monsoons so that the first effective break for the sprouts to shoot vigorously occurs only in October, which is soon followed by a dry spell till the following March or April when some pre-monsoon showers invariably render conditions more favourable again. The observations so far indicate that teak will succeed below 3000' elevation on fairly good and well-drained soils on northern and eastern aspects in sheltered pockets free from the persistent monsoon fogs. Similarly, premonsoon planting will probably give the sprouts a good start to face the onset of the heavy and constant rains. On favourable soils the teak plantations of 1958 have attained an average height of about 4' which is quite promising. The "agri-silvi" lessee has to keep the plants free from weeds. Repeated clean strips weeding is essential in the first year. Under no circumstances is the lease extended during the second year. It is necessary to keep the plantations properly weeded and cleaned departmentally for at least 5 years. To keep the weeds down and to minimise the exposures of soil, closer spacing of 6'×6' is advisable.

Kaju (Anacardium occidentale).—This has been tried on a variety of locations, viz., on barren, undulating slopes with hard compact soils, on gentle slopes with poor gravelly soils carrying sparse tree growth with lot of weeds; and on exposed ridges and spurs carrying well-stocked forests in the past but with poor and shallow red soils. The spacing adopted is 12'×6', 12'×12' and 20'×20'. The conditions under which the agri-silvicultural leases are given are the same as those in case of teak. In case of 20'×20' spacing the plants are raised in 1½'×1½'×1½' pits filled with weathered soil. The *kaju* is raised either from seeds dibbled at the break of rains, or from two months old plants raised in polythene bags. The *kaju* plantations have so far been a mixed success. In one place, on exposed barren slopes with hard lateritic pan, the plants both from transplants as well as seeds seemed to do well for a time, then gradually died off in July-August. The particular locality received about 200" rainfall and is only about a mile or so from the edge of the table land and has a constant dense fog in the rainy season. It is likely that the mortality is a combined effect of etiolation and damping off. The transplants and even sowings done in September-October to fill up the casualties have established well but it is to be seen whether they can withstand the next monsoon. Though the best results have been obtained on soils of medium fertility with a fair tree cover in the original crop, *kaju* has also done well on poor soils with very open to practically no tree cover in the previous crop. It seems this species can be made use of as a good coloniser in degraded forests as it is also very promising economically. Plants raised in polythene bags show better survival and also vigour as with dibbling, the seeds and cotyledons are often eaten by a variety of animals including man. Here again, a closer spacing is advisable; the most suitable appears to be 12'×6' to be thinned at a suitable stage later. It would also be advisable to put in a line of suitable *Eucalyptus* species between two rows as a mixture. In areas close to villages, seeds of improved variety of grass could also be sown between the lines after deep ploughing.

Other species.—In a couple of plots, mixed plantations of *kaju* and other species have been attempted. Some of the species tried and the best methods of raising them could be determined so far are :

- (a) By transplanting—*Terminalia chebula*, *Dalbergia latifolia*, *Pongamia glabra*, *Pterocarpus marsupium*, *Lagerstroemia microcarpa*, *Syzygium cumini*.
- (b) Direct sowing or not planting—*Artocarpus integrifolia*.
- (c) Pot planting—*Mesua ferrea*, *Mangifera indica*.

The various species have not been tried over areas large enough to give any generalised indications but it appears that in localities where *kaju* suffers from damping off and etiolation, *Artocarpus integrifolia* and *Dalbergia latifolia* would survive.

Nurseries.—Wet nurseries with standard beds have been established during the last two years for raising planting stock, mainly teak. Here again many seedlings die in the rains after having germinated splendidly and it appears that the time of sowing will have to be manipulated to avoid damping off during the vulnerable stage in the development of the seedlings.

Research

Under vegetation cover soil gets constantly enriched by rapidly decomposing litter. But on exposure, the top layers of the soil with its colloidal contents are promptly washed

off owing to the heavy rainfall, and the process of leaching of mineral salts commences rapidly, leading to the formation of a hard laterite pan over which vegetation cannot thrive. In the areas which were clearfelled for shifting or patch cultivation or agri-silvicultural plantations and have remained exposed for sometime now, the retrogression has reached the extreme limit. The rehabilitation of these barren lands extending over nearly 15,000 acres is the most important problem in the management of these forests. Methods are also required to be devised to re-stock the degraded forests, extending over approximately 8,000 acres, from which the tree cover has been heavily removed and in which the intervening gaps have failed to regenerate owing to heavy weed growth. For the scientific management of the remaining well-stocked forest, very little data particularly on technique of regeneration and rate of growth of important timber species is available. The forests are only about 25 to 30 miles from Belgaum town and there is a keen demand for timber, firewood and charcoal.

Investigations are thus required in this locality on the following points :--

- (1) To evolve the best nursery technique for teak in wet and dry nurseries.
 - (2) To determine the best time, method and spacing for planting teak and the best locations for raising teak plantations.
 - (3) Investigations on nursery technique and artificial regeneration of valuable evergreen and moist deciduous species suitable for replacement of the existing crop with low density.
 - (4) Evolving methods to induce and nurse natural regeneration of such valuable timber species as *Syzygium cumini*, *Mangifera indica*, *Terminalia chebula*, *Dalbergia latifolia*, *Lagerstroemia microcarpa* etc. by manipulation of the canopy without disturbing the ecological equilibrium in the moist semi-evergreen stands particularly in locations with rainfall over 200" and with dense persistent fog in the monsoon months.
 - (5) To evolve a comprehensive technique for reclothing the hill slopes rendered barren by shifting cultivation.
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TROPICAL MOIST EVERGREEN FOREST IN BOMBAY STATE

BY D. V. KHISTY,

Conservator of Forests, Poona

Introduction

With the re-organisation of States in 1956 the new composite Bombay State is practically devoid of Southern tropical wet evergreen forests, group 1-a as per Champion's classification. Western tropical evergreen forest 1-a C3 exists in North Kanara, a part of erstwhile Bombay State. These forests now form part of new Mysore State.

The Southern tropical semi-evergreen forests are represented by west coast tropical semi-evergreen forests 2-a C2 but these are found in Ghat slopes above Nilambur and South Kanara. In the present Bombay State southern sub-tropical wet hill forest is represented by subtype C3.

Distribution

Bombay sub-tropical evergreen forests [Champion's 7-a(3)] are distributed in 4 localities removed from each other as under :

- (i) *Sawantwadi sub-division and Kolhapur division* : Area occupied approximately 12,400 acres. The forests are confined to the plateau region in the vicinity of the Amboli Ghat and also occur on the precipitous slopes near about the crest of the Western Ghats.
- (ii) *Satara division* : Area occupied 11,983 acres. The forests are confined to the Mahabaleshwar plateau.
- (iii) *Poona division* : Area occupied 92,766.15 acres. The forests are confined to the higher elevation of the Western Ghats (Sahyadri main range) and extend some distance on the out lying spurs on their eastern flanks.
- (iv) *Kolaba division* : Area occupied 42,461.23 acres. The forests are confined to the inaccessible areas of the Western Ghats and Matheran plateau.

Locality Factors

(i) *Sawantwadi sub-division and Kolhapur division* : The annual rainfall in the semi-evergreen tract (Amboli Ghat) varies from 120" to 250". The temperature varies from 92°F to 72°F. The soil is sandy loam round about Sawantwadi and the remaining tract red soil of lateritic lumps is found.

(ii) *Satara division* : The average yearly rainfall at Mahabaleshwar varies from 250" to 300". The temperature varies from 72.16°F to 61.4°F. The rock of the plateau is basalt. The soil is red which is the result of disintegration of laterite. The plateau is exposed to strong winds and storms.

(iii) *Poona division* : The western hill region having southern sub-tropical hill forest receives precipitation from 125" to 275". The rock is basalt. Red soils are common in western hilly regions. The climate is generally equitable.

(iv) *Kolaba division* : The annual rainfall varies from 130" to 200" in the semi-evergreen tracts. The soil is red formed by the disintegration of laterite. The temperature at Matheran varies between 77°F to 67°F.

Composition of Forests

(i) *Sawantwadi sub-division and Kolhapur division* : The height of the crop varies between 20' to 40'. Three distinct canopies can be distinguished as below :

Top canopy—The main species found are *Memecylon edule*, *Mangifera indica*, *Terminalia chebula*, *Mallotus philippiensis*, *Bridelia retusa*, *Holigarna arnotiana*, etc.

Middle canopy—It consists of *Olea dioica*, *Leea macrophylla*, *Cinnamomum tamala*, *Erythrina indica*, *Sterculia urens*, etc.

The ground cover is generally made up of evergreen shrubs, such as *Calycopteris floribunda*, *Woodfordia fruticosa*, *Carrissa carandus*, *Zizyphus rugosa*, etc.

(ii) *Satara division* : The vegetation on Mahabaleshwar plateau consists of stunted evergreen species not exceeding 25' in height. The common species are *Eugenia jambolana*, *Terminalia chebula*, *Actinodaphne hookeri*, *Memecylon edule*, *Olea dioica*, etc. The climbers are *Elaeagnus latifolia*, *Hoya pallida*, *Atalantia monophylla*, etc.

(iii) *Poona division* : The species occurring are *Eugenia jambolana*, *Actinodaphne hookeri*, *Memecylon edule*, *Olea dioica*. The under-growth consists of *Strobilanthes*, *Murraya exotica*, *Ixora parviflora*, *Gymnema sylvestre*, etc.

(iv) *Kolaba division* : The flora is represented by *Eugenia jambolana*, *Mangifera indica*, *Terminalia chebula*, *Terminalia paniculata*, *Lagerstroemia lanceolata*. The under shrubs are *Woodfordia floribunda*, *Calycotris floribunda*, *Carissa carandas*, etc.

Natural Regeneration

(i) *Sawantwadi sub-division and Kolhapur division* : On western slopes *Memecylon edule* is disappearing and as the elevation falls predominance of such species as *Olea dioica*, *Lagerstroemia lanceolata*, *Terminalia tomentosa*, *Xylia xylocarpa* is seen, i.e. there is change over from evergreen to moist deciduous. *Kumri* (shifting) cultivation has resulted in turning 7,000 acres of these forests into grass lands.

(ii) *Satara division* : In Mahabaleshwar plateau forests, reproduction is good particularly in unexposed situations.

(iii) *Poona division* : Due to injudicious fellings to secure economic working, grassy blanks with the preponderance of thorny shrubs have been created in these forests. Regeneration is practically absent.

(iv) *Kolaba division* : Reproduction has not been determined so far.

Management

(i) *Sawantwadi sub-division and Kolhapur division*—Under Takle's plan prepared for the period 1901 to 1934 these forests were allotted in 4 working circles to be worked on Selection system. The girth limit prescribed for selection fellings was fixed at 36". The selection fellings were to be carried out on a cycle of 10 years.

As per the revised plan (1958) by Shri G. R. Mavinkurve the area is divided into three felling series. Felling series I & II are worked under light improvement fellings in the overwood and supplemented by light thinning in congested patches of the underwood. Under this method all really dead, decaying and damaged trees are removed. In the gaps created by the removal of dead and dying trees such species as *Mangifera indica*, *Artocarpus integrifolia* and *Salmaalina malabarica* are planted to improve the stocking.

(ii) *Satara division*—The working plan for the Mahabaleshwar plateau forests was prepared by Fagan in 1893-94 to be a provisional Working Plan. Roughly half the forests were reserved and half protected. These were divided into 30 annual coupes. Each coupe was subjected yearly to light improvement fellings with a view to keep dense forest crop continuously and to improve existing growth by introducing *Grevillea robusta* and *Eucalyptus* spp.

This plan was followed till the introduction of Bourke's plan in 1909 when old Blocks II & III were added. Subsequently in the years 1917-18 old Blocks IV to IX were added by Shri A. N. Master. In all the exploited blocks the working was the same that is each coupe was subjected to a light improvement felling. Old Blocks V, VII and IX were not worked till 1934.

Bourke's plan was revised in 1934 by Shri J. A. Singh. According to this plan the annual coupes are worked under light improvement fellings and the coupes thus exploited are closed to grazing for 10 years.

(iii) *Poona division*—For the semi-evergreen forests in Poona division a protection working circle was formed. Under a felling cycle of 30 years mature trees were to be removed in the form of improvement-cum-thinning. This working, however, resulted into creating grassy open patches and this practice was stopped in 1949. No fellings are carried out now in these forests.

(iv) *Kolaba division*—The semi-evergreen forests constitute unexploitable working circle. No definite prescriptions are laid down for this circle. However, Divisional Forest Officer is authorised to carry out fellings in conformity with the silvicultural principles.

Research

The main problem is of protection. There is very little data available on these irregular mixed crops. To collect the growth statistics of the few important species found in these forests it is necessary to lay out Linear Tree Increment plots. Continuous Inventory plots may also be laid out. These plots managed on proper selection-cum-improvement principles will be the basis for preparing yield and stand tables for the given quality and forest type. Preparation of stand tables for different types of unevenaged tree crops is important for safeguarding the correct distribution of size classes in the forests. However, this is only necessary for the important semi-evergreen tracts having important valuable evergreen species for which correct distribution of size classes is desired.

**TROPICAL MOIST EVERGREEN FOREST STUDY-TOUR AND SYMPOSIUM
TOUR PROGRAMME**

Date	Particulars of journey	Mode of travel
MYSORE STATE		
March		
6	Reach Hubli by train and then to Sirsi.	Rail/Road
7	Sirsi to Jog Falls.	Road
8	Halt at Jog Falls.	
9	Jog Falls to Agumbe.	Road
10	Halt at Agumbe.	
11	Agumbe to Sakleshpur.	Road
12	Sakleshpur to Mercara.	Road
13	Mercara to Tellicherry <i>via</i> Makut—State Symposium at Makut.	Road
MADRAS STATE		
14	Tellicherry to Coimbatore <i>via</i> Pōdanur.	Rail
15	Halt at Coimbatore.	
16	Coimbatore to Palghat.	Road
KERALA STATE		
17	Halt at Palghat.	
18	Palghat to Peermade <i>via</i> Trichur.	Road
19	Halt at Peermade.	
20	Peermade to Trivandrum.	Road
21-23	Halt at Trivandrum.	
MADRAS STATE		
24	Trivandrum to Kanyakumari <i>via</i> Nagercoil—State Symposium.	Road
25-26	Kanyakumari to Pondicherry.	Road/Rail
27	Pondicherry to Madras.	Rail
28	Halt at Madras.	
29-31	} Madras to Port Blair.	Sea
April 1-3		
3-7		
8	State Symposium in the morning.	
8-12	Port Blair to Calcutta.	Sea
13-14	Halt at Calcutta.	
15	Calcutta to Dhekiajuli <i>via</i> Gauhati.	Air/Road
ASSAM STATE		
15	Halt at Dhekiajuli.	
16	Dhekiajuli to Kohora.	
17	Kohora to Jeypore.	Road
18-19	Halt at Jeypore.	Road
20	Jeypore to Kohora—State Symposium.	
21	Kohora to Shillong.	Road
22-24	Halt at Shillong. Plenary Session of the All-India Tropical Moist Evergreen Forest Symposium.	Road

LIST OF DELEGATES AND OBSERVERS —STUDY TOUR

Forest Research Institute & Colleges—

1. Shri S. K. Seth, Central Silviculturist and Head, Division of Forestry.
2. Shri M. A. Waheed Khan, Ecologist.
3. Dr. J. S. P. Yadav, Soil Chemist.
4. Shri K. K. Nair, Lecturer, I. F. C.
5. Shri V. Govinda Menon, Instructor, S.F.R.C. (15-3-60 to 23-3-60).

- Mysore*—
6. Shri D. K. Deshmukh, Silviculturist.
- Kerala*—
7. Shri A. I. Iyppu, Silviculturist.
- Assam*—
8. Shri H. Kakati, Asstt. Working Plans Officer (13-3-60 to 24-4-60).
- Bombay*—
9. Shri G. B. Dashputre, Working Plans Officer.
- West Bengal*—
10. Shri A. B. Chaudhari, Silviculturist (6-3-60 to 23-3-60).
- Orissa*—
11. Shri S. S. Das, Silviculturist (15-4-60 to 24-4-60).
- Botanical Survey of India*—
12. Shri R. S. Rao, Regional Botanist, Poona (6-3-60 to 24-3-60).
13. Dr. G. Panigrahi, Regional Botanist, Shillong (15-4-60 to 24-4-60).

LIST OF DELEGATES—PLENARY SESSION

Forest Research Institute & Colleges—

1. Shri T. N. Srivastava, Director of Forest Education.
2. Shri P. Venkataramany, Chief Editor, Editorial Board.
3. Shri M. A. Waheed Khan, Ecologist.
4. Shri K. K. Nair, Lecturer, I.F.C.
5. Shri S. N. Dabral, Mensuration Officer.
6. Dr. J. S. P. Yadav, Soil Chemist.
7. Dr. Harish Bhatnagar, Research Scholar.

Mysore—

8. Dr. K. Kadambi, Chief Conservator of Forests.
9. Shri D. K. Deshmukh, Silviculturist.

Kerala—

10. Shri A. I. Iyppu, Silviculturist.

Madras—

11. Shri C. A. R. Bhadrán, Chief Conservator of Forests.

Assam—

12. Shri M. C. Jacob, Chief Conservator of Forests.
13. Shri R. M. Das, Conservator of Forests.
14. Shri P. Barua, Conservator of Forests.
15. Shri B. N. Das, D.F.O., Goalpara West Division.
16. Shri S. Rajkhowa, Silviculturist.
17. Shri P. N. Bhattacharjee, D.F.O., Cachar.
18. Shri M. L. Saikia, D.F.O., Kamrup.
19. Shri H. Kakati, A.C.F.
20. Shri T. C. Goswami, Forest Utilization Officer.
21. Shri T. Hazarika, D.R.O., K. & J. Hills.
22. Shri M. A. Islam, Planning Officer (Assam).

N.E.F.A.—

23. Shri P. B. Kar, Director of Forests.
24. Shri Ganpat Rai, D.F.O., Balipara.
25. Shri S. B. Roy, A.C.F.
26. Shri Lalthan Zama, D.F.O., Tirap.
27. Shri W. B. Bathew, D.F.O., Tezu.

Bombay—

28. Shri R. R. Chaudhari, Chief Conservator of Forests.

West Bengal—

29. Shri V. S. Rao, Conservator General of Forests.
30. Shri A. B. Chaudhari, Silviculturist.

Orissa—

31. Shri S. S. Das, Silviculturist.

Bhutan—

32. Shri S. Doley, D.F.O.

Botanical Survey of India—

33. Dr. G. Panigrahi, Regional Botanist, Shillong.