FORESTS AND FORESTRY

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INDIA—THE LAND AND THE PEOPLE

FORESTS AND FORESTRY

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PREFACE

> "I wonder sometimes if there is any other natural resource which gives us so much and of which we know so little as the forests. There is, therefore, a good case for producing readable literature to enlighten the common people about India's forest wealth."
>
> —DR. RAJENDRA PRASAD

THIS BOOK *Forests and Forestry* has been written with the object of making available to the ordinary educated Indian, the non-specialist, basic facts concerning the forests of the country and the practice of forestry in simple language.

In general, as a result of protection and management in accordance with the comprehensive forest policy of 1894, the forests have progressively improved. But as the population of men and livestock increased, insufficiency of forests made satisfaction of the rapidly rising agricultural and industrial demand more and more difficult. Therefore when the country became independent it was considered desirable to enunciate a *national* forest policy and then to plan for the progressive development of the forests. This work is continuing. There are, however, still certain lacunae because of which maximum benefits cannot accrue from the forests, viz., their inadequate extent, ill-distribution and low productivity.

The remedy is obvious. All suitable wasteland and marginal agricultural land should be afforested. The production from forests should be increased by their proper protection and introduction of valuable fast-growing, site-suitable, high-yielding species of trees, and by modernizing methods of felling, conversion, transport and utilisation, to minimise waste and to meet the rapidly rising demand for industrial wood. The forests should also be managed to fulfil their protective and bio-aesthetic role.

The spokesmen of the people could do much to carry the message of forestry to the masses and thus convince them of the need for enforcing certain restrictions on the use of forests. If this book makes the reader forest-minded and thus enlists his willing co-operation in protecting and developing the forests, so that eventually they confer the greatest good on the largest number for all time, he shall feel amply rewarded.

The writer is grateful to Shri B.K. Bhalla, A.I.F.C. Chief, Dehra Dun Centre, Logging Training Project (U.N. Sp. Fund), for going through the typescript and for making some useful suggestions.

K.P. SAGREIYA

PREFACE TO THE SECOND EDITION

I HAVE availed myself of this opportunity to bring all data, as far as possible, up-to-date, mostly from Government sources. I have also given definitions of technical words according to the latest departmental publication, "Indian Forest and Forest Products Terminology", and added some matter here and there to make the book more readable and useful.

K.P. SAGREIYA

JABALPUR
May 5, 1970

PREFACE TO THE THIRD EDITION

I am happy to learn that the second edition had a brisk demand and the Publishers have asked me to get the book ready for another edition. I have done this now.

Not only does this edition contain the latest available statistics—mostly from Government publications, but I have also availed myself of the opportunity to add from the *interim* reports dealing with forestry of the National Commission on Agriculture with which I have been associated, and from other sources.

I am gratified to find that the book has received adequate publicity and only hope this has resulted in better appreciation of the forester's view-point, namely, that the forests should be so managed as would maximise production and prove useful to the nation for all time.

वन संवर्धन जन कल्याण
K.P. SAGREIYA

NAPIER TOWN
JABALPUR
August 5, 1974

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FORESTS, FORESTRY AND MAN

DEFINITION

THE word *forest* is derived from the Latin 'foris', meaning outside, the reference being to a village boundary or fence, and it must have included all uncultivated and uninhabited land. Today a forest is any land managed for the diverse purposes of forestry, whether covered with trees, shrubs, climbers, etc., or not. The Indian word 'jungle' has been adopted in the English language to describe a collection of trees, shrubs, etc., that are not grown in a regular manner, as contrasted with 'forest', which is any vegetation under a systematic management. Technically *forest* has been defined as:

(a) (In general) An area set aside for the production of timber and other forest produce, or maintained under woody vegetation for certain indirect benefits which it provides, e.g., climatic or protective;

(b) (In ecology) A plant community predominantly of trees and other woody vegetation, usually with a closed canopy; and

(c) (In law) An area of land proclaimed to be a forest under a forest law.

Forestry is the theory and practice of all that constitutes the creation, conservation, and scientific management of forests and the utilization of their resources to provide for the continuous production of the required goods and services.

Forests are a very striking feature of the land surface. They vary greatly in composition and density, and stand in marked contrast with meadows and pastures. The scenic effect of forests changes with the seasons like the patterns in a kaleidoscope. Certain forests are evergreen, like the Deodar forests of Kashmir, while others are deciduous, becoming leafless either before the advent of winter when vegetative activity almost ceases, such as the oak forests of the Himalayas, or else just before the onset of intense dry summer, to reduce transpiration to the minimum, like the teak forests of Central India. The falling leaves in some species become bright orange or golden yellow. In others the young foliage is pink. Such autumnal and vernal tinges are in vivid contrast with the general green, or straw-coloured background, and are extremely pleasing. Unlike animals, plants do not have the power of locomotion. They also cannot construct shelters or generate heat to withstand the adverse effects of the environment of which they are captives. Therefore, to survive, they wear the evidence of this fact in the form of structural adaptations, such as leaflessness in summer to minimise transpiration, thorns to ward off browsers, poisonous sap, etc.

The forests of a country are a natural asset of immense value, which, unlike mineral resources, can be kept perpetually productive and useful under proper management. *Directly* they supply pole-wood, fuel, fodder, etc., which are the indispensable needs of the people residing in or near them; they also yield a variety of produce of commercial value, such as structural timber, raw materials for making newsprint, paper, plywood, etc., tanstuff, lac, resin, leaves, essential oils, medicinal herbs, etc., and provide employment to a large population engaged in their protection, tending, exploitation, and regeneration; as also in industries utilising forest products. These are collectively known as the *productive* functions of forests. *Indirectly*, forests preserve the earth's physical features, moderate the extremes of climate, check the speed and force of flow of rain-water, thereby minimising soil erosion and regulating the flow of streams. They also have a considerable hygienic, aesthetic and strategic value, and provide shelter to wild life which is of scientific and recreational interest. These are often referred to as the *protective* and *social* functions of forests.

FORESTS IN GEOLOGICAL AGES

The evolution of life on earth in geological ages is indicated in table 1.

It will be seen that man was evolved only a million years ago when he lived in dense forests along with other denizens. Palaeo-

TABLE 1
GEOLOGICAL AGES AND LIFE

Time (million years ago)	*Life*
1	First True Men Mammals
100	Flowering Plants Dinosaurs
200	Fishes, Insects, Amphibians: First Animal Life on Land
400	Green Plants with Stems and Roots First Plant Life on Land
600	Simple Sea Creatures: Trilobites and Sea Scorpions
1000	First Life on Earth: Single Living Cells

botanists have examined the fossils of plants found in rocks of various ages and deduced what kind of vegetation grew in those particular geological periods. Thus Birbal Sahni concluded from the fossils found in inter-trappean rocks that at that time estuarine conditions prevailed in India, and the flora belonged to the genera of plants found in London clay. These plants must have migrated to India by way of the Tethys Sea which stretched along the northern edge of the Gondwanaland before the uplift of the Himalayas. It has also been proved that Kashmir and Rajasthan once had a tropical forest, which later receded as a result of glaciation and the upthrust of the Himalayas. Prior to this upheaval, the Ganga drained northwards into the Sindhu. By this time man had already been evolved.

Forests in Pre-historic Era

In the last one million years man progressed as under:

In the eolithic age, primitive man lived in dense forests, on trees or in natural caves, and subsisted on leaves, fruits and roots of plants. He used fire for keeping off the dangerous animals of the

Years ago	*Progress*
1,000,000	Eolithic Age
300,000	Palaeolithic Age
15,000	Neolithic Age
3,000	Bronze and Iron Age
25	Nuclear Age

forests. In the palaeolithic age, he took to hunting wild birds and small animals to obtain their flesh for eating and their skin or fur for covering himself. In the neolithic age he discovered the use of fire for cooking, and, incidentally, hit upon the method of shifting cultivation, or in forestry parlance, rotating agriculture.

Shifting Cultivation

About 10,000 years ago man discovered that seeds of certain grasses could be eaten. To obtain these easily, he tried to grow them close to his abode. For this purpose he cleared a patch of forest by felling the trees and shrubs, and, to minimise the trouble, burning the debris. When he did this, he realised that forest-soil, mixed with ashes, gave bumper crops. He also found that after a few years its productivity rapidly went down and, therefore, he cleared another patch of forest. Thus started the practice of *Dahya*, (meaning burnt) or shifting cultivation—the precursor of settled agriculture.

Shifting cultivation is a method of cyclic cultivation, chiefly in vogue in the tropics, where cultivators cut the tree crop, burn it, and raise field crops for one or more years before moving on to another site and repeating the process. It is known as *dahya or bewar* in M.P., *podu* in A.P., *kumri* in Tamil Nadu, *ponum* in Kerala, and *jhum* in Assam.

It is estimated that in India nearly 26 lakh people live in this way. The total area of land utilised annually is 55 lakh hectares, and as the land is changed in rotation, the total area involved must be at least five times as much. According to an estimate of the Government of India nearly 81 million hectares, i.e., nearly 25% of the country's land, is subject to soil erosion as the inevitable consequence of the destruction of forests.

The technique used in different places varies in detail but, by and large, it consists of ruthlessly cutting down the tree growth and other vegetation and burning the debris. When this is inadequate, wood from adjoining forests is brought, spread on the area and burnt. This method of cultivation is primitive in the extreme. Indeed, in some cases, seed is broadcast, no weeding is done and the crop is harvested. To a shifting cultivator, quite ignorant of the latest developments in agriculture and the economics of balanced land-use, this appears to be the only feasible method of producing food. So long as extensive forests are available to the plunderer, he does not see any point in changing his way of life. He is unaware of the fact that total production under this method is extremely small, considering the area covered and the labour put in, and that in course of time, due to soil run-off, the land will become permanently unproductive. He is also quite unconcerned about the value of the wood that is destroyed to obtain ashes. His protagonists argue that he should not be weaned from this habit because he appears to be quite contented and happy. It is difficult to justify this argument when we have before us examples of men who live a more comfortable life with less toil on the same area of productive land. What is more significant is that in view of the rising population and the increasing demand for food and forest products, it is absolutely necessary to get the maximum yield from land and prevent any wasteful use of resources.

Sometimes even forestry experts have observed that the widely held notion that shifting cultivation in the main, is responsible, for large-scale soil erosion, needs to be effectively dispelled. In 1953, the then Inspector-General of Forests to the Government of India, making an investigation of the forestry problems in Assam, recorded:

> "The correct approach to the problem of shifting cultivation lies in accepting it not as a necessary evil, but recognizing it as a way of life; not condemning it as an evil practice, but regarding it as an agricultural practice evolved as a reflex

> to the physiographical character of the land. For too long, *jhuming* has been condemned out of hand as a curse to be ashamed of, a vandalism to be decried. This attitude engenders an inferiority complex and an unhealthy atmosphere for the launching of any development scheme seeking to improve the current practice."

In these *obiter-dicta* there is more sentiment than logic. Since these lines were written, much water has flown down the Assam hills and with it most of the productive soil. Today the ill-effects of this system are staring one in the face, and even the tribals would like to abandon it if someone will show them light. Introduction of wet cultivation, terracing and protecting *jhum* lands properly to minimise soil losses, are the obvious remedies.

FORESTS

(a) *In Geological Ages:* Palaeo-botanical evidence testifies to the fact that there were dense forests in India in the Permian period, 250 million years ago. A fossilised trunk of a tree found in the Raniganj coal-fields is nearly 30 m long and 75 cm in diameter at the butt-end and 35 cm at the top-end. It has been named by Dr. Birbal Sahni as *Dadoxylon*, an extinct genus of plants. Fossil wood is found in several places in M.P.

Man was evolved in the beginning of the Pleistocene Age, only a million years ago. At this time India had thick forests except in Rajasthan and parts of Punjab which lay buried under a swamp, the remnant of the receding Tethys.

(b) *In Historical Times:* Man progressed rapidly in historical times, and began to live in organized societies, constructed shelters using wood bark, etc., and soon took to farming and domestication of animals. Archaeological evidence shows that the Rajasthan swamps existed till as late as 4000 B.C., when Mohenjodaro culture flourished in the outskirts of Lothal in Gujarat. In these marshes grew stout reeds which were used by the Chalcolithic people to cover dead bodies. The adjoining forest contained rhinoceroses and crocodiles of which we find replicas on the seals. At this time trees must have been felled by axes of flint and bronze, as iron had not yet been used. After the disappearance of this civilization—the reasons for which are still not known—the Aryans started coming into India, from 2000 B.C. They introduced the use of iron for making axes, javelins, ploughs, etc.

There is evidence that at this period a Dravidian civilization of a high order flourished in the country, with its roots in the far south, which apparently lived in consonance with the thick extensive forest and its wild life. The Aryans were primarily pastoral people. To construct shelters for themselves and for their domesticated animals they cleared the forests wherever they went. But even so, being worshippers of Nature, they preferred for their abode, and even for their educational centres, sylvan surroundings and inspiring landscape. It is in such setting that the *Vedas*, the *Upanishads* and the *Aranyakas* were composed which sing the glory of the Creator and lay down precepts of conduct for man to live righteously. Human population at this period was very small, and forests were still plentiful. When the great epic *Ramayana* was written there were still dense forests in Naimisharanya, Chitrakoot, Dandakaranya, and Panchavati which abounded in wild life. But by the time the *Mahabharata* was compiled, onslaughts had been made on forests and we read of the burning of the Khandava Vana. To arrest such vandalism, which was adversely affecting the life of the people, some wise ancestor of ours must have declared cutting of trees a sin and planting and protecting them an act of piety. Several useful species of plants were thus saved from extinction, such as the banyan, the Pipal, the Bel, etc. Even then some disappeared in course of time from particular areas, such as the Kadam, the Ashok, and the bamboos from Vrindavan.

The chronicles of Chinese pilgrims mention dense Indian forests in the birth-place of Lord Krishna. Records relating to the invasion of Alexander the Great in 327 B.C. mention the existence of almost impenetrable forests along the Indus. Later, in Kautilya's time, protection of forests, planting of new species of trees, and preservation of wild life were considered desirable, and a special officer was appointed for the purpose. By the time of Emperor Ashoka, heavy inroads had already been made into the forests and their absence had begun to be felt. Therefore, as his Rock Edicts record, this far-sighted monarch ordered that useful trees be planted along the roads and on camping grounds. He also encouraged the cultivation of exotic medicinal plants.

Shershah Suri planted trees along the Delhi-Patna Highway. The Moghuls were not forest minded as such, but they created exquisite gardens. Emperor Jahangir introduced the famous Chinar tree in the valley of Kashmir. The Mughals also maintained large *Shikargahs* for hunting. The *Ain-e-Akbari* records that elephants roamed in the forests as far west as Mhow near Indore. But a century later Aurangzeb found only scrub forests near Burhanpur. The Marathas and the Gonds planted mangoes and other useful trees along their marching routes and halting places, some of which are still surviving. Soon after, under a somewhat more stable government, the population rapidly increased and indiscriminate destruction of forests began, particularly in the basins of important rivers such as the Yamuna, the Chambal and the Narmada.

This wanton destruction was further accelerated under British supremacy as teak and certain other Indian timbers were found very suitable for building ships for the British navy, and other woods were found suitable for railway sleepers, needed for extending the railways from the ports to the forests in the interior. Very soon, however, it became apparent to them that this was against their long-term imperial interests, and the need to work forests scientifically was felt.

Scientific Forestry

The practice of scientific forestry in India may be said to have begun with Sir Dietrich Brandis taking over as the Inspector-General of Forests, India, in 1864. Under his able guidance, Forest Departments were created in the various British Provinces. The first responsibility that devolved on the forest officers was to inspect tree-clad lands and all hilly regions and then to demarcate, survey, and map suitable areas for settlement as *reserved* or *protected* forests under the newly enacted Indian Forest Act, 1865. After these forests were inspected by the Inspector-General of Forests along with the local forest officers general principles were laid down on which they were to be managed.

Forest Policy, 1894

It was at this stage, that Government of India invited Dr. Voelcker, a German expert, to examine the condition of Indian agriculture and to suggest how it could be improved. In his report, submitted in 1893, Dr. Voelcker discussed the role of forests vis-a-vis agriculture and stressed the need for formulating a forest policy with a definite bias for serving agricultural interests more directly than before. Accordingly, the Government issued a resolution, dated October, 19, 1894, declaring their forest policy. This statement of the forest policy of India later served as a model for drawing the forest policies of various countries of the erstwhile British Empire, and other countries where management of forests on scientific lines was initiated. The basic principles enunciated in this policy were:

(i) The sole object with which State forests are administered is public benefit. In general the constitution and preservation of a forest involve the regulation of rights and the restriction of privileges of the user of the forest by the neighbouring population;

(ii) Forests situated on hill slopes should be maintained as *protection* forests to preserve the climatic and physical conditions of the country, and to protect the cultivated plains that lie below them from the devastating action of hill torrents;

(iii) Forests which are the store-house of valuable timbers should be managed on commercial lines as a source of revenue to the State;

(iv) Ordinarily, if a demand for agricultural land arises and can be met from a forest alone, it should be conceded without hesitation, subject to the following conditions:

   (a) honeycombing of a valuable forest by patches of cultivation should not be allowed;

   (b) cultivation must be permanent and must not be allowed so to extend as to encroach upon the minimum area of forest that is needed to meet the reasonable forest requirements, present and prospective;

(v) forests that yield only inferior timber, fuelwood or fodder, or are used for grazing, should be managed mainly in the interest of the local population, care being taken to see that the user does not annihilate its subject and the people are protected against their own improvidence.

Ordinarily, only the *Protection* and *Commercial* forests were declared 'reserved' and the existing rights in them either settled, transferred, or commuted; the other forests were declared 'protected', and rights over them, which were extensive, were recorded and regulated. As regards government, the chief difference was that new rights could not spring up in the reserved though they could in the protected forests, and whereas the record of rights of the former was conclusive that in the latter only carried a presumption of truth. From the people's point of view, in a reserved forest every act not specifically permitted was an offence while in a protected forest nothing was an offence that was not prohibited.

Successful implementation of this excellent policy was primarily responsible for a steady development of the forests of the country. For nearly sixty years forests were continuously conserved. The best of them were managed under working plans prepared after detailed inspection and a thorough study of the locality factors and the demand. Some efforts were also made to see that the felled-over forests were satisfactorily regenerated with valuable species, and the new forest growth was protected and tended properly. The result was a steady building up of the forest capital, the fruits of which have been reaped in later years. The proportion of valuable species, particularly teak, was in some places increased artificially by planting.

There was some depletion of forest capital in World War I, but this was more than made up by intensive conservation and management in subsequent years. But in World War II forests were heavily felled, far beyond their sustained production. Even cultural operations were neglected, for want of adequate staff and funds, with the result that the forest capital decreased considerably.

VANA MAHOTSAVA

India became independent in 1947. Soon thereafter, attention of the Government was drawn to the need for remodelling the management of Indian forests so that they could play an increasingly useful role in promoting national welfare. As a first step towards making the people forest-conscious and thus enlisting their willing cooperation in protecting the forests, the then Union Minister for Food and Agriculture, Shri K.M. Munshi, conceived a nation-wide celebration of an annual tree-planting festival. Inaugurating, in 1950, the first Arbor Day, or *Vana Mahotsava*, as it was called, he pointed out that the noblest and the best in Indian culture was born in *ashramas* where the ancient founders sang:

> "May the gods, the water, the plants and the forest trees, accept our prayers, and may their blessings protect us for ever, and ever."

He reminded the people of the description of forests in Indian classics, and pointed out how they had become unworthy of this glorious heritage, by mercilessly destroying forests which were the objects of worship. He emphasized that *Vana Mahotsava* was not a poetic fancy; nor a spectacular festival. It was a process of land transformation to recreate forests. Water tables were falling, more and more rivers were drying up, and the Rajasthan desert was advancing. He reminded the nation that if it had to survive, the philosophy of life must be rewritten not only in words, ideas or achievements, but in terms which would replant us firmly on the earth and under the shady tree. Vana Mahotsava was conceived with a view to channelise the urge for creative action, amongst the people, to fruitful ends. Its main aim was to inculcate tree-consciousness in the masses.

This festival of trees has been celebrated every year ever since. But unfortunately, by and large, it has tended to become an excuse for saying a few platitudes. It would be desirable to create *woodlands*, even if they are small, and then to protect and tend them, and thus leave for posterity, for whom we hold the forests in trust, more forests than we inherited, to meet the ever increasing demand for various forest products.

Private Forests

When the land at present under cultivation was settled nearly a century ago, care was taken by the Government to keep in every village, or a group of villages, a sufficient forest area under private ownership. The proprietors were expected to meet the *bona fide* demands of the agriculturists for forest produce, either free or at concessional rates. *This arrangement tacitly assumed that the forest owner will perpetuate the forest.* This is a very fundamental point which seems to have been totally lost sight of in subsequent years. The proprietors, in their own way, regulated and restricted the user, often asking the agriculturists to pay for the benefits in the shape of labour, but always took care to see that the forest was not destroyed, or the agriculturists antagonised. Over-exploitation for personal gains, which became rampant after independence, could have been prevented by imposing reasonable restrictions. Instead, a decision was taken by the Government to abolish proprietary rights over forests in most States. Whilst the legislators discussed the manner in which this was to be done, no effective step could be taken to prevent the proprietors from felling the tree growth and encashing it. Indeed, in certain cases, it was known that the compensation payable would depend on the actual receipts from the forests in the immediate past, and this served as an additional incentive to a more rapid and a heavier felling. After the forests were taken over by the Government no arrangements could be made for their protection and tending. An impression was also created that the forests were wrested from the proprietors for the people who were free to help themselves to whatever they liked from wherever they chose. People forgot that trees took many years to mature and if the out-turn from a forest was to be sustained, only so much produce should be removed annually as would be equivalent to a year's increment, leaving an adequate number of immature trees to meet the future requirements. The result was a holocaust. The ex-private forests got depleted in no time. Pressure was, therefore, brought to bear on the Government to meet the demand from the reserved forests. Illicit fellings also increased. In some places Government was compelled to cut forests immaturely, which was a retrograde step, the ill-effects of which are being felt now.

National Forest Policy, 1952

During the interval that had elapsed between the pronouncement of the 1894 policy and the country becoming independent, changes of far reaching importance had taken place in the economic and the political fields. The population, both of men and livestock, had increased very substantially, resulting in a heavier pressure on the forests for securing more land for agriculture and pasturage. The two World Wars had shown the dependence of defence on forests. The reconstruction schemes initiated by the Planning Commission, such as the river-valley projects, development of industries and communications, etc., all leaned very heavily on the produce of forests. Forestry was no longer regarded as the handmaid of agriculture but was recognised to be its foster mother. While the fundamental principles underlying the 1894 policy are ever true and were therefore reiterated, Government of India thought it fit to lay greater emphasis on a number of other points. It proposed the classification of forests on a functional basis into *protection* forests, *national* forests, and *village* forests. It emphasized the need for evolving a system of balanced and complementary land-use, under which each type of land was to be allotted to that form of use under which it would produce most and deteriorate least. The policy considered it desirable to establish tree-lands wherever possible for the amelioration of the physical and the climatic conditions, and for promoting the general well-being of the people. It also made provision for ensuring progressively increasing supplies of pasture, timber for agricultural implements, and firewood to release cattle-dung for use as manure. The national policy also contrived against the indiscriminate extension of agriculture by the excision of forests, as this not only deprives the local population of wood, grass, etc., but also deprives the land of its natural defences against dust storms, hot winds, and erosion. It emphasized that the notion widely entertained that forestry had no intrinsic right to land but might be permitted on sufferance on residual land not required for any other purpose, had to be combated. The role of forests, *productive*, *protective* and *bio-aesthetic*, entitles them to an adequate share of land to promote public well-being and ensure balanced economy. The policy also laid down that it would be the duty of the forester to awaken interest of the people in the development, extension and establishment of tree-lands wherever possible, and to make them tree-minded. The *national* forests were to be managed on the principle of progressively increasing, and eventually the highest, sustained yield to meet the requirements of defence, communications and industry. It also emphasized the need for affording protection to wild life by its proper management for scientific study and for recreational purposes. The policy also laid stress on (i) weaning the primitive people by persuasion, from the baneful practice of shifting cultivation; (ii) increasing the efficiency of forest administration by having adequate forest laws; (iii) giving requisite training to the staff of all ranks; (iv) providing adequate facilities for the management of forests and for conducting research in forestry and forest products utilisation; (v) controlling grazing in the forest; and (vi) promoting welfare of the people.

Future Forest Policy

The optimum utilisation of the forest resources in development is at present constrained, as the intimate linkage between the producing and the manufacturing sectors, viz., the services and the industries, has not been properly coordinated. The function of the forest services in the developing needs of the country should be changed by suitably modifying the forest policy (including the forest law and forest administration).

The forester must now weld the earlier traditional conservationist approach to a more dynamic attitude towards development by maximising the productivity of the lands dedicated to forestry at the earliest and at the minimum cost.

Unlike governmental Agricultural, Veterinary and Geological services, which are merely concerned with research, extension and advice, the Forest service besides doing all this, also actually directly manages a valuable, renewable asset covering a large area of the productive land in the country, and meeting certain indispensable needs of the population living in its vicinity.

It is now becoming increasingly urgent that the thinking about forests be broadened to include the concept of economic values. Capital forestry must compete for these and to do effectively its performance, must be efficient. Only in this way forest and forest industry sectors can make a fuller contribution to country's economic development.

In so far as Forest Administration is concerned, the long-term nature of forestry, the indispensable connexion between growing of trees and the processing of wood or other forest products, the need for continuous contact between the producer and the consumer, and above all the necessity for anticipating changes in demand patterns, and effecting procedural and functional reforms to accommodate such changes, suggest that forest service should be guided and controlled by somewhat flexible administrative arrangement, say an autonomous organ'sation. There are also procedural obstacles to efficiency which need to be eliminated.

Similarly, forest law has generally not been conceived as a positive agent of development, but merely as a means for preventing the misuse of forests. The effect of this emphasis on the punitive and deterrent aspect is that forest law becomes an obstacle to forest development. When analysing the existing forest law some basic questions arise. Should the rights of the individuals prevail over the welfare of the people as a whole? Should the emphasis be on *status quo* or a radical change is called for in public interest? Obviously the well-being of the nation should take precedence over the needs of individuals.

It is high time that a reappraisal of the National Forest Policy of 1952 is made in the light of experience gained in the last 25 years, and the research and technological advancements made in the international field of forestry. The policy should be re-enunciated to make it more purposeful, realistic and effective for the proper development of the country.

In fine, the revised policy should highlight the necessity for rehabilitating the depleted forests and restocking those that contain inferior or slow-growing species with valuable, faster growing, site-suitable trees. A greater stress is also needed on the multiple role that well-managed forests play in promoting national well-being and above all on the economic aspect of land-use under forestry.

Planned Forest Development

The new Constitution of India came into force in 1950. Soon after, the Government announced the setting up of a Planning Commission. One of the functions assigned to the Commission was to formulate plans for the most effective and balanced utilisation of the country's resources and to make an appraisal from time to time of the progress achieved in this direction and then suggest adjustments in policy and measures to be adopted to hasten the development of the country. Accordingly, to derive the maximum benefits from them, rehabilitation of the depleted forests of the country was given special attention in the Five-Year Plans. Forest-planning is a multi-faceted, consistent and well-integrated affair, where due weightage has to be given to preservation in the context of soil and water conservation, and then to the satisfaction of the present and prospective demand of the local people as also that of the industries utilising forest products.

Accordingly, the successive Five Year Plans have aimed at accelerating the pace of forestry development and the expansion of forestry organization in the country.

First Five Year Plan (1951–56)

The two World Wars drew heavily on the forest resources. Major river valley projects, development of industries and communications and other projects so vital to the developing economy of the country also leaned heavily on the utilisation of the forests and forest areas. While the fundamental concepts underlying the forest policy laid down in 1894 remained the same, the national forest policy enunciated in 1952 emphasised that the forests should

Plate 1

VANA MAHOTSAVA

(*See page 11*)

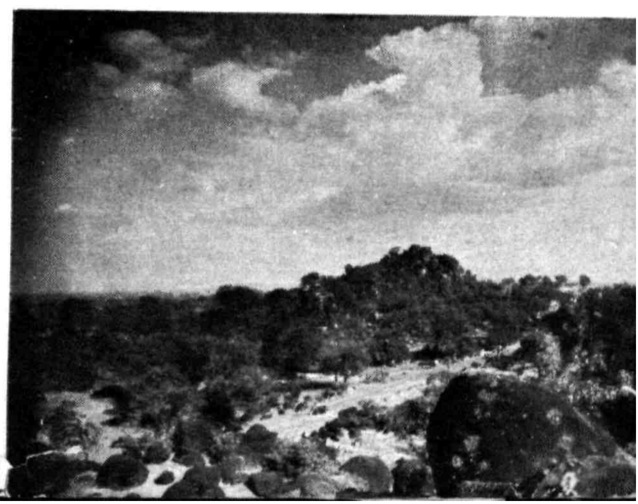


Plate 2

ROCKS EXPOSED AFTER SEVERE EROSION, MADAN MAHAL, JABALPUR

(*See page 40*)

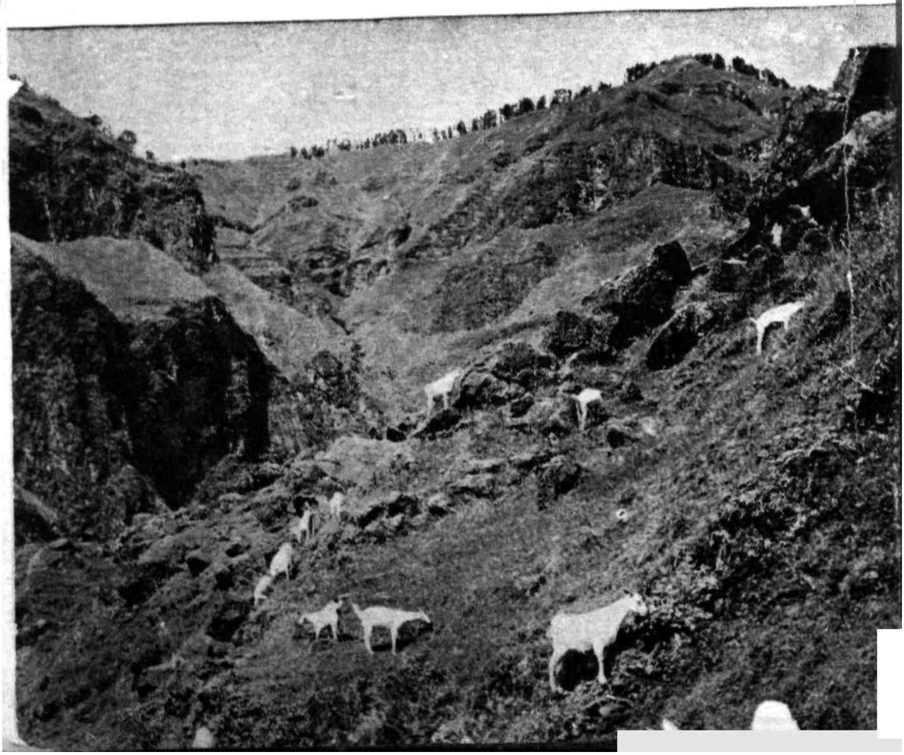
Plate 4

NORTHERN TROPICAL SEMI-EVERGREEN FOREST OF GURJAN, BENGAL

(*See page 45*)

Plate 3 UNRESTRICTED GOAT BROWSING DENUDING THE FOREST COVER. BHAKRA CATCHMENT, H.P.

(*See page 41*)



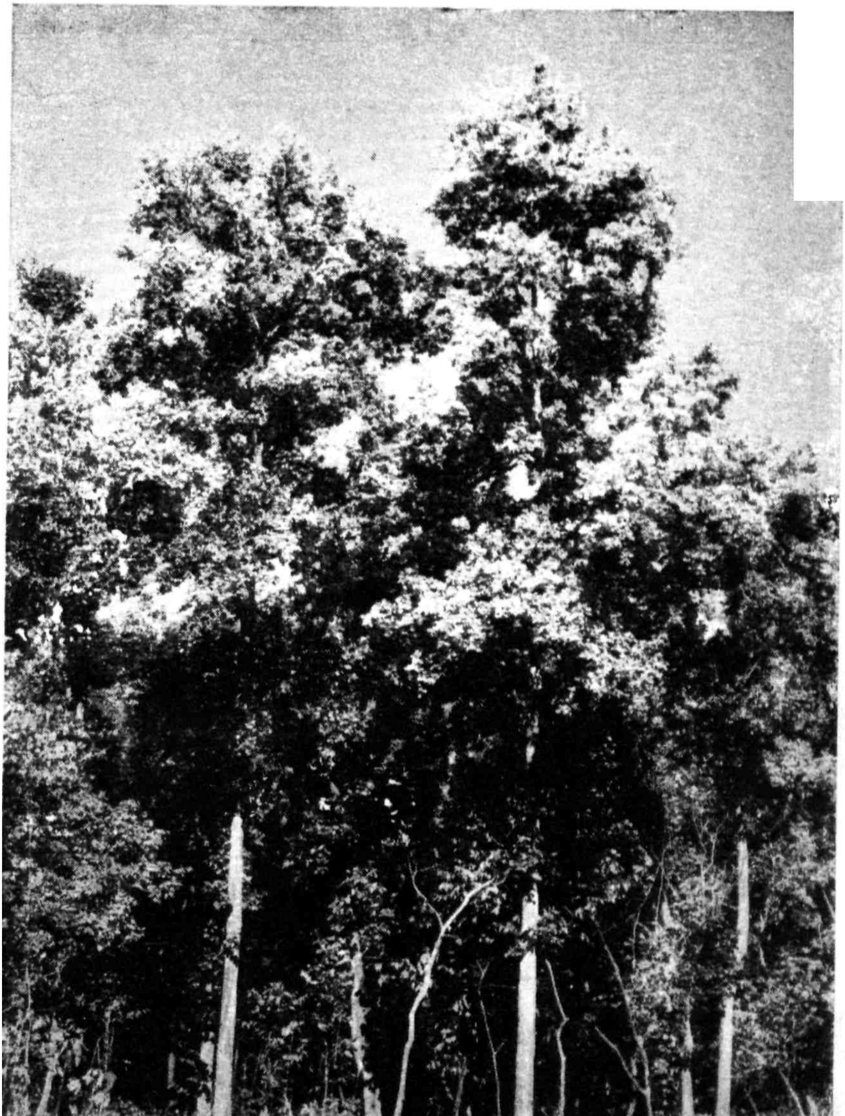


Plate 5 Tropical Moist Deciduous Forest of Sal (*Shorea robusta*) U.P.

(*See page 45*)

Plate 6 SUB-TROPICAL PINE FOREST (*Pinus roxburghii*), U.P.
(*See page 48*)

Plate 7 HIMALAYAN MOIST TEMPERATE FOREST OF DEODAR (*Cedrus deodara*) H.P.
(*See page 48*)

be managed on the principle of progressively increasing, and eventually getting the highest, sustained yield to meet the requirements of defence, industries and the people, ensuring at the same time that the production of both wood and fodder is maintained.

Therefore attention was focussed on rehabilitating the forests over-exploited during the wars, and consolidation and settlement of private forests taken over by government. A modest beginning was also made to raise plantations of matchwoods and other economic species over an area of 52,000 hectares.

During the entire First Plan about Rs. 850 lakhs was spent on the above and other developmental activities.

SECOND FIVE YEAR PLAN (1956–61)

Most of the schemes of the First Plan were continued. Some of the important new schemes initiated related to the creation of plantations of economically valuable species, conservation of wildlife and preparation of Working Plans. Plantations of valuable species were raised over an area of 163,000 hectares. A number of wildlife sanctuaries were established. Degraded forests over nearly 147,000 ha. were rehabilitated, and 16,000 kms of roads constructed.

During the Second Plan in all Rs. 2121 lakhs were spent.

THIRD FIVE YEAR PLAN (1961–66)

While the first two five-year plans centred around rehabilitation and consolidation of forests, with the third plan a beginning was made to lift forests from purely conservative and biological management to increasing production from them by creating man-made forests of quick-growing and valuable species in place of the existing ones.

The third plan laid special emphasis on measures to meet the long-term requirements and more economic and efficient utilisation of valuable forest products, and to increase the output from the existing depleted forests through better technique of timber extraction, improvement of communications and popularising the use of secondary timbers after proper seasoning and preservative treatment.

In order to encourage State governments to undertake large scale plantations of quick growing species, mainly to meet the requirements of the paper and pulp industry, 100% assistance from the Centre was given and thus over 87,000 hectares were planted.

A new scheme undertaken was "Preinvestment Survey of Forest Resources" implemented in collaboration with the U.N. Special Funds and FAO. This project was designed to investigate by stages the economic availability of surplus forest resources for feeding the wood based industries.

Another project related to the establishment of "Logging Training Centres" again with the assistance of the U.N. Sp. Funds. The object was to train forest officers and field executives of State governments and of forest lessees and contractors in basic logging, cableways, planning and efficiency studies etc. with a view to obtain higher timber yields from forests by minimising wastage.

An amount of Rs. 4594 lakhs was expended on all activities.

Post-Third Plan Period (1966-69)

The progress of developmental activities in forestry during this period was remarkable. Specific emphasis was laid on plantations of quick growing species and modernising harvesting and plantation techniques. Training of officers and forest rangers as Resource Managers was undertaken to embark upon the Fourth Plan.

During these three years, in all, Rs. 4206 lakhs were spent.

Fourth Five-Year Plan (1969-74)

While adhering to the objectives and principles of the Third plan greater emphasis was placed on increased plantation activities and intensive management of forests to attain self-sufficiency.

The basic considerations as the guiding principles were:

1. adequate forest cover to prevent floods, conserve soil and moisture, protect water reservoirs;
2. adequate supplies of growing demand of forest raw materials for wood-based industries and of construction timber;
3. adequate supplies of fuel wood;

4. preserving natural environs for scenic beauty, sport, recreation and scientific study.

Based on these considerations the specific obligations considered are: scientific management of hitherto unorganised forests: stricter protective measures against pilfering, excessive grazing, fires, encroachment etc.; formation of manageable units and appointment of adequate staff; replacement of slow growing and less valuable species by those which are quick growing and valuable; afforestation of barren lands; introduction of improved methods of harvesting; extension of communications; better housing facilities for staff; wildlife and Nature conservation; intensive research and training; provision of statistical cells etc.

A total outlay of Rs. 938.06 lakhs has been provided for the Fourth plan period in the forestry sector.

Main Achievements

The targets achieved upto end of 1969 and the expenses incurred on selected forestry schemes are indicated below:

Scheme	*Physical Target achieved '000 hectares*	*Expenses Rs. in lakhs*
1. Plantations of quick growing species	255.62	1345.93
2. Economic Plantations for commercial and industrial uses	593.51	2695.96
3. Farm Forestry cum Fuelwood Plantations	72.84	261.47
4. Rehabilitation of degraded forests	477.62	826.17
5. Communications ('000 kms)	42.16	1181.40
6. Buildings	—	583.58

Fifth Five Year Plan (1974–79)

The outlay proposed for the Forestry Sector, excluding soil conservation is Rs. 220.50 crores. This plan will introduce an important element of change in the country's strategy in forestry; conservation-oriented forestry will now give way to dynamic progress of production forestry, to increased production of industrial wood and other forest products of economic importance. Extensive man-made forests will be created, with institutional financing, to feed the existing and prospected industries utilising forest products. Lands along roads, canal banks, railway lines and flood embankments, mixed plantations for commercial uses will receive greater attention. Farm Forestry and communications will also form an important part of the forestry programme.

Forests and Man

It is against this background and the increasing demand for wood and other forest products that management of forests needs to be planned so as to derive the maximum direct and indirect benefits from them. Unfortunately the attitude of the people at large to forests is one of indifference and to forestry of one ranging between antagonism and tolerance. Some of the hostility is obviously instinctive, as man was born in dense forests and, to protect himself burnt them. Today, those who live in or near the forests, as a rule, dislike the restraints and regulations imposed by the forester, as they cannot see any justification in them. They cannot appreciate the fact that such restrictions are imposed in their own interest. Those who live away from the forests are in any way *not* interested in them much less in forestry. Only a very small percentage of them have ever seen a good forest or been inside one. They are not to blame for this. By and large, well-wooded forests have now receded too far from the main educational institutes and centres of industry and trade, and it requires much efforts and money for a townsman to visit such forests for study, recreation or sport. With increase in population, people have begun to cast covetous eyes on culturable land covered with forests, as realization is lacking that forests are no less essential to meet certain basic needs as also to sustain agriculture. The only redeeming feature is that the development of wood-based industries would soon compel the Government to revise its forest policy, viz., to change over from the present emphasis on meeting the agricultural demand of fuel and fodder, to satisfying the commercial demand, and depart from the time-honoured practice of conservation of forests by imitating and coaxing nature, to dynamic *orchard silviculture*, that is, creation of large-scale plantations of fast-growing and high-yielding valuable species.

CHAPTER II

BASIC DATA

EXTENT AND BOUNDARIES

INDIA LIES entirely in the northern hemisphere, the mainland extending between latitudes 8°4′ 28″ and 37° 17′ 53″ North, and longitudes 68° 7′ 33″ and 97° 24′ 47″ East. It measures about 3,200 km from north to south and about 3,000 km from east to west and covers an area of 327.6 million hectares. The northern boundary is generally formed by the Himalayas. Commencing from its land frontier in the north-west and proceeding in a clock-wise direction India is contiguous with West Pakistan, Afghanistan, China, Nepal, Burma and Bangladesh, with a total land frontier of 12,500 km. The Bay of Bengal lies to the east and the Arabian Sea to the west of the peninsula with a coast line of 5,700 km. The Andaman and Nicobar groups of islands in the former and the Minicoy and Amindiv groups in the latter are parts of India.

PHYSICAL FEATURES

The main land comprises three well-defined regions, (i) the mountainous Himalayan zone, (ii) the Indo-Gangetic Plain, and (iii) the Deccan Peninsula. The Himalayas have almost parallel ranges interspersed with plateaux and valley, some of which, such as Kashmir and Kulu basins, are extensive, fertile and of great scenic beauty. Some of the highest peaks of the world are to be found in these ranges. There are only a few passes across notably Jelep and Natu on the Indo-Tibet trade route through the Chumbi valley north-east of Darjeeling. The mountain ranges are over 2,400 km long and 240–320 km deep. In the east, along the borders with Burma and East Pakistan, the hill ranges are much lower. The Garo, Khasi, Jaintia and Naga Hills, running almost west-east, join the Lushai and Arakan hills sweeping north-south. The Indo-Gangetic plain is also about 2,400 km long and 240–320 km broad, forming the basin of the Indus, the Ganga and the Brahmaputra.

It is highly fertile and, therefore, very densely populated from the dawn of civilisation. There is hardly any variation in its relief. Delhi on the Yamuna, 1,600 km away from the mouth of the Ganga, is less than 200 metres above the sea-level.

GEOLOGY

The Deccan peninsula is a plateau with a mass of mountain and hill ranges 450-1200 metres high, the most prominent being the Aravalli, the Vindhya, the Satpura, the Maikal and the Ajanta in the north. The Eastern Ghats with an average elevation of 600 metres and the Western Ghats with an average elevation of 900-1200 metres (rising in places to 2400 metres), join in the south forming the high Nilgiri Plateau. Between the Arabian Sea and the Western Ghats there is only a narrow coastal strip, but the area between the Eastern Ghats and the Bay of Bengal is considerably broader.

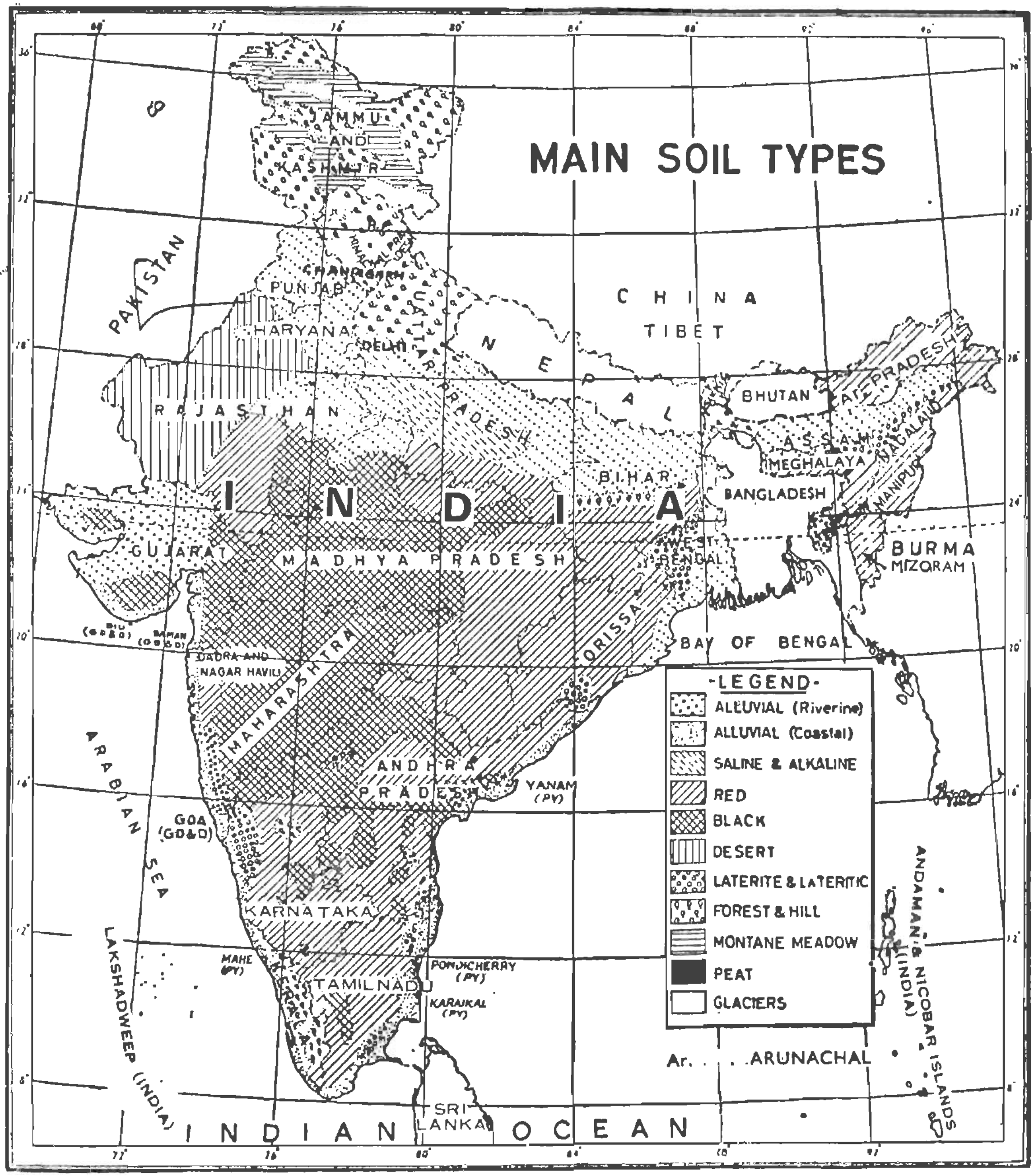
The plateau has not been affected by orogenic changes since the Cambrian period but for the very recent Koyna and Baroda earthquakes the exact causes of which have yet to be ascertained. The Indo-Gangetic plain is a macro-region of alluvium of great depth, varying in character, having been replenished in the east by the silt deposits brought down from the high snow-clad mountains and in the west by the wind-blown material. The Himalayan zone has been a region which had lain under the Tethys for the greater part of history. It was covered by successive marine deposits characteristic of the great geological periods commencing with the Cambrian period. The mountains are of the Tertiary age. The Siwalik formations represent the material derived from the erosion of the mountains themselves.

RIVER SYSTEMS

Four river systems may be differentiated: (i) the Himalayan (ii) the Deccan Plateau (iii) the Coastal and (iv) those of the inland drainage basin. The Himalayan rivers are snow-fed and are, therefore, perennial. During the monsoon months, they receive heavy precipitation and discharge the maximum amount of water,causing serious floods. The basin of the Ganga is the largest, draining about a quarter of the country. It has as its tributaries the Himalayan rivers—the Yamuna, the Ghagra, the Gandak and the Kosi. Of the rivers flowing northwards from the Vindhyas and draining into the Ganga or its tributary the Yamuna, the most important are the Chambal, the Betwa and the Sone. Each of the basins of the Brahmaputra and the Indus covers about one-tenth of the area of the country. The rivers of the peninsular plateau are purely rain-fed and, therefore, the flow in the rainless period is much less. Indeed some of their tributaries almost cease to flow and are left with mere pools here and there. The largest basin is that of the Godavari, covering an area nearly one-tenth of the country. The other important basins of this system are those of the Krishna and the Mahanadi. Mention may also be made of the long and narrow catchments of the Narmada and the Tapti which run almost parallel and drain in the opposite direction into the Arabian Sea. Their catchments have rich teak forests on the slopes and very fertile alluvial soil in the valley. The coastal streams flowing down the Western Ghats into the Arabian Sea have small catchments. They are rapid torrents in the rains but mostly cease to flow thereafter. The streams of the inland drainage basin of western Rajasthan are mostly of an ephemeral character. They drain into the inland basins of salt lakes like the Sambhar, or are lost in the sands, only the Luni flows into the Rann of Kutch.

Forest Soils

Soil, the uppermost, weathered and biologically active crust of the regolith is the product of the action of climate and vegetation upon the parent rock. Its vertical section shows a succession of natural layers, called horizons, resulting from the leaching and translocation (as distinguished from stratification) of material, usually from surface downwards. These differ in colour, texture, reaction, consistency and porosity. Within a homogeneous climatic region a close correlation exists between soil conditions and forest vegetation. Of the various soil properties those important from the forest point of view are its depth, texture, structure, drainage, organic matter content, moisture, pH and nutrient level. Deep



Based upon Survey of India map with the permission of the Surveyor General of India.

The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern Areas (Reorganisation) Act, 1971, but has yet to be verified.

soils with a good moisture status, a high nutrient reserve and a large exploitable volume are the most favourable for forest growth. The presence of an impervious layer is a serious limiting factor. As most forest trees have a high physiologic need for moisture, it is essential that forest soils should possess a high moisture-availability to meet the demand. A larger proportion of clay and organic matter increases the water holding capacity of a soil and is, therefore, desirable within certain limits. On shallow soils trees are apt to suffer from drought.

The organic matter formed by the decomposition of fallen plant debris is the most important constituent of the soil and is the seat of the maximum biological activity. It is the primary source of plant nutrients, especially nitrogen, and also determines the physical properties of the soil, namely, porosity and aeration. Excessive accumulation of undecomposed organic matter, or *per contra* indiscriminate removal of litter, reduces the productivity of forest soils. The ability of the soil to supply an adequate amount of mineral nutrients in an assimilable form to meet the requirements of trees is of fundamental importance. The quantity of nutrients returned to the soil through the fallen and decomposed vegetative debris is often much less than that removed permanently from the soil as wood, fruits, etc. Continued removal of forest growth, therefore, can impoverish forest soils. In general, the mineral requirements of most hardwoods are greater than those of conifers, especially in respect of calcium. By and large, it is the soil depth, moisture regime, porosity, aeration and availability of mineral nutrients which determine the forest type that may be expected on a particular soil. Vegetation in turn can also influence soil. A close-canopied, well-managed forest, without excessive grazing or litter removal, eventually results in the formation of a thick layer of humus which may appreciably improve soil productivity and may actually bring about a change in the composition of the forest leading to a progression.

Forest trees show wide variations in their soil preference. Teak is capable of growing over a wide range of soils, but its best growth occurs on deep, moist, fertile and well-drained alluvial soils and on soils developed from basaltic rock and those rich in calcium.

Sal can tolerate slight acidic conditions. It grows well on various soils provided they are well-drained and the moisture supply is adequate. The capacity of bamboos to grow on a variety of soils is indicative of their hardy nature. Most species avoid shallow, stiff, heavy clays, precipitous slopes and saline alkali soils. The soils of coniferous forests and of oak forests at higher altitudes under moist temperate climate are acidic in reaction and have high organic matter and nitrogen contents. Soils on which sandal grows are generally coarse, shallow, and poor: the species avoids alkaline soils. *Casuarina* grows well on deep coastal sands with a good moisture status. Sissoo does well on sandy or loamy soils, especially those developed on riverine alluvium. Most trees are unable to grow on alkaline soils but species like Palas, Babul, Neem, etc., tolerate such conditions.

The soils of India have been studied in some detail from the agricultural view-point. The major groups distinguished are:

Alluvial soils: These are found along rivers and in low-lying tracts. They are well-supplied with organic matter when under a good forest cover, and are usually deep, but show marked stratification of sand, clay and loam. The vegetation they carry is greatly influenced by moisture and soil-aeration.

Sandy soils: They occur as narrow belts along the sea coast, and vary from sandy loam to pure sand in texture. They are very porous and deficient in nitrogen, phosphorus, potassium, and sometimes also in lime;

Desert soils: These are typical of the west of the country in Rajasthan and parts of Gujarat. They are usually adequate in mineral status but with low organic matter and nutrient availability;

Peaty soils: They are found in the humid regions as a result of accumulation of a large amount of organic matter in the soils. They are characterised by a deep black colour with a high clay content and are rich in nitrogen, adequate in potash, but deficient in phosphorus;

Saline and alkaline soils: These are found in the drier parts of the country in the north-west and over the Deccan Plateau. Being deficient in underground drainage, capillary action during summer brings the concentrated dissolved salts to the surface, where they form a white crust. These soils are unfavourable for tree growth, particularly when underlain by a *kankar* pan which occurs at varying depths;

Laterite is a compact to vesicular rock composed essentially of a mixture of hydrated oxides of aluminium and iron with small amounts of manganese oxide, titanium, etc. It is developed in the regions of heavy rainfall with a typically intermittent moist climate. Lateritic soils are poor in nutrients P, K and Ca, and deficient in N. The pH ranges from 4.5 to 5.5, and the base exchange capacity is low;

Red soils: These are deficient in organic matter and poor in plant nutrients. Their colour is due to the presence of ferric oxide. They have a low base status and a poor exchange capacity;

Black soils: These are mainly developed from basaltic rocks and are commonly known as *regur* or black cotton soils. They predominate over most of the Deccan Plateau and are loamy to clay, depending on the topography. They expand on wetting and shrink on driage, and are deficient in organic matter (the black colour being due to the presence of iron salts), and low in P and N. The level of Ca is satisfactory and the presence of lime *kankar* is noticeable in some places;

Forest and Mountain Meadow soils: These are characterised by a surface layer of organic matter, and are in consequence rich in N. Their base status varies, depending on the degree of leaching;

Skeletal soils: These are of limited occurrence on the hills of the drier regions of the Peninsula and in the Himalayas. They are of local importance only.

The following are some general observations on the physio-chemical characteristics of some typical *forest soils:*

The soils of drier areas have a higher pH value and are poorer in organic matter and N, but possess greater quantities of bases like Ca than the soils of more humid areas. These facts together with the deficiency of moisture, poor structure, calcareousness, alkaline reaction, presence of *kankar* pan, excess of salts, etc., are some of the factors which lead to the growth of only xerophytic species.

Coastal sand under littoral vegetation is associated with a poor nutrient status. A higher amount of organic matter and N is found in the soil under high level conifers. The ferruginous soils with a good supply of manganese appear to be favourable for a natural regeneration of the sal. Teak attains better quality on a moist soil developed from basalt, which is acidic and has an adequate amount of exchangeable Ca and satisfactory P availability.

In short, the soils under varied forest vegetation differ considerably in their physical and chemical characteristics. Therefore, in view of the recent trend to create large-scale plantations of some valuable fast-growing species, indigenous as well as exotic, to quickly rehabilitate our forests and increase their productivity, it would be desirable to study the forest soils in greater detail *vis-a-vis* the growth of forest species, and then to make good their deficiency by proper treatment and addition of the right kind of nutrients.

Land-use Pattern

The present (1968-69 provisional) land utilization is as under:

Table 2

Category	*Area million hectares*	*% of total*
1. FORESTS	75.27	23.0
2. Agricultural land including current fallow	160.54	49.1
3. Other uncultivated land excluding fallow land	33.99	10.6
4. Land not available for agriculture or forestry	57.01	17.3
Total geographical area	326.81	100.0
	Total	per capita
1. Population	536.98 million	—
2. Cultivable area	181.22 million ha.	0.36 ha.
3. FOREST AREA	75.27 ,,	0.14 ha.

Vide Central Forestry Commission, Forest Statistics. Bull. 11 (Apr. 1971)

Besides area mentioned under category 1, some lands are also covered with trees or shrubs, including areas of category 2, particularly old fallow land. The area under category 3 is mostly open treeland, which is primarily used for grazing the village stock. It also includes the so-called 'waste land'. Not very long ago it must have carried fairly good forests. It was either brought under the plough and cultivated by primitive methods or ruthlessly cut by the agriculturists for their requirements of fuel, fencing material, etc., or subjected to uncontrolled grazing, with the result that it became unproductive and was abandoned. Large areas could be reclaimed by reafforestation, or developed as pastures, and some could even be cultivated. Areas of category 4 are used for habitation, mining, etc. Some trees stand on them and more are planted from time to time for bio-aesthetic reasons.

Basic Forest Statistics: India and Other Regions

The following table compares between India and certain other regions, the land area, the forest area and its percentage, population, and *per capita* forest area.

Table 3

BASIC FOREST STATISTICS (1966)

Region	*Land area (M. ha)*	*Forest area (M.ha)*	*Forest area %*	*Population (Million)*	*Per capita Forest (ha)*
1. Europe	493.0	138.0	27.9	445	0.31
2. USSR	2240.2	910.0	40.6	231	3.93
3. North America	1971.0	745.4	37.8	214	3.48
4. Central America	274.0	75.6	27.6	80	0.95
5. South America	1783.1	940.0	52.7	166	5.66
6. Asia	2783.1	519.6	18.6	1895	0.27
7. Africa	3026.0	604.0	20.0	311	1.94
8. Pacific	852.0	82.0	9.6	17	4.82
WORLD	13422.3	4014.6	30.0	3359	1.19
INDIA	326.8	75.3	23.0	537	0.14

TABLE 4*
GROWING STOCK OF FOREST-IN-USE AND INCREMENT

Region	Total G.S. (M.cu.m.)	Per ha cu.m.	Per capita cu.m	Increment/ha cu.m.
1. Europe	10330	80	24.0	2.5
2. USSR	69847	152	320.4	1.9
3. USA	17768	91	94.2	3.0
4. Asia	21210	90	12.3	2.6
WORLD	143290	110	46.7	2.0
INDIA	1442	32		0.5

(*India 1964-65; Other regions from older FAO records.)

The figures above show that India with 15% of the world population has less than 2% of the total forests, and if the forest growing stock has been correctly estimated it is the lowest per unit area, and less than 1% of that of the forests of the world. What is worse, bulk of the wood removed is burnt, or consists of the secondary non-durable species, usable at best as inferior timber. Only a very small proportion of the wood removed consists of good timber such as teak, Sal, Deodar, etc. At present nearly 85% of the wood burnt comes from lands outside the areas classed as forests, and this source too is fast drying up.

As against this, it has been shown that the potential production of the Indian forests is at least 5 times its present out-turn. This obviously points to intensive management and growing of valuable, quick-growing species.

CLASSIFICATION OF FOREST AREA

The classification of the forest area by legal status, ownership, composition and by functions is given in table 5.

FINANCIAL

Besides the protective functions that forests fulfil and the bio-aesthetic and social value they have, they are a source of scenic beauty, and meet the basic needs of the local population. They also supply industrial wood and other products of commercial value from which revenue accrues to the government. The present pace of

TABLE 5
FOREST CLASSIFICATION*

Forest area by	*Million ha.*	*% of Total*
Legal Status		
Reserved	32.9	45.2
Protected	22.7	31.1
Unclassed	17.2	23.7
Total	72.8	100.0
Ownership		
State	69.6	95.6
Communal	1.5	2.1
Private	1.7	2.3
Total	72.8	100.0
Composition		
Coniferous	2.8	3.9
Broad-leaved		
a. Sal	9.8	13.5
b. Teak	8.7	12.0
c. Others	51.5	70.5
	72.8	100.0
Functional Status		
Protection	10.0	13.8
Productive		
a. Merchantable	53.9	73.9
b. Others	8.9	12.3
	72.8	100.0

**Vide* "Forest Statistics," Central Forestry Commission.

development depends on how much governments of the States and Union Territories can spare out of their gross receipts. The following statements give (i) Financial working, (ii) Activity-wise Expenditure on Forests by States/Union Territories and (iii) Gross and Net National Product and National Income and Revenue compared with Forest Income and Revenue.

These figures justify the following comments: The growing stock of the Indian forests is the lowest per unit area of forest.

TABLE 6A

ACTIVITY-WISE EXPENDITURE ON FORESTS: 1969-70
(Thousand Rupees)

State	Administration		Works		Miscellaneous		Total	
1. A.P.	17349	(55.9%)	13697	(44.1%)	Incl. in works		31046	(100%)
2. Assam(incl. Meghalaya)	9971	(51.5%)	8494	(43.8%)	904	(4.7%)	19369	(,,)
3. Bihar	15530	(61.4%)	9774	(38.6%)	Incl. in works		25304	(,,)
4. Gujarat	10778	(49.7%)	10606	(48.9%)	302	(1.4%)	21686	(,,)
5. Haryana	2991	(37.5%)	4985	(62.5%)	Incl. in works		7976	(,,)
6. H.P.	18024	(32.3%)	36642	(65.5%)	1300	(2.3%)	55966	(,,)
7. J. & K.	9654	(44.0%)	12307	(56.0%)	Incl. in works		21961	(,,)
8. Karnataka	13306	(18.7%)	57725	(81.2%)	53	(0.1%)	71084	(,,)
9. Kerala	9906	(31.6%)	19147	(61.2%)	2253	(10.5%)	31306	(,,)
10. M.P.	41946	(54.8%)	34609	(45.2%)	Incl. in works		76555	(,,)
11. Maharashtra	38826	(43.6%)	40950	(45.9%)	9358	(10.5%)	89134	(,,)
12. Nagaland	1583	(48.5%)	1683	(51.5%)	Incl. in works		3266	(,,)
13. Orissa	14176	(36.2%)	24929	(63.7%)	27	(0.1%)	39132	(,,)
14. Punjab	4539	(36.5%)	7931	(63.6%)	Incl. in works		12470	(,,)
15. Rajasthan	8273	(53.1%)	7302	(46.9%)	Incl. in works		15575	(,,)
16. Tamil Nadu	23452	(86.6%)	3639	(13.4%)	Incl. in works		27091	(,,)
17. U.P.	26955	(36.6%)	46280	(62.9%)	352	(0.5%)	73587	(,,)
18. W. Bengal	12861	(56.6%)	9347	(41.1%)	527	(2.3%)	22735	(,,)
State Total	280120	(43.4%)	350047	(54.3%)	15076	(2.3%)	645243	(,,)

19.	A. & N. Is.	3958	(25.9%)	10915	(71.3%)	432	(2.8%)	15296	
20.	Delhi	141	(62.7%)	84	(37.3%)	Incl. in works		225	(,,)
21.	Dadra & N. Haveli	199	(74.0%)	63	(23.4%)	7	(2.6%)	269	(,,)
22.	Goa, Daman & Diu	818	(27.0%)	2117	(69.9%)	92	(3.1%)	3027	(,,)
23.	Manipur	564	(73.2%)	206	(26.8%)	Incl. in works		770	(,,)
24.	NEFA	2054	(29.0%)	632	(8.9%)	4402	(62.1%)	7088	(,,)
25.	Tripura	2507	(50.15%)	Incl. in Misc		2492	(49.85%)	4999	(,,)
	ALL INDIA	290361	(42.9%)	364064	(53.8%)	22492	(3.3%)	676917	(,,)

TABLE 6B

(i) **Gross and Net National Product i.e. National Income** (1969-70 provisional)

	GROSS NATIONAL PRODUCT (Rs Crores)	NET NATIONAL PRODUCT (Rs Crores)	NATIONAL INCOME (Rs per capita)
At 1960-61 prices	19173	17955	339.6
At 1970-71 prices	33019	31174	589.3

(ii) **National Income vis-a-vis Forestry Income (1969-70-provisional)**

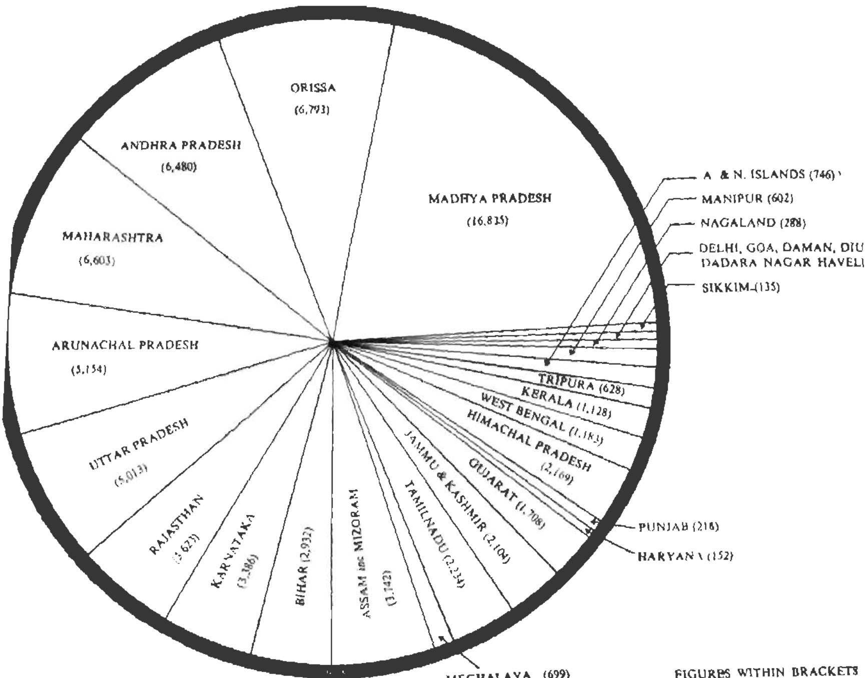
(At 1960-61 prices)

NATIONAL INCOME Total (Rs Crores)	NATIONAL INCOME Per capita (Rs)	FORESTRY INCOME Total (Rs Crores)	% of col. 3 to 2
(1)	(2)	(3)	(4)
17955	339.4	281	1.57

(iii) **National Revenue vis-a-vis Forest Revenue** (1970-71 provisional)

Population (Crores)	*National Rev.* (Rupees in Crores)	*Forest Rev.* (Rupees in Crores)	*% of Forest Revenue to National Revenue*	*Per Capita Rev. in rupees* *National*	*Per Capita Rev. in rupees* *Forest*
54.60	6023	134.69	2.24	110.31	2.47

Vide 'FOREST STATISTICS', Central Forestry Commission, *Bull. No.* 12, Tables 2,3, & 4.



FIGURES WITHIN BRACKETS INDICATE FOREST AREA IN THOUSAND HECTARES

The rather high gross revenue of M.P. (now exceeding Rs 36 crores), is mainly due to its extensive forest area, the scarcity prices in upper India of its teak and sal timber, even though of smaller size, and wood charcoal from mixed species. A contributory factor is the fact that about 35 years ago the system of Coppice-with-Reserves was applied to the forests under which all straight poles had to be reserved, which have now attained timber size. The cut probably exceeds the growth that is likely to come up on the short cycles of 30-40 years, especially as little efforts are being made to satisfactorily regenerate the worked forest and to tend and protect the regrowth against uncontrolled grazing and illicit removals.

One good feature is the introduction of State trading in *Tendu*

TABLE—6 A

FINANCIAL WORKING OF FOREST DEPARTMENTS: 1969-70

State/ Union Territory	Area under Forest Deptt. (Th. Ha)	Revenue (Plan & Nonplan) (Thousand Rupees)	Expenditure (Plan & Nonplan) (Thousand Rupees)	Surplus (Plan & Nonplan) (Thousand Rupees)	Per Sq Km (100 ha) Rev. (Rupees)	Per Sq Km (100 ha) Exp. (Rupees)	Per Sq Km (100 ha) Sur. (Rupees)	Percentage of Expenditure on Revenue	Normal + Plan
STATE									
1. Andhra Pradesh	6512	60116	31046	29070	923	477	446	51.65	42.21+ 9.44
2. Assam (inc. Meghalaya)	1711	37686	19369	18318	2203	1132	1071	51.40	37.11+14.29
3. Bihar	3055	40151	25304	14847	1314	828	486	63.02	39.31+23.71
4. Gujarat	1624	44230	21686	22544	2707	1327	1380	49.03	23.62+15.41
5. Haryana	73	3444	7976	-4532	4718	10926	-6218	231.59	152.06+79.53
6. Himachal Pradesh	2008	65235	55966	9269	3249	2787	462	85.79	59.76+26.03
7. Jammu & Kashmir	2104	49000	21961	27039	2329	1004	1289	44.81	33.13+11.68
8. Kerala	902	88289	31306	56983	9788	3471	6317	35.36	29.60+ 5.76
9. Madhya Pradesh	16813	258613	76555	182058	1538	455	1083	29.60	25.22+ 4.38
10. Maharashtra	5654	85979	89131	-3155	1521	1576	-55	103.67	81.76+21.91
11. Mysore	3115	140156	71084	69072	4499	2282	2217	50.72	37.38+13.34
12. Nagaland	83	1518	3266	-1748	1829	3935	-2106	215.14	144.20+70.94
13. Orissa	6618	65829	39132	26697	994	591	403	59.45	25.83+33.62
14. Punjab	90	6433	12470	-6037	7417	13855	-6708	193.84	99.84+94.00
15. Rajasthan	3760	10018	15575	-5557	286	414	-148	155.46	123.44+32.02
16. Tamil Nadu	2099	33516	27091	6425	1597	1291	306	80.82	58.16+22.66
17. Uttar Pradesh	4022	202214	73587	128627	5028	1830	3198	36.38	24.02+12.36
18. West Bengal	1157	24470	22735	1735	2115	1965	150	92.90	67.62+25.28
TOTAL STATES	61410	1216898	645243	571655	1981	1051	930	53.02	38.38+14.64
UNION TERRITORIES									
1. Andaman & Nicobar Islands	747	14353	15296	-943	1921	2047	-126	106.56	97.56+ 9.00
2. Delhi	2	16	225	-209	800	11250	-10450	1406.25	1406.25+ —
3. Dadara & Nagar Haveli	21	782	269	513	3724	1281	2443	34.39	22.76+ 11.63
4. Goa, Daman & Diu	105	1680	3072	-1347	1600	2883	-1283	180.17	54.16+126.01
5. Manipur	602	534	770	-236	89	128	-39	144.19	25.09+119.10
6. NEFA	5154	9830	7088	2742	191	138	53	72.10	53.79+ 18.31
7. Tripura	630	1937	4999	-3062	307	793	-486	258.07	202.58+ 55.49
ALL INDIA	68671	1246030	676917	569113	1814	986	828	54.33	39.47+ 14 86

FOREST STATISTICS BULL. 12.

leaves. It has augmented the receipts by over Rs 6 crores. Timber and Bamboo have recently been nationalised.

On the other hand the high gross yield per hectare in Kerala, Karnataka and Uttar Pradesh is due to the better quality of forests of hardwoods, particularly teak in the former two and of conifers in the latter, coupled with efficient management. The high surplus in these States would have been still higher but for the fact that large amounts are being spent to rehabilitate the forests by raising extensive plantations to augment future receipts, which is a very wise policy indeed.

The overall picture is, however, none too bright. Even conceding that the forests in their degraded state confer many indirect benefits and meet the basic needs of the local people, the financial position is very unsatisfactory. The gross revenue of less than Rs 18 per hectare is too low and at least the entire surplus of Rs 8 per hectare should be ploughed back to rehabilitate the best forest lands. Considering forests vis-a-vis other resources of the country they seem to play an insignificant role.

The moral is obvious. If the country is to derive the maximum benefits from its perpetually renewable resource of forests it must manage them more intensively and so utilise them that the forest capital progressively increases and eventually it begins to give the highest sustained yield.

CHAPTER III

FOREST AND TREES

Locality Factors of the Forest

The type of forest found, or that may develop, on a particular site, depends on the *edaphic*, the *climatic* and *biotic* factors operating there. Of these the effect of edaphic factors, namely, the role that soil plays, has already been discussed in the previous chapter, and the biotic factors, namely, the influence of the activities of man, domestic animals which have access to forest, and the wild life including insects, are discussed later in chapter XI. Only the effect of the main climatic factors which promote vegetative activity will be considered here, namely temperature, sunlight and water availability. Figures of temperature and rainfall for representative stations are given in Appendix I and rainfall distribution is shown in Map 3.

(*a*) *Temperature:* Four zones are distinguishable as under:

Zone	*Mean ann. Temp.* °*C*	*Mean Jan. Temp.* °*C*	*Remarks*
Tropical	Over 24	Over 18	No frost
Subtropical	17-24	10-18	Rare frost
Temperature	7-17	—1 to 10	Frost, some snow
Alpine	Under 7	Under—1	Snow

The character and extent of vegetation are chiefly determined by temperature together with the amount of water vapour in the air and precipitation. The mean annual temperature at the Tropic of Cancer, which passes just north of the Peninsula, is 24°C. In winter the isotherms run fairly east-west, dropping by 1°C for every 2 degrees of latitude going northwards. Altitude has a more pronounced effect; a drop of 1°C for a rise of 300 metres upto 1000 m. above m.s.l. and a more rapid drop higher up, the rate being greater in summer. In the hot season (March-May), temperature is the highest in the interior, where dry land winds prevail; the coastal regions are cooler due to a sea breeze. With the onset of the monsoon the maximum temperature falls rapidly from west to east. With the extension of the monsoon further inland, in June-July, there is a progressive drop in temperature in the north-west of the country. The autumn weather follows soon after, and there is a sharp fall from October onwards. The *annual* range is greater at higher altitudes and the drier parts of the hinterland, but less in hilly regions and near the coast. The *diurnal* range shows a similar variation, it being maximum in the dry tracts of the Punjab, upto 20° C. Occurrence of frost, that is temperatures below 0° C, has a definite effect on vegetation. This is a regular feature in winter above 100 m. in the Himalayas, above 1500 m. in Central Indian hills, and above 2000 m. in the more equable hills of the peninsula. Ground frosts which are caused by radiation, when only a thin layer in contact with the forest floor gets chilled, may kill low vegetation and seedlings of tree species. But when the cold enters a valley and fills it in some depth, a pool frost results, in which poles and even trees may get killed. At higher altitudes, where snowfalls occur, the snow lies on the ground as also lodges on tree-crowns for various periods. This has a blanket-effect of preventing further drop in the ground temperature, and when the snow thaws plants get moisture in the rainless period. Snowfalls are confined to the Himalayas and occur in places as low as 1500 m. in the north-west, but not in the east or south. Shillong, over 1500 m., or Ootacamund, over 2000 m., actually never get snow, whereas Dehra Dun, less than 740 m., had a snowfall in January 1945.

(b) *Sun Light:* The variation in sun's radiant energy at different places is due to differences in latitude, altitude, season, and time of the day, modified by cloudiness, topography, etc. The average cloudiness in India is below 50 per cent (South Punjab below 20%, Rajasthan 20 to 35%, elsewhere between 5 and 30%) . July and August are the cloudiest months (75 to 90%) whereas October to March is the period of clear skies. In general the average temperature decreases as one goes away from the equator, but because of the varying influences of other factors, in India in July, 20° N is the hottest parallel. It has been found that trees usually grow faster when there are many sunspots.

(c) *Rainfall:* Almost the entire rainfall is brought by the advancing South-West Monsoons (June to September) over practically the entire country and to a less extent, mainly in the south, by the retreating north-east monsoon (October and November). Detailed data are now available for over 60 years, which show that the general rainfall pattern has not changed. But the departure from the mean, both in quantity and in duration, is sufficient to adversely affect the forest, particularly in the dry zone.The driest tracts are the areas of Rajasthan, Kutch and parts of the Punjab. Rainfall distribution ranges from practically a rainless tract in Jaisalmer to over 15,000 mm at Mawsynram near Cherrapunji. With tropical temperatures and summer monsoon, rain becomes a primary factor to determine the luxuriance and the type of forest vegetation. The heaviest rainfall regions are the west coast where moisture laiden monsoon winds strike the Western Ghats, and the north-east parts of Bengal and Assam where the Lushai, Khasi and Jaintia hills obstruct the monsoons. These areas carry a dense tropical ever-green forest. But as one moves outwards to areas of lesser rainfall, with longer dry spells, a forest of lower height and density is met with. In general, hills receive a higher rainfall and southerly and westerly aspects get more rain, whereas the northerly and easterly aspects lie in the rain shadow. The VIII o' clock direction of the compass on a hill is the hottest and the driest aspect.

(d) *Winds:* These originate from differences in barometric pressure. In India, severe storms are rare except in the deltaic regions of Bengal and Orissa, and in parts of the Malabar coast. But the rain-laden seasonal monsoon winds influence the climate very considerably. They come from the Arabian Sea (SW) and from the Bay of Bengal (E.SE). These advancing monsoon winds bring the major portion of the summer rainfall. The direction is reversed in October-November when they are known as the retreating monsoons (SE) giving winter rain. The cold down-valley winds in winter in the north cause frost damage, for example, in the Dehra Dun forests.

(e) *Evaporation:* The relationship between rainfall and evaporation greatly affects the soil conditions. If the rainfall exceeds evaporation there is a downward flow of salts dissolved in soil with the seepage of water; but if evaporation exceeds the precipitation there is an upward movement of salts which may make it unavailable for plant growth unless the area is irrigated. The seasonal concentration of rainfall greatly affects forest vegetation because in the period of drought plants have to survive by special adaptations such as leaf-fall, early fruiting, etc. Rainfall intensity is also of importance to the forester in artificial regeneration and in anti-erosion works. Annual variations sometimes affect regeneration of forest crops. For instance, Sal seed falling in the beginning of the monsoon and remaining viable for just a few days fails to sprout if the rains are delayed. Therefore, to maintain the productive capacity of a forest, the forester has to carefully study what has been called the *biogeocoenosis*, or the interaction of plants, animals, soil and environment and to see that the factors most favourable for its development are brought about in the eco-system.

FOREST INFLUENCES

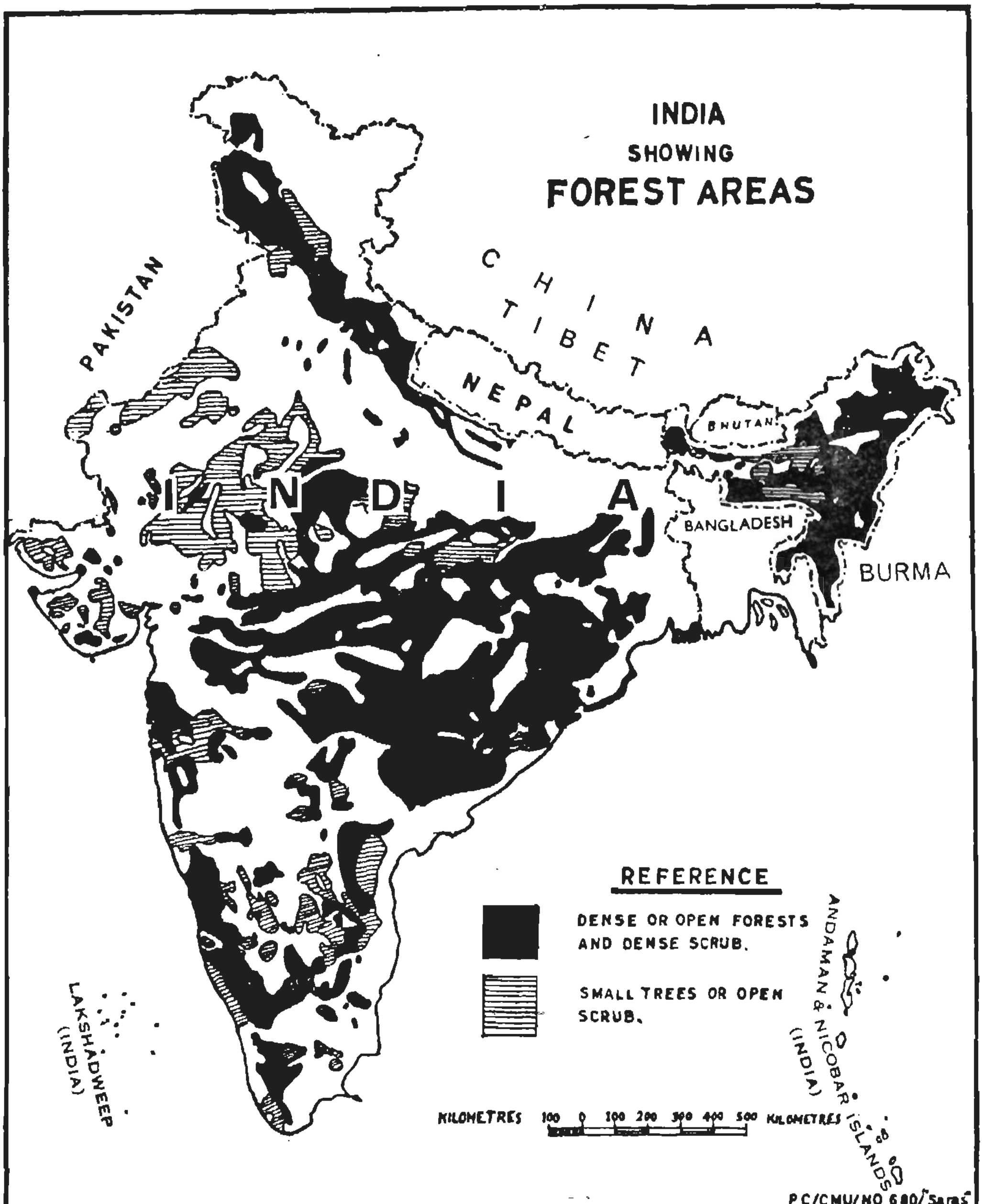
A forest and its environment are always interacting. The most important environmental factors are micro-climate, soil characteristics, moisture-availability and action of animals and insects. Micro-climate is governed by solar radiation, rainfall, wind, humidity and temperature of the air and the soil. In a dense forest temperature range is narrow and although the air temperature in and outside a forest is more or less the same, the humidity is greater inside. Soil temperature is also influenced by the forests, which in turn affects the biological activity in the top layer of the soil. Forests also stem the wind velocity. It is for this reason that shelter-belts and wind-breaks are planted to protect crops. Heavy winds may actually cause a serious erosion if the soil is dry and not covered with vegetation. As far as rainfall is concerned there is no evidence that the creation of a forest even over a fairly large tract of barren land increases the rainfall of the locality. But it is a fact that a forest makes the temperature equable both inside it and in its outskirts. Extensive forests also condense low clouds and thus to some extent increase precipitation. Falling drops of rain strike the crowns of trees and their force is retarded: some rain wets the foliage and branches, some is evaporated, a part reaches the forest-floor as stem-flow, and the remainder as a through-fall. Thus if there is a vegetative cover the force of rain falling on the forest floor is reduced, the more so if there is a good shrub and weed growth. If there is a layer of leaf mould, or humus, rain reaching the forest floor seeps through it and goes into the subsoil. It then flows through it to the lower regions by percolation and thus feeds the streams gradually all through the rainless period. After soil gets saturated and no more water can be retained by it, the excess flows away, but with a lesser velocity as it is obstructed by the grasses, herbs and leaf-litter, with the result that coarser soil particles are held back.

When the tree canopy is open there is little humus on the forest floor and, therefore, rain strikes the almost bare soil with full fury and brings about soil erosion, which leads to denudation. The ill effects of this are spectacular, particularly when the wet and dry seasons alternate, the slopes are steep, there is heavy grazing, and fires occur frequently. Gaping ravines are formed in a few years such as those that exist along the Chambal.

In rocky tracts roots of trees penetrate deep into the soil and thus bind it together. When these roots die, they act as capillaries for water to flow downward. When the forest mantle is destroyed, the protective leaf-litter and the humus are washed away, thus exposing the soil. In the rainy season the soil pores get clogged and percolation is inhibited, with the result that water rushes in torrents carrying with it soil and even gravel and small boulders, thereby exposing the underlying rock. A spectacular view of this type is provided by the Madan Mahal Hills of Jabalpur. Only four centuries ago these hills were covered with a thick forest and Rani Durgavati used to hunt tigers in it!

With run-off increasing water level in rivers rises rapidly. When water has a heavy silt-load and land is comparatively flat, rivers may change their courses and in doing so cause heavy damage to cultivated fields and other property. Much of the tragic history of the floods of Kosi—Bihar's river of sorrow—is traceable to denudation of

Map 2



Based upon Survey of India map with the permission of the Surveyor General of India.

The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

the forests in its catchment. When the waters of a river are impounded to generate power or to irrigate crops, if the watershed is subject to heavy erosion, silting rapidly reduces the storage capacity of the reservoir and hence its useful life. A typical example is the catchment of the famous Bhakra dam. Soil run-off is heavy wherever there is an unrestricted browsing by goats and a ruthless removal of vegetation. On the other hand silt-load of streams is low wherever grazing is controlled and vegetative cover is not broken by indiscriminate fellings. Hence the need for scientifically managing the forests in the catchments.

Forests consume large quantities of water. The water is absorbed by the roots, rises with the cell-sap and is finally lost through transpiration by the leaves. Rain water obstructed by crowns of trees is also lost by evaporation. The aggregate loss through evapo-transpiration for a well-stocked teak forest is the equivalent of about 1000 mm. of precipitation. Indeed, a forest loses more water in this way than bare ground, but it is still a more economic cover than other types of vegetation. Forests also add to the beauty of the landscape, make the climate salubrious, and provide a suitable habitat for the wild life.

Forest Composition

The top canopy of some natural forests is mostly, sometimes wholly, composed of a single species. A typical example is the practically pure forests of Chir pine. Sal is a good example of a tree with a gregarious habit though it can tolerate other species growing with it. Palas and Babul forests are other examples of gregariousness. An example of a simple mixture in the top canopy is the forest of Deodar, Spruce, and Fir in the higher Himalayas, or of Sissoo and Khair on the plains. The more luxuriant the growth, the more complex the composition. In the wet tropical evergreen forests of Mysore, Assam or Andamans several species grow in an intimate mixture. Even in the less vigorous forest of Central India, the top canopy may have half a dozen or more species growing together. But in these and certain other forests only one or a few out of the many species that compete for the growing space are of economic importance. Therefore, the management aims at deliberately favouring these. Typical examples of this type are the mixed forests of Madhya Pradesh containing teak, or the scrub forests of Mysore with trees of sandalwood. When a number of species grow together, they compete for getting enough nutrition from the soil and sunlight. In this struggle for existence, the most vigorous species, unless deliberately kept in check, eventually dominate and continue to grow vigorously. The slow-growing species are either dominated and their growth is restricted, or may even get completely suppressed, after which their growth is hampered, and some may even succumb. Eventually even the trees of the dominant species compete *inter se* and only the most vigorous survive. Young trees struggling for a place in the sun are exposed to many risks from adverse climatic or biotic factors. To ward off these, certain species develop special features such as a thick bark, thorns, an acrid juice, etc. Some species develop the power of growing by the shoots thrown out by the stools of felled trees; others throw out root suckers or pollard shoots. Typical examples are the coppice of teak, the root suckers of Tendu and the pollards of Anjan.

Many species are found only on poor soils. This, however, does not mean that they prefer such soil. They are there because more exacting species cannot thrive. On better soils more vigorous species oust them. Certain species are frost-tender and even in the pole stage die back (*i.e.*, their aerial portion dies but the root stock survives and throws out new shoots next year) or are killed outright. Teak is frost-tender whereas Chir pine is frost-hardy, and even more so Deodar which does not mind a temperature several degrees below the freezing-point. The production of abundant fertile seed, a good dispersal mechanism and suitable conditions of the forest floor for the seed to germinate and get established result in abundant natural regeneration, particularly if a species is shade-tolerant.

New alluvial deposits, land slips and accumulated silt in estuaries or reservoirs, if not utilised for agriculture, get colonised by forest species, grasses, shrubs and trees. Such colonisation is fairly rapid if the soil contains humus and has brought with it the seed of forest species, or seed from the neighbouring forests is dispersed on it. Common examples of this are the Sissoo-Khair riverine forest in the Siwaliks and the Palas forest on an old fallow land with black cotton soil. The pioneering vegetation is gradually replaced by other species which can grow and hold their own on the improved soil. This process goes on till the site gets stocked with vegetation which is more or less in equilibrium with the ecological factors operating in that locality. Such progression in time is called primary succession and its final stage is the climax vegetation. The Shola forests of Kerala are a typical example. But even the climax vegetation is not uniform in composition all over, nor stable. There are noticeable differences caused by micro-ecological variations. Even the more or less stable climax type may develop the germs of its own decay and thus get altered appreciably in composition. Such changes may occur in a cycle. Local changes may also occur due to special characteristics of the soil. Typical examples of such edaphic climaxes are Babul on the periodically inundated black soil, or satinwood on the sandy soil. Aspect also may be the causes of the presence or absence of certain species. Thus Chir pines prefer southern aspects in the Himalayas whereas oaks grow mostly on the northern aspects. In the plains, bamboos like sheltered, shady aspects. When a *climatic climax*, such as the mixed deciduous forests of Central India, is deliberately disturbed by making conditions more xerophytic to increase the proportion of teak, the most important species of these forests, such retrogression is referred to as a *sub-climax*.

Forest Types and their Distribution

The better defined and more stable units of forest vegetation are referred to as *Forest Types*[1]. They are distinguished in forestry mainly for the purpose of management and, therefore, the degree of sub-division depends on the intensity of treatment a particular type has to receive for purposes of its regeneration and tending. In

[1]Technically a *forest type* is a category of forest, defined generally with reference to its geographical location, climatic and edaphic features, composition and condition.

delimiting types emphasis is laid on the most emergent vegetation, namely, the main tree layers and their important constituents from the economic view-point. Thus the most complex and variable wet tropical evergreen forest with its luxuriant vegetation of big and small trees, shrubs, herbs, climbers, parasites, etc., of numerous species, which is not valuable, is referred to as a single type. On the other hand, the tropical deciduous forests, though comparatively open and with but a few species, have been categorised into moist, semi-moist, dry, arid, and other types because the methods of regeneration and tending differ for each of these types of valuable forests. As already pointed out, the main factors which define forest types are climatic, edaphic and biotic. Of climatic factors the most important are temperature and moisture and in particular their combination and seasonal variation. Provided adequate moisture is available, temperature shows itself in the luxuriant growth of the forest, in its height, density, variety of species and rate of growth. The conifers reach their best development in temperate climate in which they surpass their broad-leaved associates which grow best in a tropical climate. At higher elevations with cold increasing, winter deciduous species become more prevalent. Further higher up vegetation degenerates into scrub and only evergreen hard-leaved species such as *Rhododendrons* are left. If moisture conditions are less favourable in areas of higher temperature, the vegetation gets stunted, sparce and is reduced to a few species most of which are summer deciduous and have other xerophytic adaptations such as small leaves, thick bark, etc.

Champion and Seth have differentiated 16 climatic forest types. The temperature and rainfall data for a station in or near each type are given in Appendix I; where distinct sub-types exist more than one station has been mentioned. The general composition and distribution of the types are described below. Map 4 shows their distribution diagrammatically.

(1) *TROPICAL WET EVERGREEN FOREST:* Lofty, very dense, multi-layered forest with mesophytic evergreens, 45 m. or more high, with a large number of species, numerous epiphytes, few climbers. Found along the western face of the Western Ghats

and in a strip running SW from Upper Assam through Cachar, and in Andamans.

Exx. (i) *Ranni, Kerala,* 1000 m.

Impt. Spp. Mesua, white Cedar, *Calophyllum,* Toon, Dhup, *Palaquium, Hopea,* Jamun, Canes, etc.

(ii) *Cachar, Assam*

Impt. Spp. Gurjan, Chaplash, Jamun, Mesua, Agar, Muli, Bamboo, etc.

(2) *TROPICAL SEMI-EVERGREEN FOREST:* A closed high forest with large dominants, sometimes deciduous, with tendency to gregariousness, many species, buttressed trunks frequent, bark thicker and rougher and canopy less dense than in previous type, climbers heavy, bamboos less prevalent, epiphytes abundant. Occurs in the Western Coast, Assam, lower slopes of the Eastern Himalayas, Orissa and in Andamans.

Exx. (i) *Palghat, Kerala*

Impt. Spp. Aini, Semul, Gutel, Mundani, *Hopea,* Benteak, Kadam, Irul, Laurel, Rosewood, Mesua, Haldu, Kanju, Bijasal, Kusum, Thorny Bamboo, etc.

(ii) *Kalimpong, W. Bengal*

Impt. Spp. Bonsum, white Cedar, Indian Chestnut, *Litsea,* Holloch, Champa, Mango, etc.

(3) *TROPICAL MOIST DECIDUOUS FOREST:* Irregular top storey of predominantly deciduous species, 40 m. or more high, heavily buttressed trees, definite second storey of many species with some evergreens, fairly complete shrubby undergrowth with patches of bamboos, climbers heavy including canes. Occurs throughout Andamans, moister parts of U.P., M.P., Gujarat, Maharashtra, Karnataka and Kerala.

Exx. (i) *Andamans*

Impt. Spp. Padauk, White Chuglam, Badam, Dhup, Chikrasi, Kokko.

(ii) *Allapalli, Maharashtra*

Impt. Spp. Teak, Laurel, Haldu, Rosewood, Mahua, Bijasal, Lendi, Semul, Irul, Dhaman, Garari, Amla, Kusum, Common bamboo, etc.

(iii) *Dehra Dun, Uttar Pradesh*

Impt. Spp. Sal, Lendi, Haldu, Pula, *Litsea*, Jamun, Mahul, etc.

(4) *LITTORAL AND SWAMP FOREST:* Mainly evergreen species of varying density and height, always associated with wetness; Littoral forests are found all along the coast and swamp forests in the deltas of bigger rivers.

Ex. *Sunderbans, West Bengal*

Impt. Spp. Sundri, *Bruguiera, Sonneratia,* Agar, Bhendi, Keora, *Nipa,* etc.

(5) *TROPICAL DRY DECIDUOUS FOREST:* Upper canopy closed though rather uneven, composed of a mixture of a few species practically all deciduous during the dry season, some for several months, upto 20 m. high, some species tend to predominate over selected areas but most non-gregarious, lower canopy almost entirely deciduous, shrubs present but enough light reaches the forest floor to permit growth of grass; bamboos present unless exterminated by over cutting but not luxuriant, climbers few but some large and woody, epiphytes and ferns inconspicuous. Occurs in an irregular wide strip running NS from the foot of the Himalayas to Cape Comorin except in Rajasthan, Western Ghats and Bengal.

Exx. (i) *Betul, Madhya Pradesh*

Impt. Spp. Teak, Axlewood, Tendu, Bijasal, Rosewood, Amaltas, Palas, Haldu, Kasi, Bel, Lendi, Common bamboo, etc.

(ii) *Cuddapah, Andhra Pradesh*

Impt. Spp. Red Sanders, Axlewood, Anjan, Harra, Laurel, Satinwood, Papra, Achar, etc.

(iii) *Ramnagar, Uttar Pradesh*

Impt. Spp. Sal, Laurel, Axlewood, Bhilama, Achar, Khair, Ghont, Bel, etc.

(6) *TROPICAL THORN FOREST:* Open, low, pronouncedly xerophytic forest, thorny leguminous species predominate, trees with short boles and low branches, an ill-defined lower storey of smaller trees and shrubs, spiny and with xerophytic characteristics, climbers few. This type grows in a large strip in South Punjab, Rajasthan, Upper Gangetic Plains, the Deccan plateau and the lower peninsular India.

Exx. (i) *Sholapur, Maharashtra*

Impt. Spp. Khair, Reunjha, Axlewood, Neem, Sandalwood, Nirmali, Dhaman, etc.

(ii) *Jaipur, Rajasthan*

Impt. Spp. *Acacia senegal,* Reunjha, Khejra, Kanju, Neem, Palas, Ak, etc.

(7) *TROPICAL DRY EVERGREEN FOREST:* A low forest, upto 12 m. high with complete canopy, mostly of coriaceous leaved evergreen trees of short boles, no canopy layer differentiation, bamboos rare or absent, grass not conspicuous. Restricted to a small area of Karnataka Coast which receives some summer rain also.

Ex. *Sriharikota, Andhra Pradesh*

Impt. Spp. Khirni, Jamun,Kokko, Ritha, Tamarind, Neem, Machkund, Toddy Palm, Gamari, Canes, etc.

(8) *SUB-TROPICAL BROAD-LEAVED HILL FOREST:* Luxuriant forest evergreen species predominating limited to the lower slopes of the Himalayas in Bengal and Assam and other hill ranges such as Khasi, Nilgiri and Mahableshwar.

Ex. *Trivandrum, Kerala*

Impt. Spp. Jamun, *Machilus,* Meliosma, *Elaeocarpus, Celtis* etc.

(9) *SUB-TROPICAL PINE FOREST:* Practically pure association of Chir pine, considerably influenced by periodical fires, no underwood, few shrubs. Found throughout the whole length of NW Himalayas between 1000-1800 m. Absent in Kashmir due to weakened SW monsoon. In Khasi, Manipur and Naga Hills, Khasya pine occurs at similar altitudes.

Ex. *Maharpali, Uttar Pradesh*

Impt. Spp. Chir, Jamun, Oak, *Rhododendron*, etc.

(10) *SUB-TROPICAL DRY EVERGREEN FOREST:* Low, practically scrub forest, small evergreen stunted trees and shrubs including thorny species, herbs and grasses appear in monsoon, Met with in the Bhabar, the Siwaliks and the western Himalayas upto about 1000 m.

Impt. Spp. Olive, *Acacia modesta, Pistacia*, etc.

(11) *MONTANE WET TEMPERATE FOREST:* A closed evergreen forest. Trees mostly short-boled and branchy attaining large girth, height rarely 6 m., crowns dense and rounded leaves coriaceous, red when young, branches clothed with mosses, ferns and other epiphytes, woody climbers common. Found in the higher hills of Madras and Kerala from 150 m. upwards and in Eastern Himalayas on the higher hills of Bengal, Assam and NEFA from 1800 to 3000 m.

Ex. *Kalimpong, West Bengal*

Impt. Spp. *Machilus, Cinnamomum, Litsea, Magnolia,* Chilauni, Ind. Chestnut, Birch, Plum.

(12) *HIMALAYAN MOIST TEMPERATE FOREST:* Coniferous forest, mostly pure, 30 to 50 m. high with varying, underwood mostly evergreen, mosses and ferns grow freely on trees. Extends along the entire length of the Himalayas between the pine and the sub-alpine forests in Kashmir, Himachal Pradesh, Punjab, U.P., Darjeeling and Sikkim between 1,500 and 3,300 m.

Plate 8

TAPPING OF CHIR PINE FOR RESIN, H.P.

(*See pages 58 and 70*)

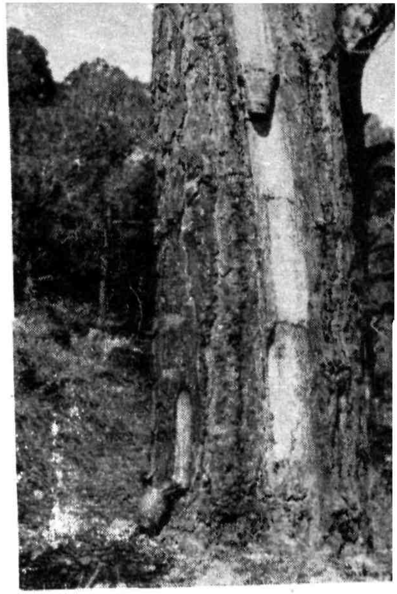


Plate 9 *Bans*—THE COMMON BAMBOO (*Dendrocalamus Strictus*)

(*See page 66*)

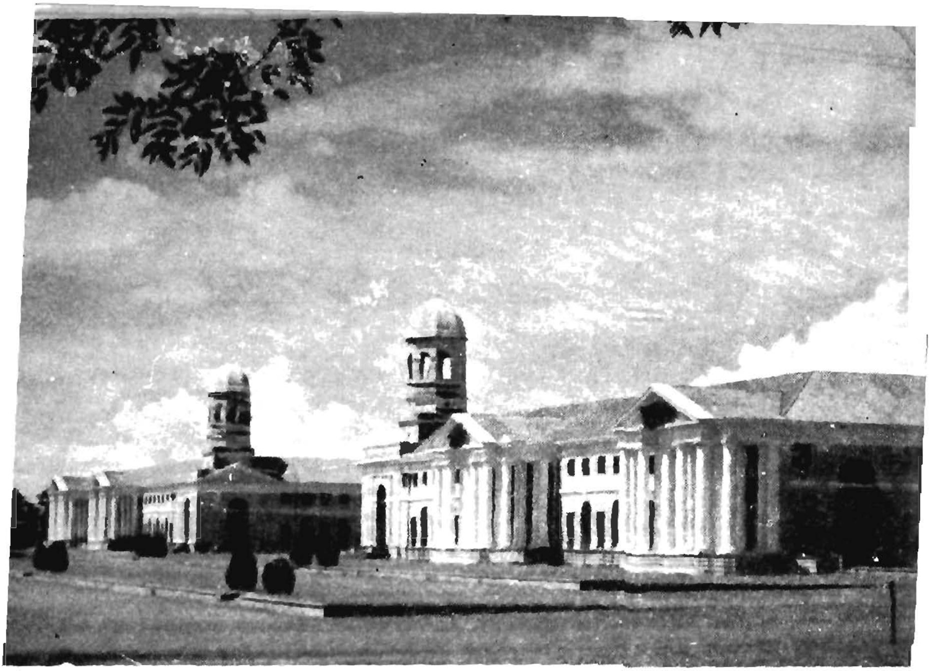


Plate 14 FOREST RESEARCH INSTITUTE, DEHRA DUN

(See page 99)

Exx. (i) *Chakrata, Uttar Pradesh*

Impt. Spp. Oak, Fir, Spruce, Deodar, *Celtis*, Chestnut, Maple, etc.

(ii) *Sutlej Valley, Himachal Pradesh*

Impt. Spp. Spruce, Deodar, Fir, Kail, Oak, Yew, Maple, Birch, etc.

(13) *HIMALAYAN DRY TEMPERATE FOREST:* Predominantly coniferous forest with xerophytic shrubs, hardly any epiphytes and climbers. Found in the inner ranges of the Himalayas where SW monsoon is very feeble, precipitation below 100 mm. mostly snow; in Ladakh, Lahoul, Chamba, Bashahr, Garhwal and Sikkim.

Ex. *U. Bashahr, Himachal Pradesh*

Impt. Spp. Chilgoza, Deodar, Oak, Maple, Ash *Celtis, Parrotia,* Olive, etc.

(14) *SUB-ALPINE FOREST:* Dense growth of small crooked trees or large shrubs with coniferous overwood, mostly fir and birch. Conifers 30 m. high, broad-leaved trees 10 m. high. Occurs at the upper limit of tree forest in the Himalayas adjoining alpine scrub and grasslands.

Ex. *Kulu, Punjab*

Impt. Spp. Fir, Kail, Spruce, *Rhododendron,* Plum, Yew, etc.

(15) *MOIST ALPINE SCRUB:* Low evergreen dense growth of Rhododendron and Birch. Mosses and ferns on the ground with alpine shrubs and flowering herbs. Occurs along the entire length of the Himalayas above 3000 m.

Ex. *Kumaun, Uttar Pradesh 3,800 m.*

Impt. Spp. Birch, *Rhododendron,* Berberis, Honeysuckle, etc.

(16) *DRY ALPINE SCRUB:* The uppermost limit of scrub-xerophytic, dwarf shrubs, over about 3,500 metres.

Ex. *High Himalayas over 4,000 m.*

Impt. Spp. Juniper, Honeysuckle, Artemesia, Potentilla, etc.

The extent of forests of different types, for the country as a whole, is as under[1]:—

	Forest Type		*Area (M. Ha.)*	*% of total*
1.	Tropical Wet Evergreen		4.503	6.0
2.	Tropical semi-Evergreen		1.854	2.5
3.	Tropical Moist Deciduous		23.303	30.9
4.	Littoral and Swamp		0.671	0.9
5.	Tropical Dry Deciduous		29.154	38.7
6.	Tropical Thorn		5.236	6.9
7.	Tropical Dry Evergreen		0.075	0.1
8.	Sub-tropical Broadleaved		0.287	0.4
9.	Sub-tropical Pine		3.740	5.0
10.	Sub-tropical Dry Evergreen		0.173	0.2
11.	Montane Wet Temperate		1.613	2.1
12.	Himalayan Moist Temperate		2.725	3.6
13.	Himalayan Dry Temperate		0.227	0.3
14.	Sub-alpine			
15.	Moist Alpine Scrub		1.790	2.4
16.	Dry Alpine Scrub			
		Total	75,351	100.0

State- and Union Territory-wise details show that the main distribution is as under:—

Type 1. Mainly in Arunachal Pradesh (1.2), Andaman & Nicobar (0.6), Karnataka (0.6) and Kerala (0.5);

Type 2. Mainly in Karnataka (0.6), Maharashtra (0.4), Assam (0.3), Orissa (0.3) and Kerala (0.3);

Type 3. Mostly confined to M.P. (7.3), Orissa (4.5), Andhra Pradesh (3.0) and Assam (2.9);

Type 5. This occurs principally in M.P. (9.8), Maharashtra (4.2), Rajasthan (3.2), Bihar (2.8), Orissa (1.8), Andhra Pradesh (1.7) Tamil Nadu (1.6) and Gujarat (1.4);

Type 6. Occurs mainly in Andhra Pradesh, Karnataka and Maharashtra;

Type 9. Mainly in Arunachal Pradesh, Himachal Pradesh and U.P.;

Type 12. Chiefly in U.P.

[1]*Vide* *Indian Forester*, July 1971, page 436.

The most abundant types are Tropical Moist and Dry Deciduous forests, occupying over 70% of the country's forest area, followed by the Tropical Thorn forest (6.9%), Tropical Wet Evergreen (6%) and Sub-tropical Pine forest (5%).

Jabalpur lies in the heart of the Tropical Deciduous Forest and has thus rightly been selected by the Forest Research Institute for concentrating research on this type in its Regional Research centre located there.

FORM AND GROWTH OF TREES

(*a*) *Form:* Four stages in the growth of a tree have been distinguished. From germination upto a height of one metre, the young plant of a tree species is called a *seedling*, from this height until lower branches begin to fall and the plant develops a definite crown it is referred to as a *sapling;* after this, until the rate of height growth begins to fall it is known as a bole, and thereafter as a *tree*. The shape and size of the crown and its proportion to the bole and the root system are characteristic of the species. For instance, Deodar is a tall tree with a straight bole, whereas Sissoo has a short and somewhat crooked trunk. The form of trees also depends on the environment. Thus Teak trees grown in a plantation have clean, straight boles, small crowns and a superficial root system, while Mango trees growing in the open develop a short trunk, a very big rounded crown and deep strong roots to give them stability. The mode of branching is also characteristic. It may be opposite, decussate, alternate, whorled, etc. Some branches grow upwards (heliotropic), others grow downwards (geotropic) or may be horizontal (prototropic). Some trees are *evergreen,* that is, their old leaves are shed after one or more years imperceptibly, while the new foliage is coming out. Others are *deciduous,* that is, they shed all their leaves and remain leafless in winter or in summer. The size of leaves also varies. Larger leaves are characteristic of moist forests, like those of banana, and small leaflets of very dry forests, like those of Babul. Leaves are coariaceous in dry climate but soft in moist climate. The phenology (the time of leafing, flowering, fruiting, etc.) of trees of the same species depends on the local climate. A typical example is Mango which bears fruit much later in north India. Similarly Teak sheds its leaves earlier in M.P. than in Karnataka. Forest trees, when suddenly isolated, throw out small branches all along the bole, giving it the appearance of a bottle-brush. These branches if allowed to grow give rise to knots, which affect the quality of timber. These epicormic branches, as they are called, may also be developed as a result of frost, fire or by a deficient water supply. Some trees, particularly in wet forests, have a buttress-like swelling at the base, which is sometimes in the form of wings thin enough to make planks, for instance in Semul. The trunks of certain trees have involutions at the base called fluting.

Roots draw nutrition from the soil. A root consists of (i) a root-cap which is the spear-head that pushes through the soil, (ii) the zone of elongation, growing longitudinally by a rapid cell division, (iii) a mass of felty root-hairs by which the plant draws nutrition from the ground; and (iv) the twisting corky root which anchors the tree to the ground and acts as a pipe for the movement of soil solution to the tips of the tree. The soil surrounding the root hairs is a veritable laboratory, called rhizosphere, where food is served to it raw along with hormones and acids secreted by soil microbes and fungi which aid their mutual development. Recent research has shown that root hairs of certain trees also secrete toxins which prevent germination of other plants. The roots of a tree are either *sinkers, i.e.*, they go downwards to tap subsoil moisture, or *spreaders*, that is, they grow all round the tree and remain in the upper layers. Babul has a tap root upto 30 metres long and has no spreading superficial roots. Therefore, if planted in fields, its roots do not compete for nutrition with the development of crops. Teak is a shallow-rooted species and, therefore, for better development, the forest floor should be clear of weeds. In swamps and tidal estuaries plants have stilt roots to ensure proper aeration even in floods. Some plants like banyan commence life epiphytically but later develop their own root system. Sandalwood trees live parasitically on the roots of other plants all the time. The root system of bamboos is different from that of trees. They have an underground stem called rhizome with a mat of rootlets, and a number of 'buds' that produce bamboo culms. Some trees, such as pine, do not possess root hairs. Instead, they have at their tips a myceleal fungoid growth called mycorrhiza which lives symbiotically with the trees. The presence of this helps the tree to absorb more nitrogen, phosphorus and potassium. It has been found that exotic pines can grow better in soil containing Chir pine mycorrhiza. Some leguminous trees have nodules that increase nitrogen in the soil.

(*b*) *Age and Size of Trees* (i) *Age:* Some trees are short-lived, like Bakain, and others live for hundreds of years such as Deodar. Banyan is more or less immortal as it throws out aerial roots which strike the ground and penetrate the soil. That is why this tree has been called *Akshaya Vat* (the indestructible tree). The following data regarding longevity of trees will be found interesting:—

Species	*Location*	*Age in years*
Redwood	California, USA	Over 4000
Sequoia gigantea	,,	3230
Yew	England	3000
Deodar	Tehri-Garhwal, UP	704
Teak	Ulandi, Madras	Over 500
Shisham	,,	about 600
Chir	Chakrata, U.P.	327
Chinar	Srinagar	293

(ii) *Height, Age and Girth:* Some Indian trees of maximum recorded dimensions are given in the following table:

TABLE 7
MAXIMUM RECORDED HEIGHTS AND GIRTHS OF TREES

	Species	*Location*	*Height (metres)*	*Girth B.H. (cms)*
1.	Blue Gum	Nilgiris, Madras	64.0	541
2.	Chinar	Bijbehara, Kashmir	—	2150
3.	Chir Pine	Garhwal, U.P.	65.5	411
4.	Deodar	Tons Division, U.P.	64.9	808
5.	Mango	Malda, West Bengal	36.6	686
6.	Padauk	N. Andamans	51.5	602
7.	Sal	Haldwani, U.P.	51.2	264
8.	Spruce	Garhwal, U.P.	64.0	732
9.	Teak	S. Chanda, Maharashtra	43.0	396
10.	Laurel	Bilaspur, M.P.	43.3	561

World's Tallest Trees[1]

California and a pocket in Southern Oregon (USA) produce earth's tallest living trees, the coastal Redwoods or *Sequoia sempervirens*. The largest untouched stands flourish in Northern California's Humboldt and Del Norte counties.

In order of height, the top trees are:—

Ht. in Ft.	*Location*
1. 367.8	Redwood Creek Grove, Humboldt County.
2. 367.4	Redwood Creek Grove.
3. 364.3	Redwood Creek Grove.
4. 356.5	Rockefeller Tree, Humboldt (Redwoods State Park, Calif.)
5. 352.6	Founder's Tree
6. 352.3	Redwood Creek Grove.

Forest monarchs of three other species grow in the Pacific coast States and in Tasmania and Australia. They include a 324′ Douglas Fir (*Pseudotsuga taxifolia*) at Ryderwood in Washington; a 322′ *Eucalyptus regnans* in the Styx River Valley of Tasmania; a 305′ tree of the same species in Victoria, Australia, and two *Sequoia gigantea* trees in California—the 291′ McKinley Tree and the 272′ General Sherman Tree both in Sequoia National Park.

World's Oldest Living Trees[2]

The late Dr Edmund Schulman, Dendro-Climatologist at the University of Arizona, studied tree rings to 'hindcast' what the weather was like in past centuries. In 1956 in the arid White Mountains of eastern California he spotted three bristlecone pines (*Pinus aristata*) which were found to be about 4,000 years old, that is, older than the oldest-known Sequoia. After his death in 1958, Dr. W. D. McGinnies and Dr. C. W. Ferguson carried on research at the laboratory where Dr. Schulman was working, and established the presence of more than 1,000 trees of the species over 4,000 years old, including one called 'Methuselah' which is 4,600 years old!

[1]*National Geographic Magazine*, July 1964
[2]*Ibid*, March 1958

Bristlecone pines occur throughout the entire Great Basin of the West—California, Nevada, Utah, Colorado, Arizona and New Mexico. The 4,000 to 4,600 years old trees are confined to the high, dry White Mountains of California. In summer they battle against the blazing sun and lack of water; in winter they struggle against snow and ice.

Why is bristlecone pine the oldest living thing? Three possibilities have been suggested: (i) there is more pitch in its trunk and branches, or pitch of a different chemical composition resistant to insects and rot; (ii) the tree dies in parts, the remainder goes on growing; and its rate of growth is very slow, about an inch in radius in 100 years.

To preserve the oldest trees the U.S. Forest Service has set aside 20,000 acres of public lands in the White Mountains as the "Ancient Bristlecone Pine Area."

Maximum Volume: The largest volumes of timber obtained from individual trees of which records have been traced are:

Species	*Location*	*Volume* (m^3)
Tectona grandis	Bhamo	38.7
Agathis australis	New Zealand	889.0
Sequoia sempervirens	California	1021.0
Sequoia wellingtonia	California	1411.6

Maximum Weight: The total weight of the Redwood tree in the Sequoia National Park known as General Sherman (Height when measured, was 273.9′, basal circumference 102.7′) is estimated to be as under:

Trunk		11,204,200 lbs.
Limbs		356,640 ,,
Roots		749,760 ,,
Bark		15,579 ..
Foliage		9,440 ,,
	TOTAL	12,335,639 lbs

or over 6000 tons!

Tree Physiology

Trees absorb soil solution or sap through their root-hairs by an osmotic pressure and absorption force and then convey it through the cortex to the endodermis layer and thence to the conducting tissues. When the soil moisture falls below a certain proportion, the plant wilts. Water absorption is difficult in acidic, or saline soils, and the wilting point is therefore reached with a higher water percentage than in average soils. Such soils are therefore said to suffer from ~~physiological~~ drought even though they may be visibly moist. Water in the sap is continuously evaporating from the leaf surface. To reduce this transpiration and prevent wilting, trees have developed various modifications such as sunken stomata, a waxy coat, a thick cuticle, a summer deciduous habit, a reduction in leaf surface, etc. And yet it is a remarkable fact that teak comes into leaf at the hottest and the driest season and with the lowest soil-moisture! Water removed by transpiration from cell walls is replaced by imbibition from the cells which in turn draw it from the water channels of leaf walls where it comes from the roots.

Light is essential for plants to grow. Many trees are *light-demanders,* such as Chir, Semul and Teak, that is, they require overhead light for their proper development. Others are *shade-bearers,* such as fir, Jamun and Mesua which can grow under shade. Some, like Sal, are shade-tolerant in the young age but partial to shade later. Lack of light leads to the death of both leaves and branches. This is how the lower side-branches of trees are killed and shed when they are shaded by their own crowns or those of neighbouring trees and thus develop clean boles. When light strikes the leaves, a part of it is absorbed by the chlorophyll in them. This brings about the assimilation of atmospheric carbon dioxide and the formation of carbohydrates, viz., sugars, which are then polymerized into starch. The absorption of CO_2 is accompanied by the release of an equal volume of oxygen. There is another process going on, namely, *respiration* by which organic substances in the plant tissues absorb oxygen and are oxidized to carbon dioxide. Such respiration increases carbon dioxide in the soil which then diffuses in the air and is utilised by the ground vegetation for photosynthesis. Proteins are also formed in the leaves. Besides this, trees get nitrogen from mycorrhiza, or bacterial nodules in the roots.

Some fifteen elements are involved in plant nutrition. Apart from C, H_2, and O_2 which are derived from the air and soil-moisture, the plants also take up as *major primary* nutrients N, P and K in large quantities, as *major secondary* nutrients Ca, Mg, and S in appreciable quantities, and as *minor* nutrients traces of B, Mn, Cu, Zn, Fe and Mo. All these except nitrogen are present in the soil derived from the weathering of rocks. The role of major nutrients in plant metabolism may be summarized as under: Nitrogen is essential as it is a constituent of protein, protoplasm, chlorophyll, nucleotides, enzymes, hormones and vitamins. It is mostly of organic origin, derived from the break-down of plant and animal residues by soil micro-organisms. It is absorbed through mineralised salts such as nitrates, but some plants also have the power to take up nitrogen as ammonia. Leaves can also take in nitrogen when sprayed with ammonia or nitrates. Nitrogen promotes vegetative growth of the sub-aerial parts. Over-doses make plants leafy, lanky and drought-sensitive. Phosphorus is a constituent of the cell nucleus and is essential for cell division. It promotes root growth and early ripening of fruits. Potassium, though not a part of any important plant substance such as protein or chlorophyll, is essential as it regulates all metabolic processes. It is present in leaves, in sap and cytoplasm, as also in wood. It increases the resistance of plants to pests. Appropriate proportion of N, P and K in the soil is essential to obtain the maximum growth. Hence the need for adding these artificially in forest eco-systems of low productivity to make good the deficiency. Besides these, there are synthetic organic compounds which promote or inhibit growth. Of the former there are the *auxins*, also occurring naturally, which cause shoot elongation, *hormones* found in plants which control specific growth such as flower formation, cell-division, etc., and *gibberellins* which increase cell-elongation and break seed dormancy. Of the plant killers the most important phytocides are 2, 4–D; L, 4, 5 trichlorophenoxyacetic acid, MCPA and their salts and esters.

Resin is exuded from ducts in the wood of conifers, dipterocarps and some other trees, the most important of which economically is Chir pine. *Essential oils* are secreted by certain conifers, Eucalyptus, etc. Rubber is the coagulated latex of *Hevea brasiliensis*. Certain trees yield gum such as Babul, axlewood, etc. On the other hand, lac is not an exudation from trees but the secretion of an insect which lives by sucking juices of certain trees.

CHAPTER IV

FOREST RESOURCES: TRENDS AND PROSPECTS

A. MAJOR FOREST PRODUCTS

PRESENT PRODUCTION

Major forest products consist of timber, small-wood and fuel-wood including charcoal.

The present (1970) recorded production of hardwoods and conifers, utilised as industrial woods, is—

Hardwoods	7.63	million cubic metres $(M)_m{}^3$
Conifers	1.29	,, ,, ,, ,,
Total	8.92	,, ,, ,, ,, ,,

This recorded production is less than the actual consumption which was estimated to be about $15M_m{}^3$. The difference is accounted for by imports of finished products and by non-recorded production.

In respect of fuelwood the picture is more alarming. Of the total consumption of 203 $M_m{}^3$ only $13M_m{}^3$ is recorded as coming from forests. The rest comes from treelands and probably substantial pilferage from forests.

FUTURE REQUIREMENTS

The estimated requirements of raw materials of wood and bamboos for industrial use and of fuel by 1980 and 1990 are—

a. Total Industrial Raw Material Requirements

	By 1980			*By 1990*		
	Conifers	*Hardwoods*	*Total*	*Conifers*	*Hardwoods*	*Total*
1. Pulpwood (Mm^3)	1.555	3.478	5.033	4.461	8.271	12.732
2. Sawnwood & Sleepers (Mm3)	1.816	10.836	12.652	2.395	14.605	17.010
3. Panel Products (Mm^3)	.189	.755	.944	.281	1.126	1.407
4. Roundwood (Mm^3)	1.385	5.542	6.927	1.887	7.549	9.436
Total Industrial wood excl. bamboos	4.945	20.611	25.556	5.024	31.551	40.575

5. Bamboos	*By 1980*	*By 1990*
a. For Paper Pulp (Million tonnes)	2.199	1.954
b. For other uses (Million tonnes)	2.173	2.960
Total	4.372	4.914

These requirements indicate that in the next 20 years, substantial quantities of raw material, both conifers and hardwoods, will have to be produced from the country's forests: namely, an additional 3.66 M_m^3 of conifers and 12.98M_m^3 of hardwoods by 1980; and by 1990 the production will have to be further augmented by another 4.10 M_m^3 and 11.04 M_m^3 of conifers and hardwoods, respectively.

b. Fuelwood Requirements

	By 1980	*By 1990*
Fuelwood	256	300 million cubic metres

The production of fuelwood from the treelands is progressively dwindling. It would also be desirable to eliminate (at any rate minimise) the pilferage from forests. It will therefore be necessary to undertake extensive fuel-cum-fodder reserves by planting, especially as cattle fodder is also in short supply. The most suitable areas for the purpose will be the existing forests and adjacent villages which have become almost treeless due to indiscriminate cuttings and uncontrolled excessive grazing. This creation of Fuel-cum-Fodder Reserves is not likely to be a commercial venture, at least in the beginning. It will have to be subsidised by State governments, who will also have to persuade the villagers living in their vicinity to give free labour (Shramdan) as also to protect and tend the growth till it is exploitable. In Madhya Pradesh agreed quantities of firewood, bamboos etc. are being allowed to be removed by consumers, and they are permitted to graze their cattle utilised on agricultural works, at nominal rates under the system of Nistar, from specified forests. Some years ago the state had appointed a Nistar Policy Committee which made far-reaching recommendations to regulate Nistar, viz. giving maximum permissible satisfaction to the villagers without depleting the forest. For some unknown reason these have yet to be implemented.

Programme and Investment Requirements

To meet the future requirements, it is essential to redefine the objectives of forestry management in the context of rational development, harnessing and utilisation of forest resources of the country. There should be a changeover from the present conservation-oriented forestry to a more dynamic programme of production forestry. Considering the advantages of an aggressive orchard silviculture or creation of man-made forests by planting, the future programme should concentrate on clear-felling the mixed forests on good soils, the mixed quality forests as also inaccessible hardwood forests after opening them up by communication, and then planting these areas with site-suitable, fast-growing and valuable species, indigenous or even exotics, yielding higher returns per unit area, per year. The resulting increased wood supply from the areas thus worked should be utilised in wood-based industries by locating additional units wherever required.

To close the gap between availability and requirements by 1980 and 1990 for sawnwood, pulpwood, panel products etc. as also for roundwood, substantial investment will be needed. This will be of two categories: (i) for clearfelling the existing depleted and less valuable forests, and (ii) for financing wood-based industries to utilise the extra material that will be obtained from clearfellings, and for creating plantations over the felled over areas.

The investments needed and the production programme during 1974-1980 and 1981-1990 are shown on the following pages.

Financing

Since large-scale financing by the States is obviously difficult by government, institutional sources will have to be tapped for meeting a major part of the programme. In order that the institutions are in a position to finance the programme, the States should retain from the revenue only an equivalent of the average revenue of the previous three years received from the area that would be

Investment Required in Forest Industries Sector: 1974-80

Industry	*New Production required Mm³ or Mt*	*New Capital required (Million Rupees)*
+1. Sawnwood	1.412	211.8
+2. Plywood & Veneer	.190	152.0
+3. Particle Board	.141	141.0
4. Fibre Board	.51	47.94
5. Newsprint	.476	1713.6
6. Printing & Writing Paper	.430	2150.0
7. Industrial Paper	.271	1138.2
8. Absorbing Paper	.044	264.0
9. Others	.283	849.0
+10. Dissolving Pulp	.297	1485.0
	Total	8142.54
Less 1,2,3,4, & 10 which will be in Private Sector		—2028.04
Hence in Public Sector		6114.8
		or 611 crore rupees.

Investment required for Production Forestry Programme 1974-80 (Logging and Plantation)

Progress of Production	*Additional Production*		*Capital Required (Million Rupees)*
	Conifers	*Hardwoods*	
	Mm³		
1. Indigenous conifers by infrastructure development	3.660	—	407.60
2. Clearfelling difficultly accessible hardwood fts. 1 Lakh ha. Yield 40m³/ha.	—	4.00	320.00
3. Clearfelling valuable fts. 50,000 ha. Yield 40m³/ha.	—	2.00	160.00
4. Felling quality mixed fts. 400,000 ha. Yield 15m³/ha.	—	6.00	420.00
5. From existing plantations mostly Eucalyptus regenerated by coppice. 124,000 ha. Yield 8m/³/ha/yr		1.00	15.00
Plantation Investment			
6. Tropical Pine, 176,000 ha.	—	—	206.912
7. Fast growing species, 275,000 ha.		—	452.925
8. Teak & other commercial spp. 203,000 ha			298.004
9. Bamboos, 72,000 ha.			57.600
		Total	2423.041
			or 242 crore rupees.

Investment Requirements in Forest Industries Sector: 1981-90

Industry	*New Production required Mt or Mm³*	*New Capital required (Million Rs.)*
*1. Sawnwood	2.765	414.750
*2. Plywood & Veneer	.247	197.600
*3. Particle Board	.078	78.00
*4. Fibre Board	.039	36.66
5. Newsprint	.491	1767.60
6. Printing & Writing Paper	.818	4090.00
7. Industrial Paper	.517	2171.40
8. Absorbing Paper	.077	462.00
9. Others	.433	1299.00
10. Dissolving Pulp	.272	1360.00
	Total	11877.01
Hence in Public Sector		9790.00
		or 979 crore rupees

Investment for Production Forestry Programme: 1981-90

Industry	*Additional Production* Conifer	Hardwood Mm³	*Capital Required (Million rupees)*
1. From Thinnings in pine plantation raised in previous decade. Yield 4m³/ha/yr	.704	—	21.120
2. From coniferous fts by infrastructural development.	3.409	—	374.990
3. From fast growing spp. planted earlier 275,000 ha.		2.750	82.500
4. By bringing additional 1 lakh ha, of difficultly accessible forest. Yield 40m³/ha.	4.000		32.000
5. By felling additional valuable forest 50,000 ha.	2.000		160.000
6. By felling additional mixed fts 1 lakh ha. Yield 15m³/ha.	3.000		210.000
7. Teak & commercial spp 130,000 ha.	—	—	190.840
8. Pine: 220,000 ha.	—	—	371.140
9. By felling & planting additional 8 lakh ha. of mixed quality ft. not specifically geared to the needs of 1990, but for export.	—	—	1330.400
		Total	3060.990
			or 306 crore rupees

*The information under this heading is culled from the interim report on *Production Forestry: Man-made Forests*, by the National Commission on Agriculture, 1972.

brought under the programme and leave the balance of the receipts from clear-fellings to support the programme.

As institutional investment can flow only when there is a Company or Corporation to receive the funds, the agency to implement the man-made forestry programme and the supporting forest industries in the State should be organised in the public sector as a fully owned State Company or Corporation. The Paper and Pulp Industry should be treated as a priority industry in the public sector.

Fuelwood Requirements

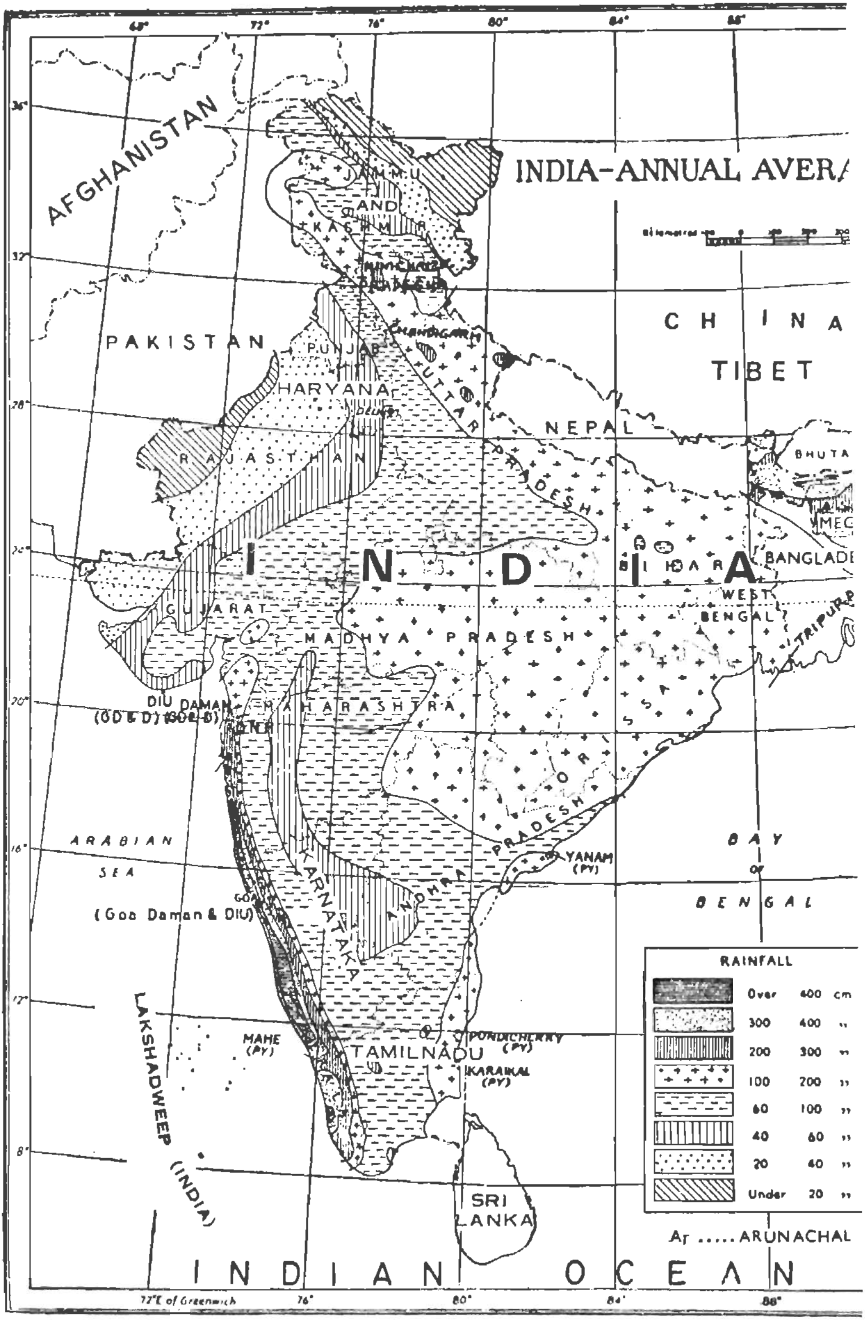
As against production forestry, which aims at producing forest products for industrial or household use, the role of forests as protectors of the physical features of the land, conservation of fertile soil and regulating the flow of water to mitigate floods and providing recreational facilities, and above all meeting the bonafide wants of the population in respect of firewood can best be referred to as the *protective* and *social* functions of forestry.

To meet the firewood demand at reasonably low rate should be the responsibility of the States, to conserve cowdung for manurial use and to prevent pilferage of wood from commercial forests. The details should be carefully worked out and adequate funds provided. Part of the cost could be met by voluntary work by the villagers for whose benefit the plantations are to be created. Government will also have to carry out intensive propaganda to convince the people of the necessity of protecting these plantations until they mature when the produce will be amicably distributed amongst them on nominal payment.

B. MINOR FOREST PRODUCTS

Definition and Present Production

By definition, 'minor forest produce' includes all products obtainable from forests other than wood and thus comprise products of vegetable, animal and mineral origin except minerals that are under the control of the Mining Department.



Based upon Survey of India map with the permission of the Surveyor General of Indi

The territorial waters of India extend into the sea to a distance of twelve nautical miles appropriate base line.

The boundary of Meghalaya shown on this map is as interpreted from the North-Eastern (Reorganisation) Act, 1971, but has yet to be verified.

In 1969-70 government realised a revenue of Rs. 36 lakhs from minor forest products out of the total forest revenue of 124 lakh rupees. Some products are allowed to be removed free and some at concessional rates. It is estimated that the total value of all minor forest produce removed must be easily over Rs. 100 crores.

BRIEF DESCRIPTION

In a small book like this, it is neither possible nor desirable to enumerate the numerous products. For a fuller description a text book on Forest Utilisation should be consulted. For convenience the products may be classified as under:

1. Fibres and Flosses;
2. Grasses (other than oil-producing), Bamboos and Canes;
3. Essential Oils including those from grasses;
4. Tans and Dyes;
5. Gums, Resins and Oleoresins;
6. Drugs, Spices, Poisons and Insecticides;
7. Edible products;
8. Leaves; and
9. Animal, Mineral and Miscellaneous products.

Some of these are very useful to the local population while others are of considerable commercial importance. Some earn substantial foreign exchange, while others give employment to the persons engaged in cottage industries utilising them.

1. *Fibres and Flosses:* Fibres are obtained from the bast tissues of certain woody species. Mostly they are coarse and used for rope-making. The shrub Ak (*calotropis spp.*) however, gives a fine, silky and very strong fibre used for making fishing nets.

Flosses are obtained from certain fruits and used for stuffing pillows, mattresses etc. The commonest is that from Semal. The floss from the fruits of Kapok (*Eriodendron anfractuosum*) is very elastic, extremely buoyant and resistant to water-logging. It is therefore used for making life-belts.

2. *Grasses, Bamboos and Canes:* Besides being utilised as fodder or for thatching, some grasses are fibrous and therefore used for cordage, matting and even for making paper. The most important

for the latter purpose is Sabai (*Eulaiopsis binata.*) It is a perennial grass found on the bare slopes of forest 'blanks' of the sub-Himalayan tract and in Bihar, Orissa, W. Bengal, M.P. and western parts of Himachal Pradesh. Annually over 80,000 tonnes are collected, pressed *in situ*, and supplied to paper mills. The roots of Khus (*Vetiveria zizaniodes*) grass are scented and used for making screens which are hung over doors and watered to provide a cool breeze. Munj (Saccharum munja) a tall grass grows in and along river beds and in lowlying places. Its stalks are used for making *chiks*, stools, chairs etc and the leaves are twisted into string.

Bamboos

Bamboos are tall, perennial, arborescent grasses. More than 100 species of them are found in the Indian forests. The most common, valuable and universally used is *Dendrocalamus strictus* which is found in almost all tropical deciduous forests except where it has been exterminated by over-cutting. The thorny *Bambusa arundinacea* takes next place in occurrence and utility. It is found mainly in Orissa, Assam and in the southern and western Indian forests. Other species have a somewhat restricted distribution.

Bamboos are characterised by woody stems, called culms, which arise from woody rhizomes. A culm attains its full growth in one season. The number of culms produced annually in a clump depends on the species and the vigour of the root stock. There is great variation in the thickness and length of culms depending on the species and the locality factors.

The strength of culms, their straightness, hardness, and the facility with which they can be split make them suitable for a variety of purposes. Indeed bamboos are the poor man's timber, used as rafters, scaffolding, roofing, walling, flooring, matting, basketry, carthoods, cordage etc. Tender shoots are eaten and when the bamboo clumps flower gregariously in 20-40 years, after which they die, the seed is collected and eaten as grain.

Bamboos are even more important from the industrial point of view. They are the only indigenous plant of wide occurrence in the Indian forests which has a comparatively long fibre suitable for making paper, just as coniferous woods are used in other countries.

The total extent of bamboo-bearing forest is not known correctly, nor the quantity of off-take utilised for domestic, commercial or industrial purposes. A rough estimate made by the Planning Commission in 1965 is as under:-

	State or Union Territory	*Bamboo Area Sq. km.*	*Potential Production Million tonnes*
1.	Andhra Pradesh	19700	0.255
2.	Assam	10000	1.210
3.	Bihar	5294	0.200
4.	Gujarat	1936	0.046
5.	Himachal Pradesh	104	.003
6.	Jammu & Kashmir	Negligible	—
7.	Karnataka	6000	0.475
8.	Kerala	631	0.108
9.	Madhya Pradesh	14864	0.800
10.	Maharashtra	8500	0.300
11.	Manipur	2500	?
12.	Orissa	10500	0.439
13.	Punjab	—	0.009
14.	Tamil Nadu	5388	?
15.	Tripura	2849	0.215
16.	Uttar Pradesh	4000	0.041
17.	West Bengal	164	0.008
18.	Arunachal Pradesh	7779	0.200
		TOTAL 100.281	4.349+?

The above figures are not based on any systematic survey and as such too much reliance should not be placed on them. As regards usage it is estimated that of the total quantity removed, construction accounts for 32%, rural use 30%, packaging 7%, paper pulp 17% and other uses 14%.

The present methods of exploitation are far from satisfactory. As a result, not only has bamboo yield decreased but even the species has disappeared from certain forests. Departmental working as now decided in M.P. should steadily increase the production.

In the interest of meeting the agricultural, commercial and industrial demand to the maximum extent it would be desirable to systematically survey the bamboo-bearing areas to determine their present production (in tonnes air dry, per year) and then work them silviculturally to realise their potential. The present usage should also be examined and where possible it should be rationalised to ensure that the industries get bamboo at the minimum cost on transport and the forest department gets a reasonable price which not only covers the cost on raising the bamboos and protecting them but also on overheads and leaves a fair margin of profit. If possible the areas set aside for agricultural, commercial and industrial demands should be separated. The bamboo-bearing area should be increased by planting suitable areas.

Certain rayon mills are using bamboo for dissolving pulp, as rayon can be made from any cellulosic material without regard to the fibre length, and as bamboos are in short supply, their use for making rayon grade pulp needs to be prohibited.

Canes occur in the forests of Andaman & Nicobar, Assam, W. Bengal, Kerala and to some extent in Tamil Nadu, Maharashtra, Bihar, Orissa and U.P. They are used as plaiting material, as ropes and cables of suspension bridges in the forests, for furniture, walking sticks, umbrella handles, sports goods, wicker works etc. Over-exploitation and lack of efforts to increase production have resulted in dwindling yields. To meet the increasing demand cultivation of better species is clearly indicated.

3. *Essential Oils:* A variety of forest plants contain essential oils. These are used in the manufacture of soaps, cosmetics, pharmaceutical preparations, confectionery, tobacco flavouring, incense etc. Important from the commercial point of view are the oils of *Eucalyptus globulus,* used in medicine, Rusa grass, Khus and the most valuable sandalwood.

Sandal is a small evergreen tree growing wild (also cultivated) over an area of 15,000 sq. km. of which 85% lies in Karnataka State and the remainder in the adjoining districts of Tamil Nadu. The tree grows as a parasite on the roots of other trees. It is susceptible to a disease called 'spike' as the affected branches produce smaller leaves, giving the twigs the appearance of a spike. The cause of this and the preventive measures are yet to be investigated. The attacked tree dies very soon and the infection can also spread to neighbouring trees. Hence the affected trees are being cut and utilised.

Sandalwood itself is extensively used for carving pieces of art. The chips of heartwood and the roots as also the wood that is unsuitable for carving are used for distilling the oil. There is a government factory at Bangalore with up-to-date equipment for the purpose. The oil is used in Indian medicine and mostly in perfumery and manufacture of toilet soaps, locally. A large quantity is also exported as it is considered an excellent base for high class perfumes. In 1968-69, 123 tonnes of oil valued at 3.15 crore rupees was exported mostly to Japan, the USSR, the USA and W. Germany. Increase of production is clearly indicated.

Lemon grass oil is obtained from *Cymbopogon flexuosus* and *C. citratus*. Kerala is the chief producer having 29,000 hectares of plantations at the foot of the Ghats. The oil contains over 80% citral, the starting material for the manufacture of Vitamin A. It is also used for the manufacture of aromatic chemicals, in perfumery, soap and cosmetic industries and for making pain balms and disinfectants. Nearly 97% of the production is exported. In 1969-70, 225,610 kg. of oil were exported, earning a foreign exchange of rupees 105 lakhs, mostly to the USA, the UK and, to a lesser extent, France and Japan. Plantations are being raised in U.P.

Rusa or palmrosa oil is obtained from the grass *Cymbopogon martini, var.* 'motia' which grows mostly in western M.P. and adjoining tracts of Maharashtra. It contains about 90% geraniol and is thus a cheaper source of it than the geranium oil from *Pelargonium*. The oil is widely used in perfumery and cosmetics, particularly in the manufacture of soaps, to which it imparts a lasting rose scent, also for flavouring tobacco. In 1968-69 India exported oil worth Rs. 37 lakhs mostly to the USA, W. Germany, Netherlands and Sudan. The demand is on the increase.

Khus oil is distilled from the scented roots of the grass *Vetiveria* *ziziniodes* which grows wild in Rajasthan, M.P., Punjab, Orissa, and Kerala. It is widely used in the perfumery trade particularly for making Ittar of Khus.

4. *Tans & Dyes:* Tannins are secretion products of plant tissues. The important tanning materials obtained from forests are:

Harra or chebulic myrobalan nuts from *Terminalia chebula,* a large deciduous tree. The largest supplies come from M.P. and smaller quantities from Bihar, Orissa, Andhra Pradesh, Tamil Nadu and Maharashtra. The nut is used in the form of an extract, or crushed or in the whole form. Besides being used in the country, in 1968-69 over 5500 tonnes of myrobalans valued at over 25 lakh rupees were exported. The exports have steadily declined since 1966-67 because of lack of proper collection and grading and increase in the export of tanned leather.

Babul (*Acacia nilotica*) bark is an important tanning material used in northern India, the main centre being Kanpur. The tree occurs on wastelands and is also cultivated.

Avaram (*Cassia auriculata*) bark is obtained from a shrub growing wild in Deccan and south India. It is chiefly used in Madras tannery.

Wattle (*Acacia decurrens* and *A. mollissima*) bark is obtained from the plantations of these species on the Nilgiri plateau and Palni Hills. By 1965 the plantations extended over 18,800 hectares. Large quantities of wattle bark are also imported.

The best-known wood dyes are from Red Sanders (*pterocarpus santalinus*) which is bright red. It is used in pharmacy. Khair (*Acacia catechu*) wood gives a chocolate colour which also has preservative properties and is thus utilised for dyeing canvas, fishing nets, mail bags, sail cloth etc. The flowers of Palas, *Woodfordia floribunda* and *Nyctanthes arbor-tritis* when boiled in water give an orange colour. Fruits of *Mallotus phillipensis* and roots of *Morinda tinctoria* are also used as dyes.

5. *Gums, Resins* and *Oleoresins:* Gums and resins are exuded by plants, partly as a natural phenomenon and partly as the result of disease or injury to the bark or wood, chiefly from the stems and sometimes even from roots, leaves or other parts. Resins are some-

times mixed with a high percentage of essential oil when they are termed oleoresins.

The most important Indian gum is Karaya obtained from *Sterculia urens* or *S. villosa* trees of the dry deciduous forests. Tapping of *S. urens* has been properly organised in M.P. The gum is a very important article both for internal consumption and more so for export. The value of exports of this gum in 1968-69 was Rs. 2.6 crores. There is a keen demand from the USA, the UK and France. The gum is used in the textile trade, cosmetics, dentrifices, cigar and food industry. The chief producing centres are M.P., U.P., Rajasthan and Gujarat.

The most important resin is that obtained by tapping the Chir pine (*Pinus roxburghii*). It is a flourishing forest industry. (*Also see under* 'Forest Industries').

6. *Drugs, Spices, Poisons and Insecticides:* The number of these products obtained from forests runs into hundreds. Therefore brief mention of some of the conspicuous ones is made here. They are derived from trees, shrubs, climbers, herbs and even from the primitive types of plants and consist of fruits, flowers, leaves, stems or roots. They are administered as solids, liquids, infusions or dust.

Other important drugs are:—

Root and underground parts: Ipecac from *Cephaelis ipecacuanha* is a native of Brazil now being cultivated in Darjeeling, Shillong and the Nilgiris. The production is about 700 kg annually, giving sufficient emetine to treat 25,000 cases of amoebic dysentery.

Liquorice from *Glycyrrhiza glabra* is being cultivated on an experimental scale in Himachal Pradesh, Delhi and Jammu & Kashmir. It has tonic, expectorant, demulcent and mildly laxative properties.

Indian Sarsaparilla is obtained from *Hemidesmus indicus*, a slender, lactiferous, twining, sometimes prostrate or semi-erect shrub occurring over the greater part of the country. This drug, also called Anantmul, is a tonic alterative, demulcent,diaphoretic, diuretic and a blood purifier.

Sarpagandha are the roots of *Rauwolfia serpentina*, a plant growing sporadically in the sub-Himalayan tract and in the plains near the foothills, also in the Western Ghats and elsewhere. It has been ruthlessly collected and natural supplies have almost disappeared. It is now being cultivated. It is found efficacious in high blood pressure as it contains reserpine. In 1968-69, 23 tonnes valued at 3 1/2 lakh rupees were exported.

Kuth or costus are the roots of *Saussoria lappa*, a perennial herb practically confined to the moist slopes of the mountains around the valley of Kashmir at elevations of 3,000 to 5,000 m. In Lahoul and Spiti the villagers cultivate the herb. In medicine it is used as a tonic, stomachic, stimulant and spasmodic. It is principally used as an incense and in perfumery. In 1968-69, 220 tonnes valued at over 8 lakh rupees were exported.

Bark Drugs: Quinine is by far the most important of all Indian vegetable drugs. It is obtained from *Cinchona ledgeriana* and *C. hybrida*. The former is cultivated in W. Bengal and Tamil Nadu and the latter in Tamil Nadu. In 1948 there were 3500 ha. and 1700 ha. of plantations in Tamil Nadu and W. Bengal respectively (not under the Forest Department). Exports in 1964-65 totalled 325,000 kg of bark valued at Rs. 75 lakhs.

Kurchi is the bark of *Holarrhena ante dysenterica*, a shrub or small tree common in tropical forests. As the scientific name implies, it is a remedy against dysentery.

Wood Drugs: Ephedra spp. are small xerophytic plants found in dry places on rocks in the Himalayas over 2,400 m. The alkaloid ephedrine is used in the treatment of bronchial diseases.

Leaf Drugs: Senna pods and leaves obtained from *Cassia angustifolia*, a small plant of southern India. It is a mild laxative. In 1968-69 over 3,000 tonnes were exported, valued at nearly Rs. 60 lakhs. Chiretta comes from *Swertia chirata*, a small erect perennial herb or shrub of the temperate Himalayas at elevations from 1200 to 3000 m. and in Khasi Hills. It is a tonic, febrifuge, laxative and anti-helmintic.

Hemp is from *Cannabis sativa* which grows wild throughout the Himalayan foothills from Kashmir to Assam. It is also cultivated as it is the source of well-known narcotics Ganja, Charas and Bhang. The flowering tops are Ganja, the resinous exudation from flowers and leaves is Charas, the basis for Hashis. Bhang is the drink made out of pounded Ganja. The therapeutic value is due to cannabinol which possesses some marijuana activity.

Drugs from Fruits and Seeds: Kala-zira is the seed of *Carum carvi*, a much valued spice because of its strong agreeable flavour. It is also a stomachic, carminative and lactagogue. The species is largely cultivated at altitudes from 2700 to 3600 m.

Chaulmogra is derived from *Hydnocarpus kurzii* a tree common in Western Ghats. The seed is expressed to get the oil which is considered a specific for leprosy.

Spices: Spices are aromatic vegetable products used in cooking to add aroma or pungency to food and to flavour certain dishes to make them agreeable to the taste, not unlike ginger, pepper and chillies, which are cultivated. The important spices obtained from forests are:—

Galangal from *Alpinia galanga*, a plant found in the Eastern Himalayas and in the Western Ghats. It has perennial rhizomes which are aromatic and pungent. It is also used as a medicine for rheumatism and catarrhal infections.

Cinnamon or *Dalchini* is the bark of *Cinnamomum zeylanicum*, a tree of the Western Ghats, from Konkan southwards upto 1800 m. elevation. It is astringent, stimulant and carminative, also used in candy, gums, incense, dentrifice and perfumes. It has a delicate fragrance and sweet agreeable taste. Indigenous production is insufficient and large quantities are imported.

Ilaychi (chhoti) or lesser cardamom are the dried capsules of *Elettaria cardamomum*, a small plant growing wild in the evergreen forests of south India. The seeds are used as a masticatory, as a flavouring for sweet dishes and as a carminative.

Ilaychi (badi) or greater cardamom is the seed of *Ammomum subulatum* growing in Sikkim forests. It is an inferior substitute for the former. Some 25 lakh rupees worth of lesser cardamoms are annually exported.

Poisons: Substances which by contact with an organism interfere with its well-being and function in a way that causes disorder or even death are referred to as poisons. In small regulated doses, some of them are good medicines. Many forest plants give such substances, such as strychnine, aconite, Datura etc. Barks of various trees are used as fish poisons. Seeds of the twiner *Abrus precatorious* or Gunja made into a paste and inserted in the flesh of cattle, kill them, and are so used by certain tribes.

Insecticides: With the advent of synthetic products like DDT, Endrine etc, plants have lost their value as insecticides. Species of Derris and Tephrosia contain rotenone, an insect poison.

Edible Products: Several forest fruits, flowers and even leaves and tuberous roots are eaten.

Species of which the fruit is eaten with relish are:—

Aam or mango (*mangifera indica*); *Bel* (*aegle marmelos*); *Ber* (*Ziziphus mauratiana*); *Jamun* (*Sysygium cumini*); *Kathal* (*Artocarpus heterophylla*); *Khirni* (*Manilkara hexandra*); *Phalsa* (*Grewia asiatica*); *Sitaphal* (*Annona squamosa*); *Tendu* (*Diospyros melanoxylon*) etc.

Species of which the kernels are eaten:—

Achar (*Buchanania lanzan*); *Akhrot* or Walnut (*Juglans regia*); *Cashewnut* (*Anacardium occidentale*); *Chilgoza* (*Pinus gerardiana*); *Kamal* (*Nelumbo nucifera*); *Singhara* (*Trapa bispinosa*) etc.

Species parts of which are used as pickles or vegetables:—

Amla (*Emblica officinalis*); *Amra* (*Spondias mangifera*); *Anar* or wild pomegranate (*Punica granatum*); *Imli* or tamarind (*Tamarindus indica*); *Karaunda* (*Carissa opaca*); *Kokam* (*Garcinia cambogia*); *Munga* or drumstick (*Moringa oleifera*); *Kachnar* (*Bauhinia variegata*); *Kaith* or wood apple (*Feronia limonia*).

Other edible products are:—

Mushrooms (*Psalliota campestris*) and *Guchchi* (*Morchella esculenta*) found in Kashmir and Himachal Pradesh; ripe fruits of *Alangium lamarckii*; *Zimikand* (*Amorphphallus campanulatus*); Palmyrah palm (*Borassus flebellifer*) which yields *nira*, a refreshing drink (on fermentation this gives the Toddy liquor), the gelatinous coat of immature seeds is also eaten; Mahua (*Madhuca latifolia*), corollas are fermented to get a liquor or eaten after frying, the seed gives edible oil; Indian Butter tree (*Diploknema butyracea*) seed on expressing gives *phulwara* butter; *Shahtoot* (*Morus alba*) fruit is eaten or made into a sherbet; *Bhilama* (*Semecarpus anacar-*

dium) the young fruit is salted and pickled, the oil from ripe seed is used to mark clothes by dhobies; and so on.

Leaves: The most important from the commercial view-point are the leaves of *Tendu* (Diospyros melanoxylon) used as wrappers of tobacco to give *Bidis*. It is a medium-sized tree found throughout the dry forests of the plains, chiefly in M.P., and Orissa and to a lesser extent in Andhra Pradesh, Bihar, W. Bengal, Maharashtra, Tamil Nadu, Gujarat, Rajasthan and southern U.P. The new flush of leaves which are gathered comes out in April-May when the maturing leaves are plucked by women and children, tied into *Gaddis* (bundles) of 50 and spread out for drying in the sun, after which they are stored in godowns. A characteristic feature of the species is the production of numerous root-suckers all round a large tree. Their hardiness and immunity from grazing enables them to establish themselves and then produce large-sized leaves. Governments get a good revenue from the sale of leaves, more so after State trading has been started as in M.P. and now contemplated in other States. The leaf pickers who were being exploited by contractors also earn a better wage. What is far more important, leaf-picking and later *Bidi*-rolling gives employment to the agricultural labour in the slack season to supplement their earnings.

The annual leaf production is estimated at more than 2 lakh tonnes (70,000 in M.P., 50,000 in Orissa; 40,000 in Maharashtra; 32,000 in A.P.; and smaller quantities in other States). Besides internal consumption in cottage industries giving employment to over 2 lakh people, *Bidis* and leaves are exported to Bangladesh, Pakistan, Sri Lanka, Nepal and other Asian and African countries. About 35,000 tonnes of leaves were exported in 1970-71, giving a revenue of over a crore of rupees. *Bidis* have been exported in attractive packets even to the USA.

It would be desirable to increase the production of leaves.

Leaves of the woody climber *Bauhinia vahlii* found in deciduous forests are collected in large quantities and made into plates and leaf cups or else used as wrappers by vendors of sweets etc.

Animal, Mineral and Miscellaneous Products: Lac is the most important animal product obtained from forests. It is a resinous secretion, formed as a protective covering on the bodies of larvae of a hemipterous, minute insect *Laccifer lacca*, living parasitically on the juicy twigs of certain plants and sucking their juice. From the forest point of view the important host plants are Kusum (*Schleichera oleosa*), Palas (*Butea monosperma*), Ber (*Zizyphus jujuba*), and Ghont (*Z. xylopyra*).

Lac has been known in India since ancient times. It is mentioned in the Vedas. Laksha in Sanskrit means, 1,00,000 and obviously refers to the tiny numerous insects seen on the twigs when they emerge and swarm on them. Formerly the more important product was the magenta-coloured dye obtained when the insect-bearing twigs were crushed and washed in water. It was used to colour silk and also as a medicine. Some lac was also used for making bangles. Now it is the lac in its refined flake form that is far more important. It is now used in plastics, electrical, adhesive, leather and wood-finishing industries, chiefly the surface coating industries. It is also the principal ingredient of sealing wax.

India produces about 45,000 tonnes of stick lac annually (nearly 85% of the world production, the only main rival being Thailand), mostly in Bihar (40%), M.P. (30%), W. Bengal (15%), Maharashtra (5%), and smaller quantities in Gujarat, U.P., Orissa and Assam. Only about 5% of this is consumed in the country and the rest exported mostly to the USA, the USSR, W. Germany and the UK earning nearly 5 crore rupees of foreign exchange.

There is a separate Lac Research Institute at Namkum near Ranchi in Bihar.

Other animal products from the forests are honey and wax, *tussar* or *Kosa* silk moths, horns and hides of dead animals, antlers of deer, and ivory.

The mineral products found in forests are building stones, road metal, mica, limestone etc.

Miscellaneous products include leaves of certain species used for various purposes, soap substitutes such as Ritha (seeds of *Sapindus emarginatus* or S. mukorossi) pods of *Acacia concinna* called *Shigakai*, sola pith, ornamental seeds, *Rudraksha* (the drupes of *Elaeocarpus ganitrus* used as beads for rosaries) etc.

CHAPTER V

WILD LIFE

WILD LIFE? This is how we refer to the magnificent animals of our jungles and to the beautiful birds that brighten our lives. I wonder sometimes what these animals and birds think of man and how they would describe him if they had the capacity to do that. I rather doubt if their description would be very complimentary to man. In spite of our culture and civilisation, in many ways man continues to be not only wild but more dangerous than any of these so-called animals.

* * *

Life would become very dull and colourless if we did not have these magnificent animals and birds to look at and to play with. We should, therefore, encourage as many sanctuaries as possible for the preservation of what yet remains of our wildlife.

— JAWAHARLAL NEHRU

But the tiger cannot be preserved in isolation. It is at the apex of a large and complex biotope. Its habitat, threatened by human intrusion, commercial forestry, and cattle grazing must first be made inviolate. Forestry practices designed to squeeze the last rupee out of our jungles, must be radically reoriented at least within our National Parks and Sanctuaries and pre-eminently in our Tiger Reserves. The narrow outlook of the accountant must give way to a wider vision of recreational, educational, and ecological value of totally undisturbed areas of our wilderness. Is it beyond our political will and administrative ingenuity to set aside about one or two per cent of our forests in their pristine glory for this purpose?

—MRS. INDIRA GANDHI *in the message for the inauguration of "Project Tiger"*

GENERAL

By *wildlife* we generally mean the animals and the birds of the wild. The term however carries a much wider and deeper meaning in the field of nature conservation.

Plant and animal communities right from *protophyte* to the most developed tree forms, and from the simplest *protozoa* to the largest mammals exist in nature in a dynamic equilibrium—the balance of nature—involving complexly intermingled and interdependent floral and faunal chains. These communities, jointly referred to as the eco-complex, vary in composition and in mass, both in space and in time, depending upon the habitat factors e.g. the climatic and edaphic characteristics, the inter-action among themselves, and the extraneous influences such as human interference. The term *wildlife* with respect to a locality or region will thus denote the entire animal community therein, covering all forms.

Seen in this perspective, the conservation of wildlife assumes new dimensions directly influencing the human environment, and can hardly be viewed apart from the conservation of forests. This is a far more important facet of wildlife conservation than the more popular facets leaning on the aesthetic and the recreational values or that referring to the now sloganistic *ahimsa*.

Indian Wildlife

The ancient and the existing fauna of the country is discussed in the paragraphs that follow, tracing its decline to the present depleted status.

Situated in the tropics and endowed with a variety of physiognomic characters giving rise to regional climatic and edaphic types, the Indian forests and countryside offer a wide range of habitat-types and this accounts for a large variety in Indian wildlife.

Wildlife in Geological Times: The remains of extinct creatures discovered in the upper layers of the Siwalik range and in other parts of the country give us a glimpse of the wonderful wealth of animal life that flourished here in the Tertiary period. Mastodons and great herds of elephants of many species trumpeted and tramped through the swamps and reedy forests of this region. With them lived hippopotamuses, rhinoceroses of various species, and a colossal four-horned ruminant, the *Sivatherium*. There were troupes of giraffes, large and pygmy horses, camels, and herds of wild oxen, buffaloes, bisons, deer, many kinds of antelope, wild pigs and pig-like creatures. The fossil beds also reveal the existence of chimpanzees, orangutans, baboons, langurs, and macaques. The carnivores included a type of cheetah, sabre-toothed tigers, wolves, jackals and foxes; also civets, martens, ratels and otters. The bears were represented by a species similar to our present sloth bear, the rodents by various genera including mole-rats, porcupines and hares.

Of the ancient literature of the country the most famous are the stories of animals in the *Panchatantra*. Ryder in his excellent translation has observed:

> "Ever since the dawn of civilisation, ever since man first realised the imperative need to know himself and, through that self-knowledge, to win friends and influence people to secure his own happiness and well-being no less than those of his fellowmen, the *Panchatantra* stories have unfailingly offered him significant dynamic aid."

Existing Fauna: Even today more than 500 species of mammals are found within the Indian region. Amongst the conspicuous ones the elephant is associated with the pomp of princely pageantry. Only till a few centuries ago he was widely distributed as far west as Indore, but is now found only in some forests of Mysore, Kerala, Tamilnadu, Orissa, Bihar, Uttar Pradesh and Assam. The one-horned rhinoceros, as borne out by the seals of Harappan culture, was once found as far west as Rajasthan. It has vanished over most tracts and now survives under strict protection in meagre numbers only, in the Kaziranga and Manas sanctuaries of Assam and the Jaldapara sanctuary of West Bengal. The *arna* or the wild buffalo in certain forests of Assam and Bastar (Madhya Pradesh); and the *gaur* or the Indian bison, the largest of the existing bovines, in the southern and central Indian forests, are yet other major herbivores.

Broadly speaking, the distribution of the major mammals in India can be recognised with respect to three zones—the Himalayas, the sub-Himalayan Tarai, and the Peninsula.

There are numerous species of bovines in the western Himalayas. Yak or the ox of the snows is found in Ladakh. Widely tamed in the region, this is used as a draught animal. The *shapu* or *urial, bhoral* the blue sheep, and *nayan*, a huge sheep with curved horns, are the specimens of the sheep tribe. *Serom* and *goral* are the goat-antelopes, which also occur in the eastern Himalayas. The majestic Kashmir *markhor*, the *ibex*, and the Himalayan *thar* are the Himalayan wild goats, the last also found in the eastern sector. The beautiful Kashmir stag, brother of the European red stag and the *kastura* or the musk deer, much sought after for its musk pod, are the only deer of the Himalayan mountains. *Thamin* is a pretty and typical deer found in Manipur. The beasts of prey upto the intermediate range are the tiger and the panther, the higher perennial snow-clad area being governed by the snow leopard. The brown bear and the Himalayan black bear are the bears found in the Himalayan region, the former only westwards from central Himalayas. The red panda inhabits the lower Himalayas in the eastern region. The common and smooth Indian otters, the beech marten and the yellow-throated marten, the Himalayan weasel, and two species of badgers represent the weasel family in the Himalayas. The Himalayan and the Longtailed Marmots are the major rodents of the region, in addition to a few species of squirrels.

The one-horned rhinoceros, the hog deer, and the clouded leopard are the typical animals of the eastern Himalayan foothills. The region also supports a wide range of other mammals, the distribution of which it shares with the peninsular India. Among these the beasts of prey are the tiger and the panther, the other main carnivores being the sloth bear, the fox, the wild dog, a number of feline cats and the Binturong—a civet cat. The chinese pangolin is also found in Assam. The elephants are numerous in Assam and so are the *arna*. The deer tribe includes the *barasinga*, the *sambar*, the *chital* or the spotted deer and the *muntiac* or the barking deer. All the three species of Indian otters, the Ratel, and a few giant and flying squirrels, apart from the Indian porcupine, are also found. The wild pig is quite common.

In the peninsular India the distinctive species are the *gaur*, the *chinkara* or the Indian gazelle, the black buck or the Indian antelope, the *nil gai* or the blue bull, the mouse deer or the Indian chevrotain, the *chowsinga* or the four-horned antelope, the *nilgiri thar*, the Indian lion, and the now extinct cheetah or the hunting

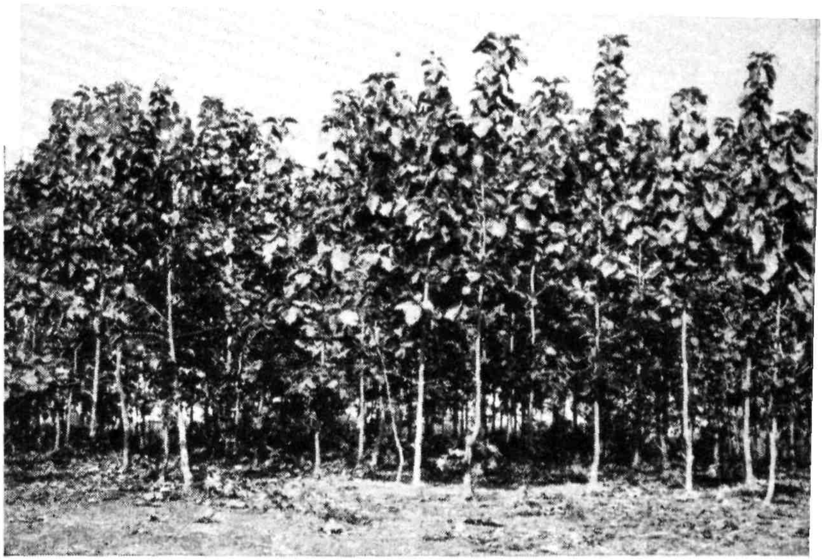


Plate 15 TEAK (*Tectona grandis*) PLANTATIONS, U.P.

(*See page 124*)

Plate 16 DEODAR (*Cedrus deodara*) PLANTATIONS, H.P.

(*See page 124*)

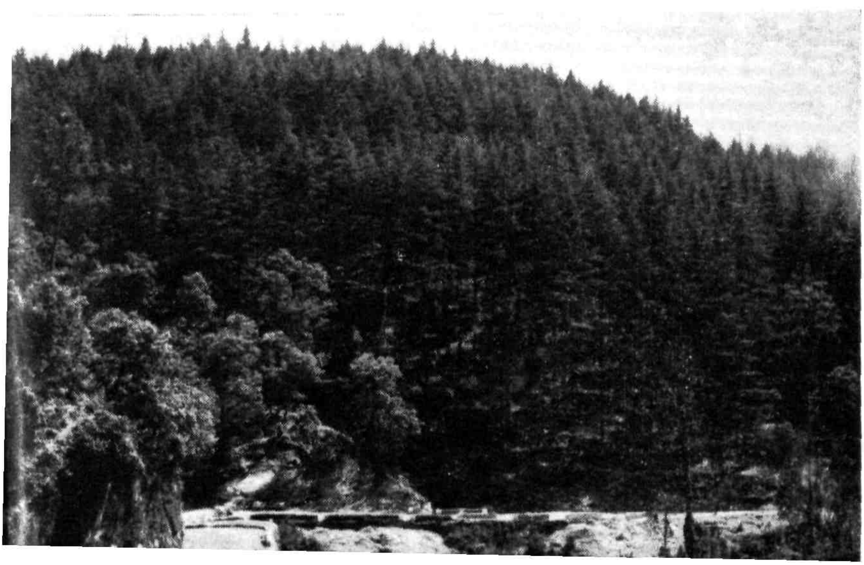


Plate 17

WORLD'S OLDEST TEAK PLANTATION (1846) NILAMBUR, KERALA

(*See page 124*)

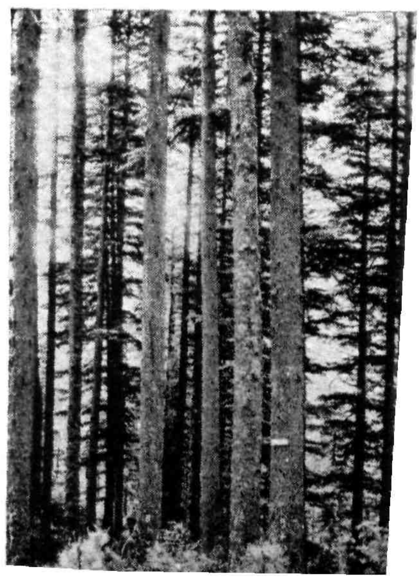
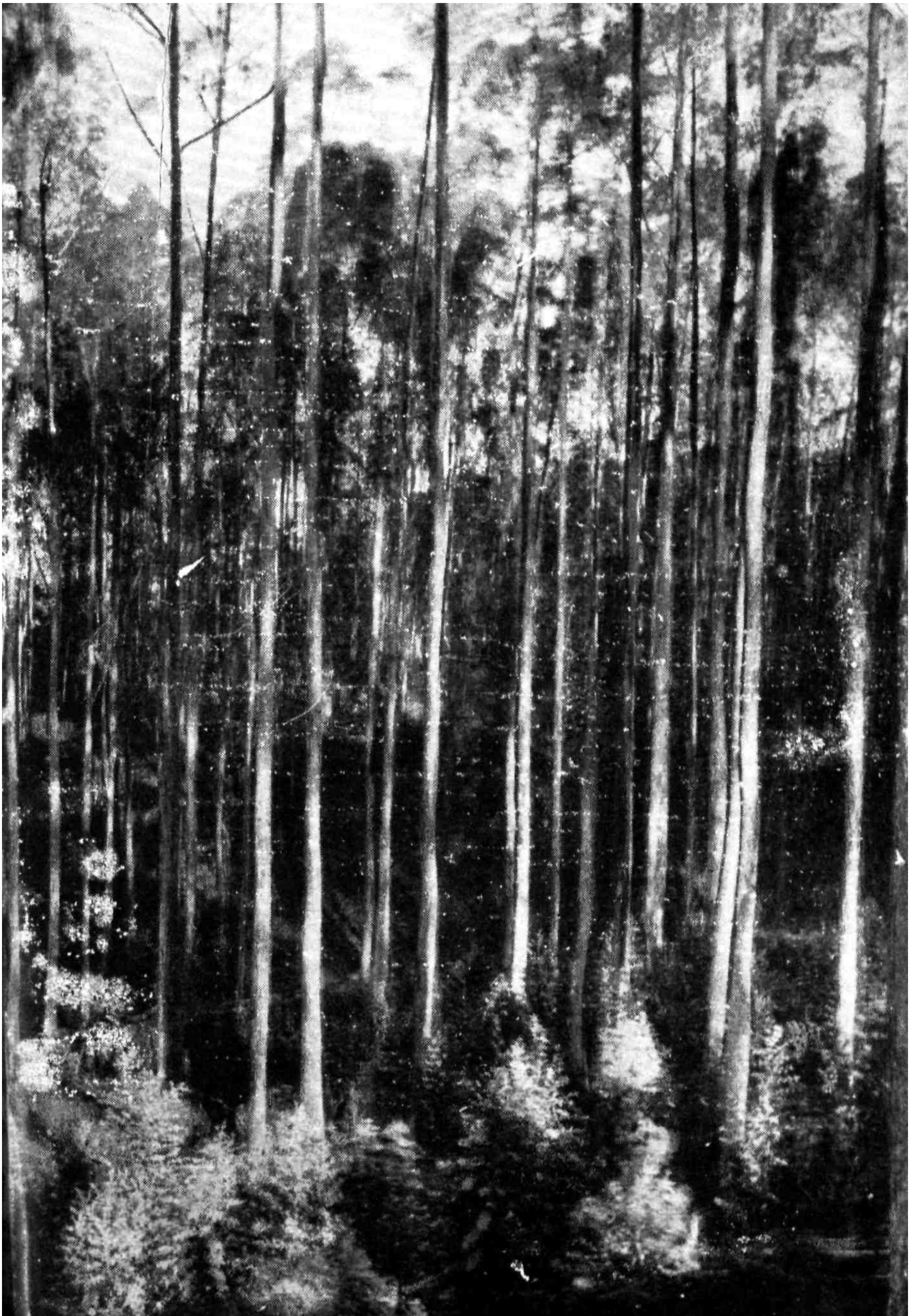
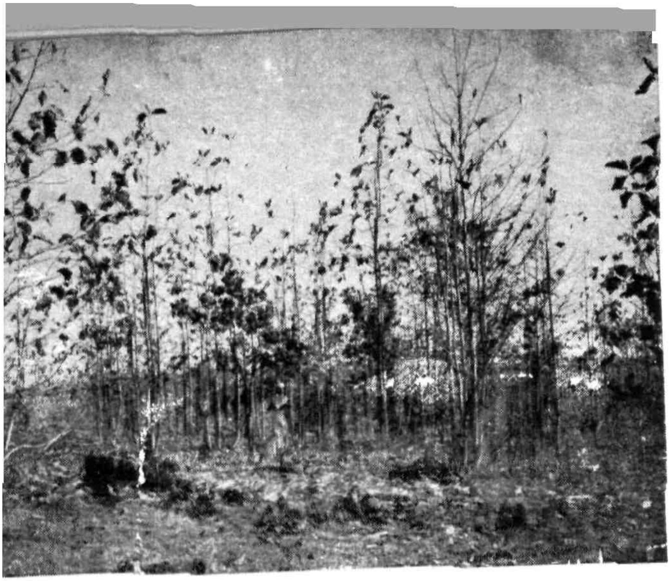


Plate 18

WELL-THINNED FOREST OF DEODAR, PUNJAB

(*See page 127*)





(a)

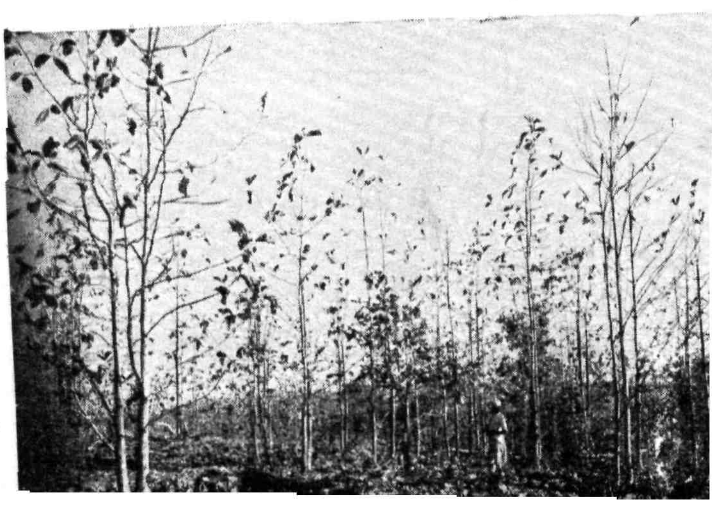
Plate 20 SINGLE STEM SILVICULTURE, M.P. TEAK FOREST

(a) Before Treatment

(b) After Treatment

(See page 127)

(b)



leopard. All the deer species of the Himalayan foothills except the hog deer are also found. Tiger and panther are the widely distributed predators. Sloth bear is also found all over. Other carnivores include a number of cats, the wild dog, the fox, the jackal, the hyena, the mongooses, civet cats and the Ratel. The *arna* is also found in a small segregated population in the Bastar district of Madhya Pradesh. Two species of otters, some giant and flying squirrels, hares and the pangolin also inhabit the region.

Avifauna: The Indian bird life is rich and there are hundreds of species of aquatic, gallinaceous and arboreal birds. A variety of storks, herons, egrets, cormorants, flamingœs and ducks—both resident and migratory—are the chief classes of aquatic birds. Among the waders and shore birds are the snipes, ibises, gulls, cranes, and lapwings. The main ground birds include the Great Indian Bustard, pea fowl, jungle fowl, partridges and quails. There are innumerable species of perchers, some of them excellent song birds. Babblers, barbets, bulbuls, cuckoos, mynas, doves, parakeets, pigeons, rollers, beaters, fly-catchers, hoopoes, drongos, finches, finch-larks, wagtails, warblers, orioles are but a few. Pied Malabar Hornbill is a rare arboreal bird. A variety of owls, eagles, kites, falcons, kestrel and the shikra are the main birds of prey, the scavenging contingent comprising several species of vultures and crows.

A Heritage

The rich heritage of wildlife came down to us through the ages mainly because of the deep-rooted Indian tradition of compassion for all life in general. Moreover, animals have been closely associated with our folklore and legends. Kautilya's *Arthashastra,* written in the 3rd century B.C., refers to definite administrative arrangements for preservation of wildlife. Special areas, called *Abhayaranyas,* were set aside for their protection. Emperor Ashoka introduced game laws, ordained the preservation of forests, and prohibited killing of animals.

Present Status

Over the last few centuries, however, the soaring human and cattle populations have brought extreme pressures upon our natural resources. The onslaught has, moreover, been steered by expediency making light of the principles of rational land use or the need for intensifying the production rather than extensive tapping, causing depletion of potential. This trend keeping pace with the rise in population started making a tangible impact upon the resources-potential during the last few centuries and since the turn of the century has been gaining momentum, so that it has now grown to menacing proportions. Diversion of pasture and readily accessible forest-lands to agriculture and to a host of other purposes and the consequent movement of cattle to the interior forests for grazing has not only wrested a large part of its habitat from wildlife, but has also caused a deterioration in the carrying capacity of the remaining habitat. Improved communications net-work in the forests, versatile vehicles, slackening of the erstwhile totalitarian colonial and feudal controls, and the fire-arms further exposed the wildlife to serious hazards. Infirm statutory provisions aggravated the situation.

Faced with a shrinking habitat, competition from cattle, and poaching hazards, the prospects for wildlife are grim. The wild herbivore populations, which not very long ago were teeming and displayed wide variety in most parts of the country, have become greatly impoverished. Many species have become locally extinct, their habitat having shrunk to a small fraction and even there the number has gone precariously low. Thus of the two sub-species of *barasinga,* that in the sub-Himalayan *tarai* region stands grossly depleted while the once teeming Central Indian hardground sub-species is being helped to fight a last-ditch battle against extinction in the Kanha National Park of Madhya Pradesh—fortunately an upward trend is now reported. The distribution of black buck, *gaur* and *arna* has now become local and scanty. Of the mountain game, the *markhor,* the Himalayan and the Nilgiri *thars* have become scarce. Several species of birds such as the Great Indian Bustard, white-winged wood-duck and the pink-headed duck face extinction. With the base of prey animals largely depleted, the carnivore populations have greatly suffered too. The cheetah or the Indian hunting leopard is now extinct, while the lion is confined only to the Gir

Sanctuary in Gujarat. Even the Tiger has entered a phase calling for intensive conservation efforts to save it from heading towards extinction. Against an estimated population of 40,000 tigers in India at the end of the nineteenth century, less than 2,000 are now left. The panther population has also been decimated.

PRESERVATION

The ability of widlife to survive depends upon the capacity of a particular species to withstand the onslaught of adverse environmental factors operating in its habitat—the forest, the scrub, the cultivated fields, the marginal waste lands and pastures, the marshes, the lakes and the rivers—the availability of ample food, and above all, conditions favourable for breeding and living unmolested. The natural predators are a part of the balance of nature and each pre-species counters the depletion from this agency by a combination of the scheme of self-preservation and breeding. Ravaging of the habitat by man and the reckless destruction with the aid of equipment and human skill, however, are factors against which even the mightiest of the beasts are helpless. Our wildlife has already suffered progressive decimation from these adverse factors. What makes it worse is the lack of public understanding and sympathy for the need of conservation.

For effective conservation in any region it is essential to ensure rigid protection accompanied by intensive effort towards re-amelioration of the habitat. Needless to say, such an intensive programme cannot be extended to the entire forested area of the country, for reasons of sheer vastness and paucity of financial resources. The only plausible approach would be to constitute more and more suitable and interior areas into national parks and sanctuaries, with rigid protection and efficient habitat—development-oriented management at the hands of a whole-time organisation within the Forest Department.

MEASURES ADOPTED AND PLANNED

Some sanctuaries and special game reserves were created in the British regime from the thirties onwards. More often than not in such sanctuaries the silvicultural requirements of tree crops took precedence over aims of wildlife management. However the protection standards being good, because of rigid controls, these proved to be good repositories of game.

In independent India the first important step was the constitution of the Indian Board for Wildlife in 1952. The Board is an advisory body created for advising the Government on the means of conservation and protection of wildlife, constitution of national parks, sanctuaries and zoological gardens, promoting public interest in conservation of wildlife in harmony with natural environment etc. The Board has been rendering valuable service in this field. Some States enacted special statutes aiming at wildlife protection and several national parks and sanctuaries were created in the country. By and large, however, the enforcement of law for wildlife left a lot to be desired and over the general forest areas, liquidation continued and so also continued the deterioration of wildlife habitats. Except in a few national parks and sanctuaries, the management was generally below par.

The Bombay Natural History Society—an old and honoured nature conservation body—also helped from time to time, in bringing into focus the threatened species or areas. The holding of the meeting of the International Union for Conservation of Nature & Natural Resources (IUCN) at New Delhi in 1969, gave an opportunity to make an assessment of the status of wildlife in the country. Since then with the blessings of the Prime Minister Smt. Indira Gandhi, several noteworthy steps have been taken.

New comprehensive legislation: Legislatures of the eleven States of the Indian Union viz. Andhra Pradesh, Bihar, Gujarat, Haryana, Himachal Pradesh, Madhya Pradesh, Manipur, Punjab, Rajasthan, Uttar Pradesh and West Bengal resolved to delegate their law-making power with respect to the wildlife to the Parliament. Accordingly the Wildlife (Protection) Act, 1972, was enacted by Parliament in September 1972. This is a comprehensive law giving firm status to the national parks and sanctuaries and other game reserves, extends effective statutory safeguards to the entire geographic area of the States concerned, prescribes potent control over the trade and traffic in wild animals and animal articles laying down deterrent punishment for the miscreants. The act has been promulgated in the aforesaid eleven States and all the Union Territories since early 1973. If all States follow suit and support the law by effective enforcement, much of the lost ground can be rapidly regained.

Project Tiger: Another cardinal landmark in the field of wildlife preservation has been the launching, in April 1973, of the Project Tiger—a wholly centrally financed Project with some assistance from the World Wildlife Fund.

Recommendations for the launching of the Project came from the Indian Board for Wildlife, which constituted a special task force to assess the status of the tiger in India and to prepare a broad scheme for the preservation of this supreme predator in good numbers in ecologically viable habitats.

Under the Project the following nine Tiger Reserves varying in extent from 400 to 1,000 sq. km. have been created in different types of habitats:

1. *Manas* (*Assam*): Representative sample of eastern foothills of rainfall and semi-evergreen to evergreen forests.
2. *Palamau* (*Bihar*): The eastern peninsula with interesting association of sal and bamboo forests.
3. *Simlipal* (*Orissa*): Moist miscellaneous forests of the east.
4. *Corbett Park* (*Uttar Pradesh*): The Central foothills of the Himalayas with sal as the predominant species.
5. *Ramthambor* (*Rajasthan*): The dry deciduous open forests of the Aravalis and the Vindhyas, in the West.
6. *Kanha* (*Madhya Pradesh*): The central highlands of the peninsular India, of sal and miscellaneous forests.
7. *Molghat* (*Maharashtra*): The deciduous forests dominated by teak and bamboo.
8. *Bandipur* (*Mysore*): Represents the miscellaneous forests of the Western Ghats.
9. *Sunderban* (*West Bengal*): Representative of the tiger's estuarine habitat.

Although given the name after the Tiger, the Project symbolises a comprehensive wildlife conservation effort for the simple reason that the Tiger is at the apex of the pyramidal eco-complex, the intermediate and the base strata of which are constituted respectively by the prey animals (herbivores) and the vegetation. An ecologically viable habitat for the tiger presupposes the incorporation of a viable base of herbivorous prey animals supported by an adequate foundation of the fodder supplying vegetation. Needless to say, the protection of the habitat and the animals from extraneous damaging and disturbing causes is another vital prerequisite.

Thus in each tiger reserve, a sizeable area has been set apart as the core where there will be no forestry operations. Other programmes under the Project include rigid protection against poaching and fires with the help of additional personnel equipped with wireless net-work and vehicles, habitat development by stopping grazing, evacuating villages, creating water bodies and the like. Systematic wildlife research by Indian scholars under the auspices of the Indian Universities is also planned. Extension activity to educate the public in favour of wildlife conservation is also proposed to be carried out.

Effective implementation of this Project, success of which is now quite evident will go a long way in regaining much of the lost glory of Indian wildlife.

Other Measures: More and more national parks, sanctuaries and zoological gardens are being created all over the country. There are now seven national parks and nearly a hundred sanctuaries in different parts of the country. Sanctuaries are also being created for individual threatened species. Special conservation efforts are also being made to protect endangered species in existing national parks and sanctuaries. More funds are being allocated for the development of national parks and sanctuaries in different States. Creation of the whole-time wing within the Forest Department is in various stages of implementation in some States. Almost all States have Wildlife Advisory Boards.

It may be relevant here to mention that like the forests, the wildlife is a renewable natural resource and if all the planned programmes are effectively executed, in a few decades we should again have teeming populations in several tracts and can even poise ourselves for scientifically regulated cropping.

The immense recreational value of the wildlife reserves in the present machine-age cannot be overemphasized. Besides, wildlife tourism can be increased manifold to bring sizable returns in the shape of foreign exchange and the generation of employment potential in the tourist-industry.

IMPORTANT NATIONAL PARKS AND SANCTUARIES

Assam	(i)	Manas (North Kamrup)—for wild buffalo and rhinoceros. *Nov-March.**
West Bengal	(ii)	Kaziranga—for rhinoceros, hog deer, barasinga, etc. *Feb-March**
		Jaddapara (Jalpaiguri district)—for rhinoceros. *Feb.-March**
Bihar	(i)	Hazaribag National Park, *Feb.-May**
	(ii)	Palamau National Park—for Gaur *Feb.-May**
Gujarat		Gir Sanctuary—for Indian Lion.
Karnataka		Bandipur Sanctuary—for elephant, gaur. *May-Sept.* Ranganthattu Bird Sanctuary. *Nov.-Jan.*
Kashmir		Dachigam Sanctuary—for Kashmir stag *May-Oct.*
Kerala		Periyar Game Sanctuary—for elephant and gaur. *Jan.-March*
Madhya Pradesh	(i)	Kanha National Park—for tiger, barasinga, gaur, black buck etc. *Mar.-June.*
	(ii)	Shivpuri National Park—for chinkara, *Dec.-May.*
	(iii)	Bandhogarh National Park—for tiger, sambar, nilgai. *March-June*
Maharashtra		Taroba National Park—for tiger and bear. *March-June*

*Best months for visiting.

Rajasthan	(i)	Bharatpur (Keolaghana) Bird Sanctuary. *Sept.-Feb.*
	(ii)	Sariska Sanctuary—for tiger, panther. *Jan.-June*
	(iii)	Ranthambore Sanctuary—for Sambar. *March-June*
Uttar Pradesh	(i)	Corbett National Park—for tiger, elephant, hog deer, gharial. *March-April*
	(ii)	Rajaji Game Sanctuary. *April-May*

To summarise, wildlife is an integral part of the forests and thus needs to be preserved for scientific purposes and for affording recreation, by very careful management. Nature has endowed India with a magnificent asset of wildlife which, even in the present depleted condition, will compare favourably in its variety and beauty, if not in numbers, with that of any other region in the world. The efforts made to protect species threatened with extinction should be pursued with redoubled vigour, because it is obvious that a species evolved as a result of thousands of years of evolutionary process when extinct will be lost for ever as the self-styled *Homo sapiens* (Man the Wise) will not be able to reproduce it.

The tiger has now been declared the national animal of India and the peacock the national bird.

CHAPTER VI

FOREST CONSERVANCY AND POTENTIAL PRODUCTIVITY

Flying to his Teheran meeting with Churchill and Stalin, Franklin D. Roosevelt looked below to discover the Biblical land of milk and honey. Instead, an uninterrupted desert of rock and stone unfolded under his eyes and made him shudder at the thought that this was the last act in the tragedy of forest destruction. As soon as he got back to Washington, he sent for his friend and Chief of the Forest Service, to ask him how close the United States was to similar disaster. 'Not yet, Mr. President,' was the answer, 'but without adequate legislation we might well reach that point one day'.

—E. GLES INGER

SOIL EROSION

FORMATION of soil as a result of integration of the sub-soil and decomposition of the vegetative debris through the activity of micro-organism is an extremely slow process: a layer one centimetre thick may be formed in more than a century. On the other hand soil in a forest is liable to get quickly eroded through the action of rain or wind, unless it is adequately covered by vegetation. Hence the need for adopting soil conservation measures in the practice of forestry. A well-managed and properly stocked forest reduces soil run-off. Rain water is absorbed by the humus and then it seeps into the sub-soil and finally moves underground, thus keeping the streams flowing perennially. Forests thus mitigate floods which can otherwise do immense damage to agricultural land in the lower region. A typical example is provided by the ravines along the Chambal which were formed after the forests in its watershed were destroyed by over-felling, gazing, and fires.

By erosion is meant the removal of soil and rock material by water, wind and gravity; generally at an accelerated rate in an environment disturbed by animal life, chiefly man. Erosion caused by water produces *gullies*, or more or less straight channels, called *rills;* erosion of a fairly uniform layer of material from the land surface, often scarcely perceptible, especially when caused by wind, is referred to as *sheet* erosion.

SOIL CONSERVATION

Soil Conservation deals with the preservation of soil against deterioration and loss, by using the land within its capabilities, and applying those conservation practices that are necessary for its protection and improvement. More especially, it consists in the use of land within the limits of economic practicability and in safeguarding it against impoverishment or depletion by erosion, deposition, exhaustion of plant nutrients through leaching, excessive cropping or over-grazing, accumulation of toxic salts, burning, waterlogging, improper use, and failure to protect the land from soil loss or impairment of productiveness. Scientific management of forests is the most effective soil conservation method which has now been practised in the country for over a century. Soil conservation in the agricultural lands received national priority only after India became independent. A Central Soil Conservation Board was set up in 1953 for initiating, organizing, and coordinating research and development in soil and water conservation, training personnel of the States, and acting as the principal agency to ensure the implementation of the programme.

In the First FYP period mainly spade work was done. At a cost of Rs. 1.6 crores 120,000 ha of land was treated, including contour-bunding on arable land over 60,000 ha, and afforestation, grassland development, etc., over 4,555 ha. In the Second FYP a million ha of agricultural land and 200,000 ha of forest and other lands were treated, covering ravines, hilly tracts, wastelands, deserts and denuded forests. Pilot schemes were started in the catchments of river valley projects. During the Third FYP a very high priority was given to the work and actually 4.7 million ha of different types of land was covered, including contour-bunding and terracing, afforestation, closure to grazing, pasture development, etc. A special scheme of soil conservation in the catchments of river valley projects was initiated. In the Fourth FYP emphasis is being laid on collecting detailed information on soil characteristic, topography, hydrology and vegetative cover for each watershed.

In the last 20 years over 185,000 million cu.m. of water has been stored by initiating 500 major and minor schemes, which has resulted in an irrigational potential of 17.40 million ha at a cost of Rs. 1,300 crores, i.e., over 20% of the cultivable land. The total catchment area of projects completed or nearing completion is over 75 million ha.

One fact that came to the notice was that the silt load of the reservoirs was far greater than contemplated. A preliminary study of 13 selected projects has shown that nearly 50% of the catchment is already under cultivation, while the area classified as forests (including denuded forests) is barely 25%, and the balance is wasteland, practically devoid of protective vegetative cover. This points to the need for reafforestation of the bared land to minimise silting.

Upto 1966-67, a total area of 0.4 million ha had been treated with various soil conservation measures. On the forestry side, these generally consisted of large-scale closure to grazing accompanied by water disposing devices, contour trenching, gully plugging, etc. Large areas of old private forests which were denuded during the transitional period of their being taken over by Government, had to be rehabilitated by cultural operations and protection.

Even at this early stage interesting evidence has become available that engineering works like silt detention dams in catchments upto 400 ha have given good results.

In terms of production, the scheme has made a phenomenal progress in certain tracts, namely, increased production of grass, wood, etc., and large areas have been planted up with Eucalyptus.

The most important prophylactic soil conservation measure is to protect forests against fire, control grazing in them, and maintain an uninterrupted vegetative cover. Various preventive methods are also used depending upon the intensity of erosion.

(*a*) *Contour trenching and bunding:* Where the soil run-off is heavy, small bunds of earth and boulders can be made by digging trenches and heaping the spoil earth on the lower side. The flood water, loaded with silt is thus caught by the drain and the silt deposited at its bottom allows only clean water to flow over after the ground gets saturated. A simple device for fixing the direction of contour trenches is shown in Diagram 1. It is a wooden frame

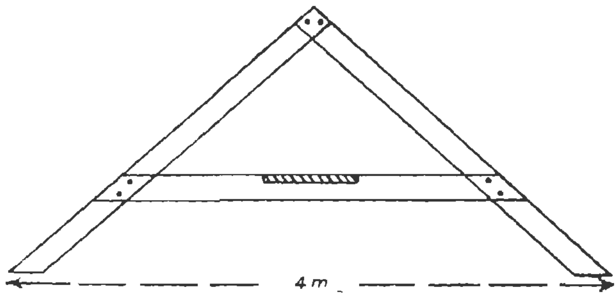


Diagram 1. Simple Contouring Device

with a spirit level fixed on it. A peg is driven at the point from where the trench is to commence and one end of the frame is placed near it. The other end is moved along the ground until the bubble in the level is in the centre; another peg is driven at this point. The frame is then swung round through 180° so that the first end then finds a point at the same level, and so on. The most commonly adopted design of a trench and ridge is shown in Diagram 2. In the rains, seeds of soil binding species are sown in the soil filled in

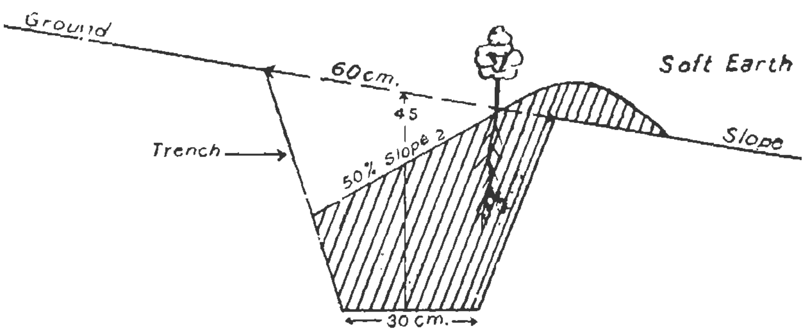


Diagram 2. Contour Trench Layout (Vertical Cross Section)

the trenches to afforest the area. Such trenches are generally not more than six metres long and they are staggered. The vertical distance between them depends on the slope of the land, the nature of the soil and the intensity of rainfall. Usually seeds of Neem, Bakain, Khair, Siris, Babul, etc., are sown on these trenches in Madhya Pradesh.

(*b*) *Terracing:* The commonest type in this group is referred to as bench terracing. Platforms or benches are cut into the hill in a step-like fashion and supported by almost vertical retaining walls made with rocks and earth, or by vegetation. The bench is sloped slightly into the hill to prevent water from flowing over the edges of the terrace and cutting them. Diagram 3 shows how these terraces are made.

(*c*) *Gully Plugging:* Where gullies have been formed, to prevent them from gaping wider and to close them they are plugged by brushwood weighted down with stones and logs and covered with stones or bricks and earth.

(*d*) *Check Damming:* After a watershed has been trenched and gully-plugged the natural drainage channel is obstructed by a structure which retards the flow of run-off and induces deposition of silt and debris; it allows the main current to flow over the dam or over a lowered portion on it. Such a check-dam may be a stone wall or a wall of interlaced brushwood with a pitching of bricks, or stakes and wattle. Just below the over-flow an apron of stones and rubble is built to prevent scouring. If the ravine gapes widely a pucca dam is built to prevent soil run-off and eventually to fill it. When a series of drains are built the height of the lower one is practically at level with the base of the next upper one.

(*e*) *Stream Training:* After check-damming, the stream bed is reclaimed to afforest it. This is done by confining the stream to a narrow channel. Low spurs are made by putting cuttings of such plants as *Vitex negundo*, etc., more or less parallel to the stream flow. When sufficient soil has been deposited, the reclaimed area is afforested, or used for growing fodder.

(*f*) *Legislation:* To carry out contour bunding, soil conservation and other land improvement measures effectively, suitable

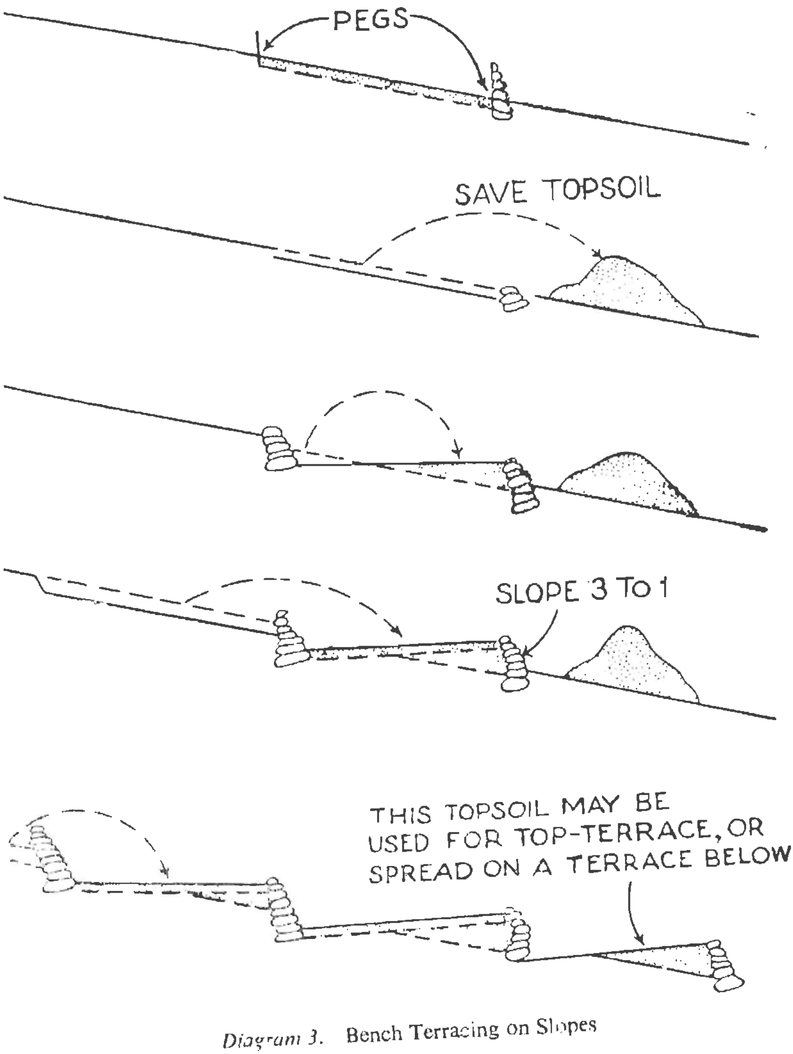


Diagram 3. Bench Terracing on Slopes

legislation is a prerequisite where it does not already exist, to empower the Government to frame suitable schemes with the help of land owners.

Potential Productivity of Indian Forests

A forester is expected to aim at getting the maximum production from forest lands. The Swedish geographer, Paterson, has estimated the potential productivity of the accessible forests of the world under ideal management. He has argued that of the various ecological factors, the interaction of which determines the ultimate resultant tree growth in a locality, the most important is climate. The main climatic factors are *precipitation, warmth* and *light*. He has suggested as a convenient qualitative measure of productivity of a forest, the yield under natural conditions, per hectare, per year, from a crop 100 years old and refers to this as the *site-class*. When a forest is so managed that it gives the *highest* economic yield by selecting the species, treatment and rotation, the annual production is referred to as the *ideal site-class*. But this is not necessarily the *absolute maximum* economic yield, as it can always be bettered by suitably modifying the various factors which govern tree growth and costs. The productivity figure defining site-class is distinct from *increment* which is the accretion in volume in a specified period. It may be high when the crop is young and growing vigorously, or low when it is nearing maturity. Indeed, there may be no net increment when a crop is over-mature. On the other hand, by definition, the site-class figure remains unaltered so long as the forests are allowed to grow naturally. The ratio between the actual increment per year, per hectare, and the site-class figure will depend on the 'cultivation level', or the degree of improvement of a forest. Under ideal management, maximum increment may be obtained in perpetuity. In such conditions, it will be equal to the ideal-site class. To measure the ability of a site for plant growth in a particular climate, and to express it as an index and then to correlate it with site-class, Paterson has evolved a formula by giving due weightage to the climatic factors which mainly govern plant growth. As this index is dependent on *Climate, Vegetation* and *Production* he has called it the CVP index, from the initial letters of these words. His formula is:

$$\text{CVP index or } I = \frac{Tv}{Ta} \quad \frac{P}{12} \quad \frac{GE}{100}$$

where Tv is the temperature of the warmest months;
Ta is the annual range of temperature of the warmest months, i.e., the period when the monthly average is 3°C or more;
P is the annual precipitation in millimetres;
G is the length of the growing season in months depending on precipitation and temperature;
and E is the 'evapo-transpiration reducer'.

The CVP index thus derived and the values of the various symbols in the above formula for some of the stations of India used by Paterson are given in the sub-joined table, arranged in the ascending order of the value of the index:

TABLE 12

POTENTIAL PRODUCTION

CVP index range	*Station*	*CVP index*	*Tv*	*Ta*	*P*	*G*	*E*	*Potential production m³/ha/yr*
Under 25	Leh	20	17.5	23.3	328	2	-	Non-productive
25 to 100	Bikaner	31	34.2	29.4	292	2	46	2.05
100 to 300	Srinagar	181	24.5	21.4	645	6	49	0.3
	Allahabad	248	33.6	18.3	900	4	45	3.6
	Khandwa	297	27.5	12.1	676	4	44	5.2
300 to 1000	Jabalpur	488	30.0	13.5	1463	4	45	6.27
	Seoni	636	29.7	11.7	1367	5	44	6.9
	Ranchi	764	26.0	9.4	1473	5	45	7.73
1000 to 5000	Madras	1140	31.6	7.4	1243	6	43	High
	Dhubri	1520	28.0	9.8	2362	6	45	9.12
	Sibsagar	1730	28.12	13.5	2396	9	46	9.29
	Trincomalee	2670	30.0	4.1	1491	7	42	10.43
	Palghat	3560	31.4	4.4	2034	7	42	11.47
5000 and above	Trivandrum	3160	27.7	2.6	1538	9	42	V. high
	Honavar	6700	29.1	3.2	3508	6	42	12
	Cherrapunji	9210	20.3	8.4	10160	10	45	12.93
	Alleppey	15500	29.1	1.8	3414	8	42	Over 12.93

The last column gives for the particular range of I, the estimate of the potential productivity, in m^3/ha/yr, derived from the formula $Y = 5.20 + \log X - 7.25$, where Y is the potential productivity, and X is the CVP index.

The potential production of the accessible Indian forests has been worked out as under:

TABLE 13

POTENTIAL PRODUCTION OF INDIAN FORESTS

CVP index range	*Cubic metres per hectare per year*	*Area in million hectares*	*Production*		*Consumption*	
			Potential (*M.m*^{3})	*Actual*	*Total M.m*^{3}	*Per hectare* (*m*^{3})
Under 25	Nil					
25-100	0-3	2.0	4.1			
100-300	3-6	3.0	14.6			
300-1000	6-9	20.5	148.3			
1000-5000	9-12	5.0	48.6			
5000 & up	Over 12	0.5	6.5			
		31.0	222.1	15.8	16.25	0.05

This shows that 31 million hectares of 'accessible' forests of India with a potential productivity of 222.1 million cubic metres, actually produce only 15.8 million m^3 of wood. The consumption (which slightly exceeds production) is 16.25 million m^3, i.e., only 0.05 m^3 per capita, 90% of which is in the form of fuelwood. A reasonable figure for the present stage of development would be 1.0 m^3, and 90% of it should be used as industrial wood. If our natural resources of climate and soil are properly harnessed by selecting valuable and fast growing tree species, and modern techniques are employed for planting, tending and harvesting, the *per capita* share of wood used industrially could be increased manifold. It is to this end that the future management should strive. Figures of production and consumption of wood in certain countries are given below:

TABLE 14

PER CAPITA WOOD PRODUCTION AND CONSUMPTION

Country	Production	Consumption	
	$M.m^3$	Total $M.m^3$	Per capita (m^3)
Pakistan	1.52	1.59	0.92
Nigeria	0.62	0.50	0.02
India	15.80	16.25	0.05
Thailand	3.75	3.63	0.16
Spain	8.00	8.17	0.30
Turkey	8.08	8.77	0.34
U.K.	2.45	23.08	0.52
Czechoslovakia	9.55	8.35	0.67
Rumania	15.00	15.00	0.94
U.S.S.R.	501.62	495.17	1.90
U.S.A.	273.67	301.68	2.05
Canada	99.39	47.78	3.43

CHAPTER VII

ORGANISATION

FOREST SERVICES

ALL government-owned forests in the Union Territories are under the administrative control of the Government of India and those in the States under the respective State Governments.

The government of India forests are administered through the Ministry of Agriculture under whom works the Inspector General of Forests (IGF), the head of the Forest Services of the country, and who is also *ex-officio* the Additional Secretary. He is in charge of all matters relating to Forestry including Wildlife at the Centre; but no forests are directly under his administrative control.

Besides his other duties, the IGF scrutinises the 5-year Plans of the States and Union Territories and recommends financial allocations; represents India in international forestry conferences; makes recommendations to the Ministry for award of foreign scholarships or fellowships for specialisation under the various training programmes; and, at the request of the State or Union Territories, inspects their forests and makes suitable recommendations concerning their management.

At Delhi, under the IGF, work Dy. IGF (general); Dy IGF (Wildlife); Secretary, Central Forestry Commission; Director (Project Tiger); Asst. IGF (Industries); Asst. IGF (Wildlife); Asst. Director (Forests Statistics); Tech. Officer (Plan) and Tech. Officer (Forest Industries).

At Dehradun the IGF has under him the Forest Institute comprising: Sec. I, Forest Research Institute & Colleges; Sec. II, Pre-Investment Survey and Logging Training Centre; and Sec. III, Forest Development (Planning, Industries and Delhi Zoological Park).

In the States and Union Territories there are separate Forest Departments. The head is, depending on the extent of forests and the work involved, either a Chief Conservator of Forests (CCF), a Conservator of Forests (CF) or a Dy. Conservator of Forests (DCF), except that since 1974 M.P. has two CCFs and over them a Conservator-in-Chief as the administrative head. The head of the Forest Department is responsible for executing the Forest Policy of the government and also acts as its professional advisor.

The CCF's charge is divided into a number of 'Circles' each under a CF. For all practical purposes, a CF is the primary unit of Forest Administration as he is reckoned as the head of a department. His main duties are to keep in contact with the Collectors within his jurisdiction to find out if the people are experiencing any difficulty because of the prescriptions of the working plans and if so how they could be mitigated within the general framework of the forest policy and the objects of management. He has also to see that the silvicultural and other prescriptions are being properly followed and are having the expected result, and if not to bring the facts to the notice of the conference that will be convened to consider such matters before taking up the revision of the working Plan.

The Conservator's charge is divided into a number of Forest Divisions in charge of generally a Dy CF or a senior SFC officer. A Divisional Forest Officer (DFO) is the immediate controlling and executive officer for his charge. All sales, exploitation of the forests, their regeneration, tending and protection, the construction and maintenance of forest roads, buildings, wells etc., are his special responsibilities. Also, he is answerable to his CF for the proper execution of works, collecting forest revenue and controlling the expenditure on establishment and works.

Forest Divisions are parcelled out into a convenient number of Ranges in charge of Range Officers (RO) who are trained Rangers. A Ranger has to tour the forests in his charge for about twenty days in the month to supervise various works in progress, to make payments to the staff and labour and to personally do some cultural works such as thinnings and markings, and above all to watch the contractors' work to see that fellings etc., are carried out in a businesslike manner and there are no illicit removals. Another important duty of an RO is to detect forest offences and to later hold enquiry into them and send his findings to the DFO for levying compensation, and then to recover it from the offenders. Indeed Forest Rangers are the backbone of the forest department.

Each Range is sub-divided into 3 to 5 sub-Ranges variously called Circles, Sections or Rounds, in charge of Deputy Rangers or senior Foresters. Their main work is to protect the forests and supervise the various works going on, register offences and collect compensation etc.

And, finally, the lowest rung of the Forest Department personnel is the Forest Guard. Their primary duty is to patrol the forest sector entrusted to them, called a 'beat', to see that it is not being damaged by pilferers or by graziers. In the fire season special fire watchers are appointed to clear fire lines and to watch the forest from towers to locate fires, if any take place, inform his superiors, and organise labour to put it out. There are FGs on other special duties such as checking removal of produce from the forests, Coupe Guard to supervise contractors' works, etc. Most FGs are trained and as they are continuously in the forests they have time to observe various operations. There have been instances when intelligent and observant FGs have devised methods of planting, protection etc. which have proved very useful. A typical example is the well-known method of raising plantations of teak by sticking out in the ground not seed or seedlings but what have been called root-shoot cuttings. This method was originally conceived and carried out by a Forest Guard.

There are a number of Functional Charges on which Forest Officers are appointed CCF, Dy CCF, CF, DCF, ACF, ROs, Foresters, and even FGs. Such works are Working Plans, Surveys, Plantations, Research, Nationalisation, Wildlife Management, Planning and Statistical work etc.

The total forest-personnel as on 1.4.1973 is shown in Table 14a.

Central Board of Forestry

To coordinate the forest works in the various States and Union Territories there is a Central Board of Forestry of which the Union Minister in charge of Forests is the Chairman and Forest

TABLE 14A

FORESTRY PERSONNEL EMPLOYED AS ON 1.4.73†

A. (Superior Service)

State/Union Territory	*CCF*	*Addl CCF*	*Dy CCF*	*CF*	*Dy CF*	*ACF*	+	*wild life warden*	*map office*	*others*	*Total*
State											
Andhra Pradesh	1	1	—	11	38	87	—	—	—	—	138
Assam	1	—	—	5	30	45	—	1	—	—	82
Bihar	1	—	1	8	43	43	6	2	—	—	104
Gujarat	1	—	1	6	31	21	4	—	—	3	67
Haryana	1	—	—	2	7	8	—	—	—	—	18
Himachal Pradesh	1	—	—	7	27	57	5	1	1	4	103
Jammu & Kashmir	1	—	—	7	23	59	2	1	—	10	103
Karnataka	5	—	—	12	53	76	2	1	—	—	150
Kerala	2	—	—	8	13	41	—	1	—	—	65
Madhya Pradesh	2	—	2	17	106	262	3	1	—	—	393‡
Maharashtra	1	1	—	15	72	143	23	1	—	4	260
Manipur	—	—	—	1	2	9	—	—	—	1	13

Meghalaya	—	—	—	1	4	3	—	—	—	—	8
Nagaland	1	—	—	1	6	1	—	—	—	—	9
Orissa	1	1	—	9	69	97	—	—	—	—	177
Punjab	1	—	—	3	13	12	1	1	1	—	32
Rajasthan	1	—	1	6	24	39	—	17	—	—	88
Tamil Nadu	1	—	—	8	35	39	5	—	—	3	91
Tripura	—	—	—	1	10	21	1	—	—	8	22
Uttar Pradesh	1	2	—	12	70	112	6	1	—	—	204
West Bengal	1	1	—	6	38	26	1	1	—	4	78
Union Territory											
Andaman & Nicobar Is.	1	—	—	2	7	10	1	—	—	3	24
Arunachal Pr.	1	—	—	2	12	8	1	—	—	1	25
Dadra & Nagar Haveli	—	—	—	—	1	—	—	—	—	—	1
Delhi	—	—	—	—	1	1	—	—	—	—	2
Goa, Daman & Diu	—	—	—	1	4	3	—	—	—	—	8
Mizoram	—	—	—	1	—	1	—	—	—	—	2
All India	26	6	5	152	739	1205	61	29	2	42	2267

†Economists, Engineers, Statisticians
**Forest Statistics* Bulletin, no 7, Revision no 2
‡In 1975 there were 1 Conservator-in-chief, over 2 CCFS and 4 Dy CCFs

TABLE 14A (*Contd.*)

FORESTRY PERSONNEL EMPLOYED AS ON 1-1-73*

B. (Subordinate Service)

State/Union Territory	*Rangers*	*Dy. Rangers*	*Foresters*	*Forest Guards*	+	*Total*	*Ministerial*
State							
Andhra Pradesh	279	284	920	2871	1344	5698	1136
Assam	164	109	719	962	77	2031	377
Bihar	216	—	649	3116	68	4049	474
Gujarat	208	—	757	2207	96	3263	1947
Haryana	55	33	167	790	53	1098	359
Himachal Pradesh	217	177	534	2312	55	3295	374
Jammu & Kashmir	233	—	774	1844	1901	4752	449
Karnataka	396	—	1209	3517	1160	6292	1041
Kerala	179	36	560	1535	48	2358	369
Madhya Pradesh	931	571	2903	12412	283	17100	3479
Maharashtra	534	—	2334	6615	766	10249	870
Manipur	12	3	53	73	116	257	32
Meghalaya	17	7	58	101	46	229	(a)

Nagaland	16	12	57	122	—	207	36
Orissa	447	60	1904	5283	—	76924	691
Punjab	62	35	169	660	—	926	167
Rajasthan	195	54	1015	2328	35	3622	581
Tamil Nadu	241	—	912	1280	1170	3603	568
Tripura	53	—	259	470	52	834	160
Uttar Pradesh	317	402	1046	3128	5169	10062	3881
West Bengal	228	—	863	1737	—	2828	1346
UNION TERRITORY							
Andaman & Nicobar Is.	25	35	75	48	—	183	86
Arunachal Pradesh	57	26	128	134	—	345	65
Dadra and Nagar Haveli	3	—	11	37	1	72	16
Delhi	3	3	6	38	—	50	10
Goa, Daman & Diu	21	—	50	208	4	283	20
Mizoram	3	4	47	99	—	153	(a)
All India	5107	1851	18189	53942	12444	91533	18528

*Supervisors, Game wardens, Game keepers etc.
+*Forest Statistics*, Bulletin no 7, Revision No. 2
(a) Included under Assam

Ministers of States/Union Territories are Members. The Secretary of the Ministry in charge of Forests and the IGF are also members and the President, FRI, a special invitee. The board meets annually in different States and considers policy, and other matters of national importance.

FOREST RESEARCH

Forest being a State subject, the primary responsibility for the management and administration of the forests is that of the respective State governments. The Central government is charged with the responsibility for the formation and implementation of high level forest research (and education, dealt in the next Section) which it discharges with the help of the Forest Research Institute and Colleges (FRI & C) and its three Regional centres located at Coimbatore, Bangalore and Jabalpur.

The functions of the FRI and its Centres are to undertake research, both basic and applied, on various problems relating to forestry, forest biology and utilisation of forest products; to establish liaison with State forest departments and industries utilising forest raw materials; to disseminate results of research through publications; to organise study tours, seminars and exhibitions; to advise various Government departments on matters relating to forest and utilisation of forest products.

The main building of the FRI was constructed in 1928, an estate covering an area of 520 hectares, four miles west of Dehradun, with the beautiful hill station of Mussoorie in the background. In 1951 it was recognised by the Food and Agricultural Organisation of the United Nations as a centre for training and research in forestry and forest products for South East Asia.

The FRI comprises three Directorates of Research: (i) Forestry, (ii) Forest Biology, and (iii) Forest Products. The chief executive is designated the President. A registrar looks after general administration, Budget and Accounts.

The President is in charge of the common services like Statistics, Editorial Board, Publicity and Liaison, Library and Documentation. The Statistical branch, created in 1947, helps the various branches in planning their experiments, viz., statistical designs, sample surveys, etc. A manual on sampling techniques for forest surveys has been published.

The Editorial Board revises old forestry literature published by the Institute, such as *Silviculture of Indian Trees, Manual of Forest Utilisation*, etc. The Board published *One Hundred Years of Forestry* in two volumes in 1961, *Handbook of Indian Forest Statistics*, 1957-68, (1961), *Timber Trends and Prospects in India*, 1961-75, (1961), *Indian Forests and Forest Products Terminology, Glossary of Terms on Nature Conservation and Management* etc.

The Publicity and Liaison branch brings to the notice of the various industries and the public the results of research and their practical value by direct correspondence and discussions, by issuing illustrated pamphlets, arranging exhibitions, erecting hoardings and posters, preparing broadcasts and speeches, and by film shows. It also makes arrangements for various conferences, symposia etc., at the Institute.

The Institute has a big library and documentation section, now housed in a separate air-conditioned building with latest books on forestry and allied sciences with facilities for research scholars.

The disciplines under the three Directorates are distributed as under:

FORESTRY

1. Silviculture (General), containing the Sections of Plant Introduction, Seed Testing and Experimental Silviculture, Documentation and General;
2. Silvics, covering Ecology, Physiology and Forest Influences;
3. Forest Soils, covering Soil Chemistry, Soil Physics and Petrology;
4. Minor Forest Products Section dealing with collection, Harvesting and Introduction;
5. Management and Mensuration;
6. Forest Genetics;
7. Logging; and
8. Forest Economics.

The work under various Sections includes, *inter alia,* natural and artificial regeneration of different types of forests and their management, standardisation of nursery and plantation techniques, studies on afforestation and soil conservation measures in different climatic and soil types, introduction and trials of economically important exotics, provenance trials, standardisation, auto-ecological, synecological and field research, and nutritional requirements and plant physiology of forest crops, studies on forest productivity, forest soils, their characterisation and correlation with forest growth, hydrological and micro-climatic studies, collection and analysis of Sample Plot data, preparation of Volume and Yield Tables, documentation of forestry literature, its dissemination and publication. Forest Genetics branch is concerned with the improvement of the genetic qualities of important forest plants. The work involves surveying of forests to find superior strains and individual *plus* trees, to assess these in terms of their value to forestry, the registration of seed stands, their silvicultural treatment to eliminate inferior phenotypes and in the case of *plus* trees, their vegetative propagation in seed orchards to provide source of genetically superior seed. Cytogenetics, induction of polyploidy etc., on which attention is at present concentrated, are perhaps not very important at this stage. The logging branch conducts research on logging practices, efficiency and suitability of basic tools and mechanised equipment for different types of forests and the economics of various operations. Forest Economics deals with economics of various forestry operations, demand and supply of forest produce, market trends etc.

FOREST BIOLOGY

1. Forest Pathology;
2. Forest Entomology;
3. Wood Anatomy; and
4. Systematic Botany

Forest Pathology branch conducts studies on decay in living trees and root diseases of important species. Forest rusts have been studied and a monograph published. Investigations are being conducted on mycorrhiza of tree roots and its role in plant growth. The branch maintains a collection of about 9000 specimens of plant diseases and about 900 fungal isolates.

Forest Entomology branch conducts fundamental and applied research on ecology, biology, epidemilogy, survey and pest situation, systematics and control of insect pests causing damage to standing trees, plantations, nurseries, felled logs, converted timber, finished products of wood-based industries, raw material for pulp and paper industries; collects, codifies and maintains all information pertaining to forest insects so as to serve as a central bureau on the subject; advises State forest departments on suitable methods of control of insect epidemics in forests and in plantations; and also advises wood-based industries and private individuals. Besides, it conducts systematic study involving identification, maintenance and expansion of the main reference collection of insects which contain about 20,000 authentically named specimens.

Wood Anatomy branch has a big timber 'library' comprising over 16,000 specimens belonging to over 1600 Indian and 3000 foreign species. Some volumes of Indian Woods have already been published, dealing with the structure, identification and properties of over 2000 species. Recently, anatomical studies on the structure of gum- and fibre-yielding species have been started.

The Botany branch was started in 1906. It has done a vast amount of work in systematics of Indian forest flora and issued several publications. It has built up a Herbarium which today houses over 2½ lakh specimens, including nearly 1200 irreplaceable types or cotype specimens.

FOREST PRODUCTS

1. Cellulose and Paper;
2. Chemistry of Forest products;
3. Timber Mechanics;
4. Timber Engineering;
5. Composite Wood;
6. Wood Working and Saw Milling;

7. Wood Seasoning; and
8. Wood Preservation.

The Cellulose and Paper branch in its early years evolved a process for using bamboos for making paper. The branch tests various cellulosic raw materials to find out their suitability for making pulp and paper. Recently it has tested specimens of mixed hardwoods which are available in large quantities for use in the paper industry.

Chemistry of Forest Products branch tests the oils, tannins etc. yielded by the various forest plants.

Timber Mechanics branch is well-equipped to carry out almost any kind of testing, except fatigue tests, but has been mostly engaged on routine determination of the strength properties of various timbers. This has helped in the use of indigenous woods for various purposes such as tool handles, sports goods, ammunition boxes, tea chests etc.

Timber Engineering branch deals with research regarding the best utilisation of woods for structural purposes. A technique has been evolved for using nail-jointed, short-length, small-dimension pieces of even secondary species for structures such as trusses, beams, roofs etc. A number of structures have been erected in different places in the country for demonstration of their suitability. The branch has also evolved designs to prevent termites from entering buildings.

Composite Wood branch undertakes the study of problems of 'improved wood' like plywood, compregnated wood, building boards etc., to devise methods of overcoming the disadvantages of natural woods, such as warping, knottiness, cross-grain etc. Various processes of *improving* wood, namely compression, impregnation with resins, lamination etc., are being experimented upon.

Wood Working and Saw Milling (including finishing) branch deals with the study of the working properties of woods both conventional and hitherto not used to determine the best method of utilising them.

Wood Seasoning branch has designed a number of air-seasoning kilns and sheds including veneer dryers. It has drawn up schedules for kiln seasoning of important timber species. The branch has also developed tools for making pencils by hand.

Wood Preservation branch has tested several patented preservatives both in the laboratory and in the 'graveyard', and railway sleepers, poles etc., under service conditions. Treating processes for various Indian timbers have been developed and simple tanks have been designed for treating.

The Coimbatore Research Centre is concerned with regional problems in entomology, mycology, silviculture and soil science. The Bangalore Centre conducts research in Spike diseases of sandal trees, wood preservation, wood anatomy and chemistry of minor forest products. The Jabalpur Centre has two wings: Forestry and Biological. The former includes General Silviculture, Soil Ecology and Seed, and the latter comprises Entomology and Forest Pathology.

New Orientation in Forest Research

The *interim* report of the National Commission on Agriculture concerning forest research has made, among others, the following suggestions:

1. Forest research should be regrouped into (i) Forestry and Biological research; (ii) Industrial and Utilisation research, and (iii) Forest Management and Operational research including statistics, economics and marketing research. Forest Research should be organised at three levels—State, Regional and National.

2. Facilities required for carrying out basic and applied forest research should be built up in the Agricultural Universities. Other Universities may also do this.

3. The State forest departments should confine themselves primarily to applied research of a local nature in the field of forestry, forest biology and forest management. They should also undertake adaptive research in social forestry and survey of forest soils with a view to delineate them.

4. Industrial research, which requires a large capital investment, special expertise and expensive equipment should be the responsibility of the Centre. It should include studies on the development and/or pilot plant stage. There should be a well organised

unit of industrial design to expedite commercial exploitation of proven pilot experiments.

5. The FRI should continue to be the premier Institute and enjoy the status of a national Institute.

6. The Forest Corporations and forest-based industries should have their own research sections, and may simultaneously extend financial support to the Central, State or university research organisations;

7. For the purpose of dissemination of research results and keeping track of their application in the field, there should be Development Officers in the Centre and the State research institutes.

In the Five Year Plans, the total funding for forest research and education should not be less than 1% of the forestry and logging sector's contribution to the Gross Domestic Product at current prices.

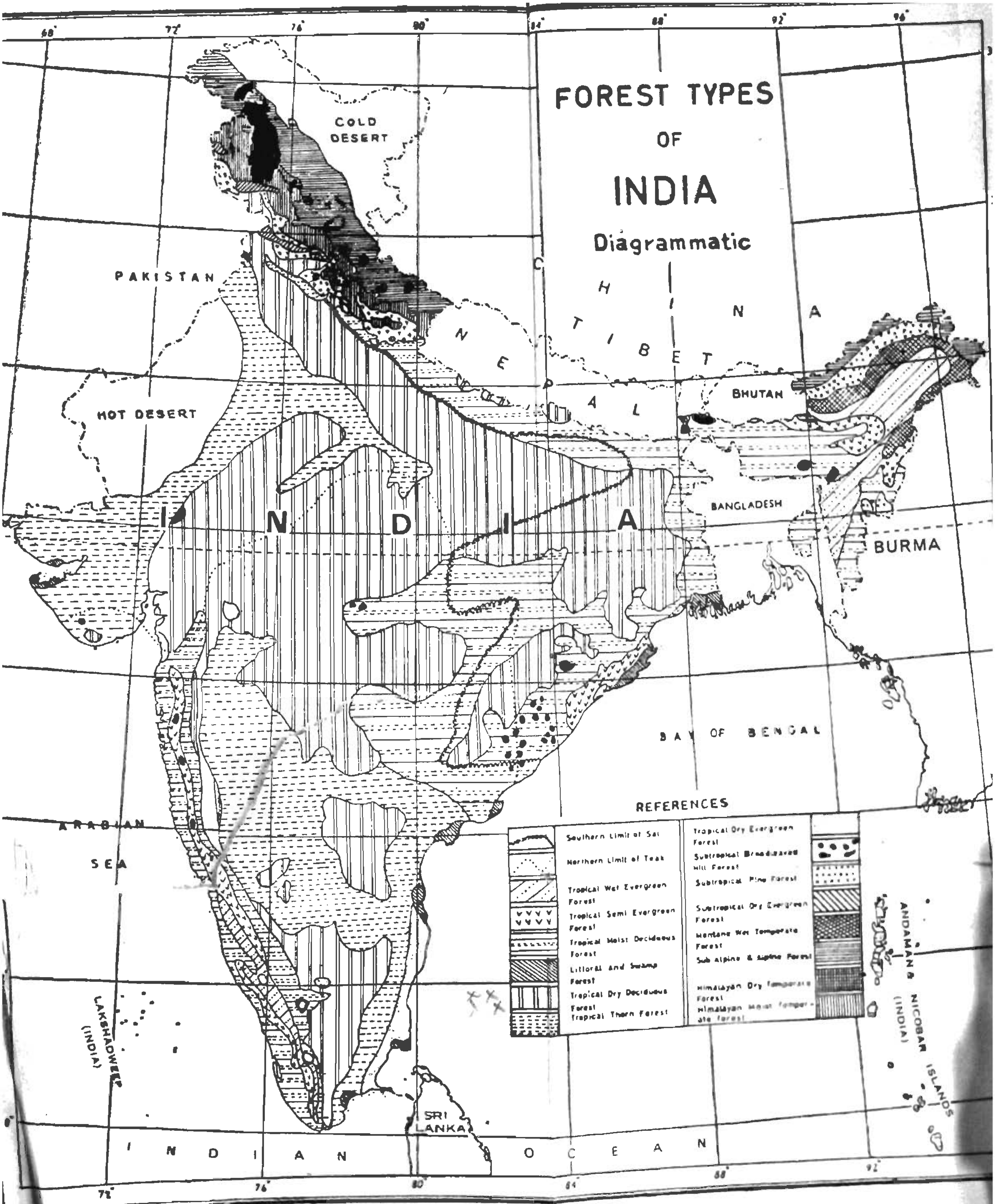
Forest Education

Professional training is imparted to the personnel recruited for service in the Forest Departments, in different grades, as under:

1. Indian Forest Service;
2. State Forest Services;
3. Forest Rangers;
3. Deputy Rangers/Foresters; and
5. Forest Guards

Indian Forest Service: This service was started way back in the 'sixties of the last century. Officers were trained first in Nancy (France), then in Hanover(Germany), later in Cooper Hill (England), thereafter in the universities of Oxford, Cambridge and Edinburgh, and after 1962 at Dehradun. Recruitment was discontinued in 1942. The service was revived, and initial recruitment was made from the serving officers, by selection, with effect from 1st October 1966.

Since then candidates are being selected, to the extent of expected vacancies, by an all-India open competitive examination conducted by the Union Public Service Commission. Only graduates in Science, including Agriculture, Engineering, Economics, Mathe-



sed upon Survey of India map with the permission of the Surveyor General of India
Government of India copyright, 1978.
Territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

matics and Statistics are allowed to compete. Ex-commissioned officers are given some concessions.

In the test, a candidate has to offer, besides General English and General knowledge, any two of the following subjects:

> Agriculture or Agricultural Engineering; Botany; Chemistry or Chemical Engineering; Civil Engineering; Geology; Mathematics; Mechanical Engineering; Physics and Zoology.

The selected candidates have to join at Dehradun for undergoing training at the Indian Forest College (IFC) for two years including a dissertation on a selected subject. Thereafter, they have to do a Foundation Training Course of four months at the National Academy of Administration, Mussoorie, with the probationers of the Administrative and Police Services.

The in-service teaching at the IFC includes —

1. Silviculture; Land Management and Soil Conservation; Forest Protection; Forest Mensuration including Elementary Statistics; Forest Management; Forest Valuation and Working Plans; Forest Utilisation including Timber Technology; and Forest Policy (Forest Economics, Public Relations and World Forestry are proposed to be included).
2. Allied Subjects: Botany; Forest Zoology; Wildlife Management; Geology; Soil Science; Surveying & Drawing; Forest Engineering: Timber Mechanics and Soil Conservation Engineering.
3. Special Dissertation.

Besides practical work connected with lectures, the class has to do field work in the New Forest and tour various forests of the country to see forests and forest works.

Forestry is now going through a period of global development particularly in the technical sphere. A trained forester is now expected to have knowledge of Industrial Planning, Environmental Conservation etc. New sophisticated techniques using aerial photography and photogrammetry, advanced statistical methods and computer technology are finding more and more use in forestry planning.

On successful completion of the training the candidates are awarded the "*Associate of Indian Forest College*" (AIFC) Diploma, and then allotted to various States and the Centre for appointment as Assistant Conservator of Forests (ACF).

It would be desirable to have an all-India seniority list at least for confirmed Conservators and then to freely shift them from one State to another to give them wider experience and as a measure of national integration.

In so far as popularising the knowledge of forestry is concerned to make people forest-conscious and enlist their willing cooperation in protecting the forests, the *interim* report of the National Commission on Agriculture has made some far reaching recommendations. Some of these are—

1. The Agricultural Universities and others which are to undertake forest research, should include Forestry as one of the subjects in the under-graduate course, the scope being gradually widened to graduate, master's and doctorate degrees;
2. The syllabus of Forest Education should be carefully drawn up by a National Committee; and
3. The FRI should organise Graduate, Master's and Doctorate degree courses in Forestry.

State Forest Services: For these services the candidates are selected by the respective Public Service Commissions. Selected candidates are then deputed as stipendiary students to Dehradun for two years' training at the IFC along with the IFS probationers. Efforts are being made to give them training separately.

Forest Rangers: The Training of Forest Rangers was started as far back as 1878 at Dehradun, by the then N.W. Province (now U.P.). The School was taken over the Government of India in 1884 and has been run as a centralised institute for training forest rangers for the whole country. In 1948 a college run by the then Madras State at Coimbatore was also taken over by the Government of India and called the Southern Rangers Forest College, and therefore the Dehradun college was called the Northern Rangers Forest College.

In 1974 yet another college has been started in W. Bengal, at Kurseong and called the Eastern Rangers Forest College. In all the three Rangers Colleges training is imparted through the medium of English. The Government of India have recently decided to open another forest college in Meghalaya, at Burmihat, eight kilometres from Shillong.

Now that in several universities teaching is done in the colleges through the medium of regional languages for example, in Hindi in the States of Madhya Pradesh, Uttar Pradesh, Haryana, Himachal Pradesh etc.,—and as Hindi has been declared the national language of the country and technical terms in Forestry and other allied sciences have been coined by the Education Ministry of the Government of India, it is time a Rangers College was started where the training will be given in Hindi. The most suitable place will be Jabalpur where sufficient land has been acquired by the Government of India and regional Research Centre of the FRI has been started. Jabalpur is the seat of an Agricultural University and the medium of instruction in the Jabalpur University is Hindi.

The minimum academic qualifications for admission are Intermediate Science or an equivalent examination of any recognized university with at least two of the following subjects—Physics, Chemistry, Botany and Zoology.

Candidates have to first pass a qualifying examination held by the President, FRI, in English Dictation, English Essay, Mathematics of Matriculation standard and General Knowledge, which includes elementary science, geography and current events.

Candidates who have qualified appear before a Board presided over by the Head of the Forest Department or his nominee for *viva voce* and selection. The selected candidates are sent to one of the Rangers' Colleges for two years training. Here they are taught—

Main subjects: Forestry; Forest Utilisation; Botany; Forest Engineering; Surveying and Drawing.

Accessory Subjects: Physiography and Geology; Soil Science; Forest law; Procedure and Account; Wildlife Management.

Besides practicals connected with the lectures, the course includes field instructions and practical training in the Experimental Forest and tours which extend to selected forests of the country. At the end of two years' training, which is primarily meant to give the candidates sufficient insight into their work as Forest Rangers, the successful candidates are awarded Certificates—Higher and Lower Standard.

The in-service training and teaching of the candidates for the IFS, SFS and Rangers services, is the responsibility of the Centre. Subject to the supervision of the Inspector General of Forests, who enjoys the status of a Joint Secretary, the administrative control of the Colleges vests in the President of the FRI. The IFC is under a Director and the Ranger Colleges under Principals. The lectures are delivered by Forest Officers on deputation from the States and by the Research personnel of the FRI and the Regional Centres.

Other Training Courses

The FRI also offers facilities for (i) Silvicultural Research and Statistical Training, (ii) Short course in Soil Science, (iii) Short Course in use of Hydrological and Climatological Instruments, (iv) Use of Basic Tools and Modern Logging Equipments and Methods, (v) Extension Course in Forest Botany and Forest Entomology, (vi) Advance Diploma Course in Pulp and Paper technology, and (vii) Advance Diploma and Certificate Course in Seasoning and Preservation of Timber.

State forest officers can also avail of the training courses by the Indian Council of Agricultural Research for soil conservation and by the Indian Photo-Interpretation Institute, Dehradun, for specialised studies in photogrammetry and interpretation of aerial photographs.

The FRI also offers Fellowships for post-graduate and doctorate studies in Forestry and allied subjects to University students.

Technical and Vocational Training in States

There are Schools in the States for training Deputy Rangers, Foresters and Forest Guards in regional languages. One difficulty experienced by the Instructors is the absence of suitable text book in forestry subjects in the regional language. Now that the Hind

Directorate of the Education Ministry of the Government of India has prepared comprehensive English-Hindi glossaries in most sciences, including Forestry, and also in other subjects and most of the equivalents are derived from Sanskrit, writing of forestry books should not be very difficult, especially as government are offering very lucrative terms for writing original books in forestry using the standardised equivalents. Such books will go a long way in stimulating the interest of foresters of lower ranks in forestry and also encourage them to express their views based on observations.

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PART II

FORESTRY

CHAPTER VIII

SILVICULTURE

DEFINITION AND SCOPE

Silviculture is the art and science of cultivating forest crops as distinguished from Silvics which deals with the study of the life history and general characteristics of forest trees and crops, with particular reference to environmental factors as basis for the practice of silviculture.

Cultivation of forest crops consists of *regeneration*, namely, renewal of forest crop after the standing, old or decrepit crop is removed, by natural or artificial means; and *tending*, that is carrying on operations from time to time for the benefit of the growing crop during its lifetime. It essentially covers operations on the crop itself and on competing vegetation by weeding, cleaning, thinning and even improvement fellings; also pruning, climber cutting and girdling of unwanted growth, but *not* regeneration fellings, nor ground operations like soil working, drainage, irrigation and controlled burning. Weeding implies removal of all unwanted plants that interfere or tend to interfere with the growth of the favoured species, whereas cleaning, usually done in the sapling stage crop, involves the removal or topping of inferior growth, including individuals of the favoured species, climbers, etc., when they interfere with the better grown individuals of the favoured species. Thinning is a more skilled operation described later; so are improvement fellings. Pruning is removing live or dead branches or multiple leaders from standing trees for the improvement of the tree or its timber; whereas girdling is cutting through the bark and outer living layers of wood in a continuous incision all round the bole of a tree, also sometimes called ringing.

As against this, *cultural operations* is a general term for works, as a rule not directly remunerative, undertaken to assist or complete existing regeneration, to promote the proper development of the crop, or to minimize the after-effects of felling damage. These, therefore, include subsidiary felling, weeding, cleaning, unremunerative improvement fellings, and thinning in groups of advance growth, girdling or poisoning of unwanted growth, climber cutting and even piling felling debris and controlled burning, but usually not other ground operations, nor pruning.

Natural Regeneration

To secure natural regeneration of the desired species at the proper time it is necessary to study the ecological conditions obtaining on the forest floor and to alter them to such an extent that regeneration is induced and then it survives and gets established. The manner in which natural regeneration of important species is being obtained is as follows:

(*a*) *Teak:* In the moist teak forests which contain a large number of other mesophilous species in the upper canopy, a dense lower storey, as also a thick cover of grasses and shrubs, natural regeneration does not come up. These forests are therefore regenerated artificially. The same is the case with the very dry, almost pure stands of teak. Here the soil is practically devoid of humus because of annual fires, it has also become very hard due to unrestricted grazing and tamping by livestock. By carefully manipulating the canopy over a series of years, by opening it up in the moist and closing it in the dry forests, suitable conditions can be brought about, in which fallen teak seed germinates naturally. The semi-moist forests of Betul in Madhya Pradesh are being regenerated in this way.

(*b*) *Sal:* This species regenerates naturally in the forests of Bihar and parts of Madhya Pradesh without any difficulty, but not so in Uttar Pradesh where, after experiments extending over a series of years, an elaborate technique has been evolved to induce natural regeneration. It consists of fencing the area to keep out deer and domestic animals and then making 'pepper-pot' openings in the canopy. The forest is also fire protected, and shrub cutting is carried out to free individual Sal seedlings that come up. After a number of years a full crop of seedlings is obtained. After this the canopy is gradually removed so that the seedlings grow to a size when they cannot be killed by frost. On the whole this is a very long and expensive process. Perhaps it would be better to obtain artificial regeneration by the Taungya method or else to plant another species which is more valuable and grows faster.

(*c*) *Deodar:* In the Deodar forests of Manali in the Punjab regeneration is being obtained under the shelter-wood compartment system. On the Shankaracharya Hill in Srinagar the Deodar, introduced artificially, is now regenerating naturally.

Artificial Regeneration

When a forest is under-stocked, or contains many mal-formed trees of several species only a few of which are utilisable as timber, and these are slow growing, or when on clear felling the existing growth, a new crop of the desired species does not come up naturally, the forest is regenerated artificially. Sometimes seed of valuable species is broadcast in the forest if there is a reasonable chance of its germination. In Madhya Pradesh in certain mixed forests of inferior species, teak seed was broadcast or dibbled at regular intervals before the monsoon. After a few years some teak plants were noticed. When these grew up and seeded, the proportion of teak steadily increased. Today teak is the predominant species and is naturally regenerating in these forests. In certain forests in Maharashtra teak is introduced by sowing or planting in patches called *rabs*, after the fallen debris is burnt and the ashes are spread uniformly. Proportion of desirable species can also be successfully increased by underplanting. Bamboos have thus been introduced in certain forests. But the commonest method is to clear fell the old wood and to restock the area with desired species by methods now standardised as a result of repeated experiments and research. Of the various species which are being utilised for creating such plantations the most important is teak. As early as 1846 a plantation of teak was made in Nilambur, now in Kerala. A part of this plantation is still surviving as a preservation plot. This is the oldest teak plantation of the world. The technique of creating teak plantations has since been considerably improved and is now being extensively utilised for creating plantations of this valuable species wherever it can grow satisfactorily. In general, it may be briefly described as under:

Teak seed from genetically superior mother trees is collected and sown on nursery beds in or around March. If the seed is obdurate, as in the dry teak forest where it has a hard seed coat, it is pre-treated by alternate drying and wetting after which it readily germinates on sowing. When the seedlings have developed two leaves they are pricked out on a transplant bed, 7.5 cm. × 7.5 cm., sideshaded, watered and weeded regularly. When the plants have developed a stem about the thickness of the thumb, they are pulled out and stumps prepared from them by cutting with a sharp instrument, the shoot portion 3 cm. above the collar and the root about 25 cm. below it. These stumps, also called root-shoots, are bundled and carefully taken to the plantation site and planted out, just before the rains in most forests, and in the dry forests after the first rain, 2 m. × 2 m., in crowbar holes; the soil around them is properly tamped. A dose of fertilisers is sometimes given at this time and again after a couple of months. After the plants get established they make rapid progress and a height of 3 metres is not uncommon in one season.

In Kashmir, plantations are being raised of Deodar, willow, etc. In Himachal Pradesh attempts are being made to create plantations of silver fir. The latest development is the creation of large-scale plantations of *Eucalyptus tereticornis* from Karnataka which has been found to be very fast growing and which succeeds in a variety of climates from sea coast to an elevation of 2,500 m., and in places with rainfall ranging from 750 mm. to 3,500 mm. The nursery and plantation technique has been worked out in great detail and plantations giving nearly cent per cent survivals are being raised. Large plantations have been created in Karnataka, Kerala, Uttar Pradesh, etc. The cost works out to about Rs. 500-700 per ha. and plantations are expected to yield after 10 to 15 years 70-100 m^3/ha. of industrial wood.

The main advantages claimed for artificial regeneration are quicker and surer results, more uniform and adequate stocking, certainty of regulating the composition of the crop, concentration of work, rapid early growth and better returns on outlay. On the other hand it temporarily exposes the soil, is more expensive, and requires a larger labour force. Ordinarily natural regeneration is preferred when it can be obtained with reasonable expedition, certainty and cost. Only when this is not possible, or a change of species is considered desirable artificial regeneration is resorted to. The choice of species for artificial regeneration depends on site-suitability and the object of management.

To reduce the cost of artificially restocking an area as also to produce some agricultural crop, as long as this can be done without interfering with the forest species, the method of agri-silviculture or *taungya* is used. This is also used to wean the tribals of the baneful practice of shifting cultivation. The extent of area planted under important forest species up to the end of 1965 was—

Teak	191,000	hectares
Other broad-leaved spp.	642,000	,,
Encalyputs species	80,000	,,
Conifers	21,000	,,
TOTAL	934,000	,,

THINNING

After a forest has been regenerated, the principal tree species and other vegetation begin to compete for the growing space and a struggle for existence sets in. Tending the species proposed to be grown thus becomes necessary. This consists of hygienic operations, such as weeding, cleaning and climber cutting as distinct from site-ameliorative operations, such as soil working, trenching, manuring, burning, etc.

When plants of the principal species reach the sapling stage, competition *inter se* sets in, and fellings are needed to reduce congestion. The best stems are retained and given the optimum freedom for development. This operation is called *thinning.* Technically it is defined as a felling made in an immature stand for the purpose of improving the growth and form of the trees that remain, without permanently breaking the canopy, viz., the cover of branches and foliage formed by the crowns of trees in a wood.

Technically speaking, thinning is a felling made in an immature stand, beyond the sapling stage, for the purpose of improving the growth and form of the trees that are *left, without* permanently breaking the canopy. The intensity and frequency *of a thinning* is determined for each type of crop by careful experimentation to secure a particular objective, such as clean timber, maximum *quantity of poles, fuelwood, bark etc. Various methods of thinning* forest crops have been evolved. They are all based on the fundamental fact that even when young trees in a crop are growing uniformly spaced they show wide differences in quality and vigour because of hereditary factors, past history or micro-climatic variations. Generally speaking one of the two principles is followed: the classical or the *negative* approach, where inferior stems are selected for felling or 'culling', and the modern, or the *positive* approach, where the best developed stems are singled out for retention or 'selection' and given the optimum freedom for development by just removing those which are interfering with them. In the classical method, trees are differentiated on the basis of their heights and crown development mainly into *dominant, dominated* and *suppressed* stems, the former two categories being further subclassified by their bole-form into *good* and *bad.* Depending on the degree of thinning considered necessary, which is generally referred to as of Grades A, B, C, etc., in increasing order of heaviness, inferior stems are removed as under:

A-Grade (Light) thinning:	Remove dead, dying, diseased and suppressed stems.
B-Grade (Moderate) thinning:	Besides the above, also remove defective dominated stems.
C-Grade (Heavy) thinning:	Further remove some good but dominated stems and bad dominants.
D-Grade (very Heavy) thinning:	Here even some of the good dominants are removed to give greater

freedom for development to the retained stems.

These thinnings are referred to as *Ordinary* or *Ground thinnings* as against another variation which is referred to as *Crown thinnings*, when trees are spaced out to allow free development of the crowns of the best of them without creating a permament gap in the canopy. It is contended that trees that are suppressed or dominated do not unduly interfere with the dominants and actually they have an ameliorative influence in as much as they side-prune the branches of dominants and prevent the coming up of weeds and insolation of the soil by exposure. There is also a saving in cost. Two kinds of crown thinnings are distinguished—*light* and *heavy*. These are considered particularly suited to the shade tolerant species such as Sal or Deodar but not so far teak or Chir.

Of the positive approach there are many variations. Mention may be made of one, evolved by the writer, which has been extensively practised in the Central Indian dry deciduous forests. In these forests young crops of teak or Sal are generally obtained by clear felling the overwood, and cutting back the advance growth. Most of the stumps of trees of the overwood as also the cut-back seedlings give coppice shoots. But their rate of growth is not uniform. Coppice from middle-aged trees grows faster. Coppice shoots are also not uniformly spaced. Thus although a more or less fully stocked young crop is obtained, retention of stems of the same size more or less uniformly spaced may leave awkward gaps in the canopy. The classical grade thinnings are also impracticable as crown class differentiation is not possible and there is much variation in size and vigour of the stems. Therefore, under the proposed method, called *Single Stem Silviculture*, well developed stems, irrespective of their size, are retained and then given the optimum freedom for development. For determining this freedom, the observation that the diameter of growing space bears a fixed relationship to the stem-diameter and is independent of the age or site quality, is being utilised. Large areas of naturally regenerated young crops of teak have been so treated. Results obtained have been extremely gratifying. Indeed someone appropriately called the thinned crops as *natural plantations!* This method is now being widely practised in teak, Sal and mixed forests of Central India and has greatly increased the value of the growing stock.

Silvicultural Systems

Silvicultural System is a method of silvicultural procedure worked out in accordance with accepted sets of silvicultural principles, by which crops constituting forest are tended, harvested and replaced by new crops of distinctive forms. They are broadly classified according to the manner of the carrying out fellings to remove the mature crop to secure a new crop, and the method employed to get it. Generally, two main categories are distinguished: High Forest and Coppice. The former comprises crops of trees, normally with a closed canopy and usually of seedling origin, whereas the latter is derived mainly from clumps of coppice shoots or root suckers. By coppicing is meant felling trees near ground level with a view to obtaining shoots from adventitious buds which then develop their own root system and grow to maturity.

Of the high forest systems the main subdivisions are according to whether the main crop is removed over an area in one operation and thus a *one-aged* young crop results, or is obtained artificially, or in a period of years to provide suitable conditions for regeneration to get induced and then established, thus giving an *even-aged* crop not differing in age by more than the regeneration period, also referred to as uniform crop, or where the regeneration fellings are distributed throughout the period of growth of trees to reach maturity, in which case the new crop obtained is *all-aged.* This kind of forest is called a Selection forest.

Of the coppice systems, where the rotation of the coppice is short, as it is mostly used as fuel, the main variations are *simple* coppice where the whole of the crop is clear-felled on attaining exploitable size; or *coppice-with-standards* where part of the mature coppice is retained for one or more rotations to get poles and some timber. The third is a variation introduced by the writer some 35 years ago to suit irregular mixed forests, and called the *coppice-*

(*a*)

Plate 21 REHABILITATION OF DEGRADED EX-PRIVATE FORESTS, M.P.
(*a*) When Acquired (*b*) After Rehabilitation *(See page 128)*

(*b*)

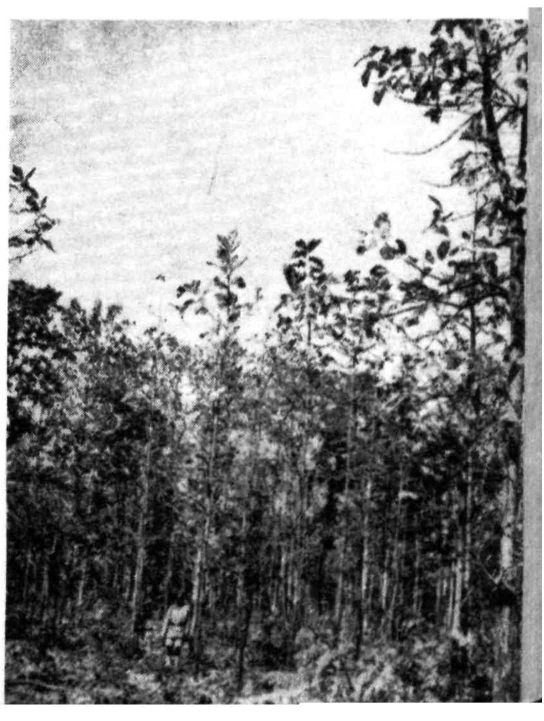


Plate 22 Ravine Afforestation, U.P. (10 year old)

(*See page 128*)

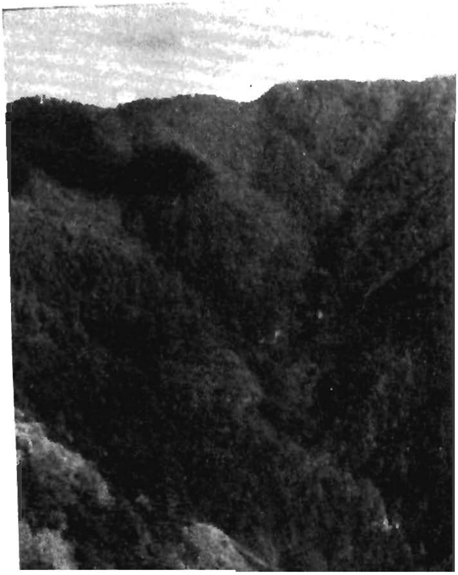


Plate 23
Well-Preserved Simla
Cantonment Forest

(*See page 128*)

Plate 24 Skin and Bone Animals Dependent Solely on Forest Grazing *(See page 196)*

Plate 25

A Sandal Tree Attacked by Spike Disease

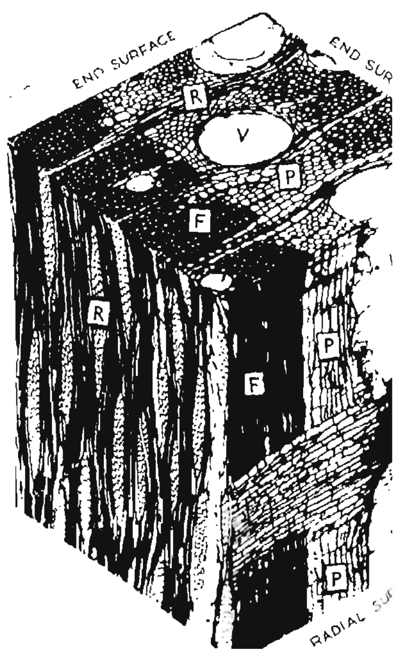
(See pages 201, 203)

Plate 26 HEART-ROT DECAY IN LIVING SAL TREE

(*See page 204*)

Plate 27 THREE-DIMENSIONAL MICRO-PHOTOGRAPH OF TEAK SHOWING ANATOMICAL STRUCTURE V-VESSELS; F-FIBRES; P-PARENCHYMA; R-RAYS.

(*See page 210*)



with-reserves system (q.v. infra). The regeneration may be natural, that is, from seedlings, or from coppice, or may have been obtained artificially by planting. The silvicultural system adopted depends on the requirements of the species, the intensity of demand and the development of communications. Forests in remote areas containing many species, only a few of which in large sizes can be economically extracted, are worked under the *Selection System*, such as the fir and spruce forests at high elevations in the Himalayas, or the mixed deciduous forests in the undeveloped tracts of M.P. As the entire forest cannot be gone over for removing marketable trees every year, it is generally divided into a number of sections, 15 to 30, one of which is worked in a year, on a *felling cycle*. Sometimes, besides the removal of marketable trees it is considered desirable to improve the condition of the forest to promote the development of younger trees of valuable species or to induce regeneration of these species. With this object in view certain trees of lesser value, interfering with the growth of value species, are also removed. This is referred to as the *Selection-cum-Improvement System*. When regeneration of the principal species is induced and established under the existing maturing crop by opening it gradually for say x years, so that eventually on clearfelling the overwood, a crop varying in age from 1 to x years is obtained, the system is known as the *Shelterwood Compartment System*. Some of the sal forests are worked under this system. It is called the *Uniform System* if on clearfelling the mature wood, adequate natural regeneration can be obtained immediately, or, in the alternative, a young crop is obtained by planting, as is the case with the teak forests of Nilambur. In certain cases, it is considered desirable to work the forest to produce both fuel wood which is best grown as coppice, and some timber and poles. Such forests are worked under a system called the *Coppice with Standards System*. Under this system, species utilisable only as fuel or as stakes are worked on a short rotation. Besides this the overwood consists of standards uniformly distributed over the forest to obtain timber. The number of standards of each age group retained at the time of felling is arbitrarily fixed, it being progressively smaller as the age becomes higher. Thus fir is the coppice rotation and R is rotation of the standards where $R = 4r$ and w, x, y, and z are the numbers of standards which are, respectively, r, 2r, 3r, and 4r years old, then the yield of the standards will be w-x, x-y, y-z and z trees of r, 2r, 3r, and 4r years old.

The irregular mixed deciduous forests of M.P. vary greatly in quality, composition, size and density. Only a few species are utilisable as timber, some only as poles and others as fuel. Certain species, for instance, Mahua, Mango, Amaltas, etc., yield economic products such as fruit, tanning material, etc. Certain trees are needed for protecting the soil or preventing frost damage to young crops. Similarly the well-grown *Pipal* and banyan trees are retained to provide shelter and food to birds. In such forests the classical system of CWS in which the standards are only of timber species and occur uniformly distributed, cannot be applied. A more elastic system was proposed by the writer in the 'thirties, and called the *Coppice with Reserve System*. Under it, the *reserves* comprise all well-formed trees the retention of which is considered necessary for any reason mentioned above. All other growth, if *silviculturally* permissible, is coppiced. The resultant crop, after say five years, has a lower storey of coppice clumps with scattered unevenly distributed reserves of various species and sizes in a heterogeneous mixture of properly thinned pole crops, trees utilisable as pole or timber, isolated trees retained for providing seed, or regulating the mixture, etc. Under this system sacrifice of young growth is minimised and the soil is never exposed to the hot sun or heavy showers. This system has been extensively applied in Madhya Pradesh in the last 35 years and has given gratifying results. Not only the forests are better stocked with well-formed trees but, what is more, the site-quality has also improved.

Rehabilitation, Reclamation and Afforestation

Besides managing the forested lands under its charge, the Forest Department has also to (a) *rehabilitate* the ex-private forests, which were ruthlessly plundered just before proprietary rights in them were abolished; (b) *reclaim* lands which have been denuded of all vegetation and whose productivity has suffered due to denudation and soil erosion; and (c) *afforest* bare lands, particularly the so-called 'waste lands'.

(a) *Rehabilitation:* The depleted ex-private forests are being rehabilitated by regularising fellings and regulating the cut so that it does not exceed the annual increment. Suitable steps are also being taken to fully regenerate the felled areas either naturally, with valuable species such as teak, sal, etc., or else artificially, by planting in patches, in strips or wholesale more valuable exotic species. The forests are also being carefully protected against illicit fellings, overgrazing and fires. As a typical example may be cited the dry teak forests of Madhya Pradesh. When taken over by the Government from private owners they mostly contained old, malformed teak trees, cut at 4 to 5 feet above ground with a number of pollard shoots. After these trees were cut back flush with the ground, they gave vigorous coppice shoots. The under-stocked areas were planted up with teak. The rehabilitated areas now contain a fully stocked pole forest of teak.

(b) *Reclamation:* India has over three million hectares of ravine lands, mostly in Madhya Pradesh, Uttar Pradesh, Rajasthan and Gujarat. In addition, a considerable area known as 'marginal lands' is in a state of actue erosion requiring immediate attention to prevent its becoming ravines. The rate of ravine formation is very rapid, for instance it is over 1,000 hectares annually in Madhya Pradesh, Hence, the importance of ravine reclamation to utilise the land for growing wood and fodder, and, where possible, fruit and food crops. The Government are now more or less convinced that the unproductive ravines along the Yamuna and the Chambal which have now become the haunts of dacoits, could best be all reclaimed by afforestation. Commendable work in this direction is being done in Uttar Pradesh, near Agra and Etawah.

(c) *Afforestation:* As there is a general shortage of forests and as wood is a bulky commodity which cannot stand long distance transport, it would be desirable to create forests on all the so-called waste lands. Afforestation is also necessary for minimising soil run-off and for aesthetic and hygienic reasons. An excellent example is the fine Deodar forests in the Simla cantonment. The technique to be adopted varies according to local conditions. Choice is ordinarily made from species that are hardy and grew on these areas formerly or are growing in the adjoining similar areas. On grassland fast growing species that quickly form a canopy and kill the grass are used. In dry tracts such as those of the Punjab and Rajasthan, where irrigation facilities are available, the land is afforested with Khair, Sissoo, Jamun, mulberry, Maharukh, Safed-siris, etc. Where irrigation facilities are not available the species that have succeeded are *Acacia modesta, Prosopis juliflora, Dodonea viscosa*, etc. Typical examples of afforestation of bare hills in the country are (i) the Seminary Hills in Nagpur; (ii) the Chamundi Hills in Mysore; and (iii) the Shankaracharya Hill in Srinagar. The Chambal ravines which are the abode of dacoits could be dedicated to the nation by the Madhya Pradesh and Rajasthan Governments and the Government of India could afforest them and then maintain them as National Forests. Keeping the forest lands in the catchment of this river properly tree-clad is essential for prolonging the life of storage reservoirs, mitigating floods and minimising erosion.

Social Forestry

There are many requirements of the rural population that are satisfied from forests in the vicinity of their villages. Indeed, these villagers, as it were, live more or less, symbiotically with the forests. They depend on the forests for their requirement of small timber for agricultural pursuits, fuelwood for their hearths, grass and grazing for their livestock, thorns for fencing the fields and *baris*, edible fruits, flowers, tubers, etc and if available, bamboos for a variety of purposes.

Satisfaction of such demand, most amicably without endangering the productivity of the forest, is what may be termed Social Forestry. It includes growing of trees and fodder on farmlands (farm forestry), reboisement of bare wastelands, Panchayat lands and village commons (extension forestry), creation of protective shelter belts, economic plantings on vacant lands (along railway lines, canals, roads and tank bunds), and bioaesthetics, namely, planting trees, shrubs etc., for their economic value, shade, or beauty (showy flowers, fragrant blossom, graceful foliage etc.).

This work is the prime responsibility of a benevolent popular government.

By and large, India is still predominantly an agricultural country, with about 82 per cent of its population residing in villages. Agricultural practices are primitive and cattle are still the main motive power. For such a country to be prosperous, Farm Forestry—the practice of forestry on the farm and village common lands, more or less integrated with other farm operations—conjures a vision of well-managed woodlots and pastures interspersed with cultivation. From the economic point of view every such farm, as far as possible, should be self-sufficient. This is certainly the ideal to be aimed at. The present picture, however, is somewhat bleak, and the prospects of its improving in the near future are none too bright for a variety of reasons. The most important of these is the lack of forest consciousness. A contributory cause is the dependence of the people on Government forests from where their requirements are still being met at concessional rates and without regard to any actual availability on a sustained basis. This results in overfelling and eventual disappearance of the forest. Similarly, excessive and continuous grazing also adversely affects the production both of trees and of fodder grasses. In the meanwhile cattle population is increasing, particularly that of scrub cattle, which are the source of the cheapest fuel: cow dung.

To improve matters, Farm Forestry should aim at:

(i) achieving the highest degree of self-sufficiency in respect of *bona fide* domestic and agricultural requirements from trees grown on the individual farms and on the common lands;

(ii) utilising lands which are of marginal productivity under agriculture, and the old fallow and culturable waste to produce the maximum quantity of small timber, fuelwood and fodder;

(iii) minimising soil-erosion, conserving soil-moisture, and regulating the flow of streams and thus indirectly helping agriculture;

(iv) improving the utility-value of the livestock by rearing the minimum number of robust animals and providing for them adequate fodder at the stall, and adequate grazing in the pastures by managing them scientifically; and

(v) satisfying the aesthetic sense.

The details of how this consummation may be brought about will depend on local conditions. The fundamental objective should be to meet the essential requirements of food, fruit, fuel and fodder to the maximum extent through a rational distribution of the productive land for agriculture, horticulture, silviculture and pasturage. Such rational land-use is in effect an extension of the National Forest Policy to all potentially productive lands at present lying barren. The proposed programme will bring the Forest Departments into closer contact with the people. This will help in protecting the forest much more than all the efforts at policing it, which are becoming less and less effective. It will be necessary to give practical demonstration of the advantages of the programme suggested.

A four-pronged drive is required with the object of :

(1) producing, on a sustained basis, more fuelwood at suitable centres in Fuel Woodlots;

(2) making better fodder and grazing available for the best cattle in Improved Pastures;

(3) growing useful trees in the village Tree Park; and

(4) encouraging cultivators to grow economic trees, shrubs, etc., on their farm to the maximum extent.

The woodlots must be as near the village as possible. Suitable areas should be selected from out of decrepit forests, culturable wastes, old fallows or the so-called permanent pastures and grazing lands. The general impression that the areas now classed as culturable waste are primarily meant for expanding cultivation, needs to be corrected. It goes counter to the accepted Forest Policy which lays down that at least one-third of the land should be under forests. In the not very distant past these waste lands must have carried good forests. They were either brought under the plough and later abandoned as cultivation became uneconomic; or else they must have been ruthlessly plundered by the agriculturists to obtain their requirement of small timber, fuelwood, fencing material, etc., and for unrestricted grazing of their livestock which denuded these lands of trees and fodder grasses.

As fuelwood must be made available as near habitations as possible, it would be desirable to have a number of planting centres. At each centre an area of, say, 4 ha. may be planted annually. The area to be planted annually at each centre being 4 ha. eventually an area of 80 ha. will be required for the normal fuelwood forest. Besides this, another 20 ha. of land will have to be set apart for settling labourers who will create these plantations as a Forest Labourers' Cooperative by the agri-silvicultural method outlined in the next paragraph, and manage the remaining area on which plantations are to be made in subsequent years according to a scheme outlined by the Forest Department. Each member of the Forest Labourers' Cooperative Society should be allowed about 2 ha. of good cultivable land for growing food crops, vegetables, etc. The Forest Department should provide reasonable amenities in the villages thus established.

The arrangement proposed for creating a model forest village over 20 ha. of land and around it the 20 coupes of 4 ha. each of the proposed fuelwood plantation is shown in Diagram 4. The central area is the model forest village with houses of 10 cultivators on either side of the main road with a field of 1.5 ha. behind each house. The coupes of the fuelwood plantation should surround the fields of the villagers. These are numbered 1 to 20.

In the first year coupe No. 1 may be planted with tree species, say with babul in lines 5 metres apart. In between the lines, the cultivators may be allowed to grow such crops as cotton, chillies, til, etc., which will not interfere with the development of the forest

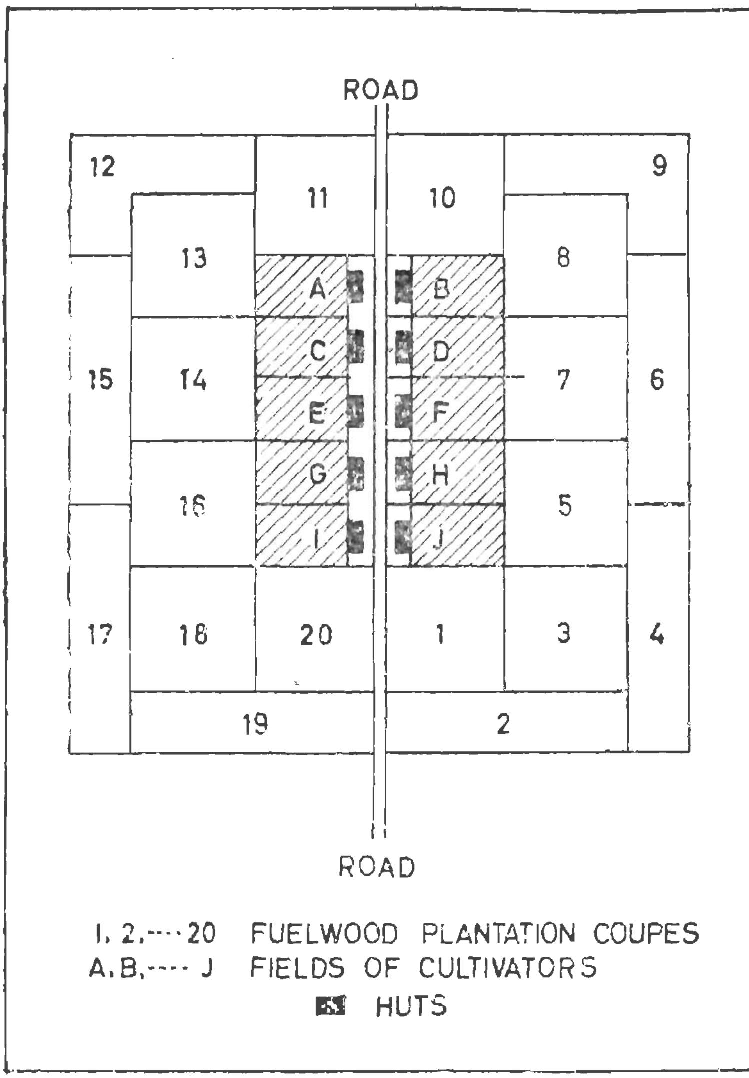


Diagram 4. A Model Forest Village

seedlings. In the next year agriculture may still be allowed in coupe No. 1 as also in coupe No. 2. In the third year field crops should not be allowed to be grown in coupe No. 1 but allowed in 2 and 3, and so on.

Thus every year, besides each cultivator having his own field, the villagers will have a cooperative farm of field crops over 8 hectares of fuelwood coupes. After the third year, i.e., when cultivation of field crops is abandoned in a fuelwood coupe, grasses may be encouraged, particularly good fodder grasses. The regenerated coupe may be thrown open to controlled grazing after the tree species are beyond damage by cattle, say, from the 6th to 10th year. It may again be closed to grazing from the 11th to 15th year to allow the grasses to recover. During this period, grass cutting may be permitted. The coupe may be again thrown open to grazing from the 16th to 20th year, i.e., upto the time it is to be clear-felled.

Ex. 1. History of Coupe No. 5

1st to 4th year	: Old trees standing. Open to controlled grazing and removal of dead wood.
5th year	: Babul seeds sown in lines 5 metres apart. Intervening space used for raising field crop (cotton, chillies, etc.).
6th year	: Weeding of babul seedling and raising of field crops in the intervening space.
7th year	: No cultivation.
8th, 9th, and 10th year	: Closed to grazing.
11th to 15th year	: Closed to grazing.
21st to 25th year	: Open to grazing, clear-felled and planted in the 25th year.

Ex. 2. Position at the end of 9th year

Coupe 1.	Plantation 9 years old		Open to controlled grazing
Coupe 2.	” 8	”	”

Coupe 3.	Plantation	7 years old	Open to controlled grazing
Coupe 4.	,,	6 ,,	do
Coupe 5.	,,	5 ,,	Closed to grazing
Coupe 6.	,,	4 ,,	,,
Coupe 7.	,,	3 ,,	,,
Coupe 8.	,,	2 ,,	,,
Coupe 9.	,,	1 ,,	,,
Coupes 10-20.	Old trees standing		Open to controlled grazing and collection of dead wood

It is suggested that before creating plantations the areas selected for being planted in the next 20 years, including the area required for settling the labourers, should be notified under the Forest Act, objections invited and, after a proper inquiry and extinguishing of all rights, declared as reserved forests.

The cost of the plantation should not exceed Rs. 500 per ha. Of this, Rs. 200 may come from the Government of India as an interest-free loan. The State Forest Department may give Rs. 100 as Taccavi to labourers in the shape of planting material and technical advice, including training. The remaining Rs. 200 should come as 'Shramdan' or *voluntary service* of the labourers engaged in doing the planting work and later in protecting and tending the plantations.

After coupe 1 has been planted, the remaining area on which subsequent coupes 2 to 20 will be planted in subsequent years should be managed by the Forest Labourers' Cooperative as under:

(i) Only dead and dry wood should be allowed to be collected.

(ii) The area should be divided into compartments, some of which should be closed to grazing to allow grass to establish (grass cutting will be permitted) and in others controlled grazing should be admitted. The Cooperative should be allowed to charge fee for grazing and removal of grass.

(iii) When the plantations need thinnings, say in the 10th year, this should be done under the supervision of a Forest

Officer and the wood either distributed equally among the members or else sold and the proceeds handed over to them.

Insofar as grazing the village livestock is concerned, the present position is extremely unsatisfactory. Too many cattle as also browsers (goats and even camels) compete for the available grass on degraded village grasslands. Grass is avidly grazed with the result that the total production under such practice is much less than what could have been obtained by allowing grass to grow and by cutting it once or twice in the season when it attains full growth and its nutritive value is at the highest. Hay harvesting and stall feeding of the cattle is not practised to any appreciable extent. All animals, good and bad, have equal chances on the village grazing grounds.

To improve matters, as a first step, the following arrangement is proposed to help the farmers who are prepared to pay for better grazing:

In every village a small area of the grazing ground should be developed as an Improved Pasture and Grass Reserve, to give selected head of animals better grazing and adequate quantities of cut grass for eating at the stall. The proposed arrangement is explained with the help of an example.

Assuming that there are 120 head of milch and plough cattle whose owners instead of grazing them without any payment in the village grazing grounds along with other cattle, are prepared to pay for better grazing. An area of 60 hectares (0.5 ha. per animal) could be selected, securely fenced and divided into three paddocks and utilised as under (Diagram 5).

PADDOCK A

1st, 4th, 7th, etc., years

January, February	Open to grazing.
March, April	Closed to grazing.
May, June	Open to grazing.
July to December	Closed to grazing. During this period one-third of the paddock

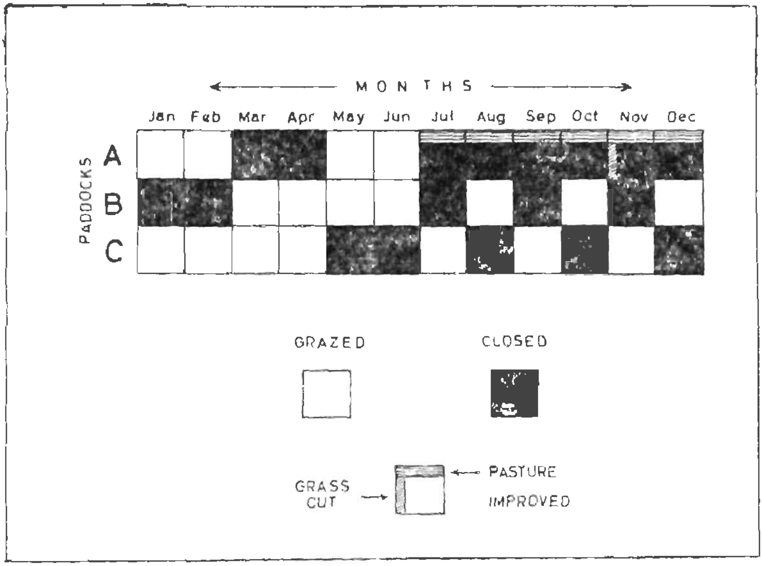


Diagram 5. Pasture Improvement Scheme

to be ploughed up, manured and reseeded with a good fodder grass mixture.

The remaining paddock to be cut at the end of October for stall feeding and again at the end of December for making hay.

2nd, 5th, 8th, etc., years	As for paddock B.
3rd, 6th, 9th, etc., years	As for paddock C.

PADDOCK B

1st, 4th, 7th, etc., years

January, February	Closed to grazing.
March, April, May, June	Open to grazing.
July, September and November	Closed to grazing.
August, October and December	Open to grazing.

2nd, 5th, 8th, etc., years	As for paddock C.
3rd, 6th, etc., years	As for paddock A.

PADDOCK C

1st, 4th, 7th, etc., years	
January, February, March, April	Open to grazing.
May, June	Closed to grazing.
July, September and November	Open to grazing.
August, October and December	Closed to grazing.
2nd, 5th, 8th, etc., years	As for Paddock A.
3rd, 6th, 9th, etc., years	As for Paddock B.

In the second year, another one-third of paddock A will be ploughed up, manured and reseeded, and the remainder of the area similarly treated in the third year. In the 4th to 6th year paddock B will be similarly improved and paddock C in the years 7th, 8th and 9th.

Note : (i) This programme of rotational grazing and hay harvesting may be modified to suit the local climate.

(ii) The fees charged should be such that they will meet all expenses except those on improving the pasture, which work should be the responsibility of the Government.

It should be possible to create a Tree Park of reasonable extent in every village planted with economic, shade-giving and flowering trees. The best arrangement will be to get this work done by employing some labour at the time of planting in the Vana Mahotsava week and then entrusting the after-care to the village teacher aided by students who should be suitably rewarded. This work should be encouraged by giving prizes annually to instil a spirit of healthy competition. A small garden and a children's park would prove an additional attraction. The cultivators should be encouraged by supplying plants of various species for being planted on their holdings.

CHAPTER IX

FOREST MENSURATION

DEFINITION AND SCOPE

Forest Mensuration deals with the determination of the dimension, form, volume, age and increment of individual trees and forest crops. Like the manager of any other property, a forester should know what capital as a forest he holds, what interest as increment it is earning, and how production could be maximised and costs reduced. Hence the need to measure trees and crops grown under different conditions. Estimates of growing stock are also required for determining the minimum price at which timber of standing trees may be sold.

MEASUREMENT OF HEIGHT OF TREES

For measuring the heights of standing trees a number of instruments have been devised, which are variously called dendrometers, hypsometers, altimeters or clinometers. They all utilise either the geometrical properties of similar triangles or the trigonometrical ratios of angles.

MEASUREMENT OF GIRTH OR DIAMETER OF TREES

Estimation of the volume of a log or the bole of a tree requires, among other things, the determination of the area of its cross-section. This is done by measuring its girth or its diameter at a specified point. It is then assumed that the cross-section is an exact circle and its area determined by the formula

$$A = \pi r^2 = d^2/4 = 0.7854d^2$$

where A is the area, r the radius and d the diameter;

or $\quad A = g^2/4\pi = 0.07958\ g^2$

where g is the girth.

The assumption that the cross-section of a tree is a circle overestimates the area because, for a given perimeter, the circle encloses the maximum area. Girth is measured with a tape. For ordinary work the usual linen tape is good enough; but where accuracy is is important for instance, in research work, steel tapes are used. Tapes are ordinarily graduated into (i) feet, inches and eighths, (ii) feet and decimals, (iii) inches and decimals, (iv) chain (66′) and links (6.6′), or (v) metres and centimetres. Special tapes directly read the diameter when put round a log or a tree. In such tapes each graduation marked 1,2, etc., is at intervals of π, 2π ,........etc., units.

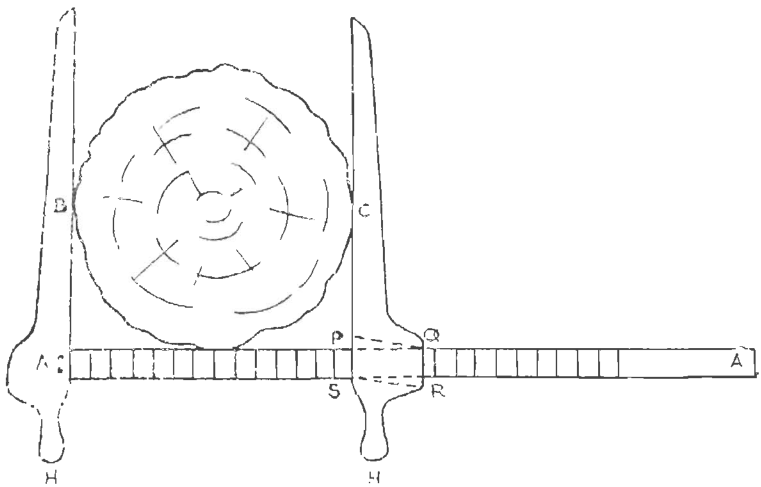


Diagram 6. Callipers

Diameters at the ends of logs or of stumps of trees, are measured with a foot-rule. Generally two diameters at right angles are measured and their average taken. For measuring the mid-diameter of a log or the diameter of a standing tree, callipers are used. (Diagram 6). A *Calliper* is a graduated rule with two arms, one fixed at one end of the rule and at right angles to it, the other moving along the rule parallel to the former. To use the instrument it is held at right angles to the axis of the tree or log, whose diameter is to be measured, with the fixed arm pressed against it; the moveable arm is then closed on the tree and the diameter read on the rule against the inner edge of the former.

ESTIMATION OF THE VOLUME OF LOGS AND TREES

(*a*) *True and Quarter-girth or Hoppus Measures*: If L is the length in feet of a log and G its mid-girth in inches, then its volume in *true measure is*

$$V = L\,\frac{G^2}{4\pi}\quad\frac{1}{144}\text{ cu. ft.}$$

The British timber trade, however, follows a different practice. It uses what is called quarter-girth or Hoppus measure under which the volume of the log is taken as

$$V = L\left(\frac{G}{4}\right)^2\ \frac{1}{144}\text{cu. ft.}$$

The Hoppus volume is 78.6/100 or 100/127.3 times the true volume. Probably this measure arose from the practice of measuring the mid-girth by a string, double-folding or quartering it, measuring the quarter-girth on a foot-rule in feet, and then multiplying its square with the length, to get the volume, avoiding thereby the awkward division by π. In any case, it does not give the sawn out-turn from the log which is much less, nor does it represent the under-bark volume.

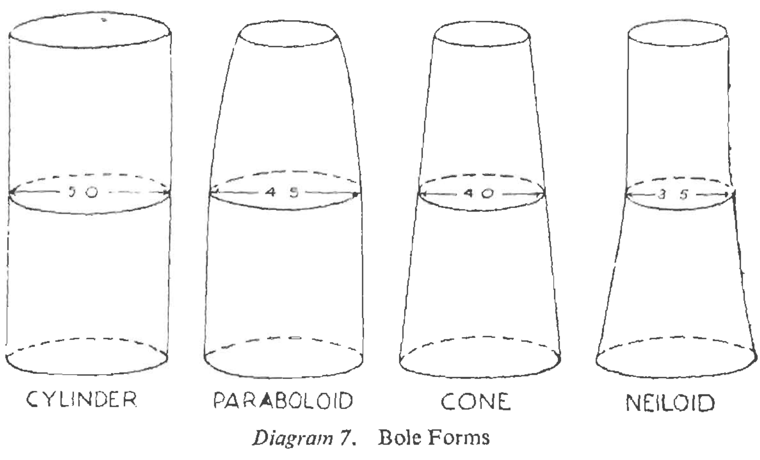


Diagram 7. Bole Forms

(*b*) *Volume of Logs* : The boles of trees and logs are never cylindrical. They vary considerably both in section and in taper (Diagram 7). The section approximates to a circle and the shape to:

(i) a cylinder, which has no taper;
(ii) a truncated paraboloid, which slowly gets thinner towards the top;
(iii) a truncated cone with a regular taper directly proportionate to the distance from the base; or
(iv) a truncated neiloid which has a rapid taper.

The volume of any of the four solids is obtained from the formula

$$V = \frac{L}{6}\ (B \times 4M \times T)$$

where L is the total length, B is the area of the base, M that of midsection and T that of the top. The use of this formula, however, entails much labour. It is, therefore, simplified to:

$$V = \frac{L}{2}\ (B \times T) \ldots\ldots\ldots \quad \text{Smalian}$$

or $V = LM$......Huber

each of which gives fairly accurate results for practical purposes. Printed tables are available giving the volume of logs in square feet when their mid-diameters or girths are given in inches and lengths in feet. Recently, tables in metric units have also been prepared.

(*c*) *Fuelwood Measurement:* Firewood is measured by volume when stacked or else by weight. The size and shape of stacks vary from place to place, one measuring 8'x4'x4' is fairly common. This is known as a cord. For its stacked volume of 128 c. ft. it generally contains about 96 c. ft. solid wood for ordinary sized billets; with thicker billets it contains more and with thinner billets less wood. When wood is measured by weight, freshly felled wood may contain as much as 50% moisture. Air dry fuel contains about 9 to 15% moisture. Charcoal is measured either by weight or by volume. Four tons of wood by weight give about one ton of charcoal.

Volume of Standing Trees: Form Factor

As mentioned earlier, the trunk of a tree is never cylindrical. The diameter of a standing tree is also not measured at its mid-point but at what is called the *breast-height* (BH). This has been fixed at 4′6″ from the ground. Now that the metric system has been adopted it would be desirable to use the international figure for breast-height which has been accepted by the F.A.O. also, viz., 1.3 m. and not the equivalent of 4′6″, i.e., 1.37 m.

To get the correct volume of a tree from the measurement of the diameter or girth at breast height, and hence its cross-section at this height, and the total height (upto which volume is to be computed) the cylindrical volume is multiplied by a fraction called the *form factor*.

Example : A tree measures 15″ in diameter at breast height and has a height of 50′. On felling and measuring, it is found to have a volume of 32 c.ft. What is its form factor? The volume of a cylinder with 15″ diameter and 50′ length is 64.14 c.ft. Hence the form factor is $F = 32/64$ or 0.5 (approximately).

The volume of wood obtained from trees is customarily differentiated as *timber* and *small wood.* Timber includes all wood down to 8″ diameter measured overbark, but timber volume is expressed *exclusive* of bark. On the other hand, small wood is everything from 8″ down to 2″ diameter overbark, but the volume is *inclusive* of bark. If the tree in the example has 24 c.ft. of timber and 5 c.ft. of small wood and the balance represents the volume of the bark on timber part of the tree, then the timber form factor will be $25/64.14=0.39$ and the small wood form factor will be $5/64.14=0.08$. Generally it is found that form factor does not vary so much with age, etc., as with height. Therefore, form factors are published with respect to height only. Here are some average figures:

Timber Form Factors

Height	*Sal*	*Chir*	*Deodar*
41′—50′	—	—	9.17
51′—60′	0.16	—	0.23
61′—70′	0.20	0.24	0.29
71′—80′	0.24	0.33	0.32
81′—90′	0.28	0.34	0.34
91′—100′	—	0.35	0.36

Diameter or Girth Classes

When the ultimate aim is estimation of the volume of a large number of trees it is customary to allot trees to *diameter* (or girth) *classes*, for instance, trees under 10 cm., 10 to 20 cm., 20 to 30 cm., etc. The diameter class 10-20 cm includes trees from above 10 centimetres upto and *including* 20 centimetres. The ratio between the diameter and the girth of a tree is not the same as between the diameter and the girth of a circle, i.e., 0.3182. The exact ratio has been determined for various species by a number of measurements.

For purposes of determining the volume of timber in a tree it is necessary to know its diameter under bark. For this purpose, bark-thickness is determined with the help of special instruments.

Age of Single Trees

This is determined either from records or by estimating it from the size and form of the tree, the condition of its bark, or the quality of the locality. But the figure so arrived at is at best an approximation. Some trees show on their cross-section, distinct annual rings. If these are counted on a section of the tree, say at breast height, and to this the period which the tree took to reach this height is added the correct age of the tree is obtained. Age of trees which do not show annual rings, such as Sal, is determined by measuring trees of various sizes at fixed intervals. The measurements of a particular year are then classified by diameter classes and the average diameter of the trees measured is determined. The same procedure followed at subsequent measurements gives the rate of increase of diameter during the period, for trees of a particular diameter. With the help of these data a *Diameter/Age* curve is constructed.

Age of Crops

Forest crops may be *one-aged* such as those which come up after profuse and full regeneration from seed immediately after clear felling or as a result of planting. In such cases the age of the crop can be determined from a single tree as explained above. But generally it takes some years to get full natural regeneration. The resultant, fully regenerated crop, is referred to as *even-aged.* In such forests after the rate of height growth has more or less culminated the canopy becomes uniform though the ages of individual trees differ. The average age of such a crop can be determined by measuring representative trees. The age of an irregular or *all-aged* crop is equal to its total volume divided by the mean annual increment. Utilising this identity, Smalian and Heyer have defined the mean age of a crop as the sum of the volumes of its *age-classes* divided by the sum of the mean annual increments of the age-classes. As age is roughly proportional to the breast-height diameter, trees are listed into diameter-classes instead of age-classes. Similarly as the chief component of volume is basal-area, for getting the mean *age* of the crop they proposed the following formula:

$$\text{Age} = \frac{s_1a_1 + s_2a_2 + \ldots\ldots}{s_1 + s_2 + \ldots\ldots}$$

where s_1, s_2..........are basal areas of the various diameter classes; and a_1, a_2,............are the average ages of each diameter class. But even this is a tedious and time-consuming process.

Volume of Crops

The following is a practical method, applicable to fairly well-stocked regular forests:

Trees are enumerated in 1″ diameter classes and the total basal area calculated. Suppose these are

Diameter Class (inches)	*No of Trees*	*Basal area (sq. ft)*
8	5	1.75
9	10	4.42
10	30	16.36
11	40	26.40
12	50	39.27
13	45	41.48
14	30	32.07
15	20	24.54
16	10	13.96
	240	200.25

The mean basal area then is 220.25/240=0.834 sq. ft. The diameter corresponding to this is 12.4″. Therefore, sample trees having diameters near 12.4″ are selected and felled and their volume computed:

Diameter	*Basal area (sq. ft)*	*Volume (c.ft)*
12.1″	0.799	20.41
12.1″	0.799	22.40
13.6″	1.009	21.87
	2.607	64.68

then as $V=vN$ and $B=bN$

where V is the volume and B the basal area of the stand, N the number of trees and v and b are the volume and basal area of the mean basal area trees,

$$=vN=\frac{vB}{b}=\frac{64.68 \times 200.25}{2.607}=49.68 \text{ cu. ft.}$$

This method presupposes that the mean-basal-area tree is also the mean-volume-tree, which is not quite correct.

Increment

The increase in girth, diameter, basal area, height, volume, quality, price or value of individual trees or crops during a given period is called *Increment*. Two kinds of annual volume increments are distinguished: the *current* and the *mean*. The trend of these increments and their relationship can best be understood with the help of concrete data given in the subjoined table:

TABLE 15

CURRENT *vs* MEAN ANNUAL INCREMENT

Age	*Volume*	*CAI*	*MAI*
5	5	1.0	1.0
10	14	1.8	1.4
15	25	2.2	1.7
20	40	3.0	2.0
25	60	4.0	2.4
30	78	3.6	2.6
35	93	3.0	2.65
40	104½	2.3	2.6
45	112½	1.6	2.5
50	117	0.9	2.3
55	119	0.45	2.1
60	120	0.1	2.0

Column 1 gives the age and column 2 the volume of the crop per unit area including volume removed in thinnings upto that age. From these a Volume/Age curve can be constructed (Diagram 8). As the volume increment per tree, per year, is small and cannot be measured accurately, in practice all trees are measured periodically at intervals of 5 or 10 years and the average annual increase in volume during this interval is taken as the *current annual increment* (CAI) of the interval. This is given in column 3. Column 4 gives the total growth built up of successive annual CAI's divided by the age, i.e., the average rate of growth per year. This is called the *mean annual increment* (MAI). The successive values of the CAI and the MAI are plotted against the age (Diagram 9). It will be seen that the CAI is not uniform during the life of the stand. In fact, it is nil in the beginning because in the sapling stage the tree has no measurable timber in it. After this, it tends to increase rapidly until it reaches a peak towards the middle age (near 26 years in the graph, when its value is 4.2). Upto this age, the volume added each year to the previous volume of the stand was greater than the average or the MAI upto that age. The rising CAI also raised the MAI,

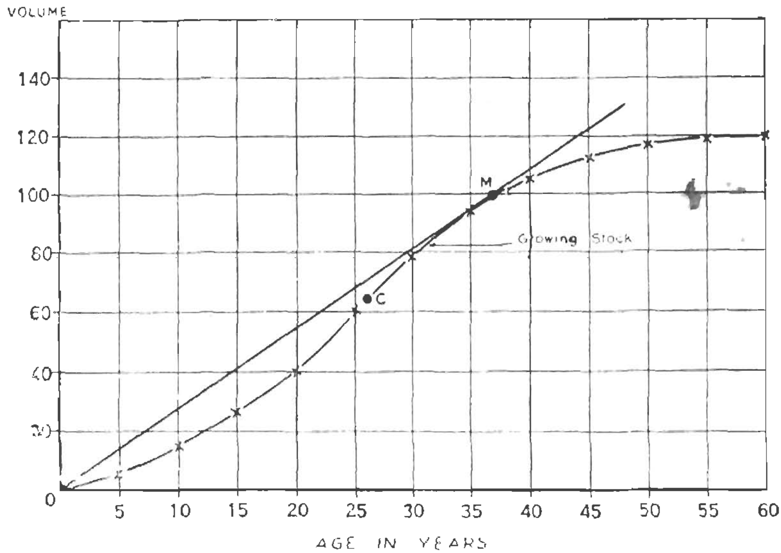


Diagram 8. Growing Stock: Volume/Age

except that the latter's curve is not so steep because the effect of increasing volume each year is spread over all the previous years. Even after the CAI has reached its maximum and begun to decline, the successive average increments, i.e., the MAI figures for each year still continue to rise, as the amount of growth added during a year, although progressively decreasing, is still greater than the average for the age. When the falling CAI curve meets the rising MAI curve, i.e., the two are equal, the latter has also reached its highest point. In other words, the MAI culminates.

In subsequent years, that is after the two curves have crossed, the CAI is less than the mean volume, hence the MAI curve also begins to drop, but only to the extent that it is pulled down by the effect of lesser CAI for single years by the fraction *Volume/Age*. Hence, as before, the MAI curve continuously drops but more gradually than the CAI curve. If the stand is still allowed to grow

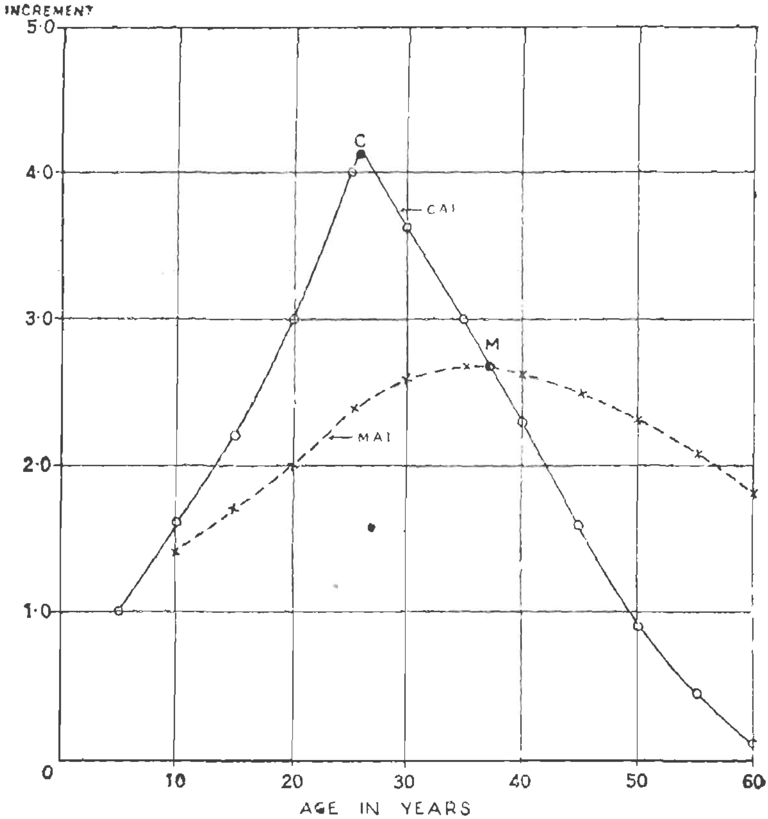


Diagram 9. CAI *vs* MAI

(?) losses in volume due to decay will exceed the accretion and the CAI will become negative. On the other hand, until the wood is actually destroyed, the curve of the MAI will always remain positive.

The age at which the MAI culminates, that is, when the CAI= MAI, is the rotation of the maximum volume production per year, per unit area, which is of great importance in forest management.

It should, however, be carefully remembered that conclusions based on studies of increments of individual trees cannot be applied to forest crops for the simple reason that as trees grow in size in a forest stand they compete for growing space and in consequence some of them get suppressed or dominated and eventually disappear. Such a struggle continues throughout the life of a wood with the result that only a small fraction of the original number of trees survives when the crop matures. Generally, these are the most robust trees with a vigorous growth, the weaklings having been crowded out or removed in thinnings. The result is that the average crop diameter increases not only by virtue of the growth of surviving robust trees but also as the thinner trees which would have lowered the average have disappeared. In other words, the average tree of the stand increases in size more rapidly than the trees composing it. Therefore, paradoxical though it may sound, it is possible for a stand to put on 11 years growth in 10 years!

Stem Analysis

As has been pointed out, the cross-section of the bole of certain species of trees shows well-defined annual rings which can be traced in sections cut at any height. This fact has been utilised to determine the rate of growth of trees in diameter and height and hence to find out their volume increment and that of a whole crop. This is known as Stem Analysis, or the analysis of a complete stem by measuring annual rings on a number of cross-sections at different heights. The main principles underlying stem analysis will be clear from Diagram 10 which is a vertical cross-section of the stem of a 10-year-old tree showing the position of the annual rings: the vertical scale is in metres and the horizontal scale in centimetres. It will be seen that at ground level there are ten rings and the last ring is 10.6 cm in radius. The total height of the tree and the radii at breast height and at base at different ages were as under:

Age	*Height (metres)*	*Radius at*	
		B.H. (cm)	*Base (cm)*
1	0.6	—	0.7
2	1.3	0.0	1.8
3	2.2	1.2	2.7
4	3.0	2.4	4.2
5	3.8	3.7	5.4
6	4.5	4.6	6.5
7	5.2	5.6	7.5
8	5.5	6.5	8.4
9	6.1	7.4	9.4
10	6.6	8.5	10.6

The number of rings on any section is equal to the age of the tree above that section. In other words, all wood put on above the section grew in a number of years equal to the number of rings on the section. Thus on the section at 3 metres there are 6 rings which means that all the growth of this tree above this section took place in the last 6 years and as the tree is 10 years old it took four years for the tree to grow to the height of 3 metres. If the lowest section examined is at breast height, then the numbers of years the tree took to grow to this height is estimated and added to the number of rings on the breast height section to get the correct age of the tree. As a section is not exactly circular, two diameters at right angles are selected and measurements taken on all the four radii and an average struck. After stem-analysing several representative trees smooth curves are drawn to give the relationship between *diameter/age* and *height/age* and finally *volume/age* curves are prepared (Diagram 11).

Enumeration of Trees and Estimate of the Growing Stock

The counting, singly or together, of individuals of one or more species in a forest crop and their classification by species, size, condition, etc., is called *enumeration*. It may be *complete* (total) or *partial* (sample); a partial enumeration may be carried out on separate sample plots, or in strips, or lines. The volume of the

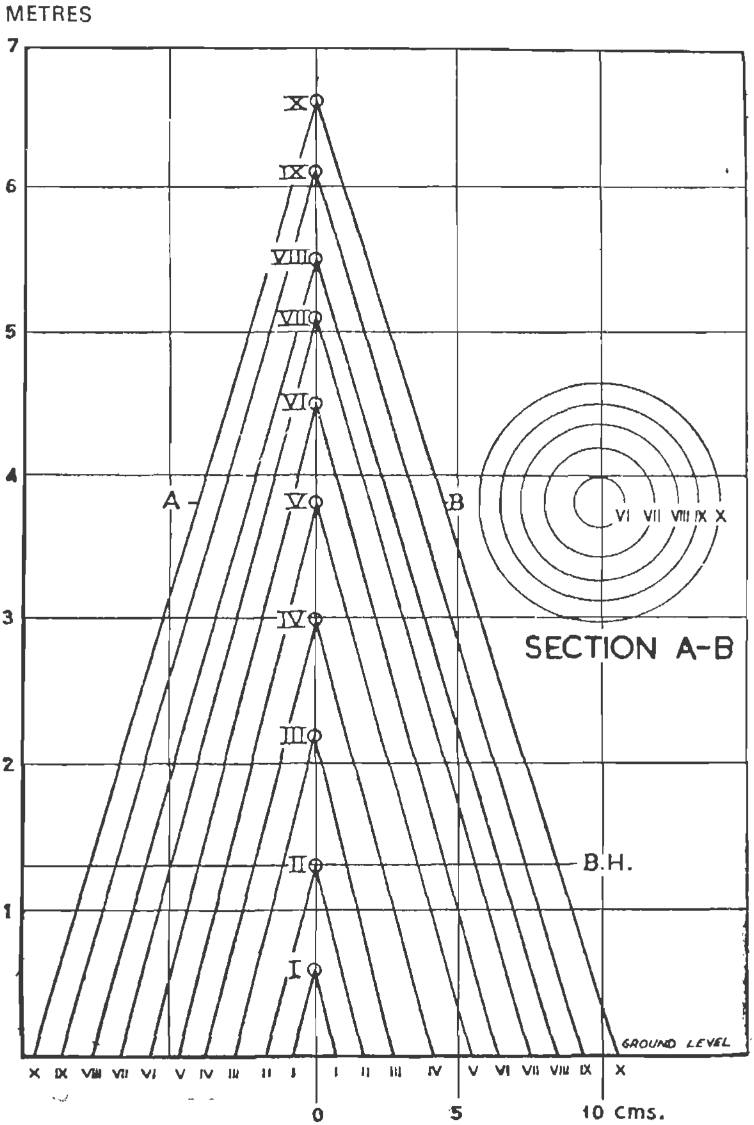


Diagram 10. Stem Analysis

growing stock of a forest is determined either by measuring all the trees in it, or only trees standing in a representative sample and then computing from it the total volume standing over the entire forest.,Trees are enumerated by species (or groups of species) into diameter or girth classes. Such data are used for arriving at the sustained yield of a forest, or for finding the value of the growth for purposes of sale, or for determining the increment of the forest.

Statisticians are now generally agreed that, if adequate care is taken, *sample* enumerations, besides being simple, expeditious and less expensive, give more accurate and reliable information than complete enumerations. Moreover, the average magnitude of sampling errors can be estimated and allowance made for it. The percentage of forest area sampled is less important than the number of sampling units. If the forest is large, a lower percentage of sampling with a larger number of units may furnish more precise estimates. The size of the sample depends on the variability of the character under study. In general the greater the variability the larger must be the number of sampling units. Thus forests of low density which are generally more heterogeneous in stocking would require a large number of sampling units to get the precise information.

Sampling is done either in isolated plots, or along a line, to the requisite extent, the location being fixed randomly. The forest to be sampled is first divided into strata, if these are clearly distinguishable, and then each stratum sampled according to the method suggested by a statistician so that results of requisite precision are obtained. Sample units of convenient size are selected randomly in different parts of the forest, the growth over them is completely enumerated, and from this the growing stock of the whole forest is worked out. It is obvious that the accuracy of the results will depend on the units being as representative as possible. The linear survey is also a count of all trees in sample units except that these lie contiguously along a randomly pre-selected line and along lines parallel to it at a specified distance. All growth occurring on either side of the line upto a specified depth is enumerated. The distance between lines and the width of the strips enumerated determine the intensity of the survey. The second method is generally preferred because it is less expensive, the layout is simpler and, what is more important, it is possible to do successive enumerations.

VOLUME TABLES

The volume of a crop is determined from what are called Volume Tables showing, for a given species, the average contents of trees, logs or sawn timber for one or more given dimensions (d.b.h., height, form or taper, etc.). Such tables give, for a particular species, the average volume of trees classified—

(i) according to the choice of variables such as diameter, diameter and height, diameter and site quality, etc.; or

(ii) on the basis of their scope of application such as General Tables, Regional Tables, Commercial Sawn Outturn Tables, etc.

Volume Tables are prepared after actual measurement of a number of trees converted in a particular way. They assume that trees of the same species, height, diameter and age have the same volume. Therefore, if the average is based on sampling a whole forest they are of general application. But if prepared from a local forest stand, they are only of local application. A specimen is given below:

TABLE 16

GENERAL VOLUME TABLE

Diameter	*Height Class*				
Class	41-60′	61-80′	81-100′	100-120′	121-140′
	Volume in Cubic Feet				
8″-12″	4	9	11⅓	—	—
12″-16″	14	21	28	35	—
16″-20″	29	39	50	61	70
20″-24″	47	63	80	59½	112
24″-28″	—	95	118½	139½	161½
28″-32″	—	135	165	192	220½

For Sal in U.P. for Stem Timber Volume in round, under bark, in 20′ height classes.

From this, a *General Form Factor Table* can be prepared by finding out the cylindrical volume of the mid-dimension tree. Thus a tree of diameter 10″ (mean of 8″ to 12″ diameter class) whose height is 50′ (mean of 41′ to 60′ height class) has a stem timber volume of 4 cubic feet whereas the volume of the cylinder of diameter 10″ and height 50′ is 27.27 cubic feet. Therefore, the Form Factor is 4/27.27 or 0.147. A Form Factor Table thus constructed is given below:

TABLE 17

FORM FACTOR TABLE

Diameter Class	*Height Class*				
	41′-60′	61′-80′	81′-100′	100′-120′	121′-140′
8″-12″	0.147	0.210	0.234	—	—
12″-16″	0.262	0.281	0.291	0.274	—
16″-20″	0.328	0.315	0.314	0.314	0.306
20″-24″	0.356	0.341	0.337	0.329	0.326
24″-28″	—	0.368	0.357	0.344	0.330
28″-32″	—	0.393	0.373	0.356	0.346

It will be seen that the Form Factors are more or less of the same order for a particular diameter or height class.

When no Volume Tables are available, for a regular and fairly well-stocked forest such as for instance a plantation, its volume can be found by one of the two methods given below:

(*a*) *By Sample Trees:* A number of trees covering the entire diameter range and uniformly distributed over the stand are measured and a statement prepared by 1″ diameter classes (see Table 18, Col. 1 and 2). For each diameter class the theoretical basal area is determined, e.g., for 15″ diameter class the basal area is

$$\pi \frac{15^2}{4} \times \frac{1}{144} = 1.227 \text{ sq. ft.}$$

Multiplying this figure by the number of trees, the class basal area is obtained (col. 4). The diameter classes are grouped (col. 5), and the number of trees in each group determined (col. 6) as also

TABLE 18

EXAMPLE OF THE METHOD OF ESTIMATING THE VOLUME OF A WOOD BY MEANS OF SAMPLE TREES

Diam. Class (inches)	*No. of Trees*	*Basal Area (sq. ft) of one tree in each class*	*Basal Area (sq. ft) of all trees in each class*	*No. of group*	*No. of trees in the group*	*Basal area of the group (sq. ft)*	*Means Sample Tree Basal area (sq. ft)*	*Means Sample Tree Corresponding diam. (inches)*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
15	7	1.227	8.589	I	38	56.993	1.499	16.4
16	11	1.396	15.356					
17	12	1.576	18.912					
18	8	1.767	14.136				Total	..
19	14	1.969	27.566	II	47	103.363	2.199	20.0
20	16	2.182	34.912					
21	17	2.405	40.885				Total	..

Selected Sample Trees				*Volume of Group*		
Diam inches	*Basal area (sq. ft.)*	*Volume c. ft. Timber*	*Volume c. ft. Small-wood*	*Timber (c. ft.)*	*Small-wood (c. ft.)*	*Total*
(10)	(11)	(12)	(13)	(14)	(15)	(16)
16.7	1.521	43.96	12.45	—	—	—
16.1	1.414	39.95	11.58	—	—	—
—	2.935	83.91	24.03	1,620	466	2,096
20.3	2.248	68.16	20.83	—	—	—
19.9	2.160	61.04	17.70			
—	129.20	38.53	38.53	3,029	903	3,932
			Total	4,659	169	6,028

the group basal area (col. 7), from which the basal area of the mean sample tree is computed (col. 8) and the corresponding theoretical diameter determined from Tables or a Basal area/Diameter curve (col. 9). Then sample trees are located in the stand with their diameters as near the mean sample tree as possible (col. 10), felled, measured up and their volume recorded (col. 12 & 13). From these the volume of the group is determined (col. 14, 15 & 16).

(*b*) *Volume-Curve Method:* A number of representative trees covering the whole range of diameters and well-distributed over the crop are selected, felled and measured up. The volumes are plotted against corresponding diameters and a smooth curve drawn. The volume of the crop is then calculated by multiplying the volume for each diameter class by the number of trees in that class and adding up.

Example

Let the measurements of 6 trees selected be:

(*Volume c ft*)

Tree No.	*Diameter inches*	*Timber*	*Small wood*
1	14.8	31.83	10.75
2	16.1	38.54	11.83
3	17.5	46.90	13.67
4	19.2	58.28	17.01
5*	20.0	60.12	21.65
6	21.4	75.30	22.70

*As the curve shows this is not a representative tree.

Figures of columns 2 and 3 are plotted and a smooth curve drawn (Diagram 11), and from it the volumes for each 1" diameter class are read off. By multiplying this with the number of trees the volume by diameter class is computed.

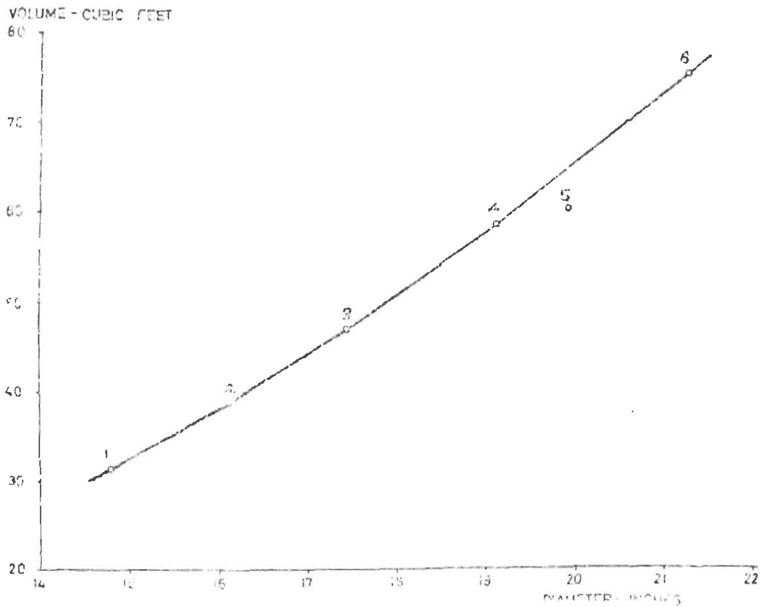


Diagram 11. Volume/Diameter Curve for Sample Trees

Diameter Class	*Timber volume per tree (c.ft.)*	*No. of trees*	*Class volume (c.ft.)*
15″	32.075	7	229.25
16″	38.00	11	418.00
17″	43.75	12	525.00
18″	50.00	8	400.00
19″	56.75	14	794.50
20″	64.25	16	1028.00
21″	72.00	17	1224.00
	Total	85	4618.75

It will be seen that the figure obtained, viz., 4618.75, compares well with the result obtained by the Sample Tree method.

Sample Plots

Sample plots, as the name implies, are representative samples of a forest. Permanent Sample plots are maintained for studying the growth of forest crops and are used for preparing Yield Tables. A number of plots are laid out to cover the entire range of site-quality and age, in even-aged, fully-stocked crops and maintained. (Each plot is properly demarcated and also provided with a surround the width of which is not less than the height of the trees at maturity. This surround is treated exactly in the same manner as the crop in the plot so that the trees in the plot grow as they will in a forest of that type.) A plot map is prepared showing the location of all trees. The trees are numbered and on each a cross mark is placed at breast-height indicating the spot at which (and at right angles to it) its diameter is to be measured periodically. (The plot file also contains a general description of the plot giving species, objects, area, situation, altitude, climate, soil, aspect, slope, type of forest, age, date of formation, interval of measurement, treatment prescribed, etc.) The trees are measured periodically and two diameters at B.H. and the crown class (dominant, dominated or suppressed) recorded in the plot file. \Some sample trees covering the range of height and diameter are felled and when not available for felling, standing trees are measured) Measurements of trees removed in thinnings are also recorded.

Yield Tables

A Yield Table is a tabular statement which summarises on a unit area basis, all the essential data relating to the development of a fully-stocked and regularly thinned even-aged crop at periodic intervals covering the greater part of its useful life. Yield Tables are prepared from the accumulated measurements of a number of sample plots of a particular species laid out in crops of various ages and site-qualities. They are a tabular statement giving for even-aged forests, of a particular species, at five or ten yearly intervals, measurements, namely, crop diameter, crop height, number of stems per unit area, basal area and volume (final and total CAI and the MAI), form factors, etc., for a unit of the forest. In India, volume-

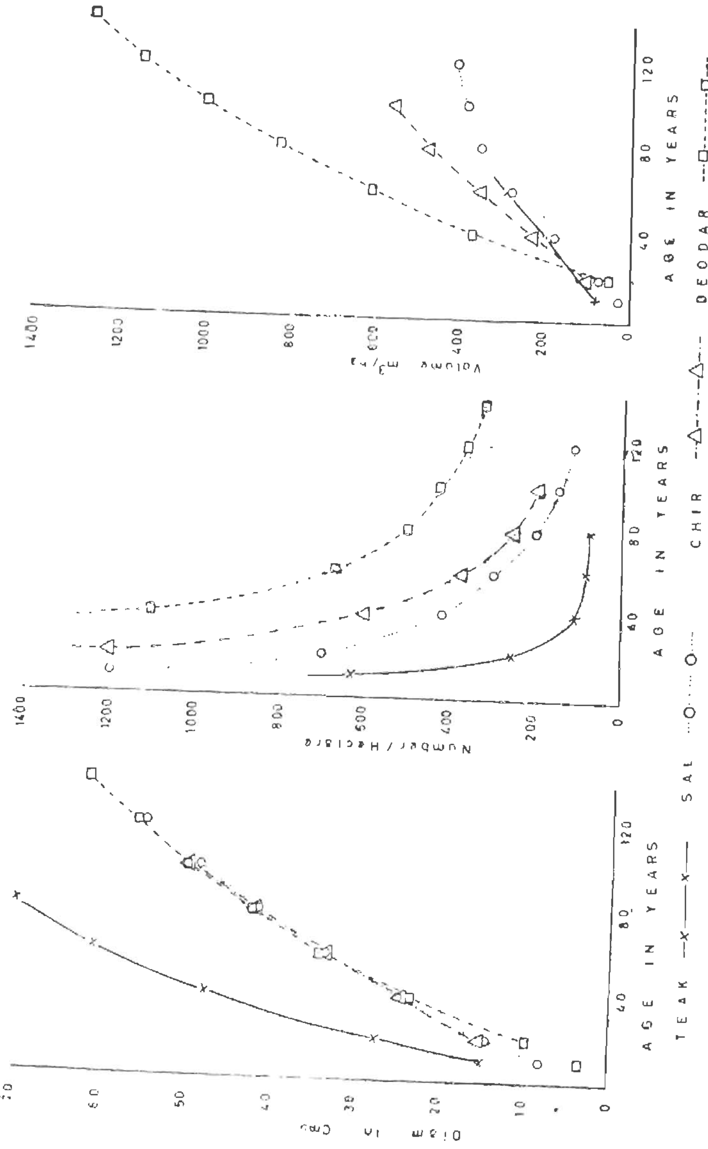


Diagram 12. Basic Yield Table Data for Even-Aged Crops: Teak, Sal, Chir and Deodar

per-acre Yield Tables have been prepared for Teak, Sal, Deodar, Chir, Kail and Sissoo, for ordinary (C-grade) thinnings, in the F.P.S. units. For Deodar they have also been prepared for other grades of thinnings.

Yield Tables are used for determining the site-quality of a forest for preparing stock-maps, for estimating the volume of the growing stock, its increment, the rotation of a forest, or as a guide to thinning, or for determining the optimum number of trees corresponding to a particular age, diameter or volume of a crop and its increment, etc. If money yields are substituted for volume a money yield table is obtained from which the most profitable rotation and the soil expectation value can be worked out.

(a) Basic Yield Table data for Even-aged Crops: The basic data for crops of Teak, Sal, Chir, and Deodar for Site Quality-II converted into C.G.S. units are given in the subjoined Statements. Smooth curves drawn after plotting these are shown in Diagram12.

(i) Main Crop Diameter (cm)

Age	*Teak*	*Sal*	*Chir*	*Deodar*
10	14.7	8.1	—	3.3
20	27.2	14.2	14.7	9.9
40	47.8	24.6	24.1	23.4
60	61.7	33.5	33.5	34.3
80	69.9	41.4	42.7	42.7
100	—	48.3	50.0	49.5
120	—	54.9	—	55.6
140	—	—	—	61.7

(ii) Main Crop Stems per hectare (Number)

Age	*Teak*	*Sal*	*Chir*	*Deodar*
10	633	1181	—	—
20	252	712	1231	2543
40	114	420	603	1117
60	86	287	268	670
80	77	200	252	511
100	—	148	193	427
120	—	116	—	361
140	—	—	—	306

(*iii*) *Main Crop Volume per hectare (Cubic metres)*

10	73.5	26.6	—	—
20	108.5	72.8	99.0	49.7
40	191.7	180.5	230.5	363.2
60	289.7	183.4	354.0	605.3
80	345.0	335.7	472.0	822.2
100	—	372.3	553.5	1005.5
120	—	411.4	—	1155.2
140	—	—	—	1285.4

(*iv*) *Final Volume Yields (cubic metres)*

10	101.1	28.0	—	—
20	145.9	82.6	110.0	51.1
40	211.3	212.7	251.0	394.6
60	198.1	337.5	375.5	671.7
80	352.0	394.6	493.5	879.5
100	—	421.2	572.5	1046.8
120	—	448.5	—	1184.6
140	—	—	—	1306.4

(*v*) *Total Volume Yield (cubic metres)*

10	122.1	28.0	—	—
20	225.0	88.7	123.0	51.1
40	416.0	290.4	323.0	404.4
60	562.2	580.8	534.5	772.5
80	645.8	867.7	738.0	1211.2
100	—	1119.6	900.5	1384.7
120	—	1325.3	—	1598.2
140	—	—	—	1773.8

STAND TABLES

With Yield Tables are also given what are called Stand Tables. They show the distribution of stems by diameter classes for each of a series of crop diameters in the following forms:

(i) Percentage of stems over a given diameter limit in crops of various diameters;

(ii) Number of stems per acre over given diameter limits in crops of different qualities for successive 5 year intervals;

(iii) Percentage of the total number of stems by 4″ diameter classes in crops of various diameters;

(iv) Number of stems by 4″ diameter classes for 100 acres of normal forests in different rotations.

Such tables are used for determining the financial value of a normally stocked forest.

British Yield Tables

Yield Table for Douglas Fir Q. II Moderate Thinning

1. VOLUME YIELD TABLE

Age years	*100 largest trees*						*Main Crop*	
	Av. ht. (*ft*)	*Average GBH* (*in*)	*No. of annual rings per inch*	*No. of stems*	*Av. ht.* (*ft*)	*Average QGBH* (*in*)	*Basal area per acre* (*sq. ft*)	*Form factor*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
13	30	4½	4.0	1000	26½	3	63	.36
16	39	5½	6.6	725	35½	4	79	.43
19	47	6¼	5.0	560	43½	5	93	.44
22	54	7¼	50.0	440	50½	5¼	101	.45
25	61	8¼	500	355	57½	6¼	110	.45
28	65	9	6.6	295	63½	7¼	116	.45
32	74	9¾	8.8	250	70½	8½	124	.45
36	81	10½	8.8	215	77½	9½	132	.45
40	87	11¼	8.8	190	83½	10½	140	.44
45	94	12	11.0	165	90½	11¼	146	.44
50	100	13	8.2	148	96½	12¼	152	.43

		Thinnings							
Vol. (*h.ft*)	*Av. vol. per tree* (*h.ft*)	*No. of Stems*	*Average QGBH* (*in*)	*Vol.* (*h.ft*)	*Av. vol. per tree* (*h.ft*)	*Total vol. to date* (*h.ft*)	*CAI* (*h.ft*)	*MAI* (*h.ft*)	*Current incr. per cent* (*h.ft*)
(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
600	0.6	400	2½	150	0.4	750	283	58	34.2
1200	1.6	275	3¼	250	0.9	1600	303	100	20.7
1790	3.2	165	4	320	1.9	2510	303	132	15.1
2350	5.3	120	4¼	380	3.2	3450	303	157	11.5
2870	8.1	85	5¼	390	4.6	4360	284	174	9.0
3340	11.3	60	6	380	6.3	5210	273	186	77.4
4010	16.0	45	7	420	9.13	6300	160	197	5.9
4620	21.5	35	7½	430	12.3	7340	247	204	5.0
5190	27.2	25	8½	420	16.8	8330	228	208	4.0
5790	35.0	25	9½	540	21.6	9470	208	210	3.4
6350	42.9	17	10½	480	28.2	10510		210	

2. MONEY YIELD TABLE

Year	*B.H. Q.G.*	*Price per h. ft after deductions*	*Vol. ob.*	*Value*	*No. of trees*	*B.H. Q.G.*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	ins.	£	h.ft	£		ins.
13					400	2½
16					275	3½
19	5	.043	1790	77.0	165	4
22	5¾	.050	2350	117.5	120	4¼
25	6¾	.057	2870	163.5	85	5¾
28	7½	.062	3340	207.1	60	6
32	8½	.068	4010	272.7	45	7
36	9½	.075	4620	346.15	35	7½
40	10¼	.079	5190	410.0	25	8½
45	11¼	.086	5790	497.9	25	9½
50	12¾	.093	6350	590.6	17	10½

Price per h.ft after deductions	*Vol. ob.*	*Value*	*Christmas Trees* *No.*	*Christmas Trees* *Price*	*Christmas Trees* *Value*	*Value with Chr. trees*	*Final Yield total value*
(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
£	g.ft	£		d.	£	£	£
.002	150	0.3	120	.05	6.0	6.3	
.011	250	2.8	150	.05	7.5	10.3	
.22	320	7.0	70	.05	3.5	10.5	85.7
.29	380	11.0				11.0	128.5
.033	390	12.9				12.9	176.4
.040	380	15.2				15.2	222.2
.46	420	19.3				19.3	292.0
.050	430	21.5				21.5	368.0
.056	420	23.5				23.5	433.5
.063	540	34.0				34.0	531.9
069	480	33.1				33.1	623.7

(*a*) *Volume Yield Tables:* For comparison a page from the Yield Table for Douglas Fir, Q. II grown in Great Britain with moderate thinning has been given to show its salient features.

All measurements are in *Hoppus* measures. Col. 1 is the age at which the plantation was thinned. Column 16 gives the total volume to date including that of past thinnings. Column 17 is the CAI, i.e., average annual volume increase in the interval. Column 18 is the MAI, i.e., total volume, including thinnings, divided by the age. It will be seen that the CAI rises rapidly, culminates between 19 and 22 years and then falls gradually; whereas the MAI is small in early years, culminates at 45 years (when it equals the CAI at this age) and thereafter falls off slowly. Column 19 gives the current increment per cent, i.e., the volume put on during a year, expressed as a percentage of the volume at the beginning of the year, calculated with compound interest during each interval. Thus volume at 25 years is 2870 whereas at 28 years including thinnings it is 3720. Therefore, the current annual increment per cent for the interval is p where $1.0p^3=3720/2870$.

(*b*) *Money Yield Tables:* These have been prepared from the volume yield tables by substituting values for volumes. In general the bigger the size the higher is its price per cubic foot. Due allowance has been made in the money yield table for the usual hazards because of which full stocking cannot be achieved. The Money Yield Table corresponds to the Volume Yield Table given earlier.

CHAPTER X

FOREST ECONOMICS

> I have often said that forestry is in a state of retreat in India. There are many reasons for this, such as public apathy, the ignorance of our legislators, the readiness with which our Government sequestrate forest land for other uses, etc. But the basic reason is that forestry has not established its title to continued use of the land in economic terms.... Orthodox forest management is based on biogeocoenotic or ecological approach....The time has come to enquire whether we should not give more serious attention to the economics of forestry.
>
> — C.R. RANGANATHAN, Professor Emeritus

GENERAL PRINCIPLES

UNLIKE AGRICULTURE, where most crops mature in one growing season, forestry is a long-term venture. Forest trees may take 5, 10, 50 years or even more to reach maturity. The capital spent on the creation of a forest and tending it, can, therefore, remain locked up for long periods, except for some intermediate receipts. When a forest is created by borrowing money, and as banks charge compound interest, the debt mounts up rapidly. It rises faster and becomes very high if the rotation of the forest is long (App. II). The forest owner is likely to be tempted to cut and sell trees while they are still immature, that is long before the maximum production per unit area, per year, has been reached. Similarly, if any land carries forest growth which is worth only a fraction of what can be grown on it in an equal time and with more or less the same cost, it will be prudent to cut and sell the trees even while they are immature and to restock the area fully with more valuable trees. Indeed, this should be the main trend in India to quickly realise the potentiality of the forest, which, as has been pointed out (q.v. *supra* Chapter VI) is at least ten times the present production. If any bare land is made available for afforestation, for instance the so called wastelands, the more fertile land should be preferred, because the financial returns on poorer soils are very low under afforestation. To find out if growing a forest crop is a profitable venture or not, it is necessary to work out all costs incurred and the receipts obtained during its life-time allowing compound interest. The forester should see that the resources available to him, viz., land, labour, money and the technical know-how are so utilised that the maximum wealth in the shape of forest produce is created. It is the function of a Forest Economist to compare the net costs incurred on the production of a particular forest product under different methods and then to determine the most profitable treatment. Forests represent wealth in more ways than one. *Directly* they yield a variety of products which meet the domestic demand of the people or provide raw-materials for industries; *indirectly* well-managed and properly sited forests of adequate extent bind the fertile soil and mitigate floods and thus help agriculture. Forests shelter wild life and provide recreational facilities and also enhance the beauty of the landscape. Strictly speaking, therefore, a forester must take credit for all these services. But as the indirect benefits cannot be evaluated, it would be justifiable instead to allow a low rental on land utilised for growing a forest. In an extreme case such imponderable values alone may justify the creation of a forest even though the soil and the climate may not be quite suitable and the cost may be high.

But when Government land is utilised for growing industrial wood or an individual grows it on his own land, no credit should be allowed for indirect benefits conferred by the forest. Hence the need to work out the economics of such plantations.

Faustman's Formula and its Application

Suppose such a plantation is created by drawing money from a bank which charges compound interest on it at 'p' per cent. Let the cost per hectare on acquiring the land be Sc; the cost on formation of the plantation be C; the amounts being drawn from the bank at the *beginning* of the year, and let 'e' be the annual expenses on maintenance incurred at the *end* of each year. The overdraft will grow as cheques are drawn to purchase land, to plant trees on it and to defray expenses on annual maintenance, including the remuneration of the manager. The overdraft will also grow, through compound interest chargeable annually on the net borrowings.

In the years a, b, etc., there will be receipts Ta, Tb, etc., from thinnings or intermediate fellings, grazing, hunting, etc., which will be paid into the bank to reduce the overdraft so that interest accrues only on the balance outstanding. When the plantation matures in the year r and is felled, a yield of Yr will be obtained. This, as also the price obtained on relinquishing the land, viz., Sc is say paid into the bank. Now let it be assumed that as a result of these withdrawals and deposits the entire overdraft is just cleared. It will then be correct to say that the money invested in the plantation earned exactly 'p' per cent compound interest; the manager earned his remuneration, and the bank made p per cent on its lendings. The position in the bank account will be

Dr. Side

Compound interest on

(i) (Sc+C) for r years $= 1.0p^r\,(Sc+C)$;

plus

(ii) that on e for r—1, r—2, ... 1 year $= e\,\dfrac{1.0p^r - 1}{1.0p - 1}$

Cr. Side

Compound interest on—

(i) Ta, Tb, etc., the value of thinnings, etc., in years r—a, r—b, ...

$$= \Sigma Ta\ 1.0p^{r-a}$$

plus

(ii) Yr+Sc at the end of the rotation.

Therefore, equating the two sides and rearranging—

$$Sc = \frac{Yr + \Sigma Ta\ 1.0p^{r-a} - C\ 1.0p^r}{1.0p^r - 1} - \frac{e}{0.0p}$$

on writing x for 1.0p

$$Sc = \frac{Yr + \Sigma Ta\ x^{r-a} - Cx}{x^r - 1} - \frac{e}{x - 1}$$

This is known as Faustmann's Formula in which p is the *Financial Yield*, which can be determined algebraically if the values of Sc, C, e, Ta, Tb, etc., and r are known. Approximate values can be found graphically as under:

The formula can be written in the form $S = A - B$ where

$$A = Yr\ (x^r - 1)^{-1} + \Sigma Ta\ x^{r-a}\ (x-1)^{-1}$$

and $$B = C\ x^r\ (x^r - 1)^{-1} + e\ (x-1)^{-1}$$

The values of the coefficients of Yr, ΣTa, C and e can be computed from tables for different values of s, r and a.

When $p = 3, 4, 5, 6$ and 8; $r = 15$ and $a = 10$, these are:

Coefficient		*Value when p—*			
	3	4	5	6	8
$(x^{15}-1)^{-1}$	1.792	1.248	1.935	0.0719	0.461
$x^5(x^{15}-1)^{-1}$	2.074	1.521	1.193	0.962	0.677
$x^{15}(x^{15}-1)^{-1}$	2.787	2.265	1.943	1.723	1.461
$(x^{15}-1)^{-1}$	33.3	25.0	20.0	16.67	12.5

If the cost of planting C is Rs. 750 per hectare, the annual maintenance cost e is Rs. 20, thinnings (wood equivalent of other receipts) in year 10 give 50 tonnes of wood, the final yield in year 15 is 100 tonnes per hectare and the wood fetches Rs. 15 per tonne; the value of S for different rates of interest 3, 4, 5, 6 and 8 will be

			Rupees per hectare		
	3%	4%	5%	6%	8%
Y	2700	1885	1395	1065	690
T	1552	1140	885	720	510
$(Y+T)=A$	4252	3015	2280	1785	1200
C	2100	1687	1448	1200	1095
e	667	500	400	333	250
$(C+e)=B$	2767	2187	1848	1623	1345
$\therefore S=(A-B)$	1485	828	432	162	-145

These values are plotted in Diagram 13. It will be seen that when the wood fetches Rs. 15 per tonne, the plantation gives a

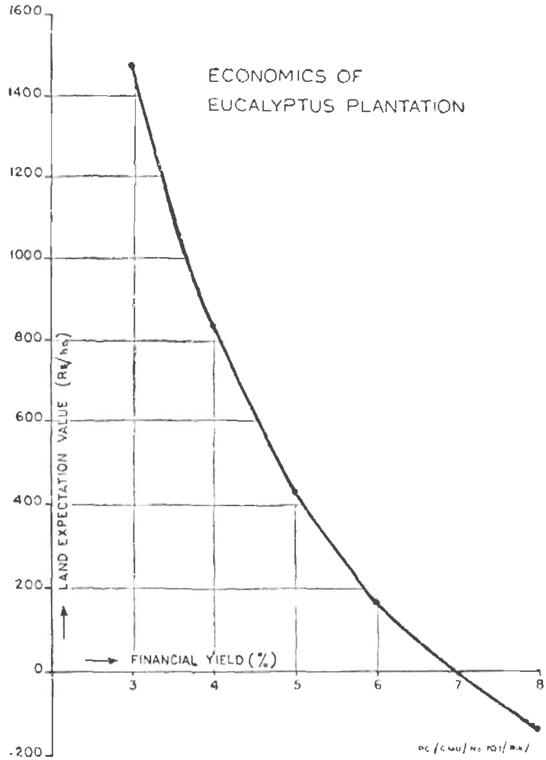


Diagram 13. Land expectation value/Financial Yield

financial yield of nearly 7%. The financial yield for different values of C, e,r, a, etc., can similarly be worked out and thus the values which give the best financial results determined.

Forest Economics also includes the study of all other aspects of forestry that deal with the forest as a productive asset, subject to economic laws.

CHAPTER XI

FOREST MANAGEMENT

FOREST MANAGEMENT deals with the organisation of a forest property for its proper maintenance and utilisation according to the wishes of the proprietor. For successfully managing it, the forester must have adequate knowledge of all the branches of forestry and allied sciences. In fact, Forest Management is applied forestry. The object of management may be: (i) *economic,* namely, production of the maximum yield of particular forest products, (ii) *protective,* namely, preservation of the physical features, conservation of the soil and regulation of the flow of water, (iii) *bio-aesthetic,* namely, enhancing the scenic beauty and preserving the fauna and flora, or (iv) a judicious combination of these. A mineral resource can get exhausted in course of time, or its exploitation through "robber" economy may become uneconomic, because of increased working costs, whereas a forest, if properly managed, can be kept perpetually productive and useful. But a forest is a very vulnerable asset. The slightest neglect or unscientific working can rapidly deplete and may even annihilate it after which reforesting of the area may not be economically feasible. Hence the need for managing forests scientifically and utilising them judiciously. When the actual production of a particular forest is low compared to its *potentiality,* it would be desirable to plan to achieve this objective.

Whereas in agriculture, land is the capital and the value of the annual crop, *less* the expenses on growing it, is the interest earned by it; in forestry, *interest*—the annual accretion—earned, is indistinguishable from *capital*—the growing stock. In agriculture there is no danger of the capital being encroached upon, although it may be destroyed or made less productive by faulty technique; but in forestry, with unwise management this may easily happen and may adversely affect the welfare of future generations for whom the forests are held in trust. Regulation of the annual yield is, therefore, of the utmost importance. Hence the need to work a forest on the principle of sustained yield. This implies that the removals from year to year must be approximately equal, or progressively increasing to the extent feasible, and in no case should the removals exceed the increment or the productive capacity of the forest. It may also be ensured that the yield will be obtainable annually and for all time.

There is however an important exception. If an existing forest is under-stocked and carries inferior growth with slow increment and in consequence its actual annual accretion (in volume or value) is far less than the potential (that is what would be obtainable if fully stocked stands of valuable species were to be grown), then in such a case it will be prudent to exploit the existing forests as quickly as feasible even when the trees have not reached the most profitable size, and to restock the area with fast growing valuable species. Indeed this is the main requirement in so far as a major portion of the Indian forests is concerned.

It is not always necessary to see that the forest capital works at the maximum rate of compound interest. Indeed it may often be impossible to evaluate the capital value of a forest, which not only includes the land and the growth thereon, but also the indirect benefits that accrue from it, namely, its protective and aesthetic value. Also, as private forest owners cannot afford to grow large-sized or high-quality, slow-growing timber which may be needed for a variety of purposes, particularly in the public sector, it becomes the duty of the State to grow it. Government-owned Indian forests are, as it were, a gift of nature. It will, therefore, be a wise policy to conserve them to the maximum extent to get the highest sustained annual yield, even if this represents a low rate of interest on the total value of the growing stock, rather than deplete them and then earn a higher rate of interest on the reduced forest capital but a lesser net income from year to year. The conserved forest will be a national asset which will be earning interest all the time in the shape of growth and can be drawn upon in an emergency. What is more, the cut can be decreased in a slump and increased in a boom, which is not possible with other industries. But when forests are created and tended by borrowing money in the open market, their management must aim at obtaining a higher return than the interest payable on the loan.

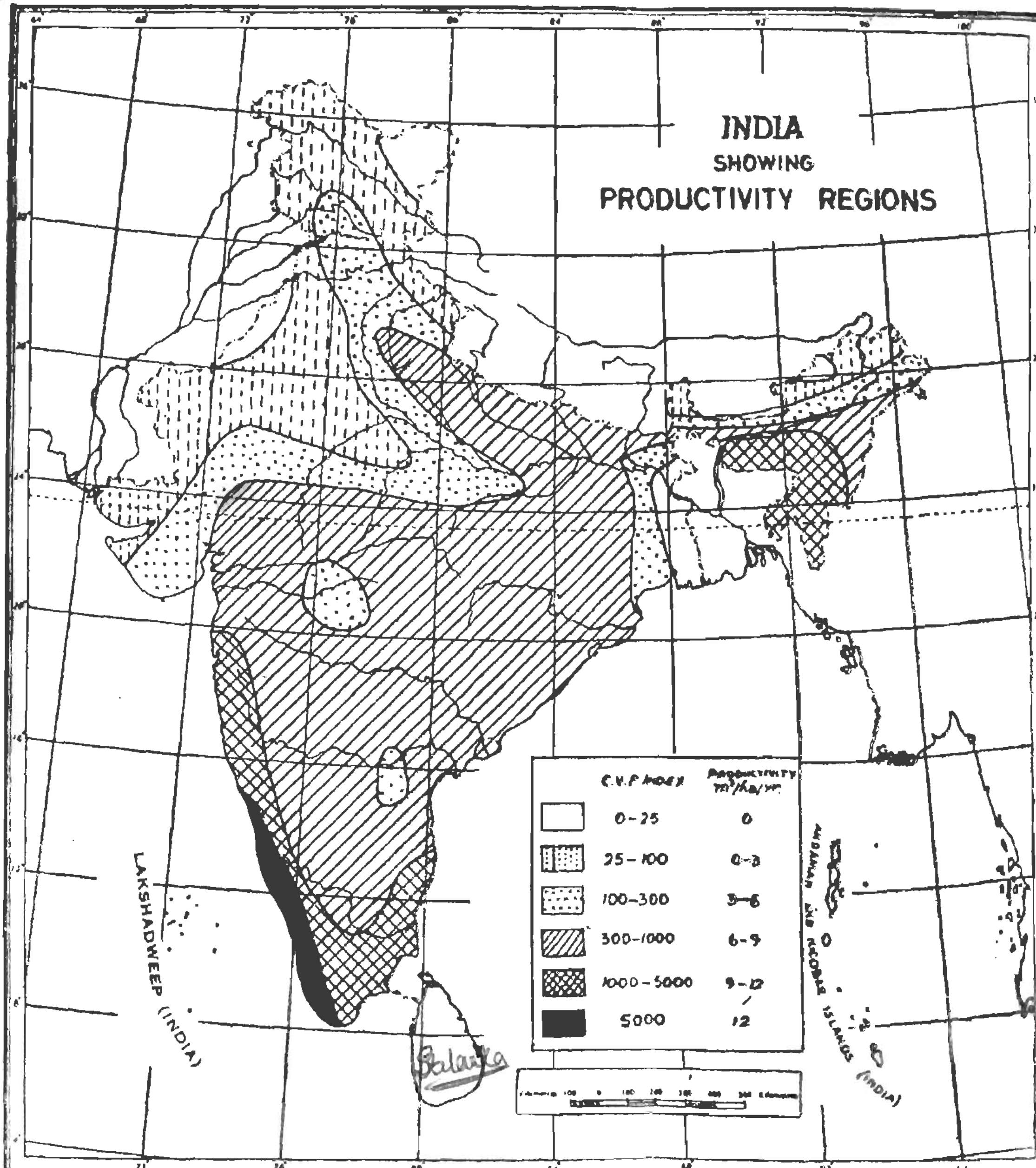
Forestry is a long-term investment, because several years elapse—often more than the life-time of a generation—between the formation of a young forest and its harvesting. The man who 'sows' seldom reaps a forest crop. Therefore, it becomes obligatory for the forester to see that the interests of the future generations are not jeopardised by neglect to satisfactorily regenerate the forest after the standing growth has been removed, and then to carefully tend the growing forest. Cutting more than the increment can deplete the forest capital and has to be carefully guarded against.

THE NORMAL FOREST

When dealing with forest management, the forester visualizes an ideal or what is technically termed a *normal* forest, which he defines as a forest which has (i) for a given site and given objects of management, is ideally constituted as regards growing stock, age-class distribution and increment, and from which the annual or periodic removal of produce equal to the increment can be continued indefinitely without endangering future yields; or (ii) by reason of its normalcy in these respects serves as a standard of comparison, for sustained yield management.

Per contra an *abnormal* forest is one in which the quantity of material in the growing stock is in deficit or in excess or in which the relative proportions of the age or size classes are defective. A *normal* forest has (1) *a normal* series of age-gradations (or age-classes); (2) *a normal* increment; and (3) *a normal* growing stock. By a normal series of *age gradations* is meant the presence in the forest of trees of 1, 2..................r years of age standing on *equal areas,* where r is the rotation of the forest, i.e., the time a tree takes to reach the exploitable size. When trees standing on the oldest age gradation of such a forest are felled and the area set free is immediately restocked, by seedlings or by coppice regrowth, or by being planted up, then after one year the forest will again contain age-gradations 2, 3,............r and 1 year old and so on. This is an essential feature of a normal forest. When full restocking is

Map 5



The territorial waters of India extend into the sea to a distance of twelve nautical miles measured from the appropriate base line.

not possible in one year, say, it takes 10 years to completely regenerate an area and the trees take 40 years to reach maturity, a new crop may be created by dividing the forest into 40/10 = 4 *periodic blocks*[1] (PB) and regenerating each in turn. At the end of the first period, the regenerated PB will contain trees 1 to 10 years old. PB-2 may similarly be regenerated in the next 10 years and so on. At the end of 40 years the whole forest would have been *normalized* and will contain trees as shown below:

PB I	*PB II*	*PB III*	*PB IV*
31 to 40 years	21 to 30 years	11 to 20 years	1 to 10 years

The crops in the various periodic blocks are referred to as *age-classes*. Diagram 14 illustrates a normal forest with 'r' age gradations and another with 4 age-classes described above. In a forest where regeneration is coming up throughout the life of a wood, trees of all ages occur in a homogeneous mixture and, therefore, neither age-gradations nor age-classes are distinguishable. But even such a forest can be normal and have trees of the various ages occupying equal area. *Normal increment* is the best, or the maximum, increment attainable per unit area on a given site. When conditions (i) and (ii) given earlier are fulfilled by a forest, it will *ipso facto* have a normal growing stock. This will correspond to the growing stock as given in a Yield Table (q.v. *supra*). In nature such a forest has rarely, if ever, been attained. While only two conditions determine the normality of a forest, viz., a normal series of age-gradations (or age-classes), and a normal increment, the converse is not true, as can be seen from Diagram 15. These forests contain the same growing stock as the normal forests of Diagram 14. In one, certain age-gradations occupy more or less than 1/rth of the area and in the other, trees 0 to 5 year old and 36 to 40 year old are missing. In fact both these forests are highly abnormal. Similarly a natural forest of low density and containing mostly mature or over-mature

[1]Periodic blocks are parts of forest set aside to be regenerated or otherwise treated during a specified period.

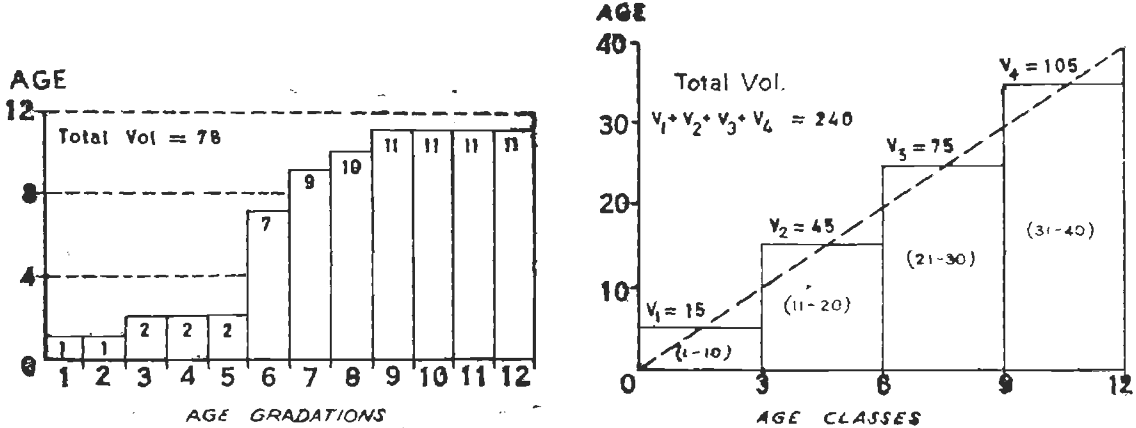
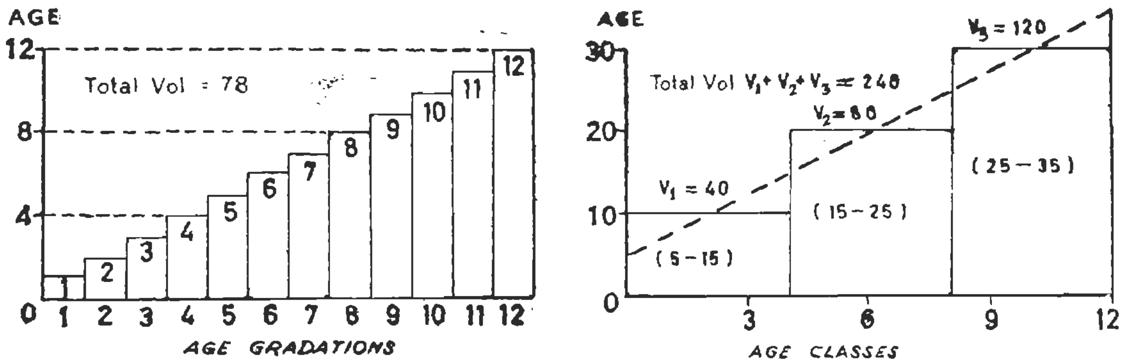


Diagram 14. Normal Forest



trees may carry growing stock equal to or greater than that indicated in the yield table, but such a forest will also be abnormal because it cannot produce a sustained yield. In other words, a forest is abnormal if it is over-stocked, under-stocked or even when ideally stocked it has abnormal distribution of age-gradations (or age-classes), or it produces abnormal increment due to defective stocking, fire damage, disease or preponderance of over-mature trees which have ceased to put on growth. Thus a virgin forest is not normal as it usually puts on practically no net increment. The nearest approach to a normal forest of rotation r is a normally stocked plantation containing crops 1, 2..............r years old standing on equal area. Even such a forest will not be called normal for a rotation of 2r years.

Normal Age Gradations

A simple picture of a complete series of age gradations can be had from an example. Suppose a person wants to get annually one mature tree, say 8 years old, for all time. Then it is obvious that he must have on his farm, one tree of 1, 2,...................8 years old so that every year the 8-year-old tree is felled and the place set free is utilised to plant another tree immediately, i.e., he must have a complete series of age gradations. If he fails to plant in any one year, 8 years hence he will not get a mature tree 8 years old. Similarly if he plants 3 trees in a year and does not plant any tree in the two subsequent years, 8 years later he will get 3 mature trees and none in the 9th and the 10th year. Similar considerations apply to forest crops. *But there is one fundamental difference.* In the example of the farm the tree was the unit, *in the case of a forest the unit is the area.* If we wanted to get from a forest a final yield of say x trees of a particular diameter with clear boles, then we will have to plant not just x trees over the forest as this will leave too much space between adjacent seedlings which will promote branchiness, encourage weeds or lead to deterioration of the soil due to exposure, but x number of trees so that they fully occupy the growing space. Thereafter as the trees grow and compete for growing space the forester will have to gradually thin the crop by removing the worst trees to give optimum freedom for development to the best trees, and eventually at the end of the rotation he will be left with just x mature trees fully occupying the growing space.

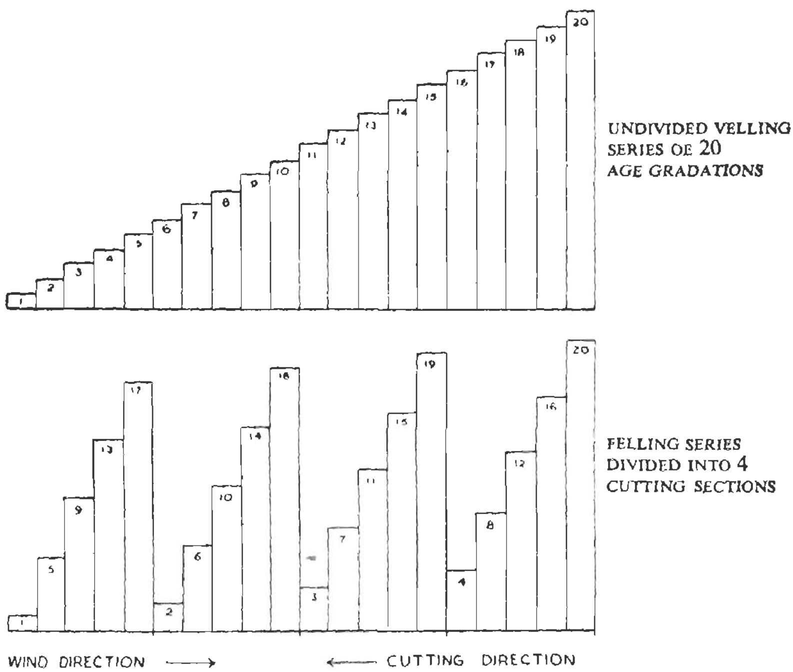


Diagram 16. Cutting Sections

As will be seen from Yield Tables (q.v. *infra*) that the normal number of trees per acre varies with age and quality; the higher the age and poorer the site quality, the less the normal number. It also varies with species.

The distribution of age-gradations (or age-classes) in the various silvicultural systems may now be considered. The unit for regulating the yield of a forest is termed a *felling series*, i.e., an area containing (or aiming at eventually having) a complete series of age-gradations, viz., crops, on equal areas, 1, 2,...............r years old. Under the *clear felling system* a felling series of area A will have r annual coupes of equal areas so that the area of each coupe is $x=A/r$. These annual coupes may be laid out contiguously for the convenience of working or may be in sections as shown in

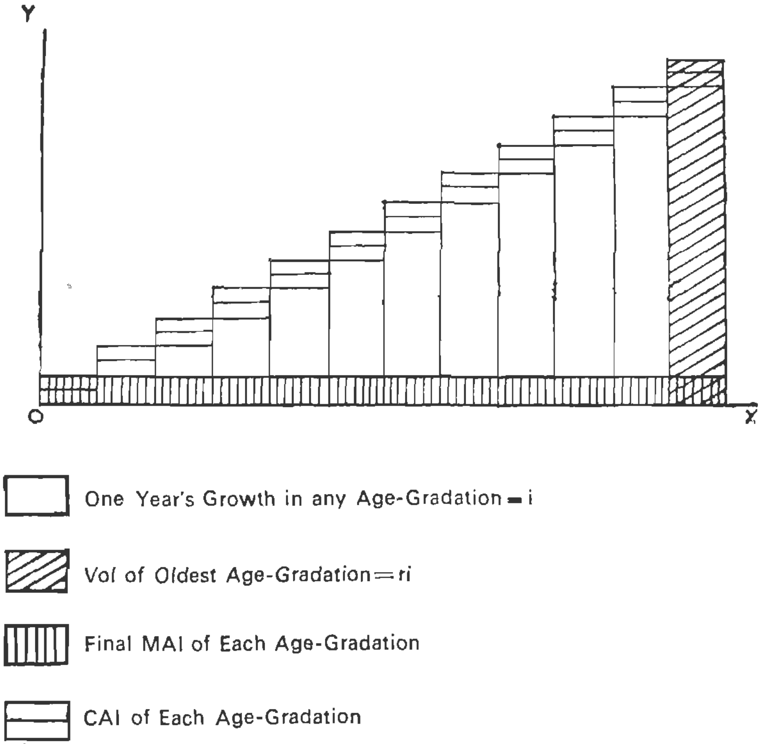


Diagram 17. Increment and Yield Relationship in a Normal Forest

Diagram 16. In a felling series under the *regular shelter-wood system* of natural regeneration, age classes take the place of age gradations and periodic blocks that of annual coupes. The yield is regulated by periods and generally prescribed by volume, as far as possible.

In the *selection system,* i.e., in forests where trees of all ages occur in a homogeneous mixture, strictly speaking the whole forest should be gone over every year to remove mature trees. But this is not convenient. The forest is, therefore, divided into a number of *sections* only one of which is worked in a particular year on a cycle which is known as the *Felling Cycle.*

Diagram 17 is a representation of a *normal* forest with age-gradation 1, 2,...........r standing on equal areas represented by the abscissae with volumes as represented by the ordinates. If a year's increment on any age-gradation is represented by a rectangle with area i, it is clear from the diagram that the volume of the oldest age-gradation r years old is equal to

(i) the total increment in r years, i.e, ri;
(ii) the final MAI of any age-gradation multiplied by Y;
(iii) the sum of the CAI of all age-gradations in the year r;
or
(iv) the MAI of the entire forest.

NORMAL GROWING STOCK

The total growing stock (GS) of the normal forest is

$$i + 2i + \dots\dots\dots + (r-1)i+1$$
$$= \frac{r\,(r+1)i}{2}$$

writing *I* for ri

$$Gs = rI/2 \;+\; 1/2$$

Therefore in the middle of the growing season it will be rI/2.

ROTATION

This word is used in forestry in a technical sense and refers to the period that elapses between the formation or regeneration of a wood and its final felling. The reason why a term, which means revolution, is used will become clear from the definitions of a normal forest. After the mature crop (r years old) is felled, the new crop coming up in its place becomes due for felling only after another r years. In the meantime fellings go once over all age-gradations (which at that time are r—1 to 1 years old), in successive years.

Under the clear felling system rotation is a definite period. Under other systems it merely represents the average felling age of stands. Under the Selection System it is the age at which individual trees attain the exploitable size. Various types of rotations are differentiated. The period that coincides with the natural lease of life of trees is called the *Physical* rotation. It is of interest in parklands and in protection forests. The rotation most favourable for obtaining natural regeneration of a particular species is referred to as the *Silvicultural* rotation. The period in which trees of a particular size are produced, for instance, pulpwood billets or pit-props, is called the *Technical* rotation. Besides this, there is the rotation of the *Maximum Volume* or *Value Production*, i.e., the age at which the mean annual volume or value increment of the forest culminates, and the rotation of *Highest Income* which is the age at which, without regard to interest on the invested capital, the annual yield in terms of value is the highest. Lastly there is the *Financial* rotation, that is, rotation at which all the money invested in the forest for creating and tending it eventually yields the highest rate of compound interest from receipts. This is the rotation which should be used when growing firewood or pulpwood for commercial sale.

Yield Regulation

The volume or number of stems that can be removed annually or periodically, or the area over which fellings may pass annually or periodically, consistent with the attainment of the objects of management is called the *yield* of a forest. The primary object of forest management is to regulate the yield so as to obtain progressively increasing, and eventually the maximum yield for all time. The yield may be obtained by working the forest on the basis of area or volume. Only the simplest methods can be described here by way of illustration.

(*a*) *Yield Regulation by Area—Judeich's Method:* This method is commonly used in India. The essence of this method is to carefully select areas to be exploited during the Working Plan period, due regard being paid to the age of the wood as also its readiness for being regenerated. The forest is divided into a convenient number of units of suitable size called *compartments*. These compartments are inspected with a view to finding out what treatment they would need during the first working plan period, say the next 10 years, and certain compartments are selected for final felling and regeneration during this period. The size of the mean annual coupe is determined by dividing the area of the forest by the rotation and from this the normal area to be felled and regenerated in 10 years is determined. If the area selected is within 10% of the normal cut, i.e., $x = \frac{10A}{Y} \pm 10\%$ no adjustments are made. When however, it is less or more, transfers are made to eventually get a normal distribution. How this is done will be clear from the following example:

Area of the forest 2000 *ha. rotation* 80 *years; working plan period* 10 *years*. Against the normal distribution when each of the four age-classes should have 500 ha. of forest, let the distribution be:

Age class (years)	*Extent (ha.)*	
	Normal	*Actual*
1-20	500	400
21-40	500	300
41-60	500	700
Over 60	500	600

The normal area that should be felled in the first period of 10 years will be 10 x (2000/80)=250 ha. But as there is an excess of old wood, with a view to normalise the forest it would be desirable to fell a larger area, say, 300 ha., in the first and second periods. Then the position after 10 years and 20 years will be—

Age class (years)	*Extent (ha.)*	
	After 10 *years*	*After* 20 *years*
1-20	500	550
21-40	350	425
41-60	500	425
Over 60	650	600

After this, if the normal rate of cut is restored, i.e., 250 ha. are felled, in the third and also in the fourth period, the forest will progressively approach normality.

Thus the age-class composition after 30 and 40 years will be—

Age class years	Extent (ha.) After 30 years	After 40 years
1-20	525	512
21-40	487	506
41-60	415	456
Over 60	563	526

(*b*) *Yield Regulation by Volume: Brandis' Method:* It would be appropriate to describe here the method suggested for the first time in 1856, for application to a forest in Burma (then a part of India) by Brandis (later Sir Dietrich), the first Inspector-General of Forests, India. Brandis was faced with the problem of exploitation of a large forest over which concessionnaires were granted right to cut trees of teak, the only marketable species of the forest, and forming hardly 10 per cent of the crop, the teak trees being in all sizes in an intimate mixture. Had all the merchantable trees been allowed to be cut from one end of the forest to the other, it would have taken very long before the forest could be productive again, even assuming that regeneration of teak did appear, could establish itself and compete successfully with the uneconomic growth of other species. Brandis, therefore, thought of an ingenious method of exploiting the forest and at the same time ensuring a sustained yield. He decided that only teak trees over a fixed diameter (exploitable size) be allowed to be removed, and then proceeded to determine the maximum and progressively increasing, sustained yield in terms of number of trees of exploitable size from one end of the forest to the other for a particular felling cycle, determined on the convenience of management.

For this purpose he collected the following information:

(i) availability of teak trees by diameter classes;

(ii) the current annual increment for each diameter class and the average period taken by trees of a lower diameter class to reach the higher diameter class;

(iii) the age corresponding to the exploitable diameter;

(iv) the percentage of teak trees of the lowest class which could survive on reaching the various higher diameter classes; and

(v) the reasonable felling cycle.

He then worked out the yield of trees of exploitable diameter and above, by taking into consideration the number of trees that would cross the exploitable size in a felling cycle, and the exploitable trees already available in the forest. The details of the method are explained below with the help of a hypothetical example. The writer used these figures for working out the mathematics of the Brandis' concept, in 1956, exactly a century after the method was evolved, as a tribute to the father of Indian Forestry.

If the diameter-age relationship for representative teak trees is

Diameter	*Age*
4″	16
8″	32
12″	56
16″	74
20″	88

and trees above 20″ diameter are considered exploitable, then the periods for which trees remain in the various diameter classes will be:

Diameter Class	*Years in Class*
over 20″	—
16 —20″	14
12 —16″	18
8 —12″	24
4 — 8″	16
Total (4 —.20″)	72

Let the percentage of trees of various diameter classes reaching the exploitable size, i.e., the survivals at 20″ diameter be—

Diameter Class	Over 20"	16"—20"	12"—16"	8"—12"	4"—8"
Survival %	100	80	60	40	25

Let the availability of teak trees in the forest be as shown in the sub-joined table, in column 2. Then their survivals at the exploitable size will be as shown in column 3 and the annual recruitment to the classes will be as shown in column 4.

Diameter Class	*Number of Trees*		
	At enumeration	*Survival at 20" diameter*	*Annual recruitment*
(1)	(2)	(3)	(4)
Over 20"	15000	15000	—
16"—20"	12250	9800	700
12"—16"	27000	16200	900
8"—12"	60000	24000	1000
4"— 8"	88000	22000	1375
	Total:	72000	

At the end of 72 years the smallest enumerated tree now 4" in diameter, if its survives, would have reached 20" in diameter and thus the total number of exploitable trees will become

Stock-in-hand	15,000
Recruitment	72,000
Total	87,000

Therefore, theoretically, it should be possible to exploit annually $87000 \div 72 = 1208$ trees. But if the forest is to be gone over on a 20-year felling cycle, i.e., it were divided into 20 equi-extensive cutting sections, only one of which will be worked annually, the availability of exploitable trees will be as follows[1]:

In every cutting section there will be a stock-in-hand 15000/20=750 trees. But the recruitment that would accrue a cutting section by the time it is due for working will be different. Only the recruitment that accrued upto the time that the section was taken up for working (say in the beginning of the year) will be realisable, and the recruitment that accrued *after* this date will accumulate and will be available for exploitation 20 years later. In the example under consideration out of the total recruitment that will accrue in the first felling cycle (at 700 trees per year for 14 years and thereafter 900 trees per year for the remaining 6 years of the cycle) namely, 15200, only 7180 trees will be realisable when working in equi-extensive coupes.[2] Therefore, the maximum yield that can be realised in the first cycle will be 15000—7180 or on an average 1109 trees per year, and by doing so the entire stock-in-hand would have been exhausted.

In the next cycle, the availability will be the accumulated recruitment from cycle 1 that is 15200—7180 or 8020 *plus* the realisable recruitment of the second cycle, namely, 9160, i.e., altogether 17180. The maximum annual yield that could be obtained in the second cycle will therefore be 17180/20 or 859 trees. This is below the yield of the first cycle. Lowering the yield will be bad management. Therefore, it would be advisable not to liquidate the entire stock-in-hand in the first cycle. It may be fully utilised in two cycles—

Stock-in-hand	15000
Total recruitment accrued in Cycle I	15200
Realisable recruitment of Cycle II	9160
Total	39360

[1]Here it has been assumed that trees of all classes are distributed uniformally and the recruitment comes up uniformly in space and in time.
[2]For details see *Indian Forester*, July 1956 and September 1962.

If this is removed in 40 years, the average cut comes to 984 trees. After this in the Third and Fourth Cycles the availability will be:

Cycle III

Accumulated recruitment of Cycle II	9640
Realisable recruitment of Cycle III	10150
Total	19790
∴ annual cut	989

Cycle IV

Accumulated recruitment of Cycle III	11350
Realisable recruitment of Cycle IV	13950
Total	25300
∴ annual cut	1265

Thus the yield will progressively increase. It would, therefore, be right to liquidate the stock-in-hand in two cycles. The best method of realising this will be as under:

The total availability in cycle I is 1109 trees per year against which 984 are to be removed in the first cycle. Therefore, proceeding from one end of the forest, 1109 exploitable trees should be marked annually, but 1109—984=125 most vigorous trees more or less uniformly spaced should be left standing for the next cycle. By this method the annual *coupe* will progressively decrease due to increased recruitment, but the entire forest will be gone over in 20 years and thus cultural operations could also be carried out and the maximum possible sustained yield under a 20-year felling cycle realised. It has been mathematically proved that if the yield is realised as suggested, in the third cycle the annual cutting sections become equi-extensive.

Typical examples of Yield Regulation in Indian Forests: The method of yield regulation suited to a particular forest to obtain the most satisfactory results, silviculturally and economically, depends upon its type, composition, locality factors, including demand, intensity of working possible, and research findings available. A few examples are cited below:

Silver Fir and Spruce forests are worked under a modification of the classical selection system with exploitable diameter for both the species at 75 cm. corresponding to a rotation of 150-200 years on a felling cycle of 30-40 years, the annual yield being regulated by the number of trees.

Deodar forests are ideally managed under the Indian Irregular Shelterwood system. As there is an intense demand for large-sized timber, advance growth upto 45 cm. diameter, if found in compact patches, is retained for the growth of large trees. On precipitous slopes the selection system is followed to prevent erosion. On easy ground where natural regeneration is deficient it is supplemented by sowings and plantings. Recent trends are towards reducing the exploitable diameter to 50 cm.

The Chir pine forests under favourable conditions of light and fire-protection regenerate naturally. The exploitable diameter is 60 cm. and the rotation 120 years. The maturing trees are lightly tapped for resin.

The broad-leaved Evergreen forests are characterised by a multiplicity of species, of which only a few are economically utilisable. They are therefore worked under the selection system where the minimum size of trees of various usable species is fixed on the basis of their rate of growth and the most feasible felling cycle.

The Moist Deciduous forests have either Sal, which grows gregariously, as the most valuable species, or else teak which occurs inextricably mixed with other species. The Sal forests of Bihar and M.P. regenerate naturally, but not so those of U.P., where a very detailed technique is followed to induce regeneration. Even artificial regeneration is being attempted. In teak forests Selection-cum-Improvement felling with an exploitable diameter for teak, depending on the locality, is followed with a felling cycle of about 20 years. The felled over area is artificially restocked with teak, as the technique for doing this has been elaborately worked out.

The semi-moist teak and Sal forests of M.P. are being worked under the Coppice with Reserves system, reliance being placed on seeding coppice from advance growth to restock the area after the main fellings. The same technique is followed for the drier forests where a thicker canopy is maintained to make soil conditions favourable for the coming up of advance reproduction throughout the life of the overwood.

Wherever the existing forest is derelict or of a pure type and the locality is suitable for artificial regeneration, species like eucalyptus, babul, prosopis, etc., are being grown.

Working Plan

Technically, a forest working plan has been defined as a written scheme of management aiming at continuity of policy and action, and controlling the treatment of a forest. The treatment depends on the objective to be achieved. This may be *economical, protective, bio-aesthetic* or a judicious combination of two or more of these. As forests take long to mature, it is essential to have a management plan to ensure continuity of action. There are certain necessary preliminaries to the preparation of a working plan. The owner must lay down a policy which he desires to follow and which is realisable. The policy must be supported by a forest law. He must also take adequate steps to see that it shall be enforced. The forest be clearly demarcated, surveyed and mapped. A record of rights should also be available, as it may become necessary to curtail or extinguish some portions to ensure proper development of the forest. When a working plan for a forest is being prepared for the first time, it is necessary to make a reconnaisance to ascertain the general nature of the terrain, the climate and the soil and their effect on the forests. An accurate assessment of the requirements of the species is also made by a rapid survey of the various ecological factors operating in the locality. In India such information is generally already available except for certain remote forests for which there are no large-scale maps and which have not yet been worked. A map must be prepared by a rapid survey before commencing other work. In the reconnaisance report, the Working Plan Officer deals with the history of the forest in the immediate past and its effects, outline of the demand, object of management, silvicultural system considered most suitable for different forests, method of calculating the yield, development of communications, etc. This report is submitted to the proprietor or in the case of Government forest to the next superior officer, generally the Conservator of Working Plans. It is examined at a conference of persons acquainted with the forest and a set of instructions is drawn up for the guidance of the Working Plan Officer on various points raised in the report, on the basis of which he commences his work. When a forest is being brought under a working plan for the first time, it is divided into convenient administrative units called *compartments.* A *compartment* is a territorial unit of a forest permanently defined for purposes of administration, description and record. Compartments are generally designated by Arabic numerals. These are generally 100 to 400 hectares in extent depending on the intensity of management. As far as possible they have natural or artificial but permanently maintained boundaries and are numbered serially for the entire forest, care being taken that the successive compartments are contiguous, as far as possible. Thereafter the forests are inspected in detail and a history written up, compartment-wise, giving boundary, physiography, soil, description of the growing stock and regeneration, past history and a rough indication of the future working. Simultaneously, a decision is taken as to which compartments need to be enumerated to find out the standing growing stock.

On the basis of information thus collected Part I of the Working Plan giving *Facts on which proposals are based* is written, under the heads: name and situation, local conditions, general history of the forests, ecological factors, economic considerations, and statistics of growth and yield. Part II of the working plan gives *Prescriptions for future management,* namely, general objects of management, division of forest into Working Circles and Period of the Plan.

Divisions of Forests for Management: Besides the classification of forests by legal status, ownership, composition and functions, *vide* Chap. II, Sec. 7) and for administrative purposes into charges of Chief Conservator, Conservator, Divisional Officer, Ranger, etc., *vide* Chap. VII, Sec. 1), for purposes of management, forests are classified as under:

The unit of forest management is a *Working Plan.* Under it the

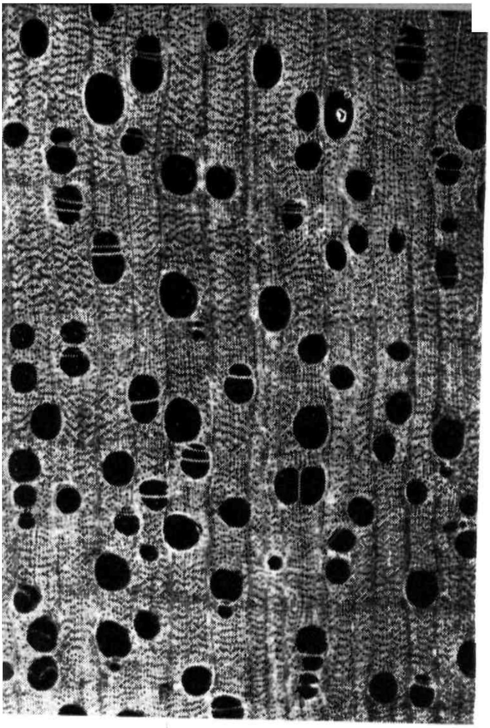


Plate 28

MICRO-PHOTOGRAPHS OF WO

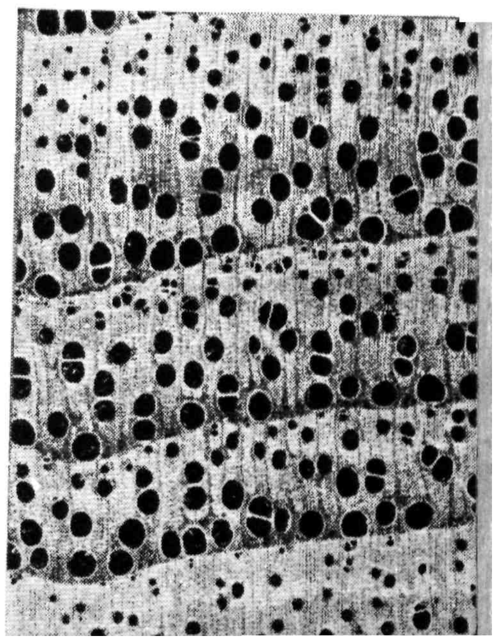
(*a*) Diffuse Porous Wo Semal (*Salmalia malabaric*

(*b*) Ring Porous Wood Te (*Tectona grandis*)

(*See page 21*

(*a*)

(*b*)



(*a*)

Plate 29

LOGGING OPERATIONS, H.P.

(*a*) Log on the long-distance sky-line crane

(*b*) Logs loaded on a truck

(*See page 218*)

(*b*)

Plate 30

MODERN INTERNAL FAN STEAM-HEATED SEASONING KILN

(*See page 226*)

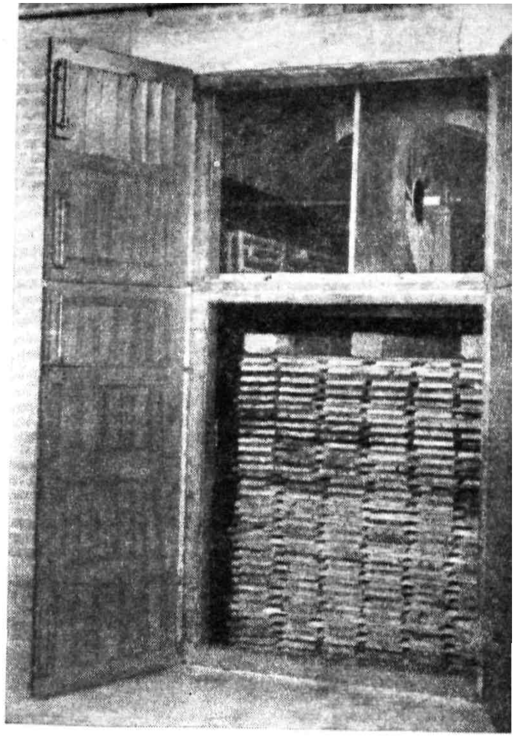


Plate 31 SALAI BILLETS AT NEPA MILLS (*See page 234*)

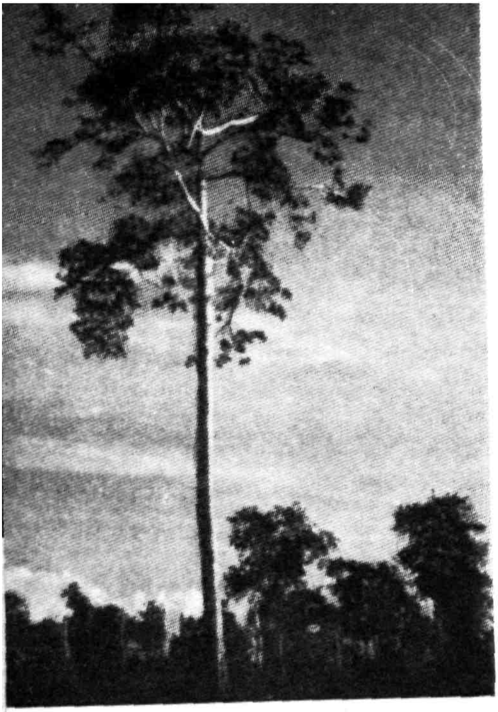


Plate 32

A LOFTY SEMAL TREE
(*Salmalia malabarica*)

(*See page*

Plate 33 SANDALWOOD TREES IN SCRUB FOREST, MYSORE

(*See page 209*)

forest is divided into a number of *Working Circles*. A working circle is a part or the whole of the working plan area, organized with a particular object, and under one silvicultural system and one set of working plan prescriptions. Sometimes working circles may overlap; for instance when bamboos occurring in the area are worked under different prescriptions to the rest of the growth. A working circle is constituted into one or more *Felling Series*. A felling series is so delimited as (i) to distribute felling and regeneration to suit local conditions, and (ii) to maintain or create a normal distribution of age classes. It should have an independent representation of all age classes after fellings have gone over it once. A sub-division of a felling series formed with the object of regulating felling in in a felling manner is called a *Cutting Section*. The area of forest in a felling series prescribed for felling each year is called the annual cutting area, or *coupe*. Coupes are usually numbered on the working plan map in Roman numerals.

There is one chapter on each working circle giving constitution, sub-division into felling series and sequence of areas to be worked from year to year; silvicultural system, rotation or exploitable sizes, technique of regeneration, tending, etc., regulation of the yield, plan of exploitation; and cultural operations. This is followed by a chapter dealing with communications, fire-control, grazing regulations and other information, including staff and labour supply, etc., and a chapter giving the cost of the plan and the financial forecast. A number of appendices are also prepared giving the statement of the area of the forest classified into quality classes and types by compartment, results of enumeration of growing stock; details of compartments allotted to various working circles; statement of fellings in the various felling series; details of enumerations carried out and statistics of growth and yield. Maps giving geology and soil, forest type and quality classes, fire protection and grazing control prescriptions, etc., and a management map showing working circles, felling series, compartments, and coupes as also the headquarters of the Divisional Forest Officer, Rangers and Forest Guards have been provided.

In short, a working plan, or more appropriately a *management* *plan*, is a complete document drawn up by a trained forester, after a thorough assessment of the potentialities of the forests laying down the details of treatment prescribed to realise the wishes of the owner, as far as feasible. Ordinarily, the object is to obtain the maximum yield of produce most in demand at the minimum cost and to keep the forest in a condition that this will be obtained on a sustained and, where possible, progressively increasing basis. As forest trees take years to mature and neglect in tending or faulty exploitation may adversely affect their growth and future yields, a working plan is necessary to ensure continued satisfactory management of a forest.

GROWING STOCK OF FORESTS IN USE (1964-65)

Total Volume		1442 million cubic metres
that is		32 cubic metres per hectare.
Area under Working Plans	..	36.575 M. ha.
Not under Working Plans	..	31.476 "
High Forest	..	17.310 "
Coppice Forest	..	25.175 "
Outturn in Value		
Major Products	..	Rs. 585,630,000
Minor Products	..	Rs. 158,594,000
Financial Working		
Gross Revenue	..	Rs. 98 crores
Expenditure		
a. Normal	..	Rs. 35 crores
b. Plan	..	Rs. 17 crores
Surplus	..	Rs. 46 crores
or 46.9 % of Gross Revenue.		

CHAPTER XII

FOREST PROTECTION

> In the economy of Nature, forests are of utmost importance. But with the spread of industrial civilisation and the rapid growth of population, unhappily forests tend to disappear. We are apt to forget that in so far as this happens, we are upsetting that economy of Nature, and doing injury to man. I am pained when I see a noble tree, which has taken long to grow and spread out in all its majesty, cut down by careless hands. There should be a strong feeling among our people to prevent this vandalism. If such cutting down becomes unavoidable, we should develop a convention that it should be replaced immediately by planting two trees. I hope that the vital importance of forests will be fully realized.
>
> —JAWAHARLAL NEHRU

> The future of India hangs not in the political but in the physical balance. Our future is tied up with the maintenance of the equilibrium of the inexorable forces of nature which brooks no interference. The shape of things to come a couple of hundred years hence will depend upon how we conserve our soil, how we organise our physical defences against nature and how, in short, we protect our forests.
>
> —M.D. CHATURVEDI, PROFESSOR EMERITUS

GENERAL

A forest is very vulnerable inasmuch as it can easily be depleted and even destroyed unless carefully protected. The main agencies responsible for damage are unrestricted grazing by domestic animals. browsing by wild animals, insects, fungi, and fires. Of the natural calamities, damage by wind, snow or lightning is not extensive, but floods can do much harm to a forest, especially if water does not recede quickly. Soil-erosion following maltreatment of a forest also considerably lowers its productivity.

UNAUTHORISED CUTTINGS

In so far as ruthless and illicit cuttings are concerned, which deplete the forests and thus reduce its productivity, no amount of policing can be effective. The only remedy is to educate public opinion by convincing the people that such malpractices are against the national interest.

Grazing

At the present stage of development the importance of livestock in the national economy of India needs no special emphasis. India possesses a livestock population of over 300 million of which 225 million are bovine animals, about one-tenth of which graze in forests. Wherever forests are easily accessible, the livestock depends entirely on grazing in them, as stall-feeding is far more expensive. Heavily grazed forests provide very little inferior fodder, mostly roughage, to the animals which are therefore poorly developed compared to those fed at the stake.

The principles on which grazing is admitted in forests are of fundamental importance as forests play an important role in the economic life of the people. Production of trees and provision of grazing and fodder are two conflicting demands on land which can overlap only to a certain extent. When the limit of safety is exceeded, the physiological balance of the plant community is so upset that both tree growth and pasture rapidly deteriorate. It is therefore of utmost importance that the optimum balance between plant cover and the adverse agency of grazing is maintained to perpetuate the forest as well as the pasture in a satisfactory condition. This is the primary reason why instead of unlimited and continuous grazing, as was the practice before the forests were reserved, controlled and restricted grazing is advocated. The national forest policy has recognized that uncontrolled grazing is incompatible with scientific forestry and has laid down the basic principle for admitting grazing in the forests. The measures taken by the Forest Department in the *reserved* forests of erstwhile Madhya Pradesh to solve the thorny question of meeting the conflicting demands of grazing and production of trees in the most amicable manner are described in brief, to illustrate the nature and extent of the present problem and how it could be tackled wherever grazing is admitted in forests.

Soon after the forests were declared reserved, browsing by goats, which are voracious feeders, was stopped. Shortly afterwards, it was found that unrestricted grazing of even cattle was detrimental to young tree growth. Large areas were, therefore, entirely closed to grazing. It was, however, soon realised that complete closure to grazing was resulting in a heavy growth of grass, which was hampering the development of important tree species. To remedy this defect, it was prescribed that a forest should be closed to grazing immediately after felling and should remain so until the tender forest seedlings have grown beyond danger from cattle. A period of ten years was considered sufficient.

Experience showed that this arrangement benefited regeneration of tree species, which could get established during the closure period. It, however, did not appreciably improve the pasture because the recovery during the period of closure was nullified by the very heavy and continuous grazing thereafter. Further modifications were considered necessary. It was recognised that the demand had increased to such an extent that certain forests must hereafter be managed with provision for grazing and grass as the principal object. In consequence, the forests were classified into (i) *Tree Forests*, and (ii) *Grazing Grounds*. In the former, grazing was restricted both in intensity and in duration, whereas in the latter, owing to a heavier demand for grazing, the cattle incidence could not be controlled, but periodic monsoon closures were prescribed to allow grasses to recuperate.

A Special Revenue Officer was appointed to examine the prescriptions of each working plan as it came up for revision, to make provision for grazing in the most amicable manner consistent with the proposed restrictions. The forests were divided into a convenient number of *grazing units* with a view to provide the most convenient areas to each village and at the same time to ensure, as far as possible, uniform grazing incidence over the entire area of a unit. The capacity of each grazing unit was worked out according to the prescribed limiting incidence and the average area open to grazing. Whenever the carrying capacity exceeded the number seeking admission all cattle were admitted. But when the number seeking admission exceeded the prescribed limit, only selected cattle were admitted. For this purpose, the stock was differentiated into three categories:

Privileged, i.e., animals absolutely indispensable for *bona fide* agricultural purposes;
Ordinary, i.e., animals necessary for quasi-agricultural pursuits; and
Commercial, i.e., the remaining stock.

For the three classes of cattle, different grazing fees were charged and thereby a wholesome convention of discriminating between the *essential* and the *surplus* livestock was inaugurated.

On the recommendations of the State Forest Policy Committee in 1952, the M.P. Government adopted a resolution by which, for purposes of management and regulation of grazing, forests were classified as follows:

(i) *Protection Forests*, viz., those forests which occur on very steep slopes (25° and over), or along river banks, and forests that have got depleted through maltreatment and further exploitation of which will accentuate soil erosion and adversely affect the productivity of agricultural lands in the lower regions;

(ii) *Tree Forests*, viz., forests situated in remote tracts on which there is little or no agricultural demand and which are pre-eminently suited for growing large-sized timber and other products of commercial value;

(iii) *Minor Forests*, viz., forests that are interspersed with cultivated lands and are capable of producing small timber and firewood and provide grazing, which are the indispensable needs of the adjoining agricultural population;

(iv) *Pasture Lands*, viz., those openly stocked forests or scrub lands that have ceased to yield even small timber which are conveniently situated for providing grazing to the cattle used on agricultural works.

(v) *Remaining Forests*, viz.:

(*a*) *Grass Reserves*, which are small blocks of forests situated amidst intensively cultivated tracts carrying scrubby growth and capable of producing good fodder grasses which are in short supply;

(*b*) *Recreation Reserves*, which are needed for bio-aesthetic purposes, i.e., as holiday-makers' resort and for the study of wild life.

(*c*) *Forest Villages*, etc.

The extent to which grazing could be allowed in the various classes of forest was indicated.

Ideal Coupe Sequence in Pasture Forests: In forests on which there is a heavy demand for grazing, and which have to be rigidly fire-protected, the sequence of coupes in a felling series should be so fixed (with due regard to the age of the crop) that closure of coupes will cause the least inconvenience to the stock owners and expenses on fire-tracing will be the minimum. The writer worked out in detail how this may be secured for various grazing-closure cycles and locations of villages. One simple example for five years' grazing alternating with 15 years' closure is illustrated in Diagram 18.[1]

In 1955, in view of a general clamour, the State Government

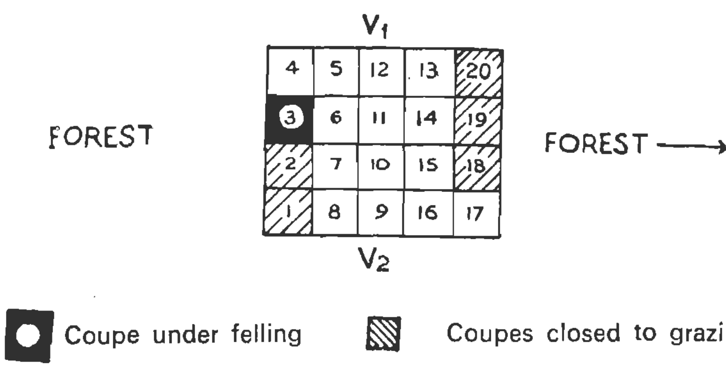


Diagram 18. Ideal Coupe Sequence

[1]For other conditions see *Indian Forester* for 1935.

was compelled to order that all cattle be allowed to graze in the nearest grazing unit. This order, in effect, did away with the provision of controlling the incidence of grazing with the result that grazing rapidly deteriorated.

These liberal concessions and cheap forest grazing are primarily responsible for the present low-utility value of the stock which has led to the vicious spiral of reckless increase in the number of cattle, inadequate forest grazing, less food per animal and hence lower utility value and further increase in the number to offset the fall in quality. There is no incentive left to stall-feed the essential stock. A stage has now been reached when no more stock can subsist even on a starvation ration. In the interests of conservation of forests, it is suggested that grazing in all forest areas should be regulated in the manner indicated. The measures suggested will naturally result in a large number of cattle being kept out of the forests. These will have to depend upon the village grazing grounds for their sustenance. In villages where there is a shortage of forest, part of the village 'waste land' should be developed as a fuel-cum-fodder reserve, paying particular attention to the raising of fodder trees. The advantage of stall-feeding over forest grazing needs no emphasis. Certain forest areas may be developed as grass reserves and works of improvement undertaken to maximise production of fodder of good quality. (*q.v.* Chapter VIII)

Cheap forest grazing is primarily responsible for the present condition of the stock. The fees charged are extremely low and out of all proportion to the value of grazing offered in return. The result is that instead of being a source of relief to the cultivator the liberal concession actually acts as a curse on him. There is no incentive left to keep a fewer number of more efficient animals and for improving the utility-value of the stock, which will be possible only after the surplus uneconomic stock is reduced and thus a greater share of fodder is made available for the essential animals. The conclusion is inescapable that if the utility-value of the stock is to be improved, a deliberate attempt is necessary to make grazing more expensive by charging for it at the market rate and by making every effort to produce more nutritive fodders in greater abundance.

Wild Animals

Wild elephants do considerable damage not only to cultivation near the forests but also to forest plantations. They are particularly fond of bamboos. Bisons also avidly eat bamboos and the bark of young teak. The deer family browse and prevent Sal and other species from coming up. Pigs dig up roots and also cause damage to plantations. Porcupines were found to eat the succulent roots of Salai in the Nepa mills plantations as a result of which planting of this species had to be given up. Rodents do a lot of damage to fallen seed in the forest and to plants in the nurseries. Birds eat certain fruits, but by and large they are very beneficial as they also eat obnoxious insects. Monkeys eat tender shoots and fruits of certain species. Bears destroy honeycombs to drink the honey, but they also eat the harmful white-ants. As typical of damage by man may be cited the case of the forests in the catchment of the Bhakra dam which are not only being browsed by goats and cattle but are also being ruthlessly lopped and felled. Experiments have shown that even five years' closure of such forests to grazing and prevention of lopping rehabilitates them to such an extent that the soil run-off practically ceases.

Insects

A large population of insects lives in forests, in timber storage depots and even in timber in use. Insects are destructive to forests especially when they suddenly increase in number, the exact reason for which is not always understood.[1] Thus there was a veritable epidemic of the borer longicorn among the standing Sal trees in 1926. Trees worth several lakhs of rupees in Madhya Pradesh were destroyed. Some insects are carriers of virus infection. The spike disease of sandal which takes a heavy toll of this valuable tree is

[1]Some insects are actually beneficial. The *tussor* moth found mostly in the forests of eastern M.P. on Saj trees gives Kosa silk. Bees give honey. Shellac is the secretion of the lac insects which thrive mostly on the Kusum, Palas and Ghont trees in Bihar and M.P.Many insects live parasitically on certain injurious insects and thus kill them. The cochineal insect brought from Australia is used to eradicate the obnoxious cactus *Opuntia*. Lady bird beetles are also very beneficial as they feed on aphids which cause damage to flowers and fruits.

believed to be so transmitted. There are several other insects which cause damage to seedlings, trees, fruits, flowers, timber in use, etc. Damage to plants may be caused by the larvae or the adults. The former mostly damage seedlings in nurseries by feeding on their tender roots or by eating the fruits, buds or flowers or other tender parts, or by boring in the wood of living trees. The adults of beetles attack wood or bamboos.

Teak Defoliators—Teak, the most valuable timber tree of the country, faces periodic outbreaks of two defoliators, a skeletonizer called *Hapalia machaeralis* and one that eats the leaves completely called *Hyblaea puera*, which affects the vigour of the tree and must be reducing the rate of its growth. Current research therefore aims at achieving an integrated control schedule which includes a judicious combination of biological control measures and a direct chemical treatment.

To prevent or minimise damage from insects, various measures are adopted—

(i) *Chemical,* viz., the use of insecticides which are stomach poisons (lead or calcium arsenate, sodium fluoride), contact poisonous preparations of nicotine, lime, sulphur, pyrethrum, derris, DDT, BHC, Aldrex, dealdrine, etc.), fumigants, HCN, CS_2, SO_2, nicotine, methylbromide, etc. Repellents (Boredeaux mixture, creosote, naphthalene, oil of citronella, etc.)

(ii) *Mechanical,* such as hand catching and destruction of beetles as was done to control the Sal borer, putting grease bands as barriers on tree trunks to prevent larvae from climbing trees, trapping by machine, etc.

(iii) *Silvicultural,* i.e., by bringing about hygienic conditions by drainage, thinning, etc., and by the selection of resistance varieties of seeds, plants, etc.

(iv) *Biological,* i.e., by increasing the population of predators and parasites of pests, encouraging insectivorous birds, introducing fungoid, bacterial or protozoal diseases of the pest; and

(v) *Legal,* i.e., introduction of quarantine rules, insistence on phyto-sanitary certificates for plant material imported from outside, etc.

PLANTS AND FUNGI

Certain trees grow and live parasitically on useful trees such as Pipal and banyan and deform or even kill them. But when these grow by themselves, they need not be destroyed as they provide food and roosting for birds which feed on injurious insects. Of the parasitic plants, mention may be made of *Viscum* or mistletoe, *Cuscuta* and *Cassytha.* Their seed is avidly eaten by birds and when it passes out unaffected, it germinates in the fork of branches of trees. These should be cut and destroyed. Some of the climbers grow to large sizes and strangle trees or over-top them and prevent their proper development. One such climber is Mahul very common in the moist forests. The leaves of this climber, however, are collected and used as wrappers or made into plates and cups. Its stem is also twisted into a rope. It would be desirable to devise methods to cultivate this climber without damaging timber trees. The shrub *Lantana aculeata* which was introduced in the country some 100 years ago has become a pest in certain forests where it climbs on trees and smothers them. When such areas are to be regenerated the shrub is pulled out with the help of elephants, heaped and burnt. *Lantana,* however, is a good soil cover for abandoned lands as it minimises soil erosion.

Protection of forests from plant pests plays an important role in the scientific management of forests. The natural losses by fire, decay, insects, wind-fall, etc., are believed to cause damage worth several lakhs of rupees. Losses from fire and insects are spectacular because of easy manifestation, but the more insidious losses occur because of pathogenic and non-infectious factors which probably exceed the combined losses from fire and insects. Parasitic plants may kill outright trees over a wide area, or seriously reduce their vigour. The loss due to decay of heartwood in the standing trees is very heavy. The living wood being normally unaffected, diseased trees continue to live and may complete their rotation, only felling may reveal that they contain no way timber. Root diseases also cause large-scale mortality of forests as in Sal and Sissoo. Among the stem and leaf diseases, mention may be made of rusts some of which can kill trees, for example that on Deodar. Of the flowering plant parasites, dwarf mistletoe causes serious deformity or mortality in blue-pine in the dry zones of the Himalayas. One of the serious virus diseases of forest trees already mentioned is the spike disease of sandal which has wiped out sandal trees in many localities in South India. So far no prophylactic or preventive measures have been found. Knowledge of silviculture and of management of a species is important in preventing infection. For example in Sal, fires cause wounds through which fungi causing decay in heartwood establish themselves in the tree. Sissoo, which grows naturally in loose sandy soils, suffers from root diseases when it is raised in plantations on stiff and clayey soils; selection of suitable soils for its healthy growth is thus important. Suitable measures of sanitation and forest hygiene like the removal and disposal of diseased trees, which may bear heavily sporing fruit bodies of fungi, are important in reducing the inoculum in the forest to keep the disease at a low level. Chemical treatment is an important measure in the control of damping off of seedlings in a nursery. This may become increasingly important in future as large-scale plantations are likely to be made of fast growing species, seedlings of many of which have to be raised in a nursery prior to their transplantation in the field. In the derelict coppiced Sal forests in the eastern part of India, there is a high incidence of decay in the stumps from where it migrates into the coppice when heartwood develops in it. As a result, such coppice stands cannot produce large timber, or even poles. A gradual switchover from coppice to forests of seedling origin is thus clearly indicated. The chemical poisoning of stumps to prevent them from further coppicing by the use of 2-4-D, 2-4-5-T, and diesel oil is recommended.

Nutritional deficiencies are likely to play a significant role when indigenous species are planted through several rotations. Large scale mortality of poor quality Sal all over North India is, in most cases, due to the deteriorating site conditions, the most important single factor being lessened soil moisture.

As pointed out earlier, roots of forest trees are frequently associated with certain fungi forming a composite symbiotic structure, called *mycorrhiza*. The root-fungal associations act as highly efficient aerobic accumulators of ions, assisting both plants and fungi in their competition for nutrients with other living organisms in the soil. Failure in forest plantings, especially of exotics, particularly in afforested lands, may be due to the absence of suitable fungi in the soil forming mycorrhizal associations. Success in such areas is frequently achieved by introducing into the soil suitable mycorrhiza-forming fungi. A typical example is the success of exotic pines when soil from Chir Pine is used. With large-scale introduction of exotics in the country, mycorrhiza is likely to play a dominant role in their establishment. If a species fails to develop a mycorrhiza naturally, it may be possible to get it established by introducing another which is suitable.

Forest Fires

A ground fire in a forest destroys the organic matter in the live soil which is necessary to maintain the proportion of humus. Nitrogen in the decomposed leaf mould is also lost. Repeated burns may expose the dead soil which when trampled over by grazing animals gets pulverised and the dislodged particles are washed away with the first heavy monsoon shower. Severe fires can kill standing trees and may even scorch or completely burn them. Only in rare cases when there is a thick mat of leaf litter on the ground, a fire may prove beneficial as it may bring about conditions favourable for the inducement of regeneration of valuable forest species. Thus a light annual fire in the semi-moist teak forests results in a crop of teak seedlings. This is why fire has been termed a bad master but a good servant of the forester.

Sometimes, fires are caused deliberately by the local people to drive away carnivora and game, such as deer and pig which are destructive to crops; or to burn the stubs of perennial grasses to get a flush carpet of young grass. Fires may also start spontaneously say from lightning or by the rubbing of culms of bamboos in a strong wind. Sparks from coal-fired railway locomotives also originate forest fires.

The tropical wet forests and the temperate montane forests are virtually immune from fire hazard because of the damp conditions. In other forests which form the major portion of the exploited forests of India, fire damage can be very considerable as it spreads quickly and rages fiercely because of the high temperature and winds, especially as the ground is covered with a mass of dry inflammable leaves. Pine forests in which there is an accumulation of a thick layer of dead needles are also highly susceptible to fire. Fires are almost an annual feature in the dry forests and have completely modified their composition by the disappearance of firetender species. This explains the occurrence of almost pure teak forest in the western parts of Madhya Pradesh. When such forests are fire-protected, miscellaneous species reappear.

The somewhat misleading phrase 'fire protection' used in forestry refers to all activities concerned with protection of a forest area from damage by fire. It comprises prevention, detection, presuppression and suppression. Presuppression implies those fire-protection activities which are concerned with the organization, training, instruction and management of a fire-control force, and with the inspection and maintenance of fire control improvements, equipment and supplies to ensure effective fire suppression. The prophylactic treatment consists of maintenance of sufficiently broad, cleared strips all round the forest and running criss-cross inside it, at suitable intervals. These are called *fire lines*. They are kept clean of inflammable material during the fire season to act as a barrier for advancing fire. Sometimes, strips of evergreen trees are planted on the periphery of valuable plantations of highly inflammable deciduous species particularly along the sides abutting on main roads. Of the preventive measures, by far the most important one in India is the creation of public opinion so that incendiarism is not resorted to and fires are not started by carelessness. When a fire does occur, people should be persuaded to cooperate to put it out. In other countries, particularly in Canada and the USA, high watch towers are erected which are provided with telescopes to watch the forests and to locate fires. They are also equipped with wireless telephones to contact fire fighting centres where up-to-date appliances are kept ready. In India, ordinarily a *machan* 10 to 20 metres high, or a perch on a tall tree commanding a good view oi the forests, is used. After a fire is located, the information is communicated to the nearest forest officer who is expected to deal with it. Besides this, there are fire watchers appointed in the fire season to patrol the forests and keep fire lines free from combustible material.

Forest Officers have powers under the Forest Act to summon any person, on payment, for extinguishing a fire in the forest and generally people come forward to do this work willingly. Ordinarily fire is beaten out by leafy branches of trees. When this is not possible, counter-firing from some distance away leewards is resorted to, to meet the advancing uncontrollable fire, so that when the two meet they automatically die out. When a fire has to be fought for several days, the forest staff has to make arrangements to provide food and shelter to the persons employed.

In the less valuable forests the elaborate system of fire tracing and appointment of special fire staff is not economically justified. Here a system known as 'early burning' is resorted to. This consists of deliberately running a surface fire by burning leaves, etc., lying on the ground on either side of frequented roads and paths, before the onset of summer. These early burnt patches act as fire barriers.

After a fire has been brought under control the burnt area is gone over to extinguish or smother all smouldering logs and then to prepare a map showing its spread, as also to assess the damage. Such fire records are very useful from the management point of view. Besides killing certain trees and damaging others which become defective and fall an easy prey to insects and fungi, fire also retards the growth of trees which survive it. This can be easily seen from the narrow annual rings for a few years after a fire. In short, fire in a forest should be regarded as a calamity and must be combated at all costs. The total loss, if evaluated, will be found to be very substantial and will justify modernising fire protection measures in the country. It will be equally necessary to create public opinion to prevent fires.

CHAPTER XIII

FOREST UTILISATION

Definition

FOREST UTILISATION deals with the most advantageous and suitable methods of harvesting, converting and profitable disposal of forest produce to purchasers or consumers, consistent with the practice of sound silviculture and amicable satisfaction of the demand. The most important forest products are (i) wood, used as timber, as cellulosic raw material, or as firewood; and (ii) a host of other products such as bamboos, resin, lac, kattha, gums etc.

Wood Structure and Properties

For the most profitable utilisation of various woods, it is necessary to know their structure and properties which determine their suitability for various purposes, and methods for removing their drawbacks. A tree makes wood out of air and water. The basic chemical process, called photosynthesis, is conducted in the leaves. Here sap, a solution of nutritive salts in water, pumped up from the roots through the bole, is compounded with carbon from the carbon-dioxide in the air to form starches and sugars. In this process, the energy required is supplied by the sun and a crucial role is played by the green matter in the leaves, called chlorophyll. In the living outer growth-ring of the tree, the starches and sugars are transformed into cellulose, lignin, and other components of wood.

(*a*) *Structure:* The gross structure of wood can be seen by the unaided eye, or with a pocket lens, particularly on the cross-cut surface of a log, or on the stump of a freshly felled tree, if a clean cut with a chisel is made (Diagram 19). On the outside is the bark (*cortex*). Its outer layer (*phelloderm*) is dead but the inner bark (*phellogen*) is living. Inside this is a thin active layer of growing cells (*cambium*) which gets transformed into living bark when growing outwards, and into wood (*xylem*) when growing inwards.

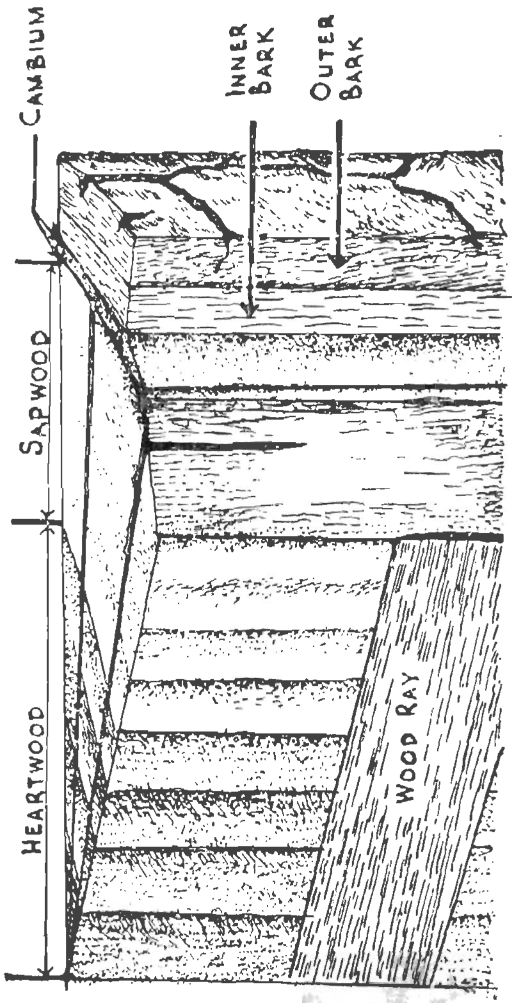


Diagram 19. Section of a Tree Trunk

The outer wood is generally lighter in colour and is called sapwood (*alburnum*). It is rich in starch and other food material and is therefore easily attacked and destroyed by insects and fungi. The inner wood is darker and is called heartwood (*duramen*). It contains oil and is therefore more durable. In certain species, however, such as spruce or mango, there is no colour differentiation between sapwood and heartwood. In a number of species, which include the valuable timbers—teak, Sissoo and Deodar—the wood formed in summer differs in appearance from that formed in spring, and therefore concentric annual rings are visible, by counting which the age of a tree can be determined.

The minute structure of wood can be seen under an ordinary microscope and in greater detail in photographs obtained with the help of an electron microscope. When so examined, wood is found to be cellular in structure with different types of cells. When first formed from the living cambium these cells are all alike but they soon get modified according to the function they have to perform, into vessels or pores, fibres, tracheids (Diagram 20) and parenchyma. *Vessels*, when seen in a longitudinal section, are long tubular cells placed end-on-end and forming pipe-like structures with numerous apertures or pits. The arrangements and size of vessels are characteristic of species and are thus of diagnostic value. In the transverse section they appear like pin holes or pores. *Fibres* are slender, spindle-shaped, elongated, thick-walled cells with tapering ends, and minute cavities or pits. Their main purpose is to give strength and rigidity to keep the tree erect. Both vessels and fibres are found in all broad-leaved trees, which are referred to as *porous* woods, as against conifers, in which they do not occur, which are called *non-porous* woods. Two kinds of porous woods are distinguished: *ring porous* that is those in which the pores formed in one season are comparatively larger and are thus noticeable as a band of pin holes as in teak, and *diffuse porous*, in which this differentiation is not seen such as in Semal. In some woods in the pores of the heartwood in-growths called tyloses are found, which are foam-like and fill the pore cavity. They give durability to the heartwood but are an obstruction to preservatives which cannot penetrate them.

In conifers the function of vessels and fibres, viz., conduction of sap and storage of food, is performed by a single type of cells known as *tracheids*. These are slender, long, thick-walled and tapering cells, scarcely visible on the transverse section. They are compressed in the autumn wood making it much harder and darker than in the spring

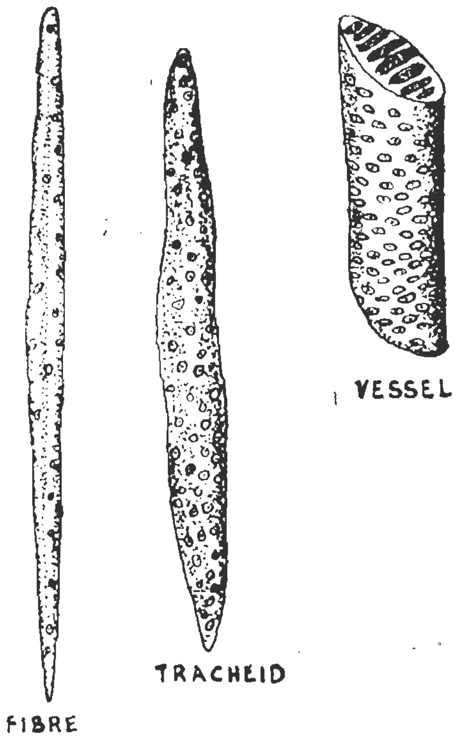


Diagram 20. Fibre, Tracheid and Vessel

wood, thus making annual rings quite conspicuous. *Parenchyma* or soft tissues are minute thin-walled cells which conduct and store food material. Their arrangement and distribution are features used forpu rposes of identification of certain woods, for instance, in Saj they are terminal, delimiting season's growth, in Siris they form an eyelet round the pore, and in Sal they are diffused. There is a group of horizontally arranged cells, running radially, which are known as *medullary rays*. They conduct food radially. On the transverse section they appear as radial lines which are hardly visible. On the tangential cut they are just visible as dark spindle-shaped structures. The difference in the size, shape and arrangement of different types of cells is used for identifying timbers.

More than 50% of the volume of wood is composed of hollow spaces enclosed by a vast area of inner surface. If the cells and cellules of the fibres in one cubic centimetre of wood could conceivably be unrolled and laid flat, they would cover an area of 250 square metres! Because of its peculiar structure, wood is not too hard and can be worked into various forms with simple tools and can take good polish. Certain woods can even be bent after steaming. Nails and screws can be driven into wood without much difficulty and they hold fast. Because of trapped air, wood is a good insulator of heat, sound and electricity and has good shock absorbing property which makes it suitable for tool handles, aircraft, carriage wheels, axles, etc. The peculiar structure of wood is also responsible for its major drawbacks. Thus with changes in atmospheric humidity, wood shrinks or swells and, as the dimensional changes are unequal in different directions, unseasoned timber warps or gets twisted. Another disadvantage is its susceptibility to decay when attacked by insects and fungi. Wood is also very combustible.

(*b*) *Physical Properties:* Woods are of various colours, white, yellow, pink, purple and black; some have dark and light streaks. This fact is utilised in inlay work to make variegated patterns. Certain timbers have a *lustre* or *sheen* which is particularly noticeable when they are sawn radially to expose the medullary rays, such as spruce. Some have a characteristic *odour*, such as sandal, freshly cut teak or rosewood. Clothes stored in boxes of highly scented woods keep insects away. But on the other hand certain otherwise suitable woods cannot be used for tea-chests as they impart a disagreeable flavour to tea. Woods vary greatly in *weight*:

Balsa is the lightest wood with a specific gravity of only 0.12, whereas Anjan is nearly ten times heavier! Curly or wavy grained woods are highly prized, for example, when an occasional Red Sanders tree has such grain, its wood fetches a fancy price as it is in great demand in Japan for making violins. Walnut burrs are sawn for table tops. *Texture* refers to the relative size of cells. Haldu has a fine, whereas Siris a coarse texture. *Figure* refers to the pattern exposed when certain woods are sawn in a particular direction, e.g., Madhya Pradesh teak or Saj gives very ornamental and pleasing figures when sawn tangentially. The effect is further enhanced by 'book-matching' alternate pieces of sliced veneers of these woods. *Hardness* is the property to resist penetration or indentation. Hard woods are preferred for paving blocks, bearings, tool handles, mallets, etc. Babul, Kusum and Mesua are examples of hard woods. *Flexibility* is the capacity to bend out of shape freely without rupture. *Per contra* resistance to bending is *stiffness*. Flexibility is useful in woods required for sieve-frames, basket work, bent-wood furniture, etc. Willows and mulberry are flexible woods. *Elasticity* is the property to return to original shape after the stress which produces the deformation is removed. Elastic woods are used for carriage shafts, bows, shoulder poles, fishing rods, etc. Dhaman and bamboos are examples of this. *Fissility* is the ease with which wood can be split. It is a useful requisite for fuelwood and for woods used for making oars, spokes, etc. Yew and teak are vey fissile.

The *strength* of wood is its ability to resist external forces tending to alter its shape. These forces depending on the direction of application may be compressive, tensile or shearing. A timber strong in one respect may not be equally strong in another, e.g., Babul is stronger than Dhaman as a beam but weaker as a strut. Resistance to tensile strains tending to pull wood fibres apart, is called tenacity: it is greatest in the direction of the grain. Tensile strength is required in wood fibres used for cordage, e.g., *Parrotia* twigs are used as ropes for suspension bridges. Resistance to shearing or separation of fibres by sliding away from each other is required in woods subjected to hammering, e.g., in piles, tent pegs, mallets, chiselheads; laurel, Babul and Khair are resistant to shear. The most important strength of wood is its resistance to a force acting at right angles to the fibre direction, required in beams, rafters, ladder rungs, cart yokes, etc. Timbers with long fibre, free from knots and well-seasoned, are the best. Kusum and Sal have great strength as beams, axlewood, Dhaman and Sissoo are tough and shock resistant. *Durability* is the property of a wood to remain sound by resisting action of varying agencies of decay such as fungi, insects, chemical action, etc. Sapwood is less durable than heartwood. A desirable quality in timbers is their aptitude for being worked with various tools. Woods are considered unsuitable if they bow, spring or tear while being sawn, are so hard that they blunt the tools, or have inter-locked or woolly fibres, high content of gum, resin or mineral deposits, hard knots, etc.

The suitability of a wood for making paper depends on the length of its fibre (actually tracheids in conifers). Woods with long fibres are more suitable, such as the conifers, fir, spruce and pines whose fibre length varies from 3 to 5 mm. As little as 15 to 20% of the chemical pulp (in which fibre length remains intact) is sufficient to make newsprint by mixing it with 80 to 85% mechanical pulp (in which fibre is broken) of these species. Bamboos are less suitable, with fibre length of 1 to 3 mm. but even so the Nepa Mills have succeeded in making newsprint with 40% bamboo chemical pulp mixed with ground wood of Salai. Broad-leaved species have a shorter fibre, less than 1 mm. and as such by themselves they cannot make acceptable paper capable of being run on fast rotary printing machines. Hence the importance of creating plantations of bamboos and introducing suitable conifers in the plains of India to increase the availability of suitable pulping material to meet the rapidly rising demand for paper and newsprint.

(*c*) *Timber identification:* There are over 2000 woody species in Indian forests. These vary considerably in their structural properties. Therefore, it is obvious that some method must be devised to identify at least the most commonly used timbers to ensure that the right species has been used for a particular purpose. Those who frequently handle timbers can often recognise the more common species by appearance, smell, hardness, and other properties. But this method is neither reliable nor desirable when purchasing timber, as adulteration is frequently resorted to. The best method of identification is to examine the structure under a hand lens (x10), or, for more accurate identification, under a microscope. No two woods are alike. If woods of known species occur in a mixed lot, it is possible to identify the species by a microscopic examination with the help of a key. Such a key has been prepared for common Indian woods by the Forest Research Institute, Dehradun.

(*d*) *Carbon-14 Dating*[1]: By this method the date when a living tree became dead wood can now be determined. It has thus become possible from specimens of wood, charcoal, etc., found in excavations by archaeologists to fix the period when a particular prehistoric culture flourished. The Indian cultures have been dated as follows:

	Place of excavation	*Carbon-dating finding*
1.	Atnur (S. India)	2300 B.C. Neolithic Culture
2.	Eran & Navadatoli (M.P.)	2300-1400 B.C. Central Indian Culture

[1]A method of dating the past. It is based on the fact that Carbon-14, a radioactive form of carbon, is being continuously produced in the atmosphere and becomes a part of all living organisms. Plants incorporate it by photosynthesis. Animals live off plants, and thus they also contain Carbon-14. Thus radio-carbon gets widely dispersed on the earth by the carbon cycle. A living organism contains radioactive carbon (Carbon-14) and normal carbon (Carbon-12) atoms in a fixed proportion. Once an organism is dead, it does not receive any fresh supply of Carbon-14. On the other hand, the Carbon-14 content of the material begins to diminish with time, according to known radioactive disintegration laws. As an illustration, the number of Carbon-14 atoms expected to be left after time-lapses of 5730, 2×5730 and 3×5730 years are, respectively, $\frac{1}{2}$, $(\frac{1}{2})^2$ and $(\frac{1}{2})^3$ of the original number of atoms present. The half-life of Carbon-14,as is obvious from the above examples,is 5730 years which is the time in which half the number of Carbon-14 atoms present initially undergo radioactive decay. The known rate of decay of Carbon-14, combined with the fact that all living matter contains Carbon-14 and Carbon-12 in a fixed proportion and that the latter does not decay, forms the basis of the method of radio-carbon "dating". The "dates" of organic objects are, in turn, the dates of the archaeological cultures in which the objects occur.

3. Kalibangan (Punjab) and Lothal (Gujarat)	2100 B.C. Harappa Culture
4. Ahar (Rajasthan)	1800-1300 B.C. Banas Culture
5. Nevasa and Chandoli (Maharashtra)	1300-1100 B.C. Chalcolithic Culture

Harvesting and Disposal

The *sine qua non* of successful forest management is the harvesting of forest products at the minimum cost and with the least wastage. When forests were brought under scientific management for the first time, some 100 years ago, the main product removed was large timber, particularly that of teak, for export to England for building ships for the British navy, and other durable woods utilisable as sleepers for extending the railway line from the ports to the forests. Small quantities of big logs of rosewood used for high class cabinet making and sandalwood for carving or for distilling to obtain its scented oil were also exported from the Malabar coast.

(*a*) *Felling and Conversion:* For felling trees, cleaning the boles and shaping them into squares or sleepers, country axes, bill hooks, levers, wedges, etc., are used. By and large, they are not very efficient, and their use entails much effort and also results in heavy wastage. Saws, both straight and curved, are sometimes used for cross cutting boles into logs. Pitsaws are also used to cut logs into sleepers *in situ*, to avoid transport of heavy logs from the forests. Hand saws are sometimes used for felling valuable trees, to minimise wastage, and for 'bucking' and ripping them into slabs, sleepers, planks and battens. Bow- and chainsaws are being gradually introduced. After the Logging Training Centres recently have trained workers in the use of basic logging tools and mechanised equipment, the wastage in conversion should go down.

The season for felling depends on local weather conditions except that coppice fellings must be done towards the end of the dormant season, i.e., just before resprouting. In the higher Himalayas fellings start from March and continue till the rains set in. In the submontane tracts and the plains the working season starts soon after the heavy rains have ended and goes on vigorously in winter and right through summer. In some forests, for instance, in Madhya Pradesh, fellings may be done even in the rains and material extracted as soon as roads become negotiable. Felling at the height of summer is avoided as too rapid drying may result in splitting and cracking of valuable timber. Similarly felling of timber trees is not carried out in wet weather as wood is liable to fungal or insect attack. Felling a tree without causing damage to the bole is an art and comes with experience. It is an advantage to have a permanent gang of experienced fellers, specially if large-scale departmental operations are to be carried out. Trees are felled so as to fall on clean ground and uphill when the ground is sloping. Trees of the species which are regenerated from coppice, e.g., teak in the dry deciduous forests, are felled flush with the ground taking care to see that the bark is not torn off and the stump is given an outward slope to prevent rain water from lodging on it. Sometimes trees are felled by digging the ground round them and then cutting the side roots. Sandal trees are so felled as it is the lower wood and the roots which contain more oil. Khair is similarly felled. Large trees are held by guy ropes to control the direction of fall and its force. After felling a tree, its bole is cleaned of side-branches and then it is logged. Sometimes the logs are debarked, but match-wood logs are removed with the bark intact. Either the logs are removed as such or else they are rough-squared, or sawn *in situ*.

(*b*) *Transport:* Trees are converted into poles, logs, rough-squares (balks), or into sawn pieces, fuel billets or charcoal, depending on their suitability, convenience and market requirements. The converted material is removed from the forest either by sliding, floating and dragging or carried manually, or by animals (mules, buffaloes or elephants) or in wheeled vehicles, including motor trucks, or by ropeways. A well-designed system of roads, paths, etc., connecting every part of the forest to the market is necessary to minimise the cost on the transport of forest produce. Roads are specially designed to suit the transport of large trees. On flat or gently sloping ground rolling roads are made and logs are rolled down by animals or men. These roads are connected with slides or chutes by which logs are hauled, helped by gravity. In the plains, carts are used for the carriage of logs, poles, sawn timber,firewood, charcoal, etc. Some of these are of a special design and are fitted with pneumatic tyres. These are being rapidly replaced by petrol or diesel driven trucks. In the Himalayas scantlings and sleepers are usually carried by men on their backs along narrow bridle paths; and logs and sawn timber are transported by wet and dry slides. Initially light railways and tramways were installed in the forest to cheapen the cost of transport, but practically all have been removed after forests became approachable by roads on which motor vehicles can ply. Forest produce from areas difficult of access is removed by aerial ropeways worked by gravity or power traction. The choice of the mode of transport depends on local conditions including cost of haulage vis-a-vis the value of material transported.

If available, water transport is the cheapest mode of transport for forest produce over long distances in hilly regions, such as the upper reaches of the Yamuna catchment. Timber is thrown into the river and allowed to drift with the swift current, piece by piece, without any man to control its course. When the river enters the plain country near Dakpatthar where the current becomes tranquil, the individually floated timber pieces are caught in a boom and then tied into rafts and navigated further down the river to the Depots. In the smaller tributaries of the river which have a moderate slope and enough water, timber is floated down by telescopic chutes made from timber pieces themselves. Eventually the tail is dismantled and slid down and thus the entire consignment of timber moves down and discharges itself into the main river. As the flow of the river fluctuates from season to season, to catch the timber at the destination, temporary or floating booms are constructed. These are dismantled after the floating season. Such a boom consists of several sections, made up of sleepers or logs held together by a main wire cable to which they are fastened. The upper end of the boom is permanently anchored and when not in use it lies along the bank. To get it in position for catching timber a number of guy ropes are attached to it at suitable intervals at right angles to the boom. When these are loosened, the boom swings back with the current and lies along the bank.

Road transport in motor trucks is the most convenient but involves heavy capital expenses on vehicles and later on road maintenance and hence transport taxes. From the Andamans, timber is being brought to the mainland by steamers.

Recent trends in logging: The Britishers left a scientific basis in forestry in so far as silviculture and management of forests were concerned but they had paid practically no attention to modernising the methods of exploitation, to minimise wastage of timber and to cut down the cost on conversion and transport. This was so because trees were mostly sold standing, and the purchasers in their turn did not consider it worth their while to utilise modern methods of logging, as adopted in other countries, much less to train the labour to use more efficient tools. The age-old primitive practices remained in vogue, with the result that the forests difficult of access remained unexploited, the earnings of loggers were meagre, and the work was a drudgery.

Soon after the country became independent, attention of the Government was drawn to improving logging techniques. Foreign experts were invited—Huberin in 1953, Koroleff in 1955, and Winklemann in 1957. A logging branch was started in the Forest Research Institute at Dehradun. It conducted a training and demonstration course in Kashmir under the foreign experts, in the use of basic logging tools, installation, working and maintenance of mechanised equipment (consisting of a long distance skyline crane for aerial transportation of logs on cableways, mountain tractors and trailers for loading and surface haulage of logs along narrow hill roads, and portable horizontal band-saw mill) for efficient and economic conversion of logs in the forest. The objective was to demonstrate the technique and train forestry personnel—both Government and private—as instructors to teach their use to workers in the field. Comparative studies were also made of the performance with modern infrastructure and extant tools.

Under a project started in 1965, with U. N. Special Funds, the FAO gave ten foreign experts to various fields in logging, training equipment, and fellowships for Indian foresters for studying advanced logging abroad. The Government of India gave the professional and non-professional staff, indigenous equipment and stores, as also the running cost of training. Besides this, the Swedish Government contributed a sum of 3 million Swedish croners, under a bilateral agreement, for physiological study, some equipment and, more than this, high quality steel tools.

Five centres were opened—at Dehradun, Kulu (Haryana), Chandrapur (Maharashtra), Coimbatore (Tamil Nadu) and Sukna (W. Bengal)—for imparting training in the use of the equipment and for planning and efficiency in the operations. The FAO collaboration ended in 1969, since when the project is being run by the Government of India with its own resources.

The training is proving very useful. Indigenous firms have also started making some of the equipment. This should help to popularise use of modern equipment and thereby substantially reduce wastage as also bring down the cost of conversion of trees and of transport of timber. In Maharashtra, tractors haul logs to the roadside. Power chain saws are used for felling and cross cutting in certain States. Use of mechanised equipment is bound to reduce wastage in conversion and bring down hauling costs where labour is not easily available.

(*d*) *Timber Depots:* Timber obtained from departmental operations in the forest is given distinguishing marks to show ownership, source, dimensions, etc., and then transported to depots by road, rail or water. In the depots it is sorted out by species, quality, size, etc., and stacked in lots for inspection by purchasers. These lots are sold periodically by auction under stipulated conditions. There are several such depots in the country such as those at Dakpatthar in U.P., Taku in M.P., Balharshah in Maharashtra, Rajahmundri in Andhra Pradesh, Pollachi in Madras, and Dandeli in Karnataka. The Dandeli depot handles nearly 20,000 tonnes of timber and over 3 lakh sleepers. The depot has a capacity to load upto 8 wagons of timber and 10 wagons of sleepers a day. Its roads are being asphalted and a mobile crane is being installed to facilitate stacking and loading. The staff is provided Government quarters and the Department also runs a dispensary for them. There are furnished bungalows and some lodges for the stay of touring officers and purchasers. The depot is connected by internal telephones to the headquarters of forest rangers. There is also a Government Saw Mill in the depot premises.

(*e*) *Saw Mills and Wood Workshops:* Logs of timber are converted into beams, planks, scantlings, etc., in saw mills and then utilised in structures or for making furniture in wood workshops. Saw mills are either erected permanently near a continuous supply of wood or are portable and moved from forest to forest. The lay-out of a good saw mill is such that logs entering at one end come out as "sizes" at the other end, duly sorted out and ready for placing dimension marks, packing and despatch. The source of power, various machines, benches etc., are carefully selected and the size of the mill is such that it can handle the entire quantity that comes for sawing. The main machines used are a breakdown saw and log-carriage, a band or gang saw, one or more cross cut saws (fixed or pendulum), good benches with rollers for the movement of sawn wood and efficient arrangement for removing saw dust. Of the staff the most important members are the Saw Doctor, the highest paid person in the Mill who decides how a log should be sawn to get the best value out of it, and the maintenance foreman who keeps all the machines in trim.

Wood workshops have, besides a small saw mill, a number of other machines for surfacing, thicknessing, over- and under-planing, moulding, tenoning, mortising and boring as also a maintenance unit.

(*f*) *Exploitation and Marketing of Trees:* In a *coupe* due for exploitation, the trees to be felled (or if it is more convenient or desirable, those that are to be retained) are marked by a special device and enumerated. The trees to be removed are either (1) felled, converted and removed departmentally; or (2) felled by Government and sold to purchasers; or (3) sold standing to purchasers or directly to consumers. The method employed depends on the quality of trees and the local circumstances, namely, silvicultural considerations (thinning or improvement felling is best carried out departmentally), liability to theft, convenience to consumers, availability of staff, etc., When a forest is worked by a Government agency, usually job contracts are given to labour for felling, conversion and transport which are done under strict supervision. Ordinarily, forests are worked through the agency of contractors to whom standing or felled trees are sold at the highest bid obtained in a public auction. Experience has shown that provided strict supervision is exercised, such working gives higher profits than are obtained under departmental working. The latter is resorted to only in special circumstances—for instance, when damage to regeneration or to trees left has to be minimised or regular supplies have to be ensured, or prices controlled. It is but natural that working departmentally is less profitable because this is a specialised calling. Unfortunately some unscrupulous contractors, and it must be said to the shame of the noble profession of forestry, some of its officers, have not hesitated to profit in such dealings at Government expense. This has led to a demand from the public to stop sales through contractors in the mistaken belief that departmental working will give greater profits to the Government and the consumers will get forest produce at a lower price! Similarly demand is being made to exploit forests through the agency of Labour Cooperatives. Experience has shown that such working not only results in lower receipts to the Forest Department, but it also does not give any appreciable profits to the members of the Cooperatives. The only persons who gain are the so-called sponsors of the members of the society. While the objective is very laudable, namely, to associate the forest dwellers with the protection and exploitation of forests, in practice the members of the cooperatives hardly earn a living wage. It would be desirable to replace the sponsors by a Government agency.

Recently, State trading in forest produce has been started in some States with the ostensible object of getting better returns. Definite evidence is not yet forthcoming to show if such working will give better profits to the Forest Department than working through contractors. It would be desirable in the national interest that *Forest Development Corporations* take up the dual function of the best utilisation of the incidental yield, and rehabilitation of the forests giving greater attention to the latter.

Forest Labour

Availability of labour for forest works and for industries utilising forest products varies from place to place. Forest dwellers when available are most satisfactory for ordinary forest works including road construction. As forest operations are seasonal, ordinarily permanent labour gangs cannot be maintained. But now that largescale plantations are proposed to be made, such gangs could be provided employment on felling, extraction, other ancillary occupations, and on work in nurseries and plantations, all the year round. This will be a definite advantage. Where labour has to be imported, it has to be kept contented. It was in such circumstances that the so-called "forest villages" were established in remote forests. These were in fact labour camps. The individuals were permitted to construct small temporary houses and also allowed to raise some food crops to supplement their earnings. The land thus utilised legally continued to remain "reserved" forests and the "village" was expected to be shifted when there were no forest works in the neighbourhood. Unfortunately with diffused working, in small coupes, sufficient work was not always available, and to supplement the wages the settlers were allowed to extend their cultivation and even grow cash crops. This has resulted in a very anomalous position in several forests. The more-or-less permanent hamlets have grown in size and in consequence the damage to the surrounding forest by unregulated fellings and unrestricted grazing by their cattle has increased. They have also adversely affected wild life by the spread of foot-and-mouth and other diseases, the village cattle competing for available fodder, and above all by the indiscriminate killings by the forest villagers, particularly where they happen to be tribals. On the other hand, the settlers and more so their so-called well-wishers have agitated for tenancy rights and freedom from the obligation of going on forest works, whenever called upon to do so by the Government or their contractors. The obvious solution is to eliminate such foci from where depletion of forests and wild life starts and to give them land for permanent settlement on the outskirts of forests or well away from them, wherever feasible.

USES OF WOOD

It is doubtful if there is any other natural resource which meets so many of man's wants as wood.

(*a*) *Timber:* Over 2000 species of wood are found in Indian forests; therefore, it should not be difficult to find a timber suited to any purpose. But in the past only a few species which possess almost all the desired properties were being used for various purposes as supplies were plentiful. When the demand rose and the available supplies of good timbers like teak, Sissoo and Deodar became inadequate, attention was drawn to finding suitable substitutes. Testing of various woods was started at the Forest Research Institute, Dehra Dun, for their important properties, namely, anatomical structure, specific gravity, strength, hardness, flexibility, elasticity, toughness, seasonability, durability, colour, grain, freedom from defects, workability in using ordinary tools, etc. As a result, a number of so far unutilised woods have been found to be suitable for particular purposes, for instance, Kardhai has been found to be a good substitute for the imported hickery wood, *Acacia chundra,* a hard self-lubricating wood for aircraft propellers in place of *Lignum vitae,* etc. A number of indigenous woods have been found suitable for bridges, superstructure, railway sleepers, piles, fence posts, transmission poles, mine props, paving blocks, use in contact with sea-water, ship and boat building, dugouts, rafts, joinery and cabinet making, camp furniture, veneers and plywood, parquetting, railway carriages, lorry bodies, aircraft parts, tool handles, crates and packing cases, tea-chests, match boxes and splints, cooperage, tent pegs, shoulder poles, billiard cues, bows and arrows, sports goods, bearings, bushes, and rollers, bentwood articles, bobbings, shuttles and picker arms, boot lasts, carving toys, cigar boxes, mathematical and musical instruments, pencil slats, picture frames, walking sticks, police batons, tobacco pipes, and so on. To know what wood is the most suitable for a

COMPARATIVE STREN[illegible]

(AS COMPARED [illegible]

SPECIES	WEIGHT	STRENGTH AS A BEAM	STIFFNESS AS A BEAM	SUITABILITY AS A POST	SHOCK RESISTING ABILITY	RE[illegible]
TEAK TECTONA GRANDIS	100	1[illegible]	100	100	100	10[illegible]
ANDAMAN PADAUK PTEROCARPUS DALBERGIOIDES	105	100	105	105	100	10[illegible]
AXLE WOOD ANOGEISSUS LATIFOLIA	135	100	95	85	170	65
BABUL ACACIA ARABICA	[illegible]	120	95	105	170	70
CHIR PINUS LONGIFOLIA	85	70	85	75	80	65
CH[illegible]OOI SAGERAE[illegible] LISTERI	120	135	125	125	200	60
DE[illegible]ODAR CE[illegible] DEODARA	80	80	80	85	60	85
DHAMAN GREWIA TILIAEFOLIA	115	110	125	125	145	60
GURJAN PTEROCARPUS SPECIES	110	100	120	100	100	5[illegible]
HOPEA HOPEA PARVIFLORA	135	120	120	120	130	65
KINDAL TERMINALIA PANICULATA	115	90	105	95	100	60
LAUREL TERMINALIA TOMENTOSA	125	95	105	95	125	65
MANGO MANGIFERA INDICA	95	75	80	75	100	9[illegible]
MESUA MESUA FERREA	140	145	150	150	160	5[illegible]
MULBERRY MORUS ALBA	100	80	75	75	155	6[illegible]
ROSE WOOD DALBERGIA LATIFOLIA	120	95	90	85	135	[illegible]
SAL SHOREA ROBUSTA	125	115	120	115	135	[illegible]
SISSOO DALBERGIA SISSOO	115	90	80	80	140	[illegible]
SUNDRI HERITIERA MINOR	150	110	130	110	130	[illegible]
YON [illegible]	125	105	105	100	180	6[illegible]

IN CALCULATING THE COM[illegible] FUNDAMENTAL STRENGTH FUNCTI[illegible] FOR ANY PARTICULAR PURPOSE [illegible] TIMBER MECHANICS BRANCH AT [illegible] HAS TESTED ABOUT 300 SPECIES O[illegible] ADVISE USERS AS TO THE MOST S[illegible] SHOULD BE ADDRESSED TO :-

THE PUBLICITY AND LIAISON OFFICER, FORE[illegible]

particular purpose, a book on forest utilisation should be consulted.

(*b*) *Fuel:* A very large proportion of wood (over 85%) is used as firewood or charcoal. The heating value of wood is determined by measuring the quantity of heat generated by a unit weight of wood in oxygen, and expressed in calories. These values for certain woods which are considered good and bad fuels are given in the table below:

Good Fuel Woods			*Calorific Value*
Babul	..	..	4870
Casuarina	..	..	4950
Jamun	..	..	4934
Lendi	..	..	4918
Sal	..	..	5264
Laurel	..	—	5210
Bad Fuel Woods			*Calorific Value*
Salai	..	..	4955
Mahua	..	..	5101
Am	..	..	4610
Chir	..	..	5015
Semul	..	..	4885

One thing is obvious from these figures: the quality of fuel for cooking does not depend on its heating power alone. It obviously depends on the wood giving steady heat for a long time and not getting burnt away rapidly nor giving offensive smell or throwing out sparks.

(*c*) *Cellulosic Fibre:* Wood is also used for making pulp, paper, newsprint, rayon, fibre board, etc. (*q.v. infra*).

Defects in Wood

All conditions which permanently reduce the value of wood are referred to as defects. These may be due to abnormal growth, such as knots, burrs, etc., rupture of tissues or wounds. Knots are parts of branches which get occluded and enclosed in wood. They reduce the value of conifers. Loose knots get dislodged when the wood is sawn. On the other hand tight knots actually improve the appearance of a plank as in maple. Twisted fibre is the result of the grain of the wood growing in a spiral manner. Planks sawn out of such wood warp, a typical example being chir-pine in certain forests. Rupture of tissues may give rise to radial, heart or ring-shakes which reduces the value of a log. Wounds caused as a result of pruning, breakage, fire or injury by animals or insects affect the value of wood.

Damage to Timber

The main agencies which destroy wood are fungi and insects, which feed on the cellulose, starch and sugars contained in it.

(*a*) *Fungi:* Some fungi attack cellulose, while others destroy lignin. They thrive only when there is enough food material uncontaminated by natural preservatives such as oil in teak or resin in Deodar, optimum temperature (about 25° C), adequate air and moisture. Thus timber stored in water is less liable to fungal attack for lack of air, or when it is seasoned by removal of moisture. There are, however, certain fungi called 'dry-rots' which can bring moisture from outside and feed on wood even in dry places. Certain fungi merely cause sap-stains. They do not seriously affect the strength of wood (except its toughness which is important in aircraft manufacture). But stained-wood fetches lesser price if it is required for furniture, or the outside layers of plywood. Certain fungi cause moulds. Such damage is superficial and can be removed by wiping. Some moulds are poisonous and therefore care is needed to see that wood attacked by them is not used for storing foodstuffs.

(*b*) *Insects:* Various insects attack wood of standing and felled trees as also wood in stores and in use. The adults of pin-hole borers make galleries in the wood which reduce its value in appearance, but not so much in strength. The shot-hole borer attack, if heavy, can seriously affect the strength of wood. The powder-post beetles, or ghoon, mostly damage bamboos and the sapwood of timbers. The so-called white ants or termites can eat and digest cellulose as their intestines contain enzymes which can break it into assimilable sugar. The termites cause immense damage to timber in use unless it is treated with preservatives. Certain marine organisms also damage timber in harbours and when used in boats, etc. Their attack is so severe that wood is honey-combed to a considerable depth and then gives way under the mechanical force of waves. As India has a long coast line and wood is used in harbours and for country craft, its preservative treatment to prevent damage by sea organisms is of vital importance.

TIMBER CONSERVATION

(*a*) *General:* Timber is one of the oldest building materials, much older than steel or concrete. It has a high strength and low weight, and a high resistance against chemical and electrical influences. It is easy to work, is comparatively cheap, and is a renewable resource. Its demerits are its non-homogeneous structure, and liability to quick decay.

When woods of various species were available in abundance, in large sizes and at a low cost, man was selective. He used only those woods which were readily available, easy to work and durable, such as teak, Sal, Deodar, Sissoo, Babul, etc. But when the demand increased and the conventional timbers were in short supply, research was started at the Forest Research Institute, Dehra Dun, to utilise secondary species and small-sized timber.

(*b*) *Timber Seasoning:* Smoking wood to dry it has been practised from ancient times. Wood used for carving was gradually dried by being stored in shade in a place without a draught. Logs of wood were also "cured" before use by carpenters by being buried in mud kept under water. But no attempts systematically to "season" wood were made in the country till the work was taken up by the Forest Research Institute some 50 years ago. Since then a mass of information has been collected on seasoning wood in the sawn state or even as poles, half-wroughts and veneers, and in designing apparatus and equipment for seasoning wood most economically. This has resulted in a large number of refractory woods being used as timber for various purposes, such as railway sleepers, ammunition boxes, rifle butts, pencil slats, battery separators, etc. Seasoning is primarily a process of drying timber in such a way that it does not lose its shape by warping or cracking or develop shakes or other defects. Timber can be seasoned by being dried gradually in air, in a kiln or under water or by girdling standing trees and felling them when the boles are dry. Of these only air-seasoning and kiln-seasoning are of commercial importance. In air-seasoning sawn timber is stacked, generally horizontally, in open sheds so that all its surfaces are exposed to a draught of air to cause the moisture to be drawn uniformly and gradually. But under this method, the rate of drying cannot be regulated. This is achieved by kiln seasoning. A seasoning kiln is a chamber made of masonry in which sawn timber is stacked on battens and crossers and its drying is carried out by circulating air at the desired temperature and humidity. Seasoned timber has a residual moisture-content of 10% to 20%, depending on the weather. Modern seasoning kilns have steam-heated chambers in which air is circulated by propeller fans and kept humid by injecting steam. Kiln-seasoning, which was originally adopted by Government organizations, has now taken its roots in the industry. Several manufacturers of furniture, packing cases, shuttles and bobbins have put up such kilns. Today there are about 150 seasoning installations in the country with a total annual seasoning capacity of 0.12 million cubic metres of timber. Since the consumption of industrial timber is over 5 million cubic metres, of which at least 60% need kiln drying before use, much headway has still to be made to ensure the most rational utilisation of timbers which are in short supply.

Wood Preservation: Wood has been used in permanent structures in India for centuries. In the course of excavations at Bulandi Bagh near Patna in 1915, Dr. Spooner of the Archaeological Department found that a wooden palisade surrounded the old town of Pataliputra. It was 21 miles long, with 64 gates and 570 watch towers. This is described by Megasthenes, the ambassador of Seleucus Nicator, Emperor of Syria, at the court of Chandragupta Maurya, Emperor of India, from 321 to 297 B.C. The timber pieces used are like railway sleepers 10″×10″ and 12 to 13 feet long, of Sal wood which must have been obtained from the Nepal *terai*. These have successfully withstood the ravages of time for 2280 years. Sandalwood, Rosewood and Red Sanders have been used for caning from ancient times as also walnut and teak. In all cases only the heartwood was used as experience must have shown that the sapwood is perishable. The heartwood of all species, however, is not durable and therefore cannot be used in permanent structures. In Central India large posts of Saj have been found in certain tanks with carved inscriptions several centuries old. These posts are called *Yupa-stambh* and commemorate certain events.

In the mid-nineteenth century, the first batch of treated wooden railway sleepers was imported. A preservation plant was established in Howrah, in 1854, by the Railways who were the main users of treated sleepers.

Research on wood preservation was taken up in the Forest Research Institute in 1908, to study the treatability of various timbers with well-known preservatives and then exposing them in 'graveyards' along with untreated specimens for testing their durability when exposed to the atmosphere, or buried in the soil. Experimental preservation and seasoning plants were also established and a large-scale research carried out on treated and untreated sleepers, laid on rail tracks. As a result of experience gained, the first commercial treating plant, with a capacity to treat a million broad-gauge sleepers in a year was started at Dhilwan in Punjab in 1926. Other plants were started in Naharkatiya and, for treating broad-leaved species, in Margherita, both in Assam, and one at Bhadravati in Mysore.

Soon after, ASCU wood preservative was developed, and later CUCHROME. Their substitution for creosote, which had then to be imported, revolutionised the field of wood preservation in the country, as even sapwood sleepers of pine were found acceptable after being treated with these chemicals.

At present there are 155 wood preservation plants, principally of the pressure treating type, with an annual capacity to treat 540,000 cubic metres of wood. Of these 10 are actively engaged in treating railway sleepers with creosote. At present almost all the requirements of preservatives and treated timbers are met from indigenous sources.

In 1962, the Timber Dryers and Preservers Association of India was started, bringing together the research workers, the industrialists and the consumers of treated wood. This should go a long way in increasing the present meagre output of timber substantially as even secondary species could now be made durable.

(*d*) *Modern Timber-Engineering Techniques:* Timber is generally used for door and window frames and panels, roof trusses of various spans, purlins and rafters, roof-joists, beams etc.

Even for such limited structural purposes, engineers and builders are now facing considerable shortage. Modern timber engineering attempts to meet this shortage as best as it can by utilising various woods so far not considered suitable by treating them with preservatives and by seasoning them to make them more durable. A Timber Engineering branch was started at the Forest Research Institute, Dehra Dun, in 1953. Much work has been done by it by way of research, design and demonstration on modern timber engineering techniques. Various systems of timber construction have been developed—such as use of nail-jointed pieces of smaller sizes, using hardwood disc dowels or metal connectors, laminates and lamellas, etc. Such construction does not require, as in conventional wood construction—still largely in vogue in the country—timber of long lengths and large sizes with joints strengthened by mild-steel bolts and straps or fish-plates. Small-dimensioned, short lengths of timber in the form of off-cuts, side-slabs and rejections in the conversion of logs into standard sizes can now be used, the joining being done with ordinary wire nails. The technique has been demonstrated by constructing light and heavy structures such as residential buildings, schools, gymnasium halls, auditoriums, sports pavilions, warehouses, theatres, exhibition halls, factory structures, aeroplane hangars, radio towers, electric and telephone transmission posts, grain silos, etc. The structures have been erected at various conspicuous places in the country and it is hoped that this will lead to wiser and better utilisation of woods in engineering.

CHAPTER XIV

FOREST INDUSTRIES

TIMBER AND FIREWOOD

THE TOTAL recorded production of wood from the forests of the country, in 1964-65, was about 20 million cubic metres 6.5 m^3 constructional and industrial wood and 13.5 m^3 fuel, including that converted into charcoal. To meet the rapidly growing internal demand, several steps are being taken like intensive forestry, extensive plantations, mechanised logging, popularisation of secondary species, rationalisation of timber uses, standardisation and grading.

Wood products worth Rs. 217 million were imported, mostly coniferous softwood, and wood for special purposes, pencil slats and cork products; and products worth Rs. 35 million were exported, chiefly rosewood and some laurel, sandalwood, Andaman-padauk, red sanders, teak and walnut.

COMPOSITE WOOD INDUSTRIES

These include plywood, particle boards, improved-wood and adhesives.

Plywood is a thin board made from 3 or more odd numbers of very thin (5 to 60 mm) layers or sheets of wood—peeled, sawn or sliced from a log—cemented together under pressure so that the adjacent plies have their grains at right angles. The origin of the industry dates back to the early 'twenties when the tea industry in Assam took initiative to make tea-chests. Today it stands as a highly developed industry. There are at present 72 factories producing 17 different types of products such as flush doors, block board, shuttering plywood, etc., valued at more than Rs. 90 million. In 1972, 32 million square metres of plywood were produced. The demand for 1978-79 has been estimated at 55 million sq. metres. The industry has reached a stage where, for economic reasons, technical considerations and consumer demand, it has become essential for factories to diversify their production to get the maximum output from the high value raw material, the ply logs of big size. The present consumption per thousand persons is only 0.2 cubic metres as against 1.5 for Asia, 5.9 for the USSR, 6.3 for Europe and 48.0 for America. Hardwoods and semi-hardwoods are used for making commercial and tea-chest plywood. Species used for decorative outer face are teak, rosewood, walnut and Champ. The present cost of manufacture in the country is rather high because of the high cost of wood and indigenous glue. M.P. teak, with an ornamental grain, and rosewood are in great demand in foreign countries.

Fibre Board: As the name implies this is made from components of fibre dimension, and is formed from an inter-felting of fibres which produces a mat, with a characteristically natural bond of the fibre itself. This is the main difference between fibre board and particle board. The industry is of a very recent origin in the country. Plants with a total installed capacity of 36,750 tonnes per annum are in production. Some boards have been successfully exported.

Particle Board is a sheet made from small particles of wood or other ligno-cellulosic fibrous substances which are bonded together with an organic binder, generally urea or maldehyde or phenol-formaldehyde. The indigenous availability of these synthetically thermosetting resins has given a fillip to this industry. Any wood waste from saw mills—but not saw dust—or from wood-working factories, lops and tops from forests or any non-commercial timber or fuelwood can be used. Because of this, and also as large-sized timber is in short supply, the industry has a great future in the country. There are at present 6 plants in production with an installed capacity of 24,700 tonnes per annum. In 1966, 15,000 tonnes of board (24,000 m^3) were produced. The investment needed for a particle board factory is much less than that for a fibre board factory and the location is also less critical as it requires negligible quantities of water.

Improved Wood includes compregnated wood for electrical parts, railway fish-plates, etc., and some compressed wood for shuttles, bobbins, insulating chair sheets, and laminated picking sticks for the textile industry. This industry is of a very recent origin.

Adhesives are produced in 4 plants with a total capacity of 6,500 tonnes annually.

MATCH INDUSTRY

This was started in 1922, prior to which matches were imported from Sweden and Japan. Today the country is self-sufficient in its requirements. The industry is divided into two sectors—the *mechanised* sectors producing nearly 60% of the output and *cottage industry* which is concentrated mainly in and around Sivakasi in Tamil Nadu. The industry consumes nearly 275,000 cubic metres of matchwoods—Semal 60%, and some other softwoods from the evergreen forests. WIMCO have large factories at Ambernath, Bareilly, Calcutta and Madras. The industry employed about 50,000 workers in 1965-66, and 52.33 million gross boxes of 50 sticks each were produced in nearly 450 units. By 1980 the demand is likely to increase to 95 million gross boxes which will require 475,000 cubic metres of match woods. The industry pays an excise duty of over Rs. 20 crores annually to the Central Government and as raising of Semal plantations is less remunerative, compared with other forest species, it would be desirable to encourage plantations of matchwoods by giving a subsidy to the State Governments.

PULP, PAPER AND NEWSPRINT

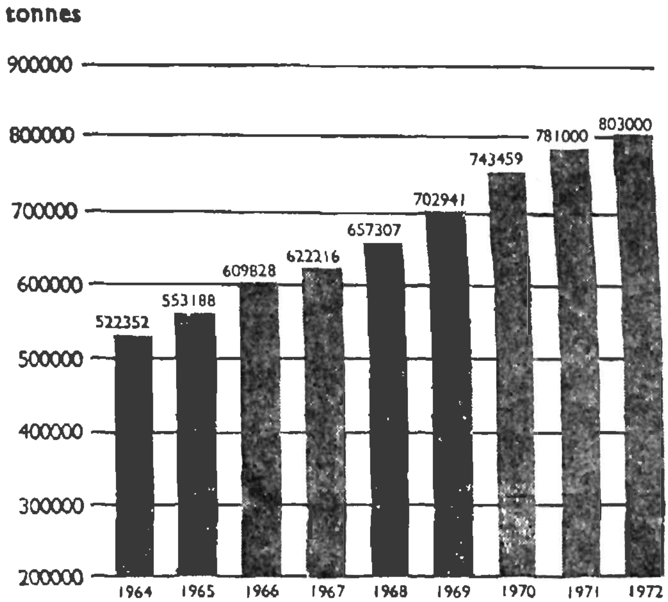
From the forest point of view, the paper industry is most important. The *per capita* consumption of paper (writing, printing, newsprint, wrapping and packing) is considered a good index of the progress of a nation. Judged by this yardstick India with its 1.4 kg. per head is far behind other countries: USA 205, UK 106, W. Germany 84, Japan 57, USSR 16, UAR, 7, Ceylon 2.5: WORLD 26.7. This is mainly due to the fact that large quantities of newsprint, so essential for the dissemination of news and for printing ephemeral literature including school text-books, have still to be imported, for which foreign exchange cannot be easily spared. If all curbs on imports were to be removed, it is estimated that the country will consume at least 300,000 tonnes of newsprint.

At present there are 57 mills for making papers of different kinds, of which only one, the Nepa Mill, makes newsprint. The total installed capacity of all mills is 730,000 tonnes but the production in 1966-67 was only 585,000 tonnes. Even so the industry was able to export paper worth 867,500 dollars but was obliged to import about 150,000 tonnes of newsprint. It is estimated that the *per capita* demand for all kinds of paper will be 6 kg. by 1980.

The first paper mill in India was established in 1867. Sabai grass, waste paper, rags, and imported pulp were the main materials used. By 1910, as a result of research at the Forest Research Institute, Dehra Dun, it was established that paper could be made from bamboos which occur in abundance in Indian forests. Today 70% of the raw material used is bamboos (sabai grass 9%, waste paper and agricultural waste 8%), imported pulp 5%, bagasse 3%, Salai wood 4% and conifers 1%.

In so far as newsprint production is concerned, there is only one mill in India at Nepanagar in M.P. which is making 30,000 tonnes of newsprint annually. Here newsprint is made from a furnish of 60% mechanical pulp made by grinding locally available Salai wood and 40% chemical pulp from bamboos. The writer was in charge of the mill from 1950 till it went into production in 1955. Attempts are now being made to raise the capacity to 45,000 and later to 75,000 tonnes per annum. Even so the mill will meet only a fraction of the country's demand, which very soon will touch the figure of 300,000 tonnes. There are proposals to make newsprint from coniferous woods and, if possible, from bagasse.

As the utilisation of bamboos for making paper has reached the saturation point, further expansion of the paper industry will have to depend upon the utilisation of hardwoods which are available in large quantities and of which plantations can be easily raised, especially of eucalyptus which grows very fast. The Research Institute has shown that it is possible to make acceptable paper from short-fibred hardwoods by mixing some long-fibred pulp and suitably modifying the process. The all-India yearly papers and boards production is shown graphically below.



All India Yearly Paper and Board-production

FURNITURE AND OTHER TIMBER-UTILISING INDUSTRIES

Furniture industry is dispersed throughout the country and flourishes especially at places where good timbers such as teak, sissoo, deodar, etc., are available. The annual requirements of wood have been estimated at about 0.15 million cubic metres. Textile industry consumes about 0.6 million cubic metres of which 50% is imported as blanks for bobbins and shutters. The packing industry consumes about 0.11 million cubic metres of timber; besides fir and spruce, several light hardwoods with good nailing properties are used, such as Salai which is also used for photo frames. The pencil industry requires nearly 4000 cubic metres of the indigenous woods. Deodar is considered quite suitable; other woods are also used after suitable treatment.

Industries like manufacture of sports goods, battery separators, tool handles, slate frames, shoe lasts, etc., as also wooden toys have been established in various places.

Industries Utilising Forest Products Other Than Timber

Sandalwood is used for carving, and because of the fragrant oil its heartwood contains, it has been known the world over from ancient times. The total annual production of its oil is 100,000 kg. valued at one crore rupees, and it earns a considerable foreign exchange. It is a small evergreen tree thriving on well-drained loamy lateritic soils of the highlands of southern India, particularly in the scrub forests of Mysore and Tamil Nadu. The tree lives parasitically on other plants by sending haustoria which attach to their roots. It attains a height of 9-12 metres and a girth of 75-90 cm. There is a Government factory in Mysore which is fully equipped with up-to-date equipment as also an excellent control laboratory. The species suffers from a 'spike' disease which is taking a heavy toll of trees. Intensive research is going on to combat this disease.

Deodar wood also gives an essential oil used as a solvent for varnishes. The annual yield is about 5,000 kg.

Resin Tapping and Manufacture of Turpentine and Rosin

Pinus roxburghii: Chir pine is the only species regularly tapped in India, The tree is widely distributed in the outer ranges and principal valleys of the Himalayas as also on the Siwalik formations at elevations between 450 and 2300 m, extending in the west to Kashmir and in the east to Bhutan. The Indian resin-tapping industry is confined to the belt of Chir pine forests, expanding from Uttar Pradesh, westwards to Jammu, in the Siwaliks and outer Himalayas upto an elevation of 1200 m, sometimes going up to about 1500 m. The total area of these forests is estimated at 8.5 lakh hectares. The annual production of crude resin is as under:

Jammu & Kashmir	3000	tonnes
Punjab & Haryana	300	,,
Himachal Pradesh	17000	,,
Uttar Pradesh	26700	,,

Crude resin consists of two principal constituents; a liquid known as oil of turpentine and a solid called rosin, or colophony. They can be separated by distillation.

There are four large government-owned factories at Clutterbuckgunj in U.P., Nahan and Bilaspur in H.P., and at Miran Sahib in J.& K. Besides these there are 17 other small private factories. The U.P. factory is the largest and is now contemplating making rubber emulsifier from resin[1].

The total yield of turpentine is about 800 kilolitres and that of rosin about 37,000 tonnes. The average rate is about Rs. 1800 per tonne of rosin and Rs. 1000 per kilolitre of turpentine.

Of the turpentine consumed in the country, 75% is used for synthetic camphor production, 15% for the paint and varnish industry, 5½% for boot-polish manufacture and the rest for other purposes. Of the rosin used indigenously, 50% is utilised by the paper industry for sizing, 25% by the paint and varnish industry, 15% by the soap factories and the rest for other purposes. The demand is continuously increasing and is expected to reach 55,000 tonnes of rosin and 17,000 kilolitres of turpentine very soon.

Resin is a very important raw material for industries like paper, paint, soap, rubber, water-proofing linoleum, phenyle, plastic, incense, industrial perfumes, *agarbattis* and bangles. Turpentine is the base for making synthetic camphor, pine oil, disinfectants, boot polish, medicines, industrial perfumes, etc.

Woods of Khair (*Acacia catechu*) and *A. chundra* when chipped and boiled in water give an extract which when concentrated gives valuable commercial products, viz., catechin and catechu. The former is the *kattha* of commerce, one of the main ingredients of *paan* (betel leaf) chewed extensively in India and the Far East. Its annual production is worth about Rs. 5 crores. Cutch which is the by-product is used in oil-drilling operations and as a timber preservative.

Barks of Babul, Wattle and fruits of Harra and leaves of several species as also galls of oak are used for tanning leather.

[1]This is an essential industrial raw material for the manufacture of synthetic rubber, which is being imported. It will save foreign exchange of about 1.5 crore rupees.

LAC AND SHELLAC

Lac is the secretion of an insect which lives parasitically on certain forest trees, mainly Palas, Kusum and Ghont. Lac has been known in India since ancient times. It is mentioned in the *Vedas* and the *Mahabharata*. Laksha, the Sanskrit equivalent, means 100,000 and obviously refers to the innumerable minute insects seen on the twigs when they are swarming. Formerly attention was confined mainly to the magenta dye produced when the insect bearing twigs were crushed and washed in water. It was used as a medicine, as a dye for colouring silk, and also as a cosmetic. Some lac was and is still used for making bangles. Western countries became interested in the resin made into fine flakes called shellac for making gramophone records. But this demand is now on the wane as substitutes with more uniform composition are available. But it is still *par excellence* an electric insulation material. India meets nearly 70% of the world demand, but Thailand has become a serious competitor. The States of Bihar and M.P. are the main producers. There is a Lac Research Institute situated at Namkum, Ranchi.

TENDU LEAVES

Leaves of Tendu (*Diospyros melanoxylon*) trees which abound in the forests of M.P. and to a lesser extent in Orissa and elsewhere, are used as wrappers of tobacco for making *bidis*. The new leaves come out in April-May when they are plucked by local women and children and made into *gaddis* of 50 each and dried in the sun, for use later for making *bidis*.

About 22 lakh standard bags (1000 *gaddis*) are annually collected in M.P., which is about 60% of the total production in the country. Prior to 1963-64 the right to collect leaves from the Government forests was auctioned for a lump sum and the purchaser had them plucked through local labour which he paid on piece-rate basis. As some leaves also grow in private lands unscrupulous contractors on payment of a nominal amount managed to 'purchase' from the pluckers from the Government forests all the leaves by paying a higher collection charge. This indirectly affected the price Government received for leaves from the forests. Increased smuggling and pilferage of this nature and continuous exploitation of private holders of lands with leaves prompted the Government to introduce State-trading in leaves by enacting a law in 1964. Besides achieving the intended objectives and increasing non-tax revenue of the State by over 4 crores of rupees, after allowing for an expenditure of nearly 3 crores of rupees, it has created a favourable atmosphere for traders to invest money for the improvement of quality and quantity of leaves. It is now a flourishing cottage industry giving handsome extra receipts to agriculturists in the off season of agriculture.

Railway Sleepers

One of the most important uses of wood is as railway sleepers, The standard railway sleeper sizes are:

Gauge	*Standard sleeper size*	*Volume (c.ft)*
Broad gauge 5′ 6″	$9' \times 10'' \times 5''$	3.125
Metre gauge 3′ $3\frac{3}{8}''$	$6' \times 8'' \times 4\frac{1}{2}''$	1.500
Narrow Gauge 2′ 6″	$5' \times 7'' \times 4\frac{1}{2}''$	1.094
Light narrow gauge 2′	$4' \times 6'' \times 4''$	0.833

The number of sleepers laid on the track is N+3 where N is the length of the rail in yards. The specifications for passing are very rigid regarding species, pre-treatment, tolerance on size, splits, cracks, shape, knots, insect attack, etc. The annual requirements are much more than the number available from the forests and in consequence iron, steel, and concrete sleepers are also being used. The percentages of wooden sleepers used are: Broad guage 19, Metre gauge 17, and Narrow gauge 72.

EPILOGUE

THE foregoing review of the forests and the practice of forestry in the country has shown that much headway has still to be made before the nation can derive the maximum, direct and indirect benefits from its forests. The national forest policy lays down that to promote balanced economy, 30% of the productive land (60% in the hilly regions and 20% in the plains) should be dedicated to properly sited forests and managed scientifically. As against this only 23.1% area is under forests and the proportion is less than this in Haryana (3.1%), Delhi (3.4%), Punjab (3.7%), Jammu & Kashmir (9.3%), Bihar (10.4%), Rajasthan (11.0%), Tamil Nadu (17.1%), Andhra Pradesh (17.7%), Mysore (18.4%), and Maharashtra (21.8%). The average forest area *per capita* is 0.15. It is negligible in Delhi, 0.01 in Punjab, 0.03 in W. Bengal and Haryana, 0.05 in Kerala and U.P., 0.06 in Bihar and Tamil Nadu, 0.08 in Gujarat, 0.13 in Mysore and 0.14 in Maharashtra and Goa, Daman and Diu, against the world average of 1.19 (S. America 5.6, USSR 3.93, N. America 3.48, Africa 1.94, Europe 0.31 and Asia 0.27).

The first requisite, therefore, is to increase the area under forests, as far as possible, and then endeavour to realise the potentialities of the forests as early as feasible. The basic needs are:

Jaume & Carol

a. Restatement of the National Forest Policy. At present the primary responsibility for the management of the forests is that of the State. As the benefits from well-managed forests or *per contra* the harm that faulty management may do, immediately or in the long run, transgress political boundaries, it is desirable in national interest that the work of the States be coordinated by the Union Government. It should be possible to declare certain forest areas which are of national importance but whose protection and management a particular State cannot afford, as *National Forests* and then manage them Centrally utilising the regional staff, crediting any nett revenues that may accrue from their management but bearing all the expenses on their management if they are unremunerative.

b. The so-called wastelands and the marginal agricultural lands that are likely to be abandoned when intensive agriculture is practised, especially in regions deficient in forests, should be afforested, preferably by the Central Government.

c. The production from the forests should be maximised and the costs on management and exploitation minimised, as also the wastage.

d. Use of wood as fuel should be discouraged and burning of cowdung prohibited.

e. Whereas application of the modern concept of multiple use of forests should ensure that the chosen use or a combination of uses results in optimum overall long-term benefit to the community, the Working Plan Officer should carefully weigh the direct and indirect benefits of forests *vis-a-vis* the policy of the forest owner and then decide on the form of single or multiple use which maximises the national benefits. Every possible effort should be made to evaluate the direct and indirect benefits from the forests economically to justify the use of any land for growing a forest.

f. The trend towards the creation of large-scale plantations, in many cases in extensive monocultures of exotic or even indigenous species from distant localities such as teak outside its habitat, will increase the hazard from insects, fungal and other pathogens inherent in such operations. Research should keep abreast to control, and if possible eliminate, such damages.

g. Forest grazing, wherever admitted, must be regulated so as not to interfere with the productive and protective functions of the forests or the continued use of forest as pasture land.

h. Nature reserves should be constituted to provide in perpetuity representative examples of indigenous flora and fauna.

i. Bio-aesthetic planting in urban areas should be encouraged.

In short, as, by and large, the forests are inadequate and understocked and an appreciable proportion of trees is malformed or consists of species which are slow-growing and poor yielders, attempts should be made to restock the forests with suitable, fast growing, valuable, indigenous or exotic species to eventually maximise production both in volume and in value of the kind most in demand. The methods of felling, fashioning and transportation should be modernised to minimise wastage and reduce costs. The existing practices of uncontrolled grazing, lopping, litter removal, irregular fellings, and inadequate protection against fires, fungi and insects should be eliminated.

The obvious need is to change over from the time-honoured somewhat static *conservation forestry*, under which nature has been coaxed, to *dynamic orchard silviculture*, that is, to man-made forests of useful and most profitable species. It is equally important that the message of forestry should be carried to the children—the citizens of tomorrow—so that when they grow up they see that the forest, a perpetually renewable natural resource, is maintained and utilised to best advantage of the nation.

वनश्री त्राण, राष्ट्र कल्याण ।

APPENDICES

APPENDIX I

TEMPERATURE, RAINFALL AND HUMIDITY DATA FOR SOME STATIONS SITUATED NEAR FORESTS

Forest Type	*Meteorological Station and its Elevation in metres*		*Temperature (°C)*					*Rainfall (mm.)*			*Mean Annual*
			Mean Annual	*Annual mean maxi-mum*	*High-est*	*Annual mean mini-mum*	*Lowest*	*Mean Annual*	*Rainy days*	*Months with less than 50 mm.*	*Hu-mi-dity (%)*
(1)	(2)		(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1. Tropical Wet Evergreen	Mangalore	22	27.2	30.7	37.8	23.6	16.7	3292	118	5	77
	Silchar	29	25.1	30.1	39.4	20.2	5.0	3294	137	4	77
2. Tropical Semi-Evergreen	Karwar	4	26.3	30.0	?	22.6	?	3006	104	6	80
	Jalpaiguri	83	23.9	29.2	40.0	19.1	2.2	3267	108	5	75
3. Tropical Moist Deciduous	Port Blair	80	26.3	29.4	36.1	23.1	16.7	3143	150	3	81
	Chanda	193	27.1	33.7	48.3	20.4	2.8	1324	63	7	56
	Dehradun	682	21.6	27.5	43.9	15.7	—1.1	2160	81	6	61
4. Littoral & Swamp	Kakinada	8	27.9	31.8	47.2	23.9	13.9	1042	56	6	73
	Calcutta	6	26.3	31.4	42.2	21.2	6.7	1600	84	6	74
5. Tropical Dry Deciduous	Nagpur	312	27.3	33.4	47.8	21.2	3.9	1251	63	7	51
	Cuddapah	130	—	35.2	46.1	23.7	11.7	769	46	6	58
	Roorkee	274	23.4	30.1	45.7	16.8	—2.2	1050	48	8	58

6. Tropical Thorn	Sholapur	479	27.0	33.7	45.6	20.3	6.1	691	441	7	47
	Jaipur	436	25.2	32.3	47.8	18.1	—2.2	610	36	8	43
7. Tropial Dry Evergreen	Masulipatam	3	27.9	32.3	47.8	23.6	13.9	1052	55	6	74
8. Sub-Tropical Broad-leaved Hill	Mercara	1143	20.4	24.5	33.0	16.3	8.9	3237	132	4	80
	Pachmarhi	1075	21.4	26.7	40.6	16.0	—1.1	2022	79	7	57
	Kalimpong	1209	17.9	21.2	30.6	14.6	0.6	2189	104	5	80
9. Sub-Tropical Pine	Ranikhet	1850	15.6	19.7	30.0	11.1	—	—	—	—	—
10. Sub-Tropical Dry Evergreen	Jammu	366	24.2	29.4	?	19.0	?	10.69	50	5	61
11. Montane Wet Temperate	Ootacamund	2245	14.2	18.9	26.1	9.4	1.7	1303	99	4	74
	Darjeeling	2265	11.8	14.7	27.0	8.8	—5.0	3034	123	5	83
12. Himalayan Moist Temperate	Chakrata	2134	15.3	17.9	29.4	9.5	4.4	1885	62	5	—
13. Himalayan Dry Temperate	Kolba	1890	—	—	—	—	—	798	62	4	9
14. Sub-Alpine	Dras	3066	2.0	9.0	33.9	—5.4	—45.0	649	57	6	77
15. Alpine (scrub)	Leh	3574	5.8	12.8	35.9	—1.3	—28.3	85	11	12	55

APPENDIX II

COMPOUND INTEREST TABLE

(Value of Re 1, n years hence, at p% compound interest = $1.0p^n$)

n years	p= 3%	4%	5%	6%	8%	10%
1	2	3	4	5	6	7
1	1.030	1.040	1.050	1.60	1.080	1.100
2	1.061	1.086	1.102	1.124	1.166	1.201
3	1.093	1.125	1.158	1.191	1.260	1.331
4	1.125	1.170	1.215	1.262	1.360	1.464
5	1.159	1.217	1.276	1.338	1.469	1.610
6	1.194	1.265	1.340	1.418	1.587	1.772
7	1.230	1.316	1.407	1.504	1.714	1.949
8	1.267	1.369	1.477	1.594	1.851	2.144
9	1.305	1.423	1.551	1.689	1.999	2.358
10	1.344	1.480	1.629	1.791	2.159	2.594
11	1.384	1.539	1.710	1.898	2.332	3.853
12	1.426	1.601	1.796	2.012	2.518	3.138
13	1.468	1.665	1.886	2.133	2.720	3.452
14	1.513	1.731	1.980	2.261	2.937	3.798
15	1.558	1.801	2.079	2.397	3.172	4.177
16	1.605	1.873	2.183	2.540	3.426	4.595
17	1.653	1.948	2.292	2.693	3.700	5.054
18	1.702	2.026	2.404	2.854	3.996	5.560
19	1.753	2.107	2.527	3.026	4.316	6.116
20	1.806	2.191	2.653	3.207	4.661	6.728
21	1.963	2.286	2.800	3.424	5.099	
22	1.921	2.381	2.946	3.641	5.536	
23	1.978	2.476	3.093	3.858	5.974	
24	2.036	2.571	3.230	4.074	6.411	
25	2.094	2.666	3.386	4.91	6.849	10.835

n years	p= 3%	4%	5%	6%	8%	10%
1	2	3	4	5	6	7
30	2.427	3.243	4.322	5.741	10.063	17.450
35	2.814	3.946	5.516	7.686	14.785	28.103
40	3.262	4.801	7.040	10.286	21.725	45.260
45	3.782	5.841	8.985	13.765	31.921	72.893
50	4.384	7.017	11.467	18.420	46.903	117.393
55	5.082	8.646	14.636	24.651	68.916	189.067
60	5.892	10.520	18.679	32.988	101.260	304.494
65	6.830	12.799	23.840	44.146	148.785	490.393
70	7.918	15.572	30.426	59.077	218.615	789.788
75	9.179	18.945	38.833	79.059	321.218	1271.965
80	10.641	23.050	49.561	105.798	471.976	2048.519
85	12.336	28.044	63.254	141.529	693.489	3299.174
90	14.300	34.199	80.730	189.470	1018.965	5313.366
95	16.578	41.511	103.035	253.554	1497.199	8557.255
100	19.219	50.505	131.501	339.312	2199.884	13781.614
110	25.828	74.760	214.382	607.659	4749.413	35746.198
120	34.711	110.663	348.912	1088.288	10253.679	92717.024
130	46.649	163.808	568.341	—	—	—
140	62.692	242.475	925.767	—	—	—
150	84.253	358.923	1507.977	—	—	—
200	369.356	2550.750	17292.581	—	—	—

APPENDIX III

LIST OF PLANTS MENTIONED

Achar—*Buchanania lanzan*

Agar—*Aquilaria agallocha*

Aini—*Artocarpus hirsuta* A very handsome evergreen tree upto 50 m. high and 5 m. in girth with a long clean bole and a dense foliage, of the evergreen forests of the West Coast. Wood moderately hard, yellowish brown, durable and of good quality. Used in building and for furniture.

Ak—*Calotropis gigantea*

Alder—*Alnus nepalensis*

Amaltas—*Cassia fistula*

Amla—*Emblica officinalis*

Anjan—*Hardwickia binata*

Ash—*Fraxinus xanthoxyloides*

Ashok—*Jonesia asoka*

Axlewood—*Anogeissus latifolia*

Babul—*Acacia arabica* A moderate-sized, thorny almost evergreen tree with a short trunk and a spreading crown of feathery foliage. Indigenous to North India and cultivated in the drier and not too cold tracts. Commonly planted on field bunds as it has a deep tap root and its crown casts only a light shade. Thorns are used for fencing, pods are a nutritive fodder for cattle and goats and bark is used for tanning. Wood (52 lb/cft) is an excellent fuel and gives good charcoal. It is also used for making cart hubs and agricultural implements. Trees in plantations attain an average girth of 150 cm in 30 years when they yield about 50 tonnes of wood per hectare.

Badam—*Terminalia procera*

Bakain—*Melia azedarach*

Balsa—*Ochroma lagopus*

Bamboo, Male—*Dendrocalamus strictus* Found in the deciduous forests of the country. It is densely tufted with strong thick-walled, sometimes solid, culms, 2.5 to 7.5 cm. diameter and 6 to 15 metres long, depending on the site-quality. Full grown culms are used for a variety of purposes: posts, basketry, walling, roofing, matting, etc. and is therefore referred to as the poor man's timber. It is also the most important and the principal long-fibred forest raw material so far used in India for making paper. Young shoots are eaten.

Bamboo, Muli—*Melocanna bambusoides*

Bamboo, Thorny—*Bambusa arundinacea* A big thorny bamboo of Central and Southern forests mostly confined to moist localities. Used chiefly for scaffolding and lately also for making pulp. Flowers gregariously in about 40 years and dies.

Bamboo, Tulda—*Bambusa tulda*

Banyan—*Ficus bengalensis*

Bel—*Aegle marmelos*

Benteak—*Lagerstroemia lanceolata* A large, deciduous tree of the West Coast moist forests. An important and valuable timber tree. Wood moderately hard, used for building, furniture, boxes etc.

Bhendi—*Thespesia populunea*

Bhilma—*Semecarpus anacardium*

Bijasal—*Pterocarpus marsupium* A large, deciduous tree with spreading branches, producing a straight clean bole under favourable conditions. Occurs throughout the greater part of the Peninsula and in limited quantities in the sub-Himalayan tract in Oudh and the Kumaon *bhabar*. One of the most important timber trees of the Peninsula, growing upto 30 m. high and 2.5 m. girth. Wood very hard, close-grained, heartwood yellowish-brown, durable, much used for building, agricultural implements, carts, wheelwork, boats, etc. Its red gum is the 'Kino' of commerce, a valuable astringent used in medicine.

Birch—*Betula utilis*

Blue Gum—*Eucalyptus globulus*

Bonsum—*Phoebe spp*

Cashew—*Anacardium occidentale* A small spreading S. American tree yielding the cashewnut of commerce. It grows well and fruits profusely in South Indian coastal climate. The edible nut is an important foreign exchange earner. In forestry the species is used primarily for afforestation of denuded coastal sand dunes and dry derelict areas in the interior. The seedlings are frost-tender and trees also do not like high temperatures. Wood can be used for inferior packing cases or as fuel. The fleshy stalk of the fruit is eaten, the pericarp gives an oil of commercial value and the nut when roasted gives the cashewnut of commerce.

Casuarina—*C. equisetifolia* In Andamans, where this species occurs naturally on sandy shores, it is a large evergreen tree 30 m. or more high with a straight stem and a feathery 'foliage' (Actually, long, slender, drooping, jointed, leafless branchlets). It thrives best near sea coast on loose sand. Because it is fairly fast growing and the wood is a good fuel, it has been extensively planted in South India. The rate of growth on a rotation of 8 years is as much as 7-8 tons per hectare per year. Of late *Eucalyptus tereticornis*, which gives a larger yield and can also coppice, is gradually replacing Casuarina in Mysore.

Champa—*Michelia champaca*

Chaplash—*Artocarpus chaplasha*

Chikrasi—*Chickrasia tabularis*

Chilauni—*Schima wallichi*

Chilgoza—*Pinus gerardiana*

Chinar—*Platanus orientalis*

Chir—*Pinus roxburghii* A large evergreen, gregarious tree, becoming partially deciduous at lower elevations. Found in the Siwaliks from 450 to 2250 m. Crown upto middle age is elongated and more or less pyramidal, later spreading out and becoming round or umbrella-like. Sapwood white, heartwood light, reddish-brown, moderately hard and coarse. Much used for common furniture, building and packing cases. This is the principal resin-producing tree of India.

Chundri—*Acacia chundra*

Cypress—*Cupressus torulosa*

Deodar—*Cedrus deodara* A very large, evergreen, coniferous tree with dark green foliage, found in the higher Himalayas at 1200-3000 m. elevation where rainfall varies from 1000 to 1750 mm. and there is heavy snowfall in winter. The wood is moderately hard, sapwood white, heartwood light, yellowish-brown, oily, strongly scented and very durable. It is extensively used in building, for sleepers, furniture, general carpentry and is a satisfactory pencil wood. Plantations of this species are being made wherever it can grow.

Dhaman—*Grewia tiliaefolia*

Dhup—*Canarium spp*

Eucalypto—*Eucalyptus spp* Eucalyptuses are natives of Australia where more than 600 species are found which range from small bushes to giant trees over 100 m. high. Several species have been successfully grown in India. *E. globulus*, the blue-gum, was planted in the Nilgiris in 1843 and has grown to very large size. Originally introduced for producing firewood, it is also used as cheap planking and the leaves are distilled for oil. Several other species have been tried in different places. Of late the progeny of seed obtained from a grove at Chikballapur, where some Eucalyptus trees were planted several years ago, has been extensively utilised for creating plantations all over the country. 99% of the plants have been identified as *E. tereticornis*. It is very fast growing and trees planted at 1m.x1m. interval are expected to give as much as 100 tonnes of dry wood per hectare, at the age of 10 years.

Farash—*Tamarix articulata*

Fir—*Abies pindrow* A very large coniferous tree of the higher Himalayas, found in Kashmir, Punjab, H.P. and U.P. The wood (33 lb/cft.) is white, soft and easy to work but not durable. Used for railway sleepers after treatment with preservatives. An excellent pulpwood because of its long fibre and low resin content.

Gamari—*Gmelina arborea*

Garari—*Cleistanthus collinus*

Gurjan—*Dipterocarpus turbinatus* A very large 50 m. or more high, evergreen tree with a long cylindrical bole and a high crown of Andamans and Assam forests. Wood used for canoes, boat-building and planking.

Gutel—*Trewia nudiflora*

Haldu—*Adina cordifolia* A large tree of the moist deciduous forests with yellow wood (40 lb/cft) much prized for structural purposes as also for making furniture, bobbins and battery separators.

Harra—*Terminalia chebula*

Hollock—*Terminalia myriocarpa* A very large evergreen tree with pendulous branches found in eastern Himalayas and Assam upto 1750 m. Wood dark brown and hard, used for house-building, canoes, cheap furniture, etc.

Honeysuckle—*Lonicera spp*

Indian Chestnut—*Castanopsis indica*

Irul—*Xylia xylocarpa*

Jack—*Artocarpus integrifolia*

Jamun—*Syzygium spp*

Juniper—*Juniperus spp*

Kadam—*Anthocephalus cadamba*

Kail—*Pinus walichiana* A large, evergreen tree with bluish feathery foliage and whorled branches. Wood moderately hard, with a pink heartwood of good quality, much used for building, furniture and general carpentry. The tree is sometimes tapped for resin.

Kanju—*Holoptelia integrifolia*

Karani—*Cullenia excelsa*

Kardhai—*Anogeissus pendula*

Keora—*Pandanus tectorius*

Khair—*Acacia catechu* A moderate-sized thorny deciduous tree found throughout India except in very moist regions. Wood largely used for house-posts, agricultural implements, cart wheels, tool handles, etc., also a good firewood and gives excellent charcoal. The heartwood is principally used for obtaining Kattha and cutch; the former is the well-known ingredient of *paans* and the latter is used as a dye and as a boiler compound.

Khasi Pine—*Pinus Khasya* A large, evergreen tree with more or less whorled branches and a rounded crown at maturity. Found in the Khasi, Naga and Manipur hills. Wood moderately hard, pale-brown to red, very resinous; used for building.

Khejra—*Prosopis spicigera*

Khus—*Vetiveria zizanoides*

Kindal—*Terminalia paniculata*

Kokko—*Albizzia lebbek* A large branchy tree indigenous to the moist deciduous forests. Wood (44 lb/cft) strong, durable and used for structural purposes. It has a grain like that of walnut.

Kulu—*Sterculia urens*

Kusum—*Schleichera oleosa*

Laurel—*Terminalia tomentosa* A large deciduous tree with a long clean bole and dark 'crocodile' bark. It is one of the commonest and most widely distributed trees of the broad-leaved Indian forests. Wood dark brown with darker streaks, hard, strong, used for buildings, carts, railway wagons, mine props, bedsteads, etc.

Lendi—*Lagerstroemia parviflora*

Locust Tree—*Robinia pseudacacia*

Machkund—*Pterospernum suberifolium*

Maharukh—*Ailanthus excelsa* A moderate-sized, fairly fast growing tree with soft, white wood. Leaves of young plants have an acrid juice and are therefore not touched by cattle. Later they are considered a good fodder and trees are heavily lopped. It is extensively planted in Rajasthan for fodder. The wood is also suitable for making match splints and is being so utilised.

Mahua—*Madhuca indica* A large, deciduous tree with a short bole, spreading branches and a large rounded crown. Flowers (actually corollas) drop in March-April, fruit ripens during June-July. Indigenous to M.P., Maharashtra, Gujarat, A.P., Orissa and extending north to the sub-Himalayan tract. Common on village lands as it is protected for its corollas which are eaten raw, cooked or dried. They are also distilled into a spirituous liquor. Oil from seed is edible and is also used for making margarine or soap. Wood is of good quality and is used as a beam. A good shade tree, young leaves bright pink.

Mahul—*Bauhinia vahlii*

Mango—*Mangifera indica* A large evergreen tree indigenous to Assam, Western Ghats, Satpuras and parts of the sub-Himalayan tract. Extensively cultivated for its fruit upto 1200 m. elevations. It has dark green leathery leaves and a dense rounded crown. A very good shade tree for highways. Not suitable for town avenues as it harbours mosquitoes. Timber is durable and used for tea-chests, packing cases, planking, canoes etc. Fruit of cultivated varieties (over 100) show great variation in size, shape, colour and flavour.

Mesquite—*Prosopis juliflora*

Mesua—*Mesua ferrea*

Mulberry—*Morus alba*

Mundani—*Acrocarpus fraxinifolius*

Neem—*Azadirachta indica* A moderate-sized to large, more or less evergreen tree with a fairly dense rounded crown. It does well even in dry and hot regions and is an excellent shade tree for planting along the highways. It is widely cultivated. The heartwood is very durable and is used for house-building, carts, etc., seed yields an oil with germicidal properties and is also used for burning and soap-making; leaves are an excellent fodder.

Nirmali—*Strychnos potatorum*

Oak—*Quercus spp*

Olive—*Olea cuspida*

Padauk—*Pterocarpus dalbergiodes* A very large, semi-deciduous tree with ascending branches, growing upto 45 m. high with a clear bole of upto 25 m. and girth at breast height of 600 cm. The bole is often buttressed. The wood is moderately hard. The principal timber tree of Andamans and highly prized for furniture, railway carriages, decorative panelling etc.

Palas—*Butea monosperma*

Papra—*Gardenia latifolia*

Paroli—*Stereospermum chelenoides*

Phulai—*Acacia modesta*

Pipal—*Ficus religiosa*

Poon—*Calophyllum spp*

Pula—*Kydia calycina*

Red Sanders—*Pterocarpus santalinus*

Redwood—*Sequoia sempervirens*

Reunjha—*Acacia leucophloea*

Ritha—*Sapindus emarginatus*

Rosewood—*Dalbergia latifolia* A large nearly evergreen tree of moist deciduous forests giving timber used for high priced ornamental veneers. Very large trees are still available in the Kerala forests which fetch fancy prices of upto Rs. 10,000 per cubic metre.

Sal—*Shorea robusta* An important, large tree of the deciduous forest of North India yielding timber for sleepers and buildings. It also yields a resin which is used as an incense. It occurs more or less gregariously on somewhat acidic moist soils.

Salai—*Boswellia serrata* A moderate-sized to large, usually gregarious deciduous tree with light spreading crown, somewhat drooping branches and thick smooth bark. The tree is common on the dry hills throughout the greater part of Indian Plains. The wood is moderately hard, whitish, resinous with a brown heartwood in bigger trees, and is used for rough planking. It has been successfully utilised for making mechanical pulp, 60% of which is mixed with 40% chemical pulp of bamboo to make newsprint in the Nepa Mills in Madhya Pradesh.

Sandalwood—*Santalum album* A small evergreen glabrous tree with slender drooping branchlets, indigenous to Indian Peninsula chiefly in Mysore, Coorg and parts of Madras. Heartwood hard, close-grained, very scented, oily; sapwood white, scentless. The wood is mostly used for carving and wastewood is distilled to obtain the scented oil. By far the most valuable wood of the world, weight for weight.

Satinwood—*Chloroxylon swietenia*

Semul—*Salmalia malabarica* A large deciduous tree with a straight cylindrical stem and massive horizontally spreading branches in whorls found throughout India and principally in hot moist regions on alluvial soils, upto 1600 m. Large trees have a buttressed base. Large red flowers appear when leafless in Feb-March. Fruit ripens in March-April. The most important matchwood of India. Also used for tea-chests and as rough planking. The floss is used for stuffing cushions, inner bark yields a good fibre and roots are used as a tonic.

Sissoo—*Dalbergia sissoo* A moderate-sized to large (very large in Nepal) deciduous tree with a light crown. It occurs throughout the sub-Himalayan tract upto 900 m., chiefly on alluvium. It is extensively planted along canal banks and as an avenue tree as it is one of the few deciduous species which come into new flush of leaves at the height of summer. It is one of the most important timber trees of North India used for building, furniture, carriage, carving etc. In 40 years trees in a plantation attain a girth of about 125 cm. It is also planted in tea gardens to shade the tea bushes.

Spruce—*Picea smithiana* A very tall evergreen tree with a conical crown, horizontal or drooping branches and slender pendulous tassel-like long branchlets. Occurs throughout the western Himalayas at heights of 2000-3500 m. Wood white, soft to moderately hard, used for planking, shingles, tea-boxes, packing shingles, packing-cases, etc. Very suitable for match manufacture and wood pulp, because of its long fibre.

Sundri—*Heriteria minor*

Tamarind—*Tamarindus indica*

Teak—*Tectona grandis* A large, deciduous tree with a rounded crown of large leaves and a clean cylindrical bole buttressed at base in large trees. *Par excellence* the most valuable timber tree of India, highly prized for house-building, bridges, piles, cabinet work, railway carriages, ornamental veneers, wheel spokes and felloes, general carpentry and so on. It seasons naturally and the heartwood is resistant to white ants due to an essential oil in it. Its best growth takes place in warm, moist forests of Kerala where the species forms upto 20% of the crop. In dry deciduous forests, teak grows almost pure but the size it attains is not large and it is mostly used as poles or as small planks and battens. It is extensively planted.

Tendu—*Diospyros tomentosa*

Tinsa—*Ougeinia dalbergioids*

Toon—*Cedrela toona* A large deciduous tree with a spreading crown, found in the sub-Himalayan forests and valleys of outer Himalayas upto 1250 m. and in Assam, Western Ghats and the Peninsula in moister forests. Wood red, soft, shining, used for furniture, tea-chests, cigar-boxes and other purposes. Easily fast growing and deserves to be cultivated for fuel and timber.

Toddy Palm—*Borassus flabellifer*

Walnut—*Juglans regia*

White Cedar—*Dysoxylum malabaricum* A very large tree of the evergreen forests of the Western Ghats. The wood is yellowish or light red, close-grained, hard and elastic and therefore suitable for rifle-stocks. A good matchwood.

White Chuglam—*Terminalia bialata* A large deciduous tree of Andamans reaching a height of over 30 m. The wood is strong, elastic, straight-grained and of good quality. It has export possibilities.

Willow—*Salix spp*

Yew—*Taxus baccata*

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