THE WORK

OF THE

FOREST DEPARTMENT IN INDIA

EDITED BY

R. S. TROUP,

Assistant Inspector General of Forests

CALCUTTA
SUPERINTENDENT GOVERNMENT PRINTING, INDIA
1917.

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Introduction.

It may safely be said that there is hardly any Government Department in India whose work and aims are so little realized by the general public as are those of the Forest Department. For one thing the work of the forest officer lies for the most part in remote places, so that few have any knowledge of it. For another the practical results of forest work are apparent only after long periods of time, so that the forest officer has to cultivate the habit of thinking in half centuries and to be content that the full effect of his labours shall be visible only to future generations.

This publication is issued with the object of bringing together in popular form the main facts connected with the work of the Forest Department in India and of sketching the outlook for future expansion, particular attention being paid to the possibility of the local development of industries which depend to a greater or less extent on a plentiful supply of forest products. Information on these subjects is to be found scattered throughout the annual reports on forest administration which are issued by Provincial Governments and in the various publications of the Forest Research Institute, Dehra Dun, but these are not readily available to the general public, and so it is hoped that this memorandum, which has been prepared by Mr. R. S. Troup, Assistant Inspector General of Forests, with the assistance of selected officers of the Forest Department, may prove useful to those interested in the subject.

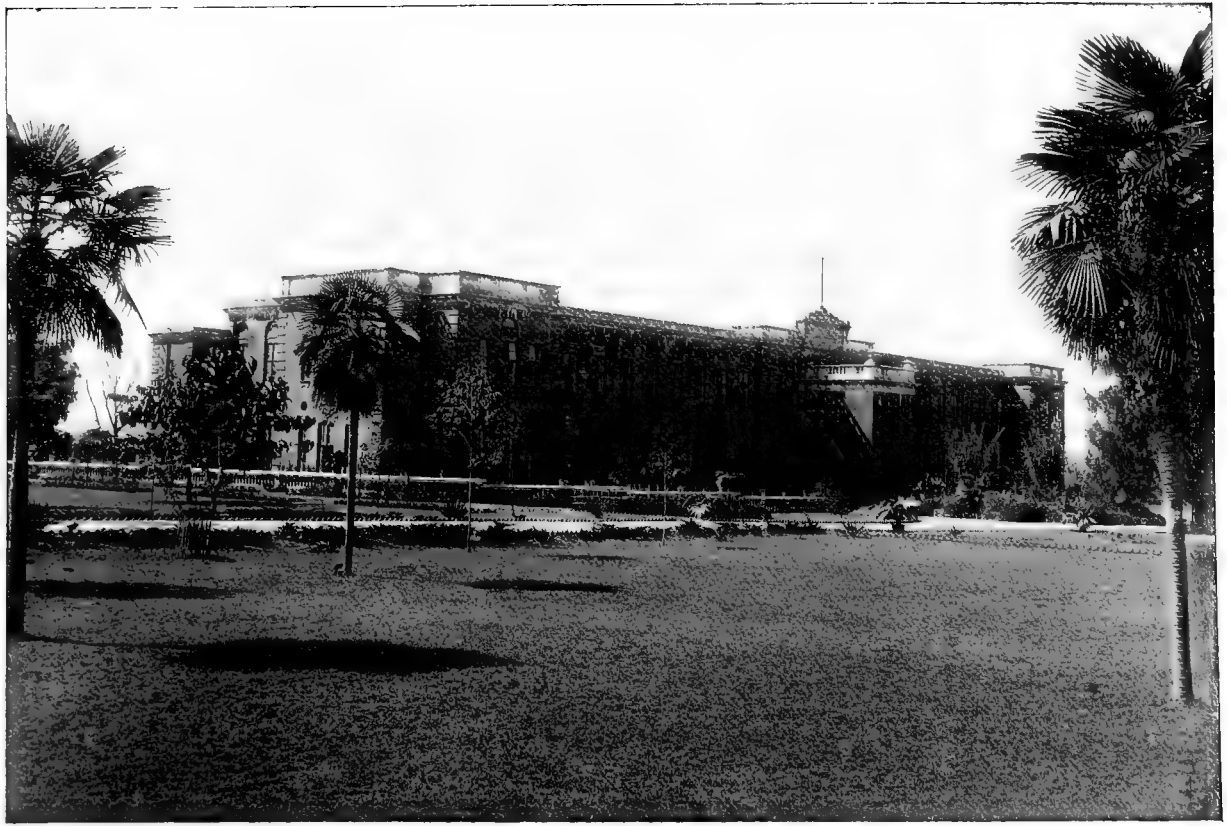

Photo.-Mechl. Dept., Thomason College, Roorkee.

The Forest Research Institute, Dehra Dun.

The Work of the Forest Department in India.

1. History of the Forest Department.

In matters of forest policy India may be congratulated on having set a noteworthy example to the British race, which has not generally displayed any marked tendency to value and cherish the heritage of Nature. Necessity has compelled continental nations to keep a considerable proportion of their acreage under forest and, after centuries of experience, to practise Forestry as a fine art. But Britain is still content to rely on foreign imports for the great bulk of her timber supply, and conservation of forest wealth has not been a special feature of her administration in the past.

Even in the earliest days of the British occupation the destruction of the forests in many parts of India indicated the necessity for a strong forest policy, but whether or not our earlier administrators realized the importance of the forests to the physical and economic welfare of the country, the fact remains that little or nothing was done. During the period of prosperity which followed on the British occupation, with an increase of population and the attendant demand for timber and fuel, with the spread of agriculture and the increase of pastoral herds, the depletion of the forests began to assume a serious aspect. In the early part of the nineteenth century desultory attempts were made to safeguard the future existence of the more valuable teak forests, on which the supply of ship-building timber for the navy depended, but these attempts developed into mere plans of exploitation without any effort to ensure conservation, until these forests became more than ever depleted of valuable timber.

It was, however, by no means for want of advice and warning that little of a practical and enduring nature was accomplished during the first half of last century, for various officers were deputed from time to time to report on the forests of different localities, and all were insistent on the need for the conservation and improvement of the forest tracts inspected by them. Thus

as early as 1827 Dr. Wallich reported on the forest resources of Tenasserim, while about 1837 Dr. Helfer reported on those of Malabar: in 1847 Dr. Gibson was appointed Conservator of Forests in Bombay, while in 1856 Dr. Cleghorn was appointed to a similar post in Madras, and both these officers submitted valuable reports on the forests in their charge. During this period the name of Mr. Conolly, Collector of Malabar, stands out conspicuous. This officer, keenly alive to the dangers attending the depletion of the forests in his district and anxious to ensure the future local supply of teak timber, founded in 1842 the now famous Nilambur teak plantations, which have been regularly extended to the present day and which form a living monument to their founder and to those who have had a share in the work of their extension.

The year 1855 marked the commencement of a new era in the history of forestry in India, for it was then that Lord Dalhousie laid down a definite and far-sighted forest policy. This policy was prompted by a report submitted by Dr. McClelland after an extended tour in the province of Pegu shortly after its annexation in 1852, in which attention was drawn to the necessity for saving the valuable teak forests of that province from destruction. The officer selected to establish forest administration on a sound basis was Dr. Brandis, who was appointed Superintendent of Forests in Pegu in 1856, the charge being extended to Martaban and Tenasserim in the following year. Dr. Brandis' appointment marks the dawn of scientific forestry in India.

Further progress was delayed for a time by the Mutiny, but from 1860 onwards forest organization was rapidly extended to the other provinces. The earlier years of forest administration were beset with difficulties, which is not surprising considering that the Department was charged with the unpopular duty of protecting the heritage of nature from the rapacity of mankind, a duty which naturally roused the antagonism of the agricultural population of India. Brandis' early struggles in Burma are but one instance of the contest against greed, ignorance and short-sightedness, for his efforts at introducing sound principles of organization and protection met with a storm of opposition from all sides, and particularly from

mercantile firms engaged in the timber business. The conflict raged for five years, but in spite of gross misrepresentations his policy prevailed in the main: had this not been the case matters would certainly have gone from bad to worse, and the valuable teak forests of Burma, instead of yielding a steady and increasing supply of timber, would by this time have been depleted of the bulk of their marketable trees. Such a contingency would have been a national disaster, for it is on first class teak that our Admiralty relies for its supplies of the best ship-building timber.

In other provinces also the early years of the Forest Department were marked by a constant struggle against opposition in various forms, for although Government had proclaimed its forest policy, this policy was not always appreciated by district officials, many of whom were unable to discern the potential value of the forests or to foresee the baneful results of their destruction.

Exploration, demarcation and settlement, followed by efforts to introduce protection and some form of regular management, were the first duties of the Forest Department. Work on these lines, which is not yet completed in the more backward parts of the country, has been pursued steadily from the commencement, and in consequence large tracts of forest have been saved from ruin and are gradually being brought under efficient management. Whatever may have been the opinions held in some quarters half a century ago as to the need for a policy such as that expressed in Lord Dalhousie's memorable enunciation of 1855, there is no longer any doubt that results have amply justified the steps taken, and that in her forests India now possesses a property of constantly increasing value, the future importance of which it is hardly possible to over-estimate.

2. Area, Classes and Types of Forests.

More than one-fifth of the total area of British India (including the Shan States) is under the control of the Forest Department. These areas are classified as reserved, protected or unclassed State forests. In the reserved forests rights of user in favour of individuals and the public are carefully recorded and limited at settlement while the boundaries are

defined and demarcated: in the protected forests the record of rights is not so complete, the accrual of rights after settlement not being prohibited, and the boundaries are not always demarcated, while in the unclassed forests no systematic management is attempted and as a rule the control amounts to nothing more than the collection of revenue until the areas are taken up for cultivation or are converted into reserved or protected forests. The total forest area of British India (including the Shan States) on the 30th of June 1915, was 249,867 square miles, of which there were 97,580, 10,405 and 141,882 square miles of reserved, protected and unclassed State forests respectively.

Throughout this vast forest area, scattered over the length and breadth of India from the Himalayan snows to Cape Comorin and from the arid juniper tracts of Baluchistan to the eastern limits of the Shan States, there is, as may be imagined, an infinite variety in the types of forest vegetation, depending on variations of climate and soil and on other local factors. Broadly speaking the following main types of forest may be distinguished:—

(1) Arid-country forests, extending over Sind, a considerable portion of Rajputana, part of Baluchistan and the south of the Punjab, in dry tracts where the rainfall is less than 20 inches. The number of species is few, the most important tree being the babul or kikar (*Acacia arabica*), which, however, in the driest regions exists only by the aid of river inundations.

(2) Deciduous forests, in which most of the trees are leafless for a portion of the year. These forests, which extend over large areas in the sub-Himalayan tract, the Peninsula of India and Burma, are among the most important, comprising as they do the greater part of the teak and sál forests.

(3) Evergreen forests.—These occur in regions of very heavy rainfall, such as the west coast of the Peninsula, the eastern sub-Himalayan tract and the moister parts of Burma, and are characterized by the great variety and luxuriance of their vegetation.

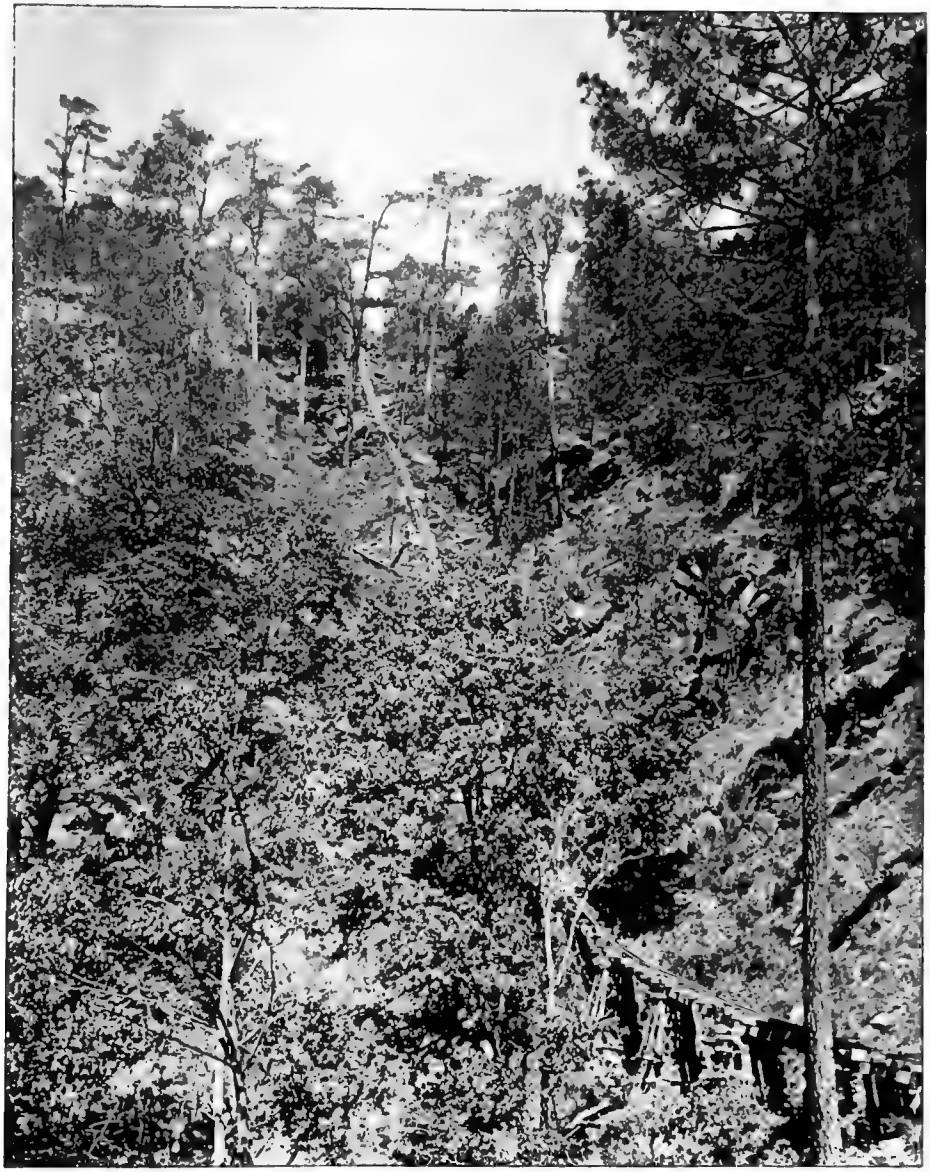

Photo.-Mechl. Dept,. Thomason College, Roorkee.

A Himalayan wet slide for the export of sleepers.

(4) Hill forests.—In these the vegetation varies considerably according to elevation and rainfall. In the Eastern Himalaya, Assam and Burma the hill forests are characterized by various oaks, magnolias and laurels, while in Assam and Burma the Khasia pine (*Pinus Khasya*) grows gregariously at elevations of 3,000 to 7,000 feet. In the North-Western Himalaya the chief timber tree is the deodar (*Cedrus Deodara*) which occurs most commonly at elevations of 6,000 to 8,000 feet and in association with oaks or blue pine (*Pinus excelsa*); towards its upper limit the deodar merges into very large areas of spruce and silver fir while below it are found extensive forests of the long-needled pine (*Pinus longifolia*), which is tapped for resin.

(5) Littoral forests.—These occur on the sea-coast and along tidal creeks. The most characteristic trees belong to the mangrove family (*Rhizophoreae*). Behind the mangrove belt is an important type of forest occasionally inundated by high tides, in which the most valuable species is the sundri (*Heritiera Fomes*).

The number of individual species of trees comprising the vast forest wealth of India is very considerable. The total number of woody species in India, including exotics, is about five thousand, of which rather more than half are trees, the remainder being shrubs and climbers. There are several hundred economically useful species, a few of the most important of which are dealt with in section 7.

3. Forest Policy and Legal Control.

The general policy of the Government of India in relation to forests was definitely laid down in 1894 by the classification of the areas under the control of the Department into four broad classes, namely :—

(*a*) Forests the preservation of which is essential on climatic or physical grounds. These are usually situated in hilly country, where the retention of forest

growth is of vital importance on account of its influence on the storage of the rainfall and on the prevention of erosion and sudden floods.

(*b*) Forests which afford a supply of valuable timbers for commercial purposes, such, for example, as the teak forests of Burma, the sál forests of Northern, Central, and North-Eastern India, and the deodar and pine forests of the North-Western Himalaya.

(*c*) Minor forests, containing somewhat inferior kinds of timber, and managed for the production of wood, fodder, grazing and other produce for local consumption; these forests are of great importance in agricultural districts.

(*d*) Pasture lands. These are not "forests" in the generally understood sense of the term, but grazing grounds managed by the Forest Department merely as a matter of convenience.

These four classes of forest are not always sharply divided from each other, and one and the same tract may to a certain extent be managed with more than one object.

The first of these classes comprises the areas which must be preserved on account of their indirect effects and without any reference to their commercial value. These indirect effects, which in many cases far outweigh the direct benefits as estimated from a commercial standpoint, may be summarised briefly as the influence of forests on climate, rainfall, water storage and the prevention of denudation. An exhaustive enquiry into this important subject was held throughout India in the years 1907 to 1914, the results of which were reviewed by the Government of India in their Circular letter to Local Governments, No. 4-F.-70—1, dated the 27th February 1915. Notwithstanding the great importance of this subject it is not possible in this memorandum to do more than indicate the main conclusions arrived at, which were—

(*i*) that the effect of forests on rainfall is probably small,

(*ii*) that denudation of the soil owing to the destruction of forests may, so far as India is concerned, be looked upon as an established fact,

(*iii*) that as regards the effect of forest preservation on rainfall and the underground water supply there is nothing to justify any change in the principles on which the forest policy of the Government has hitherto been based.

The circular in question also urged Local Governments to use every effort to induce rulers of Native States and owners of private land to co-operate in the protection of important catchment areas and in the control of the injurious practice of shifting cultivation. A summary of the enquiry and its results has recently been published in the form of a note by Mr. M. Hill, C.I.E. (Forest Bulletin No. 33 of 1916).

The second class comprises the forests which, though they may have to supply some of the requirements of the surrounding population, can be managed mainly with the object of providing the greatest possible outturn of timber for commercial purposes. It is in connection with the control of these forests that the Forest Department has been termed *quasi*-commercial.

The third and fourth classes contain the areas which are managed mainly if not entirely for the production of the forest produce necessary for the satisfaction of the requirements of the local population. In some parts of India, notably in portions of the Central Provinces, Bombay and Madras, where the work of the Department is intimately connected with the daily life of the people, this phase of his work forms the most important of the forest officer's duties. Some notion of its extent may be gathered from the fact that during the year 1913-14 the amount of forest produce removed by rightholders and free grantees was—

Timber—$7\frac{3}{4}$ million cubic feet.
Fuel—59 million cubic feet.
Bamboos—nearly Rs. 88,000 in value.
Grazing and fodder grass—nearly Rs. 33,00,000 in value.

This sketch of the policy pursued in the management of the State forests is sufficient to show that the work of the Forest Department should not be judged only from the revenue producing point of view. This side of its activities is unquestionably

of immense importance, but the first duty of the Department is to provide for the wants of the agricultural population and to maintain the areas committed to its charge in such a condition that their indirect effects shall be as beneficial as possible. Forestry has been termed the handmaid of agriculture, and nowhere does this apply with greater force than in India, which is essentially an agricultural country. Apart from their ordinary domestic and agricultural requirements for timber, fuel, thatching and fodder grass, grazing and numerous minor products, in many parts of the country the people are largely dependent on the forest for their very existence in times of famine. It is worthy of note also that among the recommendations made by Dr. Voelcker in his report on the possibilities of improvement in Indian agriculture the one which he regarded as of the greatest importance was that of providing fuel and fodder reserves by means of afforestation. To this work he alludes as " the one practical measure which calls for the most urgent attention and from which the greatest benefits may be expected to follow."

Legal control over forests is effected under the provisions of special forest enactments. The Indian Forest Act, VII of 1878, as subsequently amended, applies to the whole of British India except Burma, Madras, Assam, British Baluchistan, Ajmer and the North-West Frontier Province. Under this Act State forest or waste land may be constituted reserved or protected forest. Before any area is declared reserved forest it is subjected to a regular settlement by a forest settlement officer who enquires into the existence and nature of all private or public rights and either provides for their extinction by purchase, commutation or exchange, or settles the conditions under which and the extent to which they may be exercised. The procedure regarding protected forests is somewhat similar; rights are enquired into and recorded but not definitely settled and there is no bar to the accrual of new rights as in the case of reserved forests. The Act further provides for village forests to be settled and managed for the benefit of village communities, also for the protection of forests and trees, the control of forest produce in transit, the control of forests not the property of Government and other matters. Other special forest enact-

ments are the Burma Forest Act, IV of 1902, and the Madras Forest Act, V of 1882, while Assam, the North-West Frontier Province, British Baluchistan and Ajmer have their own forest regulations.

4. Administration and Staff.

General administration.—The forest business of the Government of India is carried out in the Department of Revenue and Agriculture. The Inspector-General of Forests is the administrative head of the Forest Department and is the technical adviser to the Government of India in forest matters.

Territorial charges.—The various provinces are divided into one or more Forest Circles, each in charge of a Conservator of Forests; provinces containing three or more circles also have a Chief Conservator who is the head of the Department for his province.* Circles are divided into a number of Forest Divisions, in charge of members of the Imperial or Provincial Forest Service; these Divisions in most cases correspond to civil districts. Each Division contains a number of Ranges in charge of junior members of the Provincial Service or of Forest Rangers or Deputy Rangers; heavy Divisions are also sometimes divided into Subdivisions. The Ranges are further subdivided into a number of beats or protective charges held by Forest Guards or in some cases by Foresters.

Non-territorial charges.—Apart from territorial charges there are various important posts of a non-territorial nature connected with Forest Research and Education, the preparation of Forest Working Plans and other special duties. Among special posts may be mentioned that of Assistant Inspector-General of Forests, who in addition to Secretariat work helps the Inspector-General of Forests in the scrutiny of working plans referred to in section 6 below.

The Forest Service.—The Forest Service comprises three branches :—

(1) The Imperial Service with a total personnel of 237 officers† consisting of the Inspector-General of

* No appointment of Chief Conservator has yet been sanctioned for Madras. For Bombay the post, though sanctioned, has not yet been filled.

† On the 1st July 1916.

Forests, Chief Conservators, Conservators, Deputy and Assistant Conservators. The Officers of this service are recruited in the United Kingdom, the present system of recruitment being by selection subject to the possession of an honours degree in some branch of Natural Science of an English, Welsh or Irish University, or of the B.Sc. degree in Pure Science of a Scottish University. Probationers are trained at a University possessing a forest school approved by the Secretary of State (Oxford, Cambridge and Edinburgh at present), this training being supplemented by a practical course, chiefly on the continent of Europe.

(2) The Provincial Service with a total personnel of 231 officers* consisting of Extra Deputy and Extra Assistant Conservators. Officers for this service are recruited in India and trained at the Forest Research Institute, Dehra Dun, though a certain number of posts in this service are filled by the promotion of specially promising Rangers.

(3) The Subordinate Service consisting of Forest Rangers (about 760), Deputy Rangers (about 850), Foresters (about 2,000) and Forest Guards (about 10,500). The Rangers are at present trained at three different centres—the Forest College at Dehra Dun (for provinces other than Burma and Madras), the Burma Forest School at Pyinmana (for Burma) and the Madras Forest College at Coimbatore (for Madras). These three institutions were established in 1878, 1898 and 1912 respectively. A scheme is now under consideration for the further decentralization of the training of Rangers, and it is probable that before long the number of training centres will be increased. The training of subordinates below the rank of Ranger is carried out in various local forest schools and training classes.

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* On the 1st July 1916.

Photo. Mechl. Dept., Thomason College, Roorkee.

Dragging teak timber in the forests of Burma.

5. Research.

For the first fifty years of the existence of the Forest Department in India no attempt was made to organize the conduct of forest research, and thus to coordinate and elaborate the scientific knowledge so necessary to successful economic working. Valuable scientific work has, it is true, been carried out from time to time as the result of individual efforts on the part of enthusiasts in special branches, but, while the results of these efforts have in many cases been published, much useful work has been lost for want of systematized methods. This state of affairs may perhaps be considered to some extent as a reproach to those concerned, but it must be remembered that the existence of the Forest Department in its earlier years depended on its justifying itself by immediate financial results, so that the very inadequate staff employed was compelled to devote the whole of its time to the preliminary work of organization, often in the face of powerful opposition.

A commencement in organized forest research was at last made in 1906 by the establishment, at the instance of Sir Sainthill Eardley-Wilmot, then Inspector-General of Forests, of a Forest Research Institute at Dehra Dun. From that time onwards research work has been prosecuted energetically in spite of deficient accommodation. This deficiency has, however, been remedied, for the Institute buildings were completed in 1914 and further land was taken up in the following year to provide for the requirements of the Provincial Service students. The main building of the Institute contains museums and offices for the Silvicultural, Economic and Zoological branches, as well as the general library and lecture rooms, while the Botanical and Chemical branches and the various laboratories and workshops are housed in separate buildings. In addition to quarters for forty students and a fine playing field there are also a residence for the house tutor and two houses for research officers. The estate, which is situated in a desirable part of Dehra Dun, is a fine one and contains ample room for the expansion that will certainly be necessary in course of time.

The Forest Research Institute, which is under the administrative control of the Inspector-General of Forests, is in the

charge of a President. There are five main branches of research, namely Silviculture, Forest Botany, Forest Economic Products, Zoology and Chemistry, each branch being in charge of a research officer. In addition specialists are appointed temporarily when necessary and are attached to the Institute to carry out investigations in subjects of particular economic importance. Thus a cellulose expert has been employed for some time to investigate possible new sources of paper-making materials, of which the forests of India contain abundant supplies, while more recently a tannin expert has been engaged to study the question of tanning materials.

It is unlikely that all forms of forest research will continue to be centralized wholly at Dehra Dun. It has now been recognised that as regards Silviculture at any rate, on which the future treatment and economic working of the forests must depend, the best results can be attained only by the employment of local research officers who will carry out detailed investigations under the widely differing conditions of climate, soil and other environment factors in their respective provinces. These local research officers will, however, work in close communication with the Central Institute, thus ensuring continuity of general principles and preventing duplication.

The results of forest research are published from time to time in the form of memoirs, records or bulletins. Such publications, however, do not by any means represent the total results of the research officers' labours, for much information and advice is imparted verbally or by correspondence both to officers of the Department and to others. In addition the research officers deliver courses of lectures in their own subjects to the Provincial Service students, who thus imbibe during the period of their training the latest results of scientific enquiry.

6. Forest Organisation and Exploitation.

Organisation.—The management of some 250,000 square miles of forest of many and widely differing types and under a variety of local conditions is a large undertaking, and matters are not simplified either by the fact that in many cases these areas had been more or less ruined by misuse of all kinds before

they were made over to the charge of the Forest Department or by the numerical weakness of the staff employed for the management of this vast estate. Again the introduction and elaboration of efficient systems of management is necessarily a slow process, for the forest officer must look many decades, and it may be a century or more, ahead, while mistakes made are not rectified in a day and may prove extremely costly before they are discovered.

Natural forest tracts, when first taken in hand, are seldom in a condition lending itself to the immediate adoption of the most efficient form of management. Nature does not select the most valuable timber trees or produce regular and sustained yields of these to the maximum possible extent, but rather endeavours to multiply the species best fitted to flourish in the particular environment. Thus in rich tropical forests the economic value of the crop may be small owing to the large admixture of worthless species struggling for existence under conditions favourable to vegetative activity, while on the other hand in arid tracts the sparse and stunted nature of the forest growth may make it impossible to produce valuable forest without the aid of irrigation. Steps have accordingly to be taken to make fuller use of the productive capacity of the soil by increasing the proportion of valuable species, improving the density of the crop, and bringing the forest into the condition of producing the maximum possible amount of valuable timber or other produce per acre year after year and century after century. Nature has to be studied closely, imitated and even coerced where necessary, and the process must often be a lengthy one.

Working Plans.—The first step towards the introduction of a regular system of management in a given forest tract is the preparation of a working plan setting forth the general objects to be attained and prescribing for a series of years the operations to be carried out in order to reach these ends. Thus the foundations are laid for the gradual amelioration of the forest with the view of building up an active capital which will, when established, produce the highest possible return. The working plan further estimates what amount of timber or other produce may be removed annually or periodically from the forest with-

out encroaching on the capital and determines at what age the trees can be most profitably removed. It also indicates how this annual depletion is to be made good by means of regeneration, for it is on this basis that true forest management rests: with this object a constant supply of young plants in the correct relative proportion has to be brought on to the ground, either by natural or by artificial means, and has to be tended carefully during the critical period of youth.

The framing of a suitable working plan thus involves an intimate knowledge of the requirements of the various species dealt with and of their rate of growth, knowledge which depends largely on the results of scientific research, and without which working plans must necessarily be of a tentative and provisional nature, as indeed many Indian plans are at present. Revisions of working plans to allow for modifications due to altered conditions or to advancing knowledge, are carried out periodically at intervals usually varying from 10 to 30 years.

In order to ensure preparation and revision on correct lines, each plan, before it is sanctioned by the Local Government concerned, is subjected to detailed scrutiny by Conservators in Madras and Bombay, by Chief Conservators in Burma, the Central Provinces and the United Provinces and by the Inspector General of Forests in other provinces.

Of the 107,985 square miles of reserved and protected forest on the 1st July 1915 only 55,629 square miles or 51·51 per cent. were actually under sanctioned working plans. Thus there is room for considerable progress in this most important work, even allowing for the fact that a certain proportion of the forest area is not yet ready for regular management.

Plantations.—Under forest organisation in its wide sense may be included the formation and upkeep of plantations, which in some localities is a very important part of the forest officer's work. Among extensive plantations under the management of the Forest Department may be mentioned the teak plantations of Nilambur in S. Malabar, dating originally from 1842 and now aggregating about 6,400 acres, the teak plantations of Burma, aggregating nearly 80,000 acres, the irrigated sissoo

plantations of the Punjab which will cover 60,000 acres on the completion of the current scheme for the formation of fuel plantations for the canal colonies, and of which the largest, Changa Manga, commenced in 1866-67, now has an area of 9,605 acres, the rubber (*Ficus elastica*) plantations of Assam, the exotic plantations of the Nilgiris, chiefly eucalyptus and Australian acacias, aggregating 1,639 acres, the babul plantations of Sind and Berar, the teak and other plantations of Bombay, the coniferous and other plantations of the Punjab, United Provinces, and the Bengal Himalayas, the plantations of mangrove, Para rubber, padauk and teak in the Andamans, and many others of various kinds in different localities. The total area of plantations under the Forest Department on the 1st July 1915 amounted to 150,210 acres. It is to be noted that the gradual introduction of methods of concentrated working is likely to lead to a considerable extension of regeneration by artificial means.

Protection.—The protection of the forests from injury by fire, illicit grazing, felling, lopping and other abuses, the protection of game and fish, and the prevention of theft of timber and other produce both in the forest and during transit, form an important branch of the forest officer's duties. Fire protection in particular imposes a very severe tax on the forest staff, who require to be constantly on the alert throughout the hottest time of the year, preventing the occurrence of fires and extinguishing any which may arise. Protection from fire is generally provided for by dividing the forest into blocks of convenient size by cleared fire-lines, which act partly as checks to the spread of fire and partly as bases for counter-firing, and by the appointment of special patrols during the fire season.

Exploitation may be effected by one of two main agencies, (1) departmental or (2) purchasers or consumers. In the former case the felling, extraction and collection of the produce at recognised sale depôts is carried out under the direct agency of the Forest Department : sales are made by auction, tender or at fixed rates and the price realized is credited directly to Government. In the latter case the produce is cut, collected and removed by the purchasers or consumers themselves, the purchase price or royalty being realized in various ways according to local usage :

under this system much produce is removed free of charge by right-holders and free grantees.

The decision as to which of these two methods should be adopted in any particular case depends on a variety of circumstances. Generally it may be said that where means of extraction are easy and markets assured it pays best to rely on the agency of purchasers, more especially where standing trees can be sold annually. On the other hand it is not always wise to rely on this agency where it is necessary to develop communications or instal mechanical appliances in order to facilitate extraction on a large scale. The following extract from the quinquennial review on forest administration for the period 1909-10 to 1913-14 expresses the views of the Government of India on this important subject.

"The question of the agency by which forest produce should be extracted has given rise to considerable discussion in the past, and although certain general principles may be laid down, the form of agency most suitable to any particular province or area must necessarily depend upon local conditions.

"In forest administration the object in view is two-fold—first, to conserve and improve the forests, and this is the first concern of the trained staff, and secondly to secure to the tax-payer the greatest immediate benefit from their commercial working. To obtain the best commercial results departmental or private agency should be employed as circumstances dictate, and provided always that Government receives a fair share of the profits earned private agency should be freely employed. But when this is done the term of the contract should on the one hand be sufficiently long to enable the initial outlay to be recovered, while on the other hand provision should invariably be made for a revision of the rates of royalty at stated intervals so that Government may not be deprived of its fair share of any rise in prices which may take place. Should it be found impossible to employ private agency on these terms, departmental working should be adopted, and if this cannot be undertaken by the trained staff without prejudice to its work of conservation and improvement there seems to be no reason why a separate staff specially trained in commercial exploitation should not be employed. At times, indeed, departmental working is essential as, for instance, in the extraction of little known timbers or other products for which it is desired to create a market, when for any reason the system of extraction by purchasers breaks down, or when it becomes necessary to prevent trade manipulation or the creation of a monopoly.

Photo.-Mechl. Dept., Thomason College, Roorkee.

The *chos* of Hoshiarpur. Example of erosion caused by destruction of forest growth.

"Having regard to these general principles, which in their opinion should govern the decision as to the form of agency to be employed, the Government of India are inclined to believe that in some parts of India departmental agency might perhaps be profitably employed more extensively than at present."

Extraction and transport.—The extraction and transport of forest produce, and particularly of timber, is often attended with much difficulty and, more especially where timber is concerned, may involve engineering problems demanding a high degree of technical skill. Timber is exploited either in the round or after partial or total conversion in the forest: the methods vary greatly according to local conditions, but fall naturally under the two main heads of land and water transport.

Under land transport the following forms may be mentioned:—

(*i*) By human agency. This includes the removal of headloads of fuel and bamboos to centres within a short distance of the forest, the carriage of sleepers and other scantlings in the Himalayas from the forests down to slides or floating streams and the extraction of heavy logs in the same localities with the help of rolling roads and earth slides. The carriage of sleepers is often a difficult and dangerous operation, for a freshly cut broad gauge deodar sleeper weighs about 150 lbs. or more and the men have to work on very steep paths over difficult ground.

(*ii*) By animals. This includes the removal of produce by carts where suitable roads exist or by pack animals where the produce can be handled by this form of transport, the employment of elephants to drag heavy timber to floating streams as in Burma and the Andamans and to a lesser extent in other localities. Buffaloes are also used for this purpose, and their employment is extending in localities where they can work owing to the steadily increasing cost of purchase and upkeep of elephants.

(*iii*) By mechanical appliances. These include tramways, ropeways and skidders. Some of the most import-

ant forest tramways in British India are those in the Goalpara division, Assam, which has recently been converted for steam traction, in the Andamans, at Changa Manga in the Punjab and at several places in Burma. The best forest ropeway is that in the Rawalpindi division of the Punjab, which was erected a few years ago in order to facilitate the delivery of fuel to the troops stationed at Murree. Simpler ropeways worked principally by gravity are used in various parts of the Himalayas for the carriage of sleepers over difficult ground. So far there is only one instance, in Burma, in which skidders have been used by the Forest Department.

There can be no doubt that the gradual introduction of systems of management involving concentrated working will be accompanied by great expansion in the use of mechanical appliances for the extraction of timber. No very great attention has been paid to this subject so far, but with the appointment of forest engineers and the increase in the demand for timber it is hoped that there will be considerable progress in the near future.

Water transport includes wet slides for the conveyance of sleepers to points whence they can be floated, telescopic floating in small streams where there is not enough water, or where the obstructions are too great for the scantlings to pass down unaided, ordinary floating, rafting and conveyance by boats. The department possesses a small steamer for the carriage of timber from the forest camps in the Andamans to Port Blair.

7. Forest Products.

Forest produce is divided into two main heads (1) Major produce, that is, timber and firewood, and (2) Minor produce, comprising all other products such as leaves, fruits, fibres, grass, gums, resins, barks, animal and mineral products, etc.

The average annual volume of timber and fuel and the value of minor produce removed from State forests during the five

years 1910-11 to 1914-15 is given in the following statement :—

Forest produce removed from State forests, average per annum for the period 1910-1911 to 1914-1915.

Agency of exploitation.	Major produce (volume.)		Minor produce (value.)			
	Timber.	Fuel.	Bamboos.	Grazing and Fodder Grass.	Other minor produce.	Total.
	c. ft.	c. ft.	Rs.	Rs.	Rs.	Rs.
By Government .	7,326,689	16,791,908	81,529	1,79,746	4,43,454	7,04,729
By purchasers . .	69,752,314	116,349,006	10,49,397	28,72,958	21,44,016	60,66,371
By free grantees .	2,928,310	10,153,339	18,671	4,18,517	2,67,636	7,04,824
By right-holders	4,077,721	52,705,209	64,428	26,70,575	3,51,369	30,86,372
Total	84,085,034	195,999,462	12,14,025	61,41,796	32,06,475	1,05,62,296

Much information regarding Indian timbers will be found in Gamble's Manual of Indian Timbers (1902) and in Troup's Indian Woods and their Uses (Indian Forest Records, Economic Products Series, Volume I, Part I, 1909), while information on the more important timbers and minor forest products will be found in Troup's Indian Forest Utilization (2nd Ed., 1913) and Pearson's Commercial Guide to the Forest Economic Products of India (1912). The following is a necessarily brief account of some of the more important major and minor forest products of India :—

(1) Major produce : principal timber trees.

A large proportion of the many species of Indian trees have little or no value at present, partly because they are imperfectly known, partly because they are so rare as to be of no consequence economically and partly because they are wanting in durability, strength or other necessary properties. Still there are several hundred species of Indian trees the timber of which is used for some purpose or other. A few of the most important of these

are enumerated below arranged in alphabetical order by their scientific names :—

Abies Pindrow, Spach, and *A. Webbiana*, Lindl. The Himalayan silver firs. The former occurs only in the western Himalaya, at 7,500—10,000 ft. (sometimes higher), and the latter both in the Eastern and in the Western Himalaya, in the latter region at a higher elevation than *A. Pindrow*. Both are tall evergreen conifers, with soft white not very durable wood, suitable for planking, packing-cases, shingles, wood-pulp, matches and possibly after impregnation for sleepers. Worked to a very small extent at present. Quantity available very large but at present more or less inaccessible.

Acacia arabica, Willd. Babul. A moderate-sized to large tree of the drier parts of the plains of India, chiefly in Sind (on tracts irrigated by the Indus), the plains of the Punjab and United Provinces and the Indian Peninsula generally. The wood is light red to reddish brown, hard and durable, used for building, carts and carriages, wheels, agricultural implements, turnery and many other purposes; it yields excellent fuel. Bark used for tanning, pods for cattle fodder and tanning; also yields a gum. Present supplies generally fully utilized: heavily worked since the outbreak of war for the tanning industry.

Acacia Catechu, Willd. The cutch tree. A moderate-sized to large tree, common in most of the drier parts of India and Burma; grows gregariously on the shingly and sandy beds of streams in the sub-Himalayan tract. Wood light or dark red, very hard and durable, used for house-posts, carts, boats, wheels, furniture, tool-handles, agricultural implements, etc.; an excellent fuel. Cutch and kath are obtained by boiling down chips of the heartwood. Supply largely utilized especially in Burma.

Adina cordifolia, Hook. f. Haldu. A large tree, found in mixed deciduous forests throughout the greater part of India and Burma. Wood yellow, moderately hard, durable, rather apt to warp and crack, used for building, boats, furniture, agricultural implements, boxes, turnery, carving, toys and other purposes: this timber has been recently used for the manufacture of bobbins with considerable success. Moderate supplies available.

Albizzia Lebbek, Benth. Siris: known on the English market as "Indian Walnut," (though not the true walnut, which is *Juglans regia*). A large tree, wild in certain parts of the sub-Himalayan tract, the Indian Peninsula, Burma and the Andamans; largely planted along road-sides and in gardens. Wood dark brown, streaked with darker or lighter streaks, handsome, used for building, furniture, agricultural implements, wheels, carving, turning, etc. The timber is available in considerable quantity in the Andamans, where it is known by the

Photo.-Mechl. Dept., Thomason College, Roorkee.

Teak plantation, 20 years old. Nilambur, S. Malabar.

The Nilambur teak plantations were commenced in 1842, now aggregate 6,400 acres, and are a great financial asset to the State.

Burmese name *kôkko;* handsome carvings in this wood are executed by the convicts at Port Blair. The "burrs" which are sometimes formed on the trees are specially valuable for veneers.

Bombax malabaricum, DC. The cotton tree, simal. A very large tree, common throughout the greater part of India and Burma. Wood soft, whitish, rather perishable, used for packing-cases, tea-boxes, inferior planking, canoes, matches, well-linings, toys, and other purposes where a soft wood is required. A similar wood of rather better quality is yielded by *B. insigne*, a very large tree of Burma, the Andamans and the W. Coast of India. Present supplies generally utilized in accessible localities, especially for tea chests in Bengal and Assam.

Calophyllum tomentosum, Wight. The poon-spar tree. A large straight-stemmed evergreen tree of the West Coast. Wood reddish brown, used for masts and spars, house-building, ship-building and construction generally. In fair demand in accessible localities.

Cedrela Toona, Roxb. Toon, red cedar, Moulmein cedar. A large tree found in various parts of India and Burma, and often cultivated. Wood red, soft, handsome, fragrant, easily worked and seasons quickly, used for furniture and cabinet work, planking, doors, boxes and general carpentry, tea-boxes, cigar-boxes, boats, carving and many other purposes. A very useful wood, resembling open-grained mahogany, and esteemed in the London market. Generally fully utilized.

Cedrus Deodara, Loudon. The deodar, Himalayan cedar. A very large evergreen coniferous tree (a true cedar) of the Western Himalaya, most common between 6,000 and 8,000 ft. Wood yellowish brown, moderately hard, oily, strongly scented, very durable. This is one of the most important timbers of India, and is largely used for railway sleepers, building, carpentry and construction of all kinds. Fully utilized.

Chloroxylon Swietenia, DC. Satinwood. A moderate-sized tree of the Indian Peninsula, furnishing the well-known satinwood of commerce, a hard yellow wood often with a beautiful wavy grain and satiny lustre, used for carving and ornamental work of all kinds. This wood is exported chiefly from Ceylon and to a lesser extent from India, where the trees are usually of small size, approaching fair dimensions only in the south. Available in fair quantity but of small size.

Dalbergia latifolia, Roxb. Blackwood, rosewood of S. India. The shisham of the Indian Peninsula. A large tree of Central and Southern India, extending north to the sub-Himalayan tract in Oudh, where it is of small size. This tree furnishes the well-known blackwood of commerce, a handsome hard dark purple wood with black streaks, which is exported for furniture and ornamental work. In India it is used for a variety of purposes, including furniture, door and window frames,

panelling, carts, tool handles, gun-carriage wheels, and fancy work of various kinds. Fully utilized wherever accessible.

Dalbergia Sissoo, Roxb. The sissoo or shisham of N. India. A large tree of the sub-Himalayan tract, chiefly gregarious in river-beds; extensively planted in other localities. Wood brown with darker streaks, very hard, strong and durable, used for building, furniture, cart and carriage frames, wheels of carts, carriages and gun-carriages, carving and turning, and many other purposes. Fully utilized.

Dipterocarpus tuberculatus, Roxb. The in or eng tree of Burma. A large tree growing gregariously over extensive tracts in Burma, and largely used for building, particularly in the form of boards and scantlings; also used for boats, carts, etc. The wood has been exported to some extent to Europe, sometimes under the name of "eng teak." The future yield is estimated roughly at 50,000 tons per annum.

Dipterocarpus turbinatus, Gaertn. f. Gurjan. A very large evergreen tree of Burma, the Andamans, Chittagong and Cachar. Wood reddish brown, moderately hard, used for building, boats, etc. The timber has been exported in some quantity from the Andamans to Calcutta and Madras, and recently a consignment sent to London has been very favourably reported on. There are large supplies available in the Andamans and experiments are in progress to ascertain the possibility of employing the wood for railway sleepers after antiseptic treatment. The tree yields a wood-oil known as gurjan oil.

Duabanga sonneratioides, Ham. Lampati. A large tree of Bengal, Assam, Chittagong, Burma and the Andamans. Wood grey, often yellowish, soft, seasoning well without splitting, largely used for tea-boxes, and also for canoes, planking and other purposes. Generally utilized.

Gmelina arborea, Roxb. Gumhar. A moderate sized or large tree, scattered throughout the greater part of India and Burma. Wood greyish white, fairly soft, even grained, of good quality and seasoning well, used for planking, furniture, door panels, carriages, agricultural implements, boats, toys and general carpentry. A valuable timber tree which however occurs sporadically and not in large quantities.

Grewia asiatica, Linn, *G. tiliæfolia*, Vahl, *G. vestita*, Wall. The grewias, known indiscriminately as "dhamin," have tough elastic wood used for shoulder-poles, spear-handles, bows and other purposes requiring elasticity. Not fully utilized.

Heritiera Fomes, Buch. Sundri. A tree of the Sundarbans and other tidal regions, the coast of Arakan and Tenasserim and the Irrawaddy Delta. Wood dark red, very hard, durable, strong, tough and elastic, used for building, boats, masts and spars, shafts, wheels and

furniture. Fully utilized in the Sundarbans, but large quantities available in Burma.

Hopea odorata, Roxb. Thingan. A tall evergreen tree of Burma and the Andamans. Wood yellowish brown, hard, very durable, used for house building, bridge construction, piles, boats, wheels, carriage-building, agricultural implements, etc. One of the most valuable timbers of Burma.

Hopea parviflora, Bedd. Irumbogam, ironwood of Malabar. A large tree of the W. Ghats from S. Kanara southwards to Travancore and Tinnevelly. Wood brown, hard, very durable; uses similar to the preceding. A valuable timber which is used to a considerable extent: large quantities available in localities which at present are more or less inaccessible.

Juglans regia, Linn. Walnut. A large tree of the Himalaya at 3—10,000 ft.; hills of Upper Burma. This is the true walnut of commerce, possessing a beautifully mottled brown wood with darker streaks. The "burrs" are particularly valuable for veneers, and have been considerably worked in Kashmir and elsewhere. The wood is used for furniture, veneering, carving, panelling, gunstocks, etc. The tree is fairly common in many of the Himalayan forest tracts, but many localities in which it grows are remote and extraction is often impossible at present. It is extensively cultivated in the Himalaya for its fruit.

Largerstræmia Flos-Reginæ, Retz. Jarul (Bengal), pyinma (Burma). A large tree of Bengal, Assam, Burma and the moister parts of the Indian Peninsula; often cultivated for its handsome mauve flowers. Wood light reddish grey, hard, very durable, used for house-building, bridge construction, boats, ship-building, carts, agricultural implements, wheels, furniture, etc. One of the most important timbers of Burma. Available in fair quantity.

Lagerstræmia lanceolata, Wall. Benteak. A large tree of the W. Ghats, extending southward to Travancore. Wood reddish brown, moderately hard, strong and durable, used for house-building, ship-building, furniture, carts, wheels, etc. Available in fair quantity.

Mesua ferrea, Linn. Nahor. A large evergreen tree of Assam, Burma, the Andamans, W. and S. India. Wood dark red, extremely hard, very strong and durable, used for bridge and house construction, railway sleepers, piles, carts, boats, tool handles and other purposes. Utilized wherever accessible.

Michelia Champaca, Linn. Champ. A large tree of Sikkim, Bengal, Assam, Burma, W. and S. India. Wood light olive-brown, soft, with a shiny lustre, very durable, used for planking, panelling, furniture, carriage-building, boats, carving and turning and general carpentry. Fully utilized where accessible.

Michelia excelsa, Bl. Safed champ. A large tree of the Eastern Himalaya at 5—8,000 ft. Wood olive-brown, soft, glossy, very durable, used for planking, door and window frames, furniture, carving and turning. Fully utilized where accessible.

Pentacme suavis, A. DC. Ingyin. A large tree found throughout Burma, growing gregariously in so-called "indaing" forest. Wood brown, hard, very strong and durable, used for house-building, bridges, piles, boats, carts, wheels, agricultural implements and other purposes. Fully utilized in accessible localities.

Picea Morinda, Link. The Himalayan spruce. A tall evergreen conifer of the Himalaya at 7—11,000 ft. Wood white, sometimes reddish or brownish in the centre in large trees, soft, not very durable, used for planking, packing cases and general carpentry. Has been found very suitable for matches and also for wood-pulp, its fibres being longer than those of any other spruce known. The timber is available in large quantities in the Himalayan forests, and it is only the cost of extraction which prevents its being more extensively utilized. Very large quantities available in localities which at present are more or less inaccessible.

Pinus excelsa, Wall. The blue pine, kail. A large evergreen conifer of Himalaya at 6—12,500 ft. Wood pink, moderately hard, of good quality, used for building, boats, furniture and general carpentry. After antiseptic treatment this timber possesses all the qualities necessary for good railway sleepers: the quantities available are however not very large and the timber is so valuable for general purposes that its use as a sleeper wood on a large scale is problematical.

Pinus longifolia, Roxb. The long-needled pine, chir. A large conifer of the Himalaya and Siwalik hills at 1,500 to 7,500 ft. Wood light reddish brown, moderately hard, used for building, common furniture, tea-boxes, boats and general carpentry. Is now being utilized on a fairly large scale for sleepers after antiseptic treatment. The wood is available in large quantities. The resin of this species is now extensively tapped in the United Provinces and the Punjab for the manufacture of rosin and turpentine.

Pterocarpus dalbergioides, Roxb. Andaman padauk or redwood. A large tree of the Andamans, yielding a valuable ornamental moderately hard wood of a deep rich red colour. Andaman padauk is largely used for panelling, house-fittings, ornamental furniture and cabinet-work, billiard-tables, pianos, railway carriage fittings, carving and other ornamental work, as well as for wheels, boat-building and other purposes. This wood has for some years past been exported to Europe and America, and with the development of forest extraction in the Andamans it will be available in larger quantity in future.

Pterocarpus macrocarpus, Kurz. Burma padauk. A large tree scattered in the mixed forests in several parts of Burma from Bhamo to Tenasserim. The wood is yellowish red to brick red, sometimes streaked with brown, hard and very strong: although inferior to Andaman padauk in colour it excels it in strength, and is perhaps the best wood for ordnance work of various kinds, such as gun-carriage wheels and many other purposes. In Burma it is extensively used for naves, spokes and felloes of cart and carriage wheels, carriage-building, shafts and other purposes for which strength is required. Fairly fully utilized in accessible localities.

Pterocarpus Marsupium, Roxb. The gum-kino tree, bijasal. A large tree of Central and Southern India, extending north to Oudh and the Kumaun Bhabar. Wood yellowish brown with darker streaks, very hard, durable, used for door and window frames, posts, beams, furniture, agricultural implements, wheels, carts, boats, and many other purposes. The wood when damp is apt to produce a yellow stain. The tree yields a red astringent medical gum known as "kino" from wounds in the bark. Fairly fully utilized where accessible.

Pterocarpus santalinus, Linn. f. Red sanders. A small or moderate sized tree occupying a limited region in the hills of the E. Deccan. A valuable wood, dark purplish red, extremely hard, used for wheels, shafts, agricultural implements, and particularly for carvings. Supply limited.

Quercus. The oaks. There are nearly 40 species of oak in India and Burma, chiefly in the Himalaya, Khasia hills, Chittagong hills and Burma. Several of these are of local importance, partly for building and other purposes but especially for fuel. None of them have as yet proved to be of any special value for export or for general use outside their immediate regions. Not fully utilized. Large quantities available.

Santalum album, Linn. Sandalwood. A small tree of the Indian Peninsula from the Nasik and Nagar districts southwards, particularly in Mysore, Coorg and some of the Madras districts—N. Coimbatore, N. Arcot, N. Salem, Bellary and the Nilgiris. The heartwood is yellowish brown, hard, very close-grained and strongly scented: it is used for carving and fancy work of all kinds and is burned as incense, while sandalwood oil is distilled from it. Volume for volume this is by far the most valuable wood in India; it is sold by weight, and every portion of the tree which yields heartwood of any size is utilized, the heartwood from the roots being the most valuable. Fully utilized.

Shorea obtusa, Wall. Thitya (Burmese). A large tree common, chiefly in "indaing" forest, throughout Burma. Wood brown, very hard and durable, used for house and bridge construction, piles, carts,

wheels, agricultural implements, etc. Fully utilized in accessible localities.

Shorea robusta, Gaertn. f. Sal. A large gregarious tree of Northern and Central India, in the sub-Himalayan tract from Kangra to the Darrang and Nowgong districts of Assam and in the Garo Hills, Chota Nagpur, Orissa, the Central Provinces and the Ganjam district of Madras. Wood brown, hard, very durable, used for building, bridge construction, piles, railway sleepers, agricultural implements, railway waggons, ordnance work, and many purposes. Sal is one of the most important timbers of India, owing its reputation to its great strength and durability; otherwise it is a somewhat coarse and cross-grained wood and seasons slowly. The timber is in great demand, particularly for railway sleepers and building, and as large tracts of sal forest have been saved from destruction and are under regular management a sustained yield of this valuable timber may be relied on in future. Fully utilized.

Tectona grandis, Linn. f. Teak. A large tree of Central and Southern India, Bombay and Burma. Wood yellowish brown, extremely durable, seasons well without warping or splitting and works well. Teak is the most important timber of India, being superior to all other known woods for ship-building, for which purpose it is largely exported to Europe. It is put to numerous other uses, including building, furniture and cabinet work, panelling, carving, railway carriages and waggons, spokes and felloes of wheels, agricultural implements, etc. For export purposes the great bulk of the teak timber comes from Burma, where the trees do not ordinarily form pure forests of any extent but are scattered among a large number of other species. In Burma the timber is extracted by floating and the trees are girdled three years before felling in order to kill them and render the timber buoyant. The importance of teak in the world's markets may be realized from the fact that during the 5 years ending 1914-15 the average annual value exported from the Indian Empire amounted to Rs. 83,74,039, the great bulk of this coming from Burma. Although in India proper the trees do not ordinarily reach the dimensions attained in Burma there are tracts in Western and Southern India where timber of very fair dimensions is produced, while there is always a strong demand within the country even for teak of small size. The question of maintaining and increasing future supplies of this valuable timber has engaged the earnest attention of the Forest Department from its infancy, and in addition to efforts to improve natural regeneration, extensive teak plantations have been formed, chiefly in Burma and S. India. Fully utilized.

Terminalia Chebula, Retz. The myrabolan tree, harra. A large tree, found throughout the greater part of India and Burma. Wood

Photo.-Mechl. Dept,, Thomason College, Roorkee.

Valuable sal forest killed by abnormal drought ; one of various natural calamities which the Forest Officer has to face and to guard against.

brownish grey with a small irregular dark purple heartwood, very hard, used for building, furniture, turnery, carts, naves and felloes of wheels, and agricultural implements. The tree is valuable chiefly owing to its fruits, which are the myrabolans of commerce and are largely used for tanning.

Terminala myriocarpa, Heurck and Muell. Arg. Panisaj, hollock. A very large tree of the Eastern sub-Himalayan tract and outer hills, Assam, Upper Burma. Wood dark brown, handsome, hard, used for building, tea-boxes, common furniture, boats and cart shafts. After impregnation this timber may prove suitable for sleepers. Large quantities available.

Terminalia tomentosa, W. and A. Sain, saj, asan. A large tree, common throughout India and Burma. Wood dark brown with darker streaks, hard, apt to split in seasoning, durability variable, used for building, rough furniture, oil-mills, agricultural implements, carts, boats, mining timber and other purposes. The timber is available in large quantities and is likely to make a good sleeper wood after impregnation.

Xylia dolabriformis, Benth. Ironwood of Burma, pyinkado. A very large tree, abundant in Burma. Wood reddish brown, extremely hard, heavy, very strong and durable, used extensively for house-building, bridge-construction, railway sleepers, railway trucks and carriages, boats, carts, wheels, carriage-frames, agricultural implements, tool-handles and many other purposes. This is, after teak, the most important timber in Burma, where it is extensively used for railway sleepers. It is very plentiful and obtainable in large size.

Xylia xylocarpa, Roxb. Jamba, irul. A large tree of the Indian Peninsula from the Central Provinces and Bombay southwards. Wood reddish brown, very hard, heavy, durable, apt to split in seasoning, used for house-building, bridge-construction, agricultural implements and other purposes. Available in fair quantity.

(2) Minor Produce.

The forests of India are so rich in minor products of all kinds that it is possible to refer only to those which are or are likely to be of commercial value. A classification together with a brief description of the more important products will be found in Troup's Indian Forest Utilization (1913), while much useful detail regarding them is contained in Watt's Commercial Products of India (1908). Among the more prominent classes are comprised bamboos, grass (including grazing), leaves for fodder,

litter and manure, fibres and flosses, oil seeds, tans and dyes, oils, gums, resins, rubber, drugs and spices, edible products of various kinds, animal products such as lac, honey and wax, silk, hides, horns and ivory and mineral products. Some of the principal items are considered below.

(*a*) Bamboos.

Bamboos are extensively used for building, basket-making and innumerable other purposes, and are extracted in enormous quantities, the average annual value during the five years 1910-11 to 1914-15 amounting to no less than Rs. 12,14,025. In some localities, as in Burma, they are so abundant as to be regarded as weeds, while in others, for example in the sub-Himalayan tract and the drier parts of the Peninsula, they are carefully worked on a system designed to prevent depletion. Within recent years special attention has been given to the utilization of bamboos for the manufacture of paper pulp, a subject dealt with on pages 48-51 below; this is an industry in which extensive development is possible, and bamboo forests at present little exploited will no doubt in time be worked to their full capacity for the manufacture of paper pulp.

(*b*) Grass and grazing.

The question of fodder grass and grazing is one of the most important and difficult matters with which the Forest Department has to deal, for whereas on the one hand the agricultural prosperity of India must depend largely on the supply of grass from and grazing facilities in the forest tracts, on the other hand strict regulation and limitation of grazing is necessary in the interests of the forests themselves, for excessive grazing must in the majority of cases result in the extermination of tree growth, since it prevents the regeneration of tree species, while on hill slopes its evil effects are intensified by causing denudation. In times of famine the supply of grass from forest tracts is a matter of great importance, and cutting and baling operations on a large scale are organized for supplying the affected districts. During the five years 1910-11 to 1914-15 the average annual

value of grazing and fodder and thatching grass yielded by the forests amounted to Rs. 61,41,796

(*c*) Fibres.

It is usual to classify fibres according to the part of the plant from which they are obtained. Flosses are silky cottons yielded by the fruit capsules of certain trees. The true "kapok" of commerce is a floss produced by *Eriodendron anfractuosum*, which is sometimes planted in India but is not an indigenous forest tree. The most important substitute for kapok is the floss obtained from the fruits of *Bombax malabaricum* while among other species yielding silk cottons are *Cochlospermum Gossypium* and *Calotropis* spp. Species of wild plantain (*Musa*) yield strong fibres from their sheathing leaf-stalks, and the leaves of the wild sago palm, *Caryota urens*, give a fibre of some value known as *kitul* and used for making fishing nets and lines as well as for brush bristles, ropes, baskets and sacking. Bast fibres are yielded by a large number of trees and by certain climbers and are employed for rough cordage though some are suitable for finer work. Among the best known are those produced by species of *Sterculia*, *Grewia* and *Bauhinia*, and several species of the orders *Malvaceæ* and *Urticaceæ*. Of forest fibres which seem to have commercial prospects may be mentioned those of the shrubs *Helicteres Isora* and *Urena lobata*. Both are very common in certain localities, and the former yields a strong greyish white fibre used in rope making while the latter produces a strong fibre nearly equal to jute. Of fibrous grasses the two most important are the munj (*Saccharum Munja*) and the bhabar, baib or sabai (*Ischœmum angustifolium*); the latter is better known as a paper making material, but both are largely used for making ropes and mats.

(*d*) Oil Seeds.

Although many forest species yield useful oil-seeds, the cost of collection from trees scattered over large areas renders it impossible for them to compete with oil-seeds cultivated as agricultural crops. The collection of forest oil-seeds, therefore, is commercially remunerative only if they possess special pro-

perties; the inhabitants of the jungle, however, utilize the forest oil-seeds to a large extent as food and for cooking or lighting purposes.

Probably the best known oil-seed obtained from any Indian tree is that of the Mohwa, *Bassia latifolia.* The oil is a yellow buttery fat, obtained from the seed by expression to the amount of from 45 per cent. to 50 per cent. on the weight of the seed. It is used in India primarily for adulterating ghee; also as an ointment and for burning, cooking and soap making. It is exported to Europe in large quantities: thus in 1913-14 the total exports amounted to 665,979 cwts, valued at £364,000 of which quite 85 per cent. found its way to Germany: since the war much of the trade has been diverted to England. Bombay exports by far the greater proportion of the outturn, while the Central Provinces and the Bombay Presidency produce the majority of the crop.

The seeds of *Taraktogenos Kurzii* yield the true 'chaulmugra' oil of commerce used in cases of skin disease and leprosy. The tree is fairly common in Assam, the seeds being exported from the Khasi Hills and sold in Sunamganj. It is also common in the Sylhet and Sibsagar divisions of that province, while considerable quantities of the seed are available from the Rangoon and Shwegyin divisions of Burma. A very similar oil, which is also a variety of chaulmugra oil, is obtained from the seed of *Hydnocarpus Wightiana,* which is found in the forests of the West Coast, especially in South Malabar and in the Cochin and Travancore States.

The cotyledons of *Shorea robusta* yield a substance known as sâl butter, used for cooking and adulterating ghee. Amongst other seed-oils may be mentioned those obtained from the seeds of *Mesua ferrea,* used in the preparation of glycerine, of *Pongamia glabra,* used for cooking and for burning, of *Juglans regia* (the walnut) used in confectionary and for cooking and lighting, of *Melia indica,* a bitter oil used in native medicine and of *Vateria indica,* a tree of Western India and Malabar. Of recent years the tallow obtained from the seeds of this last named species has come into prominence on the English market in connection with the preparation of margarine.

Photo.-Mechl. Dept., Thomason College, Roorkee.

Sal forest of good quality, Bengal.

(*e*) Tanning materials.

The old methods of tanning with barks are being rapidly replaced by the use of extracts, the consumption of tanning materials is steadily increasing, and local supplies may soon prove inadequate; it is therefore probable that the tanners of Europe and America will have to depend in future, at any rate to some extent, on imported materials. The forests of India are rich in undeveloped tanning materials and there is unquestionably a great opportunity for technical research as well as for industrial and commercial development in this country. The study of tanning materials is being steadily prosecuted at the Forest Research Institute, and with the object of enquiring into the commercial possibilities of preparing tan extracts the Government of India have recently secured the services of a tannin expert from England. Among the more important tannin producing materials at present known the following may be mentioned :—

Myrabolans.—The fruits of *Terminalia Chebula*, or chebulic myrabolans, are tanning agents of primary importance. By themselves they do not tan leather of good texture but they give excellent results when mixed with other deeply coloured barks and are in great demand all over the world. The statistics of exports from India are as follows :—

Export figures, myrabolans.

	Quantity.					Value.				
	1910-11.	1911-12.	1912-13.	1913-14.	1914-15.	1910-11.	1911-12.	1912-13.	1913-14.	1914-15.
	cwt.	cwt.	cwt.	cwt.	cwt.	£	£	£	£	£
British Empire.	707,133	505,926	704,138	520,341	677,100	181,958	129,579	188,544	147,678	187,591
Foreign countries	951,762	727,735	693,617	716,053	487,161	283,139	203,941	225,736	231,948	162,859
Total .	1,658,895	1,233,961	1,397,755	1,236,394	1,164,261	465,097	333,520	414,280	379,626	350,450

Except as regards the possibility of manufacturing extracts locally and of exporting the dried pulp after removal of the kernels, it does not seem possible to do much more in connection with this product.

Zizyphus Xylopyrus fruits.—The fruits of *Zizyphus Xylopyrus* have recently been examined at the Forest Research Institute. They contain about 20—25 per cent. of tannin, together with 20 per cent. of non-tannin, mostly consisting of pectom substance. They yield good light coloured leather of fair texture. Except that they tan slowly, taking about double the time of babul bark, they are in every way a good auxiliary tanning material.

Caesalpinia digyna is a shrub found growing scattered in Burma and elsewhere, the pods of which are very rich in tanning material, containing as much as 50 to 60 per cent. of tannin. If cultivation is possible this may prove to be a valuable tanning material.

Babul pods.—The pods of the babul (*Acacia arabica*) are not so extensively used as might be expected, the chief objection to them being that they ferment badly in the tan yard. The conditions under which they may be employed as tanning agents are under study. From the work done so far it appears that they can be utilized if tan liquors are prepared from them and the refuse materials discarded before use. They contain 18—20 per cent. of a bloom yielding pyrogallic tannin, and if an extract can be prepared from them it may be of considerable value.

Mangrove barks.—The barks obtained from the mangrove forests of littoral regions are rich tanning materials, containing on an average 25—30 per cent. of tannin. They are used to a limited extent by the native tanners of Burma and Calcutta. It has been demonstrated that it is possible to make a saleable mangrove tan extract but unfortunately a prejudice exists amongst tanners in Europe and America against it as it gives a red leather which is also inferior in other respects to leather tanned with other materials. Unless its preparation is substantially improved and the cost of manufacture considerably reduced, the commercial possibilities of working this product are, to say the least, doubtful.

Babul bark.—The bark of the babul (*Acacia arabica*) is one of the commonest substances used for tanning, especially in Northern India. This bark, which yields an essentially harsh

tan, is pre-eminently suitable for tanning sole leather. It contains 15—20 per cent. of tannin. In conjunction with myrabolans it gives a fairly light-coloured leather of good texture. Very large quantities are available, though the supply is by no means inexhaustible, which indicates the necessity of creating plantations in the vicinity of the more important tanneries. Recently the babul has been very heavily exploited for its bark to supply the greatly increased demand of the Cawnpore tanneries during the war.

Cassia auriculata or tarwar bark is probably the best bark available in India for tanning purposes and is the standard tan bark of Southern India. It gives good weight to leather and though it contains catechol-tannin like the mangrove bark, it is less highly coloured and yields a fairly light-coloured leather. About 50,000 maunds of it are stated to be available annually from the forests of Marwar alone. It is found in large quantities in the wild state and is cultivated: its cultivation might with advantage be largely extended.

Kahua (*Terminalia Arjuna*) and dhaura (*Anogeissus latifolia*) barks.—These barks have recently come to notice, and give promise of being useful tanning materials.

Sâl (*Shorea robusta*) and sain (*Terminalia tomentosa*) barks. —These are inferior to the two previously mentioned barks, though of considerable value and extensively used in Northern India. Their value in the preparation of tan extracts has still to be proved.

Oak barks.—These cannot be considered as marketable articles on account of the inaccessibility and distance of the oak forests from the centres of consumption. They contain a similar amount of tannin to the European oak barks.

Leaf tans or sumach.—Some work regarding the possibilities of leaf tans has been carried out at the Research Institute. It has been found that the autumn leaves of *Rhus Cotinus* and *Rhus parviflora* are richest in tannin. Recently it has been proved at the factory owned by the Eastern States of Central India Export Trust that the young leaves and twigs of *Anogeissus latifolia* (the dhaura or bakli) contain valuable tanning properties. Should the results of experiments lead to

the development of an extensive industry, it will be necessary to devise a special system of working in order to maintain supplies without inflicting permanent injury on the forests.

Cutch is the name given to the solid and semi-solid extract prepared from the heartwood of *Acacia Catechu*, though at times this name is also applied to lighter coloured tan extracts such as Borneo cutch. The chief use of the cutch in the United Kingdom is for dyeing fishing nets. It imparts a deep reddish-brown colour to the material and also acts on the fibre as a preservative. Most forms of cutch made from *Acacia Catechu* contain a fair percentage of catechin, a white crystalline substance which is insoluble in cold water. This insoluble catechin is also deposited on the fibre and slowly oxidises into tannic acid and other products by the action of the sea water. Its present price varies, according to quality, between Rs. 840 and Rs. 1,240 per ton. Hitherto no serious effort has been made to organise the industry on strictly scientific lines for the reason that the prices obtained for it do not justify extra capital being sunk in elaborate machinery similar to that required for the preparation of tan extracts.

The export figures for cutch from British India are as follows :—

Export figures, cutch and gambier.

	Quantity.					Value.				
	1910-11.	1911-12.	1912-13.	1913-14.	1914-15.	1910-11.	1911-12.	1912-13.	1913-14.	1914-15.
	cwt.	cwt.	cwt.	cwt.	cwt.	£	£	£	£	£
British Empire .	58,348	53,187	47,186	36,748	46,417	74,289	58,213	48,463	38,626	50,487
Foreign countries	32,699	27,820	21,565	22,111	15,624	37,152	28,320	22,636	23,536	19,357
TOTAL .	91,047	81,007	68,751	58,859	62,041	111,441	86,533	71,099	62,162	69,844

Katha or catechin, though not a tan extract, may be conveniently referred to here, as it is another product of *Acacia Catechu*. This substance is much in demand in India for edible purposes. In Kumaun and other places the katha is prepared by allowing the aqueous extract of *Acacia Catechu* of a particular concentration to cool and deposit the small needle

like crystals which are separated from the mother liquor by throwing the magma into a sandpit. The tan liquor is absorbed and the catechin remains as a soft pliable mass which is slowly dried. This crude method of making katha is open to great improvement, especially in separating katha from the liquor in hand-worked filter presses and by drying the resulting mass in a chamber heated to about 100° C.

(*f*) Essential oils, oleo-resins and gums.

(*i*) Essential oils.

Sandalwood oil is distilled by the wet process from chips of the heartwood of the sandalwood tree (*Santalum album*) the root-wood being preferred. This valuable oil is largely used in perfumery and in medicine. Before the war the wood was largely exported to Europe for distillation, although this process has always been carried out at various centres in India by primitive methods. The question of improving the methods of distillation is receiving attention in India, and it is hoped that the time is not far distant when the whole output of sandalwood required for distillation purposes will be distilled in India by modern methods and not exported for distillation abroad. The Mysore Government is now working a distillery at Bangalore with successful results.

The eucalyptus oil industry has already assumed considerable proportions in the Nilgiris, but no expansion is possible unless special plantations are formed for leaf supply.

Rosha oil.—One of the most important essential oils in this country is East Indian geranium oil or palm-rosa-oil obtained from the grass *Cymbopogon Martini*, Stapf. The distillation of this oil was probably commenced in the 18th century, and it was first brought to the notice of Europe in the early part of last century. Recent investigations at the Forest Research Institute have shown that improvements in distillation can be effected by employing a modern type of steam still. The main conclusions arrived at are that it is more economical to distil the grass with steam and that 20 per cent. more oil can be obtained in this way. By redistilling the crude oil, a water-

white oil of a standard composition can be put on the market, which should materially benefit the trade in this article.

Lemon grass oil.—The distillation of lemon grass oil from *Cymbopogon citratus* is a more modern industry than that of rosha oil, for the former was imported into England for the first time in 1832. Distillation by crude methods has been carried out for many years. The industry started in Travancore and extended later to Malabar, where stills of improved construction have been used. When Travancore held the monoply the oil was exported from Cochin, but now that the industry has extended northwards into Malabar, Calicut is becoming a centre of distribution. The oil has lately been prepared in Assam. Before the war from 2,000 to 3,000 cases each containing one dozen quart bottles of oil were exported annually from Cochin to Bombay and to various other ports, chiefly New York, Hamburg and London. A large proportion of the oil is absorbed in the manufacture of citral and ionone, an artificial violet perfume. An export trade in the oil has recently developed in Java. The demand for lemon grass oil is steadily on the increase in Europe, and all things considered this oil would seem to have a promising future.

Saussurea Lappa.—"Kuth" roots are an important forest product. The plant grows in Kashmir at an altitude of from 6,000 to 10,000 feet. It is exported largely to China where it is burnt as incense and was sent in large quantities to Germany before the war for the distillation of costus oil, which was then valued at Rs. 150 a lb. It is used to adulterate violet perfumes. Lengthy experiments in order to ascertain the best method of distillation and the factors which determine its oil value are approaching completion at the Forest Research Institute. The work done up to date indicates that the best method of extracting the oil is with the help of alcohol. The roots should first be treated in a modern extraction plant in which the loss of solvent does not exceed 1—2 per cent. and the extract thus obtained should be steam distilled. A complete note on the subject will be issued as soon as the experimental results have been confirmed on a commercial scale.

Wintergreen oil.—Mr. Puran Singh, Chemical Adviser at the Forest Research Institute, is believed to have been the first to

Photo.-Mechl. Dept., Thomason College, Roorkee.

Forest steam tramway running through sal forest, Goalpara, Assam.

show that wintergreen oil can be distilled at a profit in India from the leaves of *Gaultheria fragrantissima* collected in Assam during the winter. The fresh leaves gave as much as 0·65 per cent. of oil, or 1·2 per cent. calculated on the dry material. The Nilgiri plant gave only 0·12 per cent. of oil from fresh leaves and 0·23 per cent. calculated on dry material. The plant grows gregariously in the Nilgiris, in Assam and in Ceylon, but for a regular supply of the leaves it would be necessary to cultivate it on an extensive scale. From the wintergreen oil so distilled it has been shown that natural salicylic acid and natural sodium salicylate can be easily prepared.

(*ii*) Oleoresins.

Pine resin is by far the most important oleoresin obtained from the forests of India, and as its collection has now reached the stage of an important industry it is dealt with separately below. Of other oleoresins the following deserve mention:—

The gum-oleoresin of *Balsamodendron Mukul* (gugal).—This is a useful product, yielding ·05 per cent. of oil and 73·62 per cent. of a yellow resin similar to that obtained from Siam, the so-called acroid resin used for metal polishing. It also yields 13·66 per cent. of gum of an inferior quality.

Boswellia serrata.—The gum-oleoresin of *Boswellia serrata* may prove to be of considerable importance. Unlike the pine oleoresins, it is made up of three ingredients (1) an oil, (2) a rosin, and (3) a gum. Though it was known that the oil of myrrha and this gum-oleoresin resemble each other and that both contain pinene, it is only recently that an attempt has been made to isolate these ingredients commercially. The enquiry was initiated by the Forest Research Institute, and after much work and with the help of the Imperial Institute, a process for the isolation of the products has been evolved. A full report on the subject is under preparation, and though there are difficulties to be overcome in connection with the collection of the raw oleoresin there are good prospects for the establishment of this industry on a commercial scale.

Dipterocarp oleoresins.—The oleoresins of the Burma dipterocarps have received little attention from chemists up to

date. They yield the so-called wood-oil for which there is a great demand in Burma for the manufacture of torches and for oiling soap and caulking boats. It has been suggested as a solvent for caoutchouc. Chemical research may discover new derivatives of this product and thereby increase its market value.

Thitsi.—The oleoresin derived from *Melanorrhoea usitata*, called thitsi in Burma, has been employed by Burmans in lacquer work for a long time. The chemical composition of this oleoresin has been studied at the Forest Research Institute and its identity with the Japanese *urushi* or lacquer seems certain. Many enquiries have been received from Europe and the possibilities of developing the market for this article are considerable.

(*iii*) Gums.

The number of Indian trees which exude gum is very large, though only a limited number produce gums of commercial importance. The more important uses to which gums are put are for mucilage, medicine, the preparation of sweetmeats, and in the textile and paper industries in connection with calico-printing and sizing respectively.

The most important mucilage gum is that obtained from *Acacia arabica*, the babul tree. It resembles true gum arabic, obtained from *Acacia Senegal*, which, however, is only available in small quantities in Sind, the Punjab and Rajputana, its true habitat being the Blue Nile. *Acacia arabica* gum is collected in large quantities in India; in addition to the purposes mentioned above it is utilized in fixing paint and whitewash. Fine qualities fetch 8 annas per lb., while a fair average quotation is 4 annas per lb.

An important astringent gum is obtained from *Pterocarpus Marsupium*, and is known on the market as gum kino. The gum is collected chiefly in South Kanara and North Malabar. It finds its way to Bombay through the small ports on the West Coast and so to England and France. Prices fluctuate considerably, 10 to 12 shillings per lb. being a fair average quotation. The demand is limited.

The dhaura tree, *Anogeissus latifolia*, yields a whitish-yellow gum used extensively for sizing paper and calico printing. It makes up into a poor mucilage.

Bauhinia retusa, a tree of North-West and Central India, yields a clear yellow to reddish coloured gum with a bright fracture. It is collected in considerable quantities in the outer Himalaya, being used for medicinal purposes. Professor Dunstan in a report gives its viscosity as eight times that of gum arabic.

Odina Wodier (jhingan or mohin) yields a copious gum used in fixing whitewash, sizing paper and in medicine. It is a common tree of the deciduous forests of India.

Cochlospermum Gossypium yields the "katira" gum of commerce; it exudes from the tree in long whitish corrugated streams, and is used by shoe-makers, in medicine, and as a poor substitute for gum tragacanth.

Buchanania latifolia, a tree found throughout India and Burma, yields large quantities of gum, making up into a fair mucilage which deserves further attention.

Gardenia lucida yields a hard opaque yellow to greenish-brown gum-resin used in cutaneous diseases, while that of *Gardenia gummifera* is used for similar purposes and is also edible.

(*g*) India rubber.

The only indigenous rubber tree of importance is *Ficus elastica*, a large evergreen tree found wild in the moist forests of the outer Eastern Himalaya, Assam and Upper Burma, chiefly in the Hukong Valley. In order to supplement the natural supplies, plantations on a fairly extensive scale have been made by the Forest Department in Assam. With the advent of plantations of Para (*Hevea*) rubber, however, it was found that the Assam plantations could not compete financially with them, mainly for the reason that it takes some 12 to 14 years for *Ficus elastica* to come into bearing as against 4 to 6 years for *Hevea*, while age for age the yield of *Ficus* plantations cannot compare with that of *Hevea* plantations.

The Forest Department took its share in the initial experimental work connected with the formation of *Hevea* rubber plantations in Burma. In the year 1878 the experimental planting of *Hevea* at Mergui in Tenasserim was commenced by the department: more recently planting was undertaken on a larger scale and was extended until in 1910 the total planted area amounted to 1,500 acres approximately. By this time it had been fully demonstrated that the planting of Para rubber could be carried out successfully in Tenasserim, and that the industry could be taken up safely by private agency. The plantations were accordingly sold to a Company in 1910.

(*h*) Drugs and spices.

Although the forests yield various drugs and spices which are collected for trade purposes, the intensive cultivation of these in gardens and plantations is not part of the regular work of the Forest Department. Of natural products collected from the forest may be mentioned aconite, belladonna, nux-vomica, podophyllum, barberry (" rasaut "), violet (" banafsha "), wild pepper, cardamoms, amaltas pods (*Cassia Fistula*), tamarinds and others. The experimental cultivation of *Podophyllum Emodi* has been carried out in the North-West Himalaya for some years past, but the growth of the plant has been found to be so slow that its cultivation for profit is as yet problematical: in the meantime supplies of this important drug are obtained from natural plants.

(*j*) Edible and other products.

Forest trees, shrubs and herbs yield an important natural supply of food which the various jungle tribes do not fail to take advantage of, particularly in times of famine. Special mention may be made, under this head, of the flowers of the mohwa tree (*Bassia latifolia*), the corollas of which are eaten fresh or are dried, ground and mixed with flour for bread, or are distilled into an intoxicating liquor. Recently they have proved to be an important source of supply of acetone.

(*k*) Animal products.

Lac, the resinous incrustation secreted on the twigs of certain trees by the lac insect (*Tachardia lacca*), and largely

Photo.-Mechl. Dept., Thomason College, Roorkee.

A blue gum (*Eucalyptus Globulus*) plantation in the Nilgiris, age 30 years, average height 143 feet.

used in the preparation of varnishes, in the manufacture of gramophone records, sealing wax, lithographic ink and for other purposes, is one of the most important of the animal products of the forest. There is an extensive literature on the subject of lac and its propagation. Lac cultivation is by no means confined to the forest; in many localities it is a source of profit to the cultivator in open waste or cultivated lands. The extensive propagation of lac by the Forest Department is attended with many difficulties, of which not the least is that of guarding it from theft while still on the trees. Strenuous exertions have been made to cultivate lac departmentally in the Central Provinces, but so far the results have been disappointing, and it is probable that its cultivation in future will have to be entrusted to a very large extent to private agency, the Forest Department leasing tracts of suitable forest for the purpose. The importance of this industry may be realised from the fact that in 1914-15 the value of various forms of lac exported from India amounted to as much as Rs. 1,60,57,434.

Silk is likewise a product which requires more intensive cultivation than it is possible for the Forest Department to undertake directly. The whole question of silk-production in India has recently been the subject of special investigation by Mr. Maxwell Lefroy.

Horns, hides, bones, ivory and other animal products are collected as a rule under permits.

8. Forest Industries.

The important rôle which the forests of a country play in its general commercial welfare and in providing employment for its population is not always fully recognised. Ten years ago it was estimated that in Germany work in the forests provided employment for 1,000,000 persons, while 3,000,000 persons, earning £30,000,000 a year, were employed in working up the raw material yielded by the forests.* If similar estimates were available for India they would no doubt show that apart from the jungle population which is directly dependent on the forests

* Schlich's Manual of Forestry, Vol. I, 3rd Edition, 1906, pp. 22 and 23.

and the large numbers of wood-cutters, sawyers, carters, carriers, raftsmen and others working in and near them, employment on an extensive scale is provided to persons engaged in working up the raw products. Among these latter may be mentioned carpenters, wheel-wrights, coopers, boat-builders, tanners, rope-makers, lac-manufacturers, basket-makers and many other classes of skilled labourers. And yet with the further opening up of the forests, the extension of systematic working, the wider use of known products and the possible discovery of new products, a steady and extensive development of industries dependent on the forests of India may be confidently anticipated in the future.

A detailed consideration of the many important forest industries would fill a large volume; all that can be done here is to review shortly a few of them by way of example.

(1) The Indian pine-resin industry.

The commercial exploitation of the resin of the Indian pines serves a wide range of subsidiary industries. It provides rosin for shellac making, soap manufactories, paper concerns, oil cloth, linoleum, sealing wax, printing inks, electric insulation, gramophone records, and wheel grease. And it also provides turpentine, which is the chief thinner and solvent employed in the paint and varnish trades, a mordant in print goods manufacture, the basis of synthetic camphor, and an ingredient of boot-polishes, embrocations and liniments. This field is wide enough in peace time, but is considerably expanded in war time by the rosin used in "setting" shrapnel bullets in shells.

Of the world's trade in rosin and turpentine, or "naval stores," the United States of America command about 80 per cent. of the output, France coming second with some 15 per cent. and the rest of the world taking the remaining 5 per cent.

It is now well over a quarter of a century since forest officers in the North-West of India began to realise the potentialities of the wide pine belt along the foot hills and lower slopes of the Himalaya. Many of them being French-trained, it was not surprising that the splendidly organized tapping

of the maritime pine of the Landes should serve them as a model, and so from the very start the conservative cup and lip method in use in France was adopted, thus ensuring the best possible yield of resin with the minimum risk of injury to the tree. And so from small beginnings in the United Provinces, and later in the Punjab, the industry has grown till to-day (for the year ending on 30th June 1916) the annual resin collection in the United Provinces and the Punjab amounts to 69,980 maunds net (2,592 tons), the operations covering 62,000 acres of forest with 2,141,000 blazes or channels in work, giving employment to at least 2,400 operatives.

In the last five years, in the United Provinces more especially, extensive and successful organization has brought the harvesting of the resin to a high state of efficiency. Mr. E. A. Smythies' interesting pamphlet on the "Resin Industry in Kumaun" (Forest Bulletin No. 26, 1914) is available for those who wish to study the question further.

The work of setting up a crop of pots (or cups) and lips preparatory to tapping pine trees for resin is simple, when properly organized, and the resin collection in the forests offers exceptional opportunities to the surrounding villages to utilize the old and the young for earning excellent wages.

The bark of the tree to be tapped is first of all lightly smoothed, then, as close to the base of the tree as possible, the bark is entirely removed so as to expose the sap-wood on a strip some 6″ high and 4″ wide. A galvanised iron lip 6″ wide by 2″ deep is driven in at the lower end of this strip or gash and an earthern pot, made by local village potters, is hung below the lip, being kept in position by a nail or a hard wood peg. This preliminary work is done in the winter months.

The tapped forests are grouped into depôts, sub-blocks and blocks for purposes of control, the unit of work being a section of 1,000 blazes (equivalent to an average of 700 trees, spread over 25 to 30 acres of forest) in charge of a tapping coolie, and the unit of control being a depôt taking the produce of about 25,000 blazes or channels.

The tapping coolie at the beginning of the tapping season, sometime in March, cuts away the sap-wood on the already

prepared strip to a depth of about $\frac{1}{2}''$ to $\frac{3}{4}''$, thus severing the resin ducts and channels in the wood and causing the liberated resin to flow down the cut surface over the guiding galvanised lip into the cup below. These severed channels clog after a while, and the whole art of the tapping lies in refreshening the blaze at fixed intervals, gradually extending it upwards, till at the end of the seven or eight months embraced in the tapping season the blaze should be about 24″ long and the coolie in charge of the section of 1,000 blazes should have delivered 45 to 55 maunds net (say 2 tons) of resin in his depôt.

Work goes on in this way for five years, the lip and cup being raised annually with the increase in height of the blaze, so as to reduce the distance the resin has to flow before reaching the cup, as the resin oxidises (and deteriorates commercially) very rapidly in contact with air. In the 5th year of tapping the coolie has to be furnished with a light ladder to reach his work. After five years the blaze is left alone and a fresh one is started, and so the tree continues yielding resin uninterruptedly for some 60 years out of its normal life of a century and a quarter. Trees under 3′ girth are not tapped and above this girth the number of blazes varies with the size of the tree. Those trees destined to be felled within five years of the time of starting tapping are specially heavily worked for their resin, *à mort*, to quote the French expression. With this necessarily brief account the forest operations connected with the harvesting of the resin have to be left and the factory processes and the markets taken up in review. The cost of the resin delivered at the factory site varies from Rs. 2-4-0 to Rs. 3-4-0 per maund net.

It was in the factories and in the selection and devising of manufacturing methods best suited for the distillation of the Indian pine resin that the Forest Department found its hardest task, a task in which the Forest Research Institute at Dehra Dun and the Imperial Institute, London, gave much helpful advice and assistance. America, thanks to the happy chemical constitution of its principal pine-resin, produces a turpentine which stands in a class by itself, though manufactured in the most primitive, direct fire-heat apparatus. French manufacturers found, but not till they had learnt by bitter and costly

experience of adverse trade criticism and adverse markets, that an apparatus good enough for America was not good enough for the maritime pine resin of the Landes and so, since 1900 or thereabouts, technical French engineers at Bordeaux, energetically assisted by the chemical section of the Bordeaux University, have devoted much attention to the subject of the resin distillation. The result has been a score or more of patents, in all of which fire heat is eliminated and complete control of temperature is maintained by systems of steam-heating and steam injection. France has thus been enabled to do the best with its pine resin and produces rosin with a good reputation in the trade and a thoroughly sound, merchantable turpentine.

The lesson learnt in France gradually penetrated to India. The primitive stills first used in the United Provinces and the Punjab were re-modelled and modified till to-day the United Provinces possesses a battery of stills and secondary apparatus which ingeniously overcomes the defects produced by excessive unregulated heat, while the Punjab, boldly scrapping its obsolete plant, has erected a modern French one, modified to suit Indian conditions, which is giving entire satisfaction by the excellence of its products and the economy of its working. The Punjab rosin has been recently pronounced in some respects superior to French rosin by the well known paint and varnish firm of Messrs. Wilkinson, Heywood and Clark, Limited, London, and a large scale commercial test is now under contemplation definitely to determine the commercial value of Indian rosin in relation to American, French and Spanish rosins. Such a test, if favourable (as there is every indication of its being), will materially assist the Forest Department in capturing the whole of the Indian trade and that of Java, China, and possibly even of New Zealand and Australia. The Indian turpentine too has been standardized and certificate No. 1766-C., dated the 7th July 1916, of the Railway Board Test House, Alipore, testifies that the sample submitted (Jallo Factory, Quality I) gave "a very satisfactory paint film" and "should prove very suitable for paint manufacture." The turpentine is guaranteed up to this sample and the Joint Sales Manager, Bhowali Post Office, Naini Tal District, United Provinces, is always glad to furnish samples and quotations, either direct or through local agents.

A short account of the actual distillation of pine-resin as carried out at the modern Government turpentine factory (managed by the Punjab Forest Department), Jallo, North Western Railway, Lahore District, may be of interest. The resin received from the forest is taken out of the air-tight receptacles, loaded into tip-waggons and conveyed along an elevated tramway to large melting and mixing vats. There the resin is melted and mixed, steam heat only being used, the melting being assisted by the addition of turpentine from a previous distillation. The specific gravity of the resin is thereby reduced, so that, when the melting and mixing is finished, a period of rest enables the water and dirt, etc., to sink by gravity to the bottom of the vat, the clean light resin floating on the top. Evaporation is prevented by the lids of the vats being fitted into water-joints. The next stage consists in drawing off the clean resin to a storage tank, whence a measured quantity is taken over, as required, into a steam elevator and thence into the still.

In the still, which is steam jacketted and kept hot by steam under pressure, giving one command of a wide range of temperatures, the turpentine in the resin is driven off by injecting steam. The water and turpentine vapours first pass into a trap-still to prevent any resin or rosin accidentally driven over from going further, and then through a huge condenser in which they liquefy and whence they flow into a mechanical separator, the turpentine being pumped to bulk storage, while the water runs to waste.

To ensure standard qualities the turpentine is redistilled in a subsidiary still, passed through lime water to remove any traces of resinous acids, and de-hydrated by filtration through anhydrous sodium sulphate. As however this last mentioned process is thought to be a possible source of contamination it has recently been replaced successfully by a period of rest in bulk storage tanks. Experiments are also in progress to dispense with redistillation by accurately fractionating the distillate in the primary distillation. The turpentine is put up for sale in five gallon drums bearing distinctive stencil marks, bung-hole discs and labels, to prevent tampering by retail traders.

Photo.-Mechl. Dept., Thomason College, Roorkee.

A promising natural pole crop of chir pine (*Pinus longifolia*).

The hot rosin in the still is drawn off by means of a sluice-valve into a waggon and transferred to the rosin shed, where it is filtered through a layer of cotton wool and then run into casks, bags or tins while still moderately hot and fluid. The rosin is graded according to American standard into pale, medium and dark shades. Gross weight, actual tare, etc., are carefully stencilled on the packages before despatch. The rosin has proved uniform in quality, very clear and free from dirt, a most important matter in paper and shellac manufacture.

The process of manufacture at the Bhowali Factory, United Provinces, is similar, but there they have the disadvantage of working with older plant. This defect, it is understood, will be removed as soon as more normal conditions prevail in Europe.

The cost of distillation and packing varies from Rs. 1-8 to Rs. 2 per maund net, including all costs. A maund of resin yields on an average $\frac{2}{3}$rds of a maund of rosin and 1·75 gallons of turpentine, of which up to 1·5 gallons is Quality I.

For the year ending 30th June 1916, the combined output in the United Provinces and the Punjab was 67,078 maunds of resin distilled (27 maunds = 1 ton), yielding 47,149 maunds of rosin and 111,835 gallons of turpentine, all classes. The gross revenue was Rs. 5,04,249, the gross trading account profit Rs. 1,73,892 and the net trading account profit Rs. 1,46,794, while the invested capital stood at Rs. 1,61,905. Interest and depreciation, per maund of resin distilled, varies from annas 5 to annas 10. The financial aspect of the industry may therefore be considered quite satisfactory. This question has been dealt with instructively and exhaustively by Mr. E. A. Smythies in the "Indian Forester" for April 1916, pages 187—201, the most striking fact there brought out being that whereas a chir pine tree yields at maturity at most Rs. 30 gross revenue, the gross value of its resin comes to Rs. 138, inclusive of compound interest at $3\frac{1}{2}$ per cent. per annum.

The possibilities of development of the Indian pine resin industry are considerable. The average annual imports of rosin and turpentine into India for the five years 1907-08 to 1911-12 were about 3,000 tons and 2,27,000 gallons, respectively. Today India is herself producing over 1,300 tons of rosin and 111,000 gallons of turpentine towards her annual

requirements. At present the resin industry is practically in the position of having to retard or accelerate its expansion with direct reference to the speed with which the remainder of the Indian market can be secured and outside markets such as Java, China, etc., developed. It is here that closer co-operation with the trade interests of India is necessary and more active measures have to be adopted to advertise Indian rosin and turpentine.

So far only the resin of the *chir* pine has been dealt with commercially. This pine covers some 1,500 square miles in Government forests and another 1,800 square miles in Native States, while the blue pine, the Khasia pine and *Pinus Merkusii*, the resin of all of which has been well reported on, extend over some two hundred, eighteen hundred and twelve hundred square miles respectively, all under the control of the Forest Department. It would not be safe to assume that even half of the Government owned area will ultimately prove workable, but these figures are sufficient to show that the revenue now derived from this industry is only a fraction of the return which may one day be realized.

The industry is, therefore, one to which in recent years the Forest Department has rightly devoted a good deal of attention, and though expansion must be gradual, yet the prospects are there and it only requires effort along sound commercial lines to reap a good harvest. Any forest industry which yields such satisfactory financial results and yet leaves the main source of forest wealth, namely the timber, a realisable asset, is deserving of the most careful study.

(2) The paper pulp industry.

In India the manufacture of paper is a well established if not a large industry: it dates back some fifty years and is carried on side by side with that of paper-pulp, differing in this respect from the practice in force in Europe and America, where the two form entirely separate industries. This state of affairs is due to the difficulty of preparing either mechanical or chemical wood-pulp in India, for though suitable species of

timber are available they cannot at present be extracted at sufficiently cheap rates. To overcome this difficulty the paper maker has had to resort to importing wood-pulp, which is expensive, and to preparing his own half-stuff from grass and waste products, thus combining the art of paper making with that of preparing pulp from indigenous raw materials.

The largest paper mills in India belong to the Titaghur Paper Mill Co., Ld., who run two mills, one at Titaghur and the other and newer mill at Kankinara, with a combined outturn of over 15,000 tons of paper per annum. The next most important paper mill with an outturn of 6,700 tons of paper is situated at Raneeganj, some 120 miles from Calcutta, on the East Indian Railway, and is owned by the Bengal Paper Mill Co., Ld. The third largest mill in India is at Lucknow, with an outturn of about 2,500 tons of paper per annum, and is owned by the Upper India Couper Paper Mill Co., Ld. The only mill working in Western India is situated near Poona; it has a capacity of a little over 1,000 tons of paper per annum and is owned by the Deccan Paper Mill Co., Ld. There also exists a paper mill in the Gwalior State, which is not working at present.

The present demand for paper is supplied by the mills mentioned above, by imports, and to a small extent by hand-made paper prepared locally. Of the total demand, the Indian paper mills produce, in normal times, about 25,000 tons, which during the war has risen to nearly 30,000 tons, owing to the difficulty and high cost of importing paper. The imports of paper and paste boards into India in 1914-15, exclusive of note-paper and envelopes, amounted to 51,390 tons, valued at £709,372, or including note-paper, at a total of £879,298. The demand for paper in India may therefore be put at about 75,000 tons per annum, of which India supplies one-third.

Turning now to the question of paper-pulp, we find that India imported no less than 13,250 tons of pulp in 1912-13, that is in pre-war times, while in 1914-15 the amount fell to 4,630 tons owing to the prohibitive cost of obtaining the half

stuff and to shipping difficulties. In spite of this fact the outturn of paper from Indian mills increased in 1914-15 by at least 5,000 tons of paper, a fact strongly indicating the possibilities of expanding the output in this country even when the difficulties of obtaining chemicals are abnormal.

The most important raw material used in India at the present day for the production of half-stuff is sabai, bhabar or baib grass, *Ischœmum angustifolium*, which is obtained from the forests of Bengal, Chota Nagpur, Orissa, Nepal and the United Provinces. The other materials used in India for the manufacture of paper are rags of poor quality, hemp, jute, gunny bags, waste paper and old ropes. Since the war began, limited quantities of munj grass, *Saccharum Munja*, have been used, though the yield of pulp from this grass is not high, while in many parts of the country its value is considerable owing to the demand for other purposes.

The two most important substances from which pulp is prepared all over the world are wood and grasses, of which wood claims 90 per cent. of the outturn. In India owing to the large number of species and the generally mixed character of the forests, only one or two timbers are available which fulfil the necessary conditions, namely concentrated large supplies and suitability for the manufacture of pulp. The chief of these are the Himalayan spruce and silver fir.

Under the natural order *Gramineœ* we have bamboos and grasses, both of which are available in large quantities in certain localities of British India, and some of which have, from experiments, given very favourable results. Up to date the best results have been obtained with *Bambusa polymorpha* (kyathaungwa), a species which occurs in great abundance in Burma. *Cephalostachyum pergracile* (tinwa) and *Dendrocalamus strictus* (the common male bamboo) have given almost equally good results, while *Bambusa arundinacea* (the thorny bamboo) and *Melocanna bambusoides* (the single-stemmed bamboo) have given results little inferior to the best as yet obtained. All these species are available in very large quantities and can be extracted at relatively cheap rates. A complete note has been published by the Forest Research Institute

Photo.-Mechl. Dept., Thomason College, Roorkee.

The natural regeneration of a chir pine forest, showing how a young crop is created by opening out the overwood to admit light and protecting from fire. The old trees are being tapped for resin prior to being felled.

printed on pure bamboo paper, giving figures of outturn, cost of extraction, suitable localities in which to erect factories, cost of manufacture and the results obtained based on tests carried out on a commercial scale.

The elephant grasses, found in certain localities of India and Burma, afford material nearly as promising for the manufacture of pulp as that yielded by bamboos. According to Mr. W. Raitt, the cellulose expert, those grasses which yield the best pulp are, in order (1) *Anthistiria gigantea*, including the two sub-species *A. arundinacea* and *A. villosa*, (2) *Phragmites Karka*, (3) *Saccharum Munja*, (4) *Saccharum arundinaceum* and *Saccharum Narenga* bracketted, (5) *Saccharum spontaneum* and (6) *Arundo Donax*. Recently experiments on a commercial scale were made with *Saccharum spontaneum* and *Saccharum Narenga* grasses obtained from Assam, resulting in the manufacture of several tons of paper prepared from each species; both species gave good results, the former especially making up into a very fair grade of paper. The possible outturn of these grasses is very large, especially from Assam, Bengal, the United Provinces and Burma, while the cost of extraction is moderate. A note on the laboratory experiments carried out by Mr. Raitt, with a preface by Mr. R. S. Hole, the Forest Botanist, gives valuable information as to the possibilities of elephant grasses for the manufacture of paper pulp.

The enormous available supplies of bamboos and elephant grasses could therefore be utilized for the manufacture of the 50,000 tons of paper and paste boards which India now imports annually. It is true that neither bamboo nor grass pulp could be made to meet all requirements, since certain classes of paper cannot be made from these raw materials; nevertheless, looking to the figures of cost of manufacturing bamboo and elephant grass pulps, there is no doubt that a large proportion of Indian requirements could be met from this class of pulp. Again, the commercial prosperity and the diffusion of education in India justify the belief that the requirements for paper will rapidly increase in the near future. Moreover everything points to the future possibility of exporting pulp from India, but to the East rather than to the West.

(3) The match industry.

India is largely dependent for its supplies of matches on imports from other countries. The bulk of the matches come from Japan, Sweden and Norway while in pre-war times smaller quantities came from Austria-Hungary, Belgium and Germany. About 20 years ago India made a definite attempt to manufacture its own matches, one of the first factories to be erected on modern lines being that of the Gujrat Islam Manufacturing Co., Ld., at Ahmedabad. A detailed enquiry into this question led in 1910 to the publication of a treatise, entitled "The Prospects of the Match Industry in the Indian Empire, with Particulars of proposed Match Factory Sites and Woods suitable for Match Manufacture" (Indian Forest Memoirs, Volume II, Part I). At that time there existed in India eight factories, namely three in the Bombay Presidency, two in the Central Provinces, one in Kashmir, and two in Calcutta. At the present time the number of match factories in India has not increased, for although new ones have been established, some of the older and smaller ones have disappeared. Amongst the newer ventures are the North India Timber Co., Ld., Bareilly, the Irrawaddy Match Manufacturing Co., Ld., Mandalay, the South India Match Factory, Ld., near Tenmalair, South India and the Ahmedabad Match Manufacturing Co., Ld., while of the older establishments the Gujrat Islam Match Manufacturing Co., Ld., also at Ahmedabad, the Amrit Match Factory, Bilaspur, Central Provinces, the Rangoon Match Factory and the Oriental Match Manufacturing Co., Ld., Calcutta, may be mentioned. There are also some smaller factories working with a more limited outturn than those mentioned above.

The imports of matches in 1914-15 amounted to close on $15\frac{1}{2}$ million gross boxes, valued at Rs. 113 lakhs, as compared with Rs. 49 lakhs in 1904-05. The imports have therefore more than doubled in value in 10 years, in spite of the fact that the local supply has materially increased during that period. The passing of the Indian White Phosphorus Matches Prohibition Act V of 1913 temporarily checked imports, but the trade soon recovered, especially that with Japan, owing to the careful manipulation of the trade by the Japanese combine of manu-

facturers and shippers, who have now practically captured the Indian trade at the expense of Sweden and Norway.

In the above mentioned memoir on the prospects of the match industry in India is given a detailed list of timbers suitable for making match-splints and boxes compiled from the results of tests carried out mainly by an up-to-date firm in Germany. The most universally used wood in India for match-making is *Bombax malabaricum*, the simul or cotton tree. The timber of this tree makes up into a strong good box of fair appearance. It yields fair sticks, the drawbacks to the timber being that it discolours, that it does not allow of the stick being cut uniformly square in section, and that the waste in conversion is considerable. A far superior stick can be obtained from *Abies Pindrow* and *Picea Morinda*, the silver fir and spruce respectively. The chief drawback to these species lies in the difficulty of extraction from the high elevations at which they grow in the Himalayas, a difficulty which, however, can probably be overcome by mechanical extraction. Many other species of timber occur which are fairly suitable for match making, amongst which may be mentioned *Anthocephalus Cadamba*, *Bombax insigne*, *Boswellia serrata*, *Evodia fraxinifolia*, *Givotia rottleriformis*, *Populus euphratica* and *Trewia nudiflora*.

The difficulties under which the industry has laboured in India may be summarised as follows:—(1) imported matches are sold at extraordinarily cheap rates, (2) great difficulty has been experienced in obtaining a first-class indigenous timber within a working figure of cost, (3) railway freight has hit the local trade, especially in connection with imports of chemicals and distribution of the manufactured product and (4) the cost of landing the timber in the round at a factory site has in many cases turned out to be excessive. In spite of the manifold difficulties experienced the industry still persists, and the solution to the problem in Northern India may perhaps be found to lie in the erection of portable or semi-portable splint machines in the hills, in the vicinity of the spruce and silver fir forests, and by exporting the prepared splints to central match factories in the plains, a system of working which it is understood has been inaugurated in Japan and other countries.

In Central and Southern India the cost of extraction to a line of communication and the high freight on the timber in the rough to the factory are the chief difficulties to be overcome; the solution undoubtedly lies in the formation of plantations, and as *Bombax malabaricum* is easily propagated and grows fast this should present no difficulties.

(4) The antiseptic treatment of timber.

As early as 1854 the question of treating timber came under consideration in India, prominence being given to the subject by the erection of a creosoting plant by the East Indian Railway Company at Bally, near Howrah. As far as is known the plant was not a success, and in any case it did not remain long in existence. From that time onward considerable attention has been paid to the subject, resulting in the erection at various times of plants embodying the burnettizing, haskinizing, creosoting, Boucherie and powellizing processes. In 1878, Dr. Warth was appointed by the Government of India to make a thorough investigation into the value and best methods of treating timber antiseptically. His appointment resulted in the publication of a valuable report, embodying definite proposals, to which unfortunately full effect was not given. Sir Dietrich Brandis, the then Inspector-General of Forests, about the same time wrote a report on this subject, in which he gave a complete list of timbers which, it was thought, would be suitable for sleepers after treatment. The enquiry was started afresh in 1905, and has been prosecuted steadily at the Forest Research Institute from the time of its foundation in 1906, though it is only during more recent years that the preliminary work has commenced to bear fruit and that the Forest Department has actually turned out treated sleepers in commercial quantities.

The idea of protecting timber by artificial means is a very old one. The use of paints and tars was well known to the Romans, while that of charring and smoking timber, to protect it from decay, dates back to the later Egyptian period. It was not, however, until modern times that it became possible, with the help of science and machinery, to treat timber so as to give it thorough protection against decay and insect attack.

The methods by which timber can be treated may be divided into four classes, namely, (*i*) brush treatment, (*ii*) immersion in open tanks, (*iii*) treatment in pressure cylinders and (*iv*) hydrostatic injection. The first is not an impregnation method but relies on protecting the timber by applying a superficial layer of paint or antiseptic oil. Immersion in open tanks is suitable for treating posts, telegraph poles, mining props, and limited quantities of sleepers or building material. Of timber artificially protected in Europe and America, the greater proportion is treated in pressure cylinders, while hydrostatic injection is not now in common use.

Many treating processes have been evolved, differing both in the antiseptic used and in the method of introducing it into the timber. The antiseptics which are at present employed may be divided into two main groups, namely, oils and salts; by far the most important oil is coal-tar creosote. Many other antiseptic oils have, from time to time, been put on the market, either patents or otherwise, but nearly all of them are derived from coal-tar creosote. The other oils to which attention has been paid in recent years are petroleum products.

A large number of salts have been employed in the treatment of timber, of which chloride of zinc has best withstood the test of time. Of other well known salts may be mentioned copper sulphate, corrosive sublimate or bichloride of mercury, saccharine and arsenic solutions and compounds of fluorine. The various processes embodying the employment of these salts have generally been named after the inventors of the processes, such as burnettizing, employing chloride of zinc, the Boucherie or Margary process, in which copper sulphate is used, and powellizing, in which molasses and arsenic form the chief ingredients. Besides the above processes may be mentioned the Haskin or vulcanising process, in which the substances in the timber are sterilized and rendered unfit for the nourishment of insects and fungi.

The primary factor governing the treatment of timber in any country is the procurability of a good grade of cheap coal-tar creosote. This oil is not at present available in India, all supplies having to be imported. Again, the variable climate in different parts of India not only affects the timber to be treat-

ed but limits the number of antiseptics which it is possible to use. For instance, the excessive heat experienced in the plains makes the use of a high boiling point oil imperative, while the excessive moisture during the monsoon months precludes the use of soluble salts.

Some seven years ago it was decided to carry out a series of experiments by treating Indian timbers in connection with the supply of sleepers to the Indian State Railways, the experiments being carried out by the Forest Economist, Mr. Pearson. The object of the enquiry was two-fold, first to ascertain the best and cheapest method of treating certain timbers and second to prove to the railway engineers that certain of the less durable timbers, after treatment, would meet their requirements. The chief difficulty in deciding on what lines the enquiry should be carried out was due to the fact that the cost of the most universally used antiseptic, namely, coal-tar creosote, was excessive in India, while the cheaper salts if used alone were liable to be washed out of the timber. With the object of keeping the cost of treatment within practical limits it was decided to give a trial to the Powell process, to undertake the treatment of timber with small quantities of avenarius carbolineum oil, with chloride of zinc followed by a thin protective covering layer of a good grade of creosote, and lastly with a mixture of high boiling point coal-tar creosote and cheap petroleum oil.

The scheme further contemplated treating 1,000 sleepers of each of five species, *viz.*, *Pinus longifolia*, *Pinus excelsa*, *Terminalia tomentosa*, *Dipterocarpus alatus* and *Dipterocarpus tuberculatus*, with the four antiseptics mentioned, and handing over these treated sleepers to the State Railways to be kept under observation. The work of treating these sleepers by four different methods extended over four years; the first sleepers to be laid down were those treated in 1911 by the Powell process, while the rest were treated with the other three antiseptics and laid down in successive years. All these sleepers were treated in open tanks. More recently sleepers of the five species mentioned, together with several other kinds of timber, were creosoted in pressure cylinders either in India or in England, some by the open cell or Rüping process, others according to

Photo.-Mechl. Dept., Thomason College, Roorkee.

A young teak plantation formed with the aid of shifting cultivation (*taungya*), Burma.

the straight or full cell process, and after treatment were laid in the line. The oldest sleepers have now been more than five years in the line, and under half a dozen of them have had to be rejected for mechanical defects, the rest being in good condition, not one sleeper having so far been rejected for either white ant or fungus attack. It is not possible to say how long these sleepers will last, or which antiseptic will give the best result, nevertheless as pine sleepers untreated last only two years, while those treated are still doing well after five years, there is much to be said in favour of the treatment, especially as the cost of the process has been kept within working limits.

A very large number of timbers lend themselves to treatment, though certain timbers do so more readily than others. As a rule hard dense timbers, containing only small irregular pores, are difficult to treat, though hardness does not necessarily prevent the timber from absorbing the antiseptic provided large straight pores are present, as is the case in *Terminalia tomentosa*. Again, certain soft timbers are refractory to treatment, such as silver fir, spruce and Douglas fir, all of which require more drastic measures to make them absorb the oil. Generally speaking straight grained timbers, those containing large ducts and porous timbers readily absorb an antiseptic; under the first category fall many, though not all, of the dipterocarp timbers, under the second are included many of the pines, while such porous timbers as *Bombax malabaricum*, *Odina Wodier*, *Kydia calycina*, etc., when in a dry state, soak up the antiseptic faster than is convenient for working purposes.

When considering the selection of timbers which after treatment might be suitable for sleepers, mechanical strength has to be considered as well as durability and facility of treatment, for unless the sleeper is sufficiently strong to withstand the wear and tear to which it will be subjected, however well it may be treated it will be rejected for mechanical defects at an early period of its life. Again, the outturn of sleepers from any locality together with the cost of extraction has a direct bearing on the commercial possibility of supplying treated sleepers to the railways. Based on the above considerations it is thought that the species of timber most suitable for treatment as railway sleepers are *Dipterocarpus turbinatus* and *Termina-*

lia Manii from the Andamans, *Abies Pindrow*, *Picea Morinda* and *Pinus longifolia* from the Punjab and United Provinces, *Dipterocarpus alatus*, *Dipterocarpus tuberculatus* and *Terminalia tomentosa* from Burma, *Dipterocarpus pilosus*, *Terminalia myriocarpa* and possibly *Cynometra polyandra* and *Altingia excelsa* from Assam and *Terminalia tomentosa*, *Terminalia paniculata*, *Dillenia indica* and *Vateria indica* from the West Coast forests.

A large variety of timbers are used for constructional purposes, for fencing props, posts and telegraph poles, which in India are not treated at all or at most are given a coating of paint. In Europe and America, on the other hand, practically all timber is first treated before being used in engineering works and as posts, an example which might with advantage be followed in India.

The cost of treatment depends on the nature of the solution employed, the amount of the solution introduced into the timber, and the cost of handling and processing the timber. The cheapest method of treating timber is with a salt solution, such as chloride of zinc; thus, to treat a broad-gauge sleeper with 10 lbs. of a 2 per cent. solution of chloride of zinc per cubic foot costs 1 anna 11 pies for the salt and about 5 annas 1 pie for processing, handling, spreading and stacking, or 7 annas in all. This treatment is, as has been stated elsewhere, insufficient to protect the timber under Indian conditions, as the salt must be protected either by a coating of creosote alone or by a mixture of creosote and petroleum oil. This may amount to 6 lbs. of oil per broad-gauge sleeper, the cost of the mixture amounting to 6 annas, to which must be added processing charges at 3 annas, thus bringing the total cost of treatment with the salt and oil combined to Re. 1 per sleeper. To treat a broad-gauge sleeper with 6 lbs. of a mixture of creosote and petroleum oils per cubic foot comes to approximately Rs. 1-2-0, to which must be added 5 annas for processing, handling, spreading and stacking or a total of Rs. 1-7-0 per sleeper. To powellize a broad-gauge sleeper costs about Rs. 1-5-0. Comparing the cost of treatment by any of the above methods with that in Europe it is expensive, solely owing to the fact that coal-tar creosote is not

produced in India. The solution to the difficulty lies in producing coal-tar creosote locally; were this undertaken, there can be no doubt that not only would an entirely new industry spring up but also the sleeper requirements of the railways would be far more easily satisfied.

In reviewing the position of affairs in regard to the treatment of timber, in connection both with sleeper work and with constructional timber, there can be no doubt that India is far behind most civilized countries. On the other hand the possibilities are great, for suitable timber is available in large quantities, which after treatment can be successfully employed for sleepers and constructional work, while the growing scarcity and ever increasing rates paid for the better classes of constructional timber all point to the utilization of our auxiliary species, which after careful seasoning and treatment might well take the place of timbers now more commonly in use. Another aspect of the position which deserves attention is that relating to the growing demand for timber due to increase of population and higher civilization. Owing largely to the inaccessibility of many of our important forest tracts this can be barely met by our present supplies and has to be augmented by imports, so that every effort should be made to husband resources. There can be no doubt that the treatment of timber to make it more durable is a matter which deserves more serious consideration than it receives at present.

(5) The dry distillation of wood.

The manufacture of charcoal is as old an industry as civilisation, though even now the methods usually employed involve the loss of all the volatile products given out during its preparation. A stage further than simple charocal-making, is found in the wood-tar industry of Sweden and the United States of America, where the wood is burnt in masonry kilns. The tar as it trickles from the burning wood is collected in a channel at the bottom of the kiln and so passes out through a pipe to a collecting vessel. In this process, however, only two out of many valuable products are recovered.

The modern dry distillation plant is almost perfect. It consists of a system of retorts which are heated by coal and wood

gases, connected with a system of separating condensers and receivers for tar, pyroligneous distillates and gases. Complete control over the temperature of distillation is secured. Heating wood in small retorts at a high temperature gives much gas and little charcoal, acetic acid and tar, while slow heating in larger retorts gives an increased yield of acetic acid and charcoal. For the production of acetates and wood alcohol, hard woods are more suitable than resinous woods, which yield principally tar and wood oils. The dry distillation of wood is one of the principal forest industries in Europe and America. The capital invested in the industry in Europe alone exceeds £40,000,000. In France about 98,000 cords of beech and oak are employed for distillation (a cord = 125 cubic feet).

Before the present war Germany showed the greatest production, owing to the development of chemical industries which consume large quantities of acetic acid. America is another large producer.

The yields of products per cord are :—

	Charcoal, in bushels.	Alcohol, in gallons.	Calcium acetate, in lbs.	Tar, in gallons.	Wood oil, in gallons.	Turpentine, in gallons.
Hard woods . .	40—50	8 –12	150—200	8—20	...	.....
Resinous woods . .	25—40	2—4	50—100	30—60	30—60	heavy woods 12—25. light woods 2—10.
Saw dust . . .	25—35	2—4	45—75	...	...	.....

The chief products of dry distillation are :—

(1) Wood gases which are employed as fuel.
(2) Pyroligneous acid containing wood alcohol and acetic acid.
(3) Wood tar.
(4) Charcoal.

The following are the principal uses of the different products :—

Charcoal is used for the production of pig-iron in blast furnaces, in copper and sugar refineries, in the manufacture of gunpowder and for fuel.

Wood alcohol is largely used in the varnish industries as a solvent for resins, for the manufacture of formaldehyde and for the purposes of denaturing ordinary grain alcohol.

Acetate of lime is used for the manufacture of wood acetic acid, acetates, acetic ether, acetone, iodoform and chloroform.

The financial success of this industry rests on the disposal of the main products, acetates, charcoal, alcohol and tar, for which a high development of chemical industries is essential: in ordinary times, the manufacture of acetone from the acetates for the purpose of making cordite or smokeless powder cannot absorb all the output.

In countries where ordinary grain alcohol is produced on a large scale denatured alcohol is cheaper than wood alcohol, so that the demand for the latter, even in the varnish trade and for fuel, is limited. Charcoal, when produced on a large scale from a destructive distillation plant, has to be disposed of wholesale for the manufacture of pig-iron, and for this again there is not much demand at remunerative rates, the pig-iron being now made with coal instead of charcoal. An article on the hard-wood distillation industry by Katzenstein in the Scientific American of 1st January 1916, while paying a tribute to the great service of the industrial chemist in improving the processes and plant necessary for the rectification of acetic acid and wood alcohol, thereby making a substantial reduction in the cost of their production, betrays the somewhat unsound condition of the industry in America before the war, due entirely to the difficulty in finding a ready market for the different products. In this connection the Scientific American states:—

"The hard-wood distillation industry has been brought to popular attention of late, on account of the rapid increase in value of one of its products, acetate of lime, which is being converted, in large amounts, into acetone for the manufacture of smokeless powder. This recent impetus has been a great boon in the industry, for with low prices for

wood alcohol since the passage of the denatured alcohol act, overproduction and low prices for acetate of lime and a constantly decreasing premium for charcoal pig-iron, the outlook for the industry has not been brilliant for the past few years."

It seems somewhat premature to think of wood distillation in India when countries like the United States of America, which is so much better placed in respect to markets, experience difficulties in disposing of the products.

Destructive distillation on a commercial scale necessitates the supply of timber in considerable quantities. The wood must be of little value for other purposes, while, as has already been stated, hard-woods are preferable to soft-woods for the preparation of acetic acid, wood alcohol, etc. In India, these conditions are not ordinarily fulfilled in the more accessible localities, where there is usually a fair demand for wood. In the Kumaun hills, however, there is a large supply of chir timber, *Pinus longifolia*, which owing to twisted fibre is useless for sleepers or constructional timber and which it may be possible to utilize for the production of Stockholm tar.

If the question of starting destructive distillation of wood in India should at any time take practical shape the mangrove forests of Arakan and the Tavoy and Mergui coastal areas of Burma are examples of tracts capable of furnishing very large supplies of wood, more especially if it is found possible to produce a satisfactory tannin extract from mangrove bark.

Of other species of timber which might be found to meet the necessary requirements are the oaks of the Himalayas, certain hard-woods of the evergreen forests of Assam, such as *Cynometra polyandra*, or again various species found in the forests either of Burma or of the West Coast.

9. Financial Results.

The steady growth of forest revenue, expenditure and surplus during the past 50 years is shown in the following

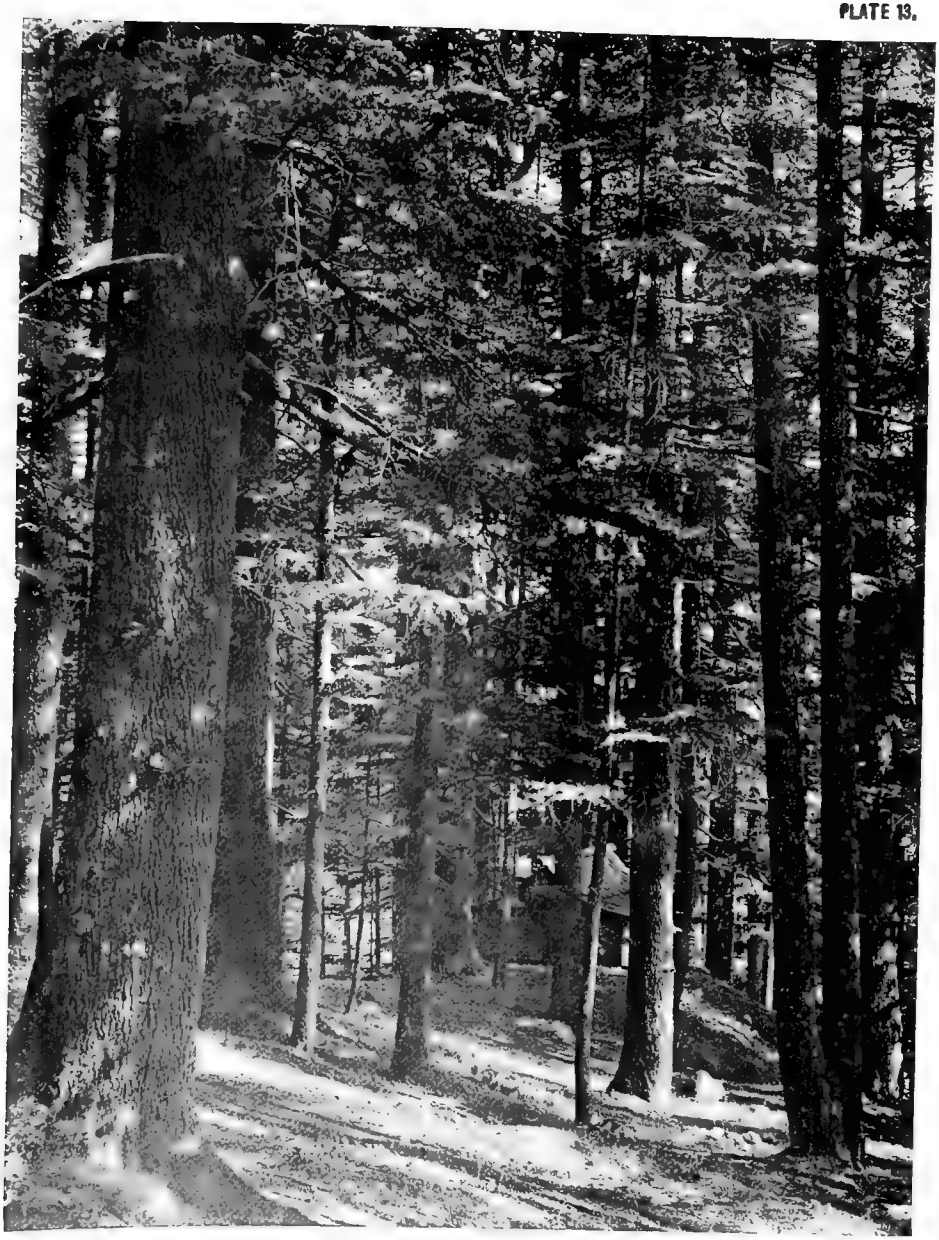

Photo-Mechl. Dept., Thomason College Roorkee.

Deodar forest (*Cedrus Deodara*) in the Himalayas.

statement, which gives annual averages for quinquennial periods* :—

Financial Results of Forest Administration in British India from 1864-65 to 1913-14 (in lakhs of rupees).

Quinquennial period.	Gross revenue (average per annum).	Expenditure (average per annum).	Surplus (average per annum).	Percentage of surplus to gross revenue.
	Lakhs.	Lakhs.	Lakhs.	Lakhs.
1864-65 to 1868-69	37·4	23·8	13·6	36·4
1869-70 to 1873-74	56·3	39·3	17·0	30·2
1874-75 to 1878-79	66·6	45·8	20·8	31·2
1879-80 to 1883-84	88·2	56·1	32·1	36·4
1884-85 to 1888-89	116·7	74·3	42·4	36·3
1889-90 to 1893-94	159·5	86·0	73·5	46·1
1894-95 to 1898-99	177·2	98·0	79·2	44·7
1899-1900 to 1903-04	196·6	112·7	83·9	42·7
1904-05 to 1908-09	257·0	141·0	116·0	45·1
1909-10 to 1913-14	296·0	163·7	132·3	44·7

This statement exhibits the striking fact that the surplus has increased nearly ten-fold during the past 50 years, and that it averaged £882,000 sterling per annum during the last quinquennial period, without including the large sum represented by the value of forest produce given away free or removed by right-holders, which at a rough estimate amounts to over £400,000. The increase in the surplus is all the more satisfactory when it is considered that all capital expenditure has been met from revenue and that a considerable proportion of this expenditure is incurred on silvicultural and other operations which as a rule do not show any return for a long period of time.

Forest revenue and expenditure prior to the 1st April 1911, were in the major provinces shared equally between imperial and provincial, but in the minor provinces were wholly imperial. From the date mentioned, however, revenue and expenditure in the major provinces were wholly provincialized. Under the terms of the latest provincial settlements forest revenue and expenditure are imperial in Coorg, the Andamans and Ajmer: in the North-West Frontier Province and Baluchistan forest revenue and one-half and one-third forest expenditure respectively are provincial.

* From the Quinquennial Review of Forest Administration in British India for the period 1909-1910 to 1913-1914.

10. Future Prospects and Requirements.

The past work of the Forest Department has already borne fruit, not only in a steady rise of revenue but also in the improved condition of the forests resulting from careful protection and tending. Much has been done in the way of opening up the forests to regular exploitation; but there is still room for enormous development in this respect, for there are extensive areas of valuable forest as yet almost untouched, and these represent a vast capital locked up and not only lying idle but even deteriorating. Perhaps the two most pressing needs at present are the introduction of improved silvicultural systems and the extension of roads and other export works to facilitate and cheapen extraction. These two must proceed simultaneously, since they are inter-dependent, for it is obvious that timber and other produce can be extracted far more economically if it is available in large quantities within a limited radius than if it is scattered in small quantities over large tracts of country ; indeed this question must often decide whether extraction is possible or not. Silviculture teaches us how to effect this concentration and is therefore the bed-rock on which future results, financial and otherwise, must rest ; it is of little avail to seek and develop new markets for timbers and other products if these cannot be produced in regular and sufficient quantities and extracted at a reasonable cost.

The matter primarily resolves itself into one of an adequate staff, on the one hand of forest officers endowed with a thorough scientific training, and on the other of engineers competent to deal with the many difficult problems of extraction which are awaiting solution. The necessity for a staff of scientifically trained forest officers has long been recognised, but the numerical strength of this staff can hardly be said to have always kept pace with the ever increasing work entailed in the development and more intensive management of the forests. The question of a staff of forest engineers is, however, only now beginning to receive attention. A further matter which will require consideration in the near future is whether the business of marketing forest produce should continue to be entrusted entirely to the ordinary staff of the Department or whether a special agency should not be organized for this purpose.

Given the necessary staff, the organisation and development of the forests should in future proceed even more satisfactorily than it has done in the past, for the pioneer work is approaching completion and the results of scientific research cannot fail to make themselves felt in an increasing degree. The present yield of the forests as judged by the productive capacity of the soil is a mere fraction of what it might be, and gives little idea of their potential value when fully brought under scientific management. India may therefore rest assured that in her vast forests she has an asset of great potential value which holds out a bright promise for the future.

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