



Eroded country, typical of areas being afforested.

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

PRACTICAL FOREST MANAGEMENT

A HANDBOOK
WITH SPECIAL REFERENCE
TO THE
UNITED PROVINCES OF AGRA AND OUDH

Compiled in the Working Plans Branch by
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Glossary

OF PRINCIPAL ENGLISH, VERNACULAR AND SCIENTIFIC NAMES.

Sal	<i>Shorea robusta.</i>
Sain or asaina	<i>Terminalia tomentosa.</i>
Haldu	<i>Adina cordifolia.</i>
Bakli	<i>Anogeissus latifolia.</i>
Bahera	<i>Terminalia belerica.</i>
Dhauri	<i>Lagerstroemia parviflora.</i>
Simal	<i>Bombax malabaricum.</i>
Banj or ban	<i>Quercus incana.</i>
Moru or tilonj	<i>Quercus dilatata.</i>
Kharshu	<i>Quercus semecarpifolia.</i>
Deodar	<i>Cedrus Libani</i> var. <i>deodara.</i>
Blue pine or kail	<i>Pinus Excelsa.</i>
Chir or chil pine	<i>Pinus longifolia.</i>
Cypress	<i>Cupressus torulosa.</i>
Spruce	<i>Picea Morinda.</i>
Silver fir	<i>Abies Pindrow.</i>

PREFACE.

THIS book has been prepared with the object of placing on record in one place the details of forest management and working plan procedure as at present adopted in the United Provinces. It is written for trained forest officers and does not pretend to be a text-book for the student. Consequently it omits much matter which finds a place in text-books on silviculture and forest management, it presupposes in the reader a knowledge of forestry in all its branches and acquaintance with the ordinary professional terms of the science. It deals almost entirely with the practical management of the *sal*, *chir* and *deodar*, the three principal forest trees of Northern India, under the different silvicultural systems applied to these species, and describes in such detail as is necessary for working plans the technique of their treatment from infancy to maturity. Only the methods of calculating the yield which are actually used in practice have been described and examples from working plans have been given in every case. The book is published under the authority of the Chief Conservator of Forests, United Provinces, and is intended as a handy guide to executive and working plan officers in the ordinary course of their daily work. Much of the material has of necessity been abstracted from various text-books and other sources, a list of which is given, and the writings of officers of the working plans circle, both published and unpublished, have been drawn on and separately acknowledged as far as possible. More especially is acknowledgement due to Broillard's "Cours d'Amenagement" which has been repeatedly consulted and abstracted from in writing this book.

The book does not pretend to be anything more than a useful compilation reviewing as a whole the forestry of the province, constituting a guide to the best methods of up-to-date management and

laying down certain principles of technique to be followed by working plan officers. It is hoped that its publication will increase the interest of all in the professional side of their work and improve the details of forest management in all divisions; it may even be found useful in stimulating the interest of politicians in the forest activities of the province and so induce a more sympathetic attitude towards the aims and objects of forestry. If so, the compilers' labour will not have been in vain.

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INTRODUCTION.

THE FOREST AND CIVILISATION.

"Les forêts précèdent les peuples

Les déserts les suivront"—JACQUOT.

AT the beginning of this book it has been thought fit to give a brief *résumé* of the history of forests in relation to mankind; to indicate the dependence of man on the forest and the results nations have suffered from the destruction of the forest in which their civilisation sprung up.

"Under primeval conditions the greater part of the surface of the earth was covered with forest, they very name savage signifies the people of the wood. Man lived on the fruits of the forest, the forest was his home, his sanctuary, the trees of the forest his god. The arms of Rome were never able to penetrate the black depths of the Hercynian forest, stretching for endless days march beyond the Rhine. As conditions of life became more settled, as the population increased and agriculture began to flourish, the valley lands were cleared for villages and cultivation. As the demand for land grew, so more and more of the forest was destroyed. Presently the valley land was used up, the demand for fields, for building timber and firewood increased. The herds of cattle were turned off the cultivated land to graze where they might; the forests were burnt by the carelessness of man. In time and in some countries they were practically destroyed. With the destruction of the forest on the mountain the prosperity of the valley only too often disappeared. The above sequence of events has been going on in the world from the beginning of civilisation and at the present time is best exhibited in North America where the vast forests which covered that country within

INTRODUCTION.

very recent times are being destroyed with great rapidity and with the inevitable results. Even in the countries most enlightened in forest management such as France the results of forest destruction are still very much in evidence.

"When the mountains are laid bare¹ all is ruined. The rains . . . fall in torrents and rush off the denuded soil. They first carry off the vegetable cover. The mountain shows its rocky skeleton, the rocks break up, cones of erosion are formed, landslides, gullies, unstable slopes become so many running sores by which the substance of the mountain is carried down. The rocks offer more or less resistance according to their texture, but none withstands. Even granite splits up into enormous blocks which roll irresistably down into the valley . . . When the highlands are ruined, what becomes of the plain? . . . The river becomes a torrent when it rains, carrying down earth, trees and rocks. Swollen beyond measure, it flows over the plain in a sudden flood which destroys houses, flocks, villages and people . . . The sudden flood is characteristic of denuded countries. . . The mountain can no longer supply the valley with water. Now is the time of drought and famine. Irrigation is impossible, for the rivers are dry."

In support of the statement that the destruction of mountain forests is prejudicial to irrigation it may be noted that the canal irrigation of Mesopotamia became disorganised by the sinking of the spring level due to deforestation and erosion. Babylonian tablets of great antiquity refer to the attempts to reclaim the country thus thrown out of cultivation.² The Arab conquest of Irak was completed with the capture of the cities Al-Medain in 637 A.D., at which time the plain of Chaldaea was still a fruitful garden³; its present condition is well known. At the time of the Spanish conquest of the plateau of Mexico the country was irrigated and intensively cultivated; the forests of larch, oak and pine were protected by the most stringent

laws. The Spaniards deliberately destroyed the woods as they were the refuge of the Indians. To-day the irrigation system of the plateau is mostly decayed, the lake of Mexico itself has shrunk, the teeming population, the famous gardens, the general prosperity of the country has vanished.⁴

"Following excessive deforestation, the local climate becomes worse. The prosperity of agriculture, the health of the inhabitants, the public fortune itself depends upon a normal proportion of forest. This percentage is itself an element to regulate the world's circulation of cloud, rain, snow, flood and even the ocean. The denuded zones in the mountains must be re-stocked in order to re-establish order in nature, without which all economics are profoundly upset; it is partly due to the absence of forests that one must attribute the burning climate of the interior of Asia, Africa and Australia. The destruction of stands has produced disastrous climatic changes in Greece, in Russia, . . . in Asia Minor, and in certain regions of India. All history agrees on this point. It shows clearly the disastrous effects of great deforestation on climate. Aristotle, Pliny and Strabo predicted to their contemporaries the sterility which would follow deforestation . . . which, in lowering the humidity necessary for vegetation . . . has brought on something more terrible than any war, namely, the decadence of the most powerful empires. At the middle of the seventeenth century, the Chinese had transformed Tartary into a desert by removing the trees which protected it⁵.

Benskin⁶ has given instance after instance in India of the destruction of fertile land on account of denudation. The dessication of the country is in active progress. With forest destruction on the hills the streams dry up or become raging torrents, their beds choked with debris. Springs of drinking water disappear, cholera becomes endemic. The forests of the plains where the Moghul Emperor hunted have gone and in their place we have horrible ravines. The forests

¹ "Deboisement et Decadence." F. REGNAULT. *La Revue*, March 1, 1904. Studies in French Forestry by WOOLSEY.

² *Afforestation in the United Provinces*—BENSKIN.

³ *The Caliphate. Its rise, decline and fall*—MUIR.

⁴ *Conquest of Mexico*—PRESCOTT.

⁵ *La Foret*—JACQUOT. Studies in French Forestry—WOOLSEY.

⁶ *Afforestation in the United Provinces*—BENSKIN.

of the United Provinces only cover 7 per cent. of the whole area : a totally inadequate amount. Much of this small area is given up to grazing, and efforts are constantly being made by interested parties to reduce the already inadequate area of the forests.

The effects of forests on the stability of the hills, on the run off, on the spring level, on local climate and precipitation are nowadays generally known. We have shown that ruin inevitably follows in the train of deforestation, that the forest is the friend of man and indispensable to him. It, therefore, behoves us to make the most of the small area still remaining, to conserve it with the greatest care, to introduce the best and most intensive systems of management, to the end that the greatest possible amount of produce may be available to meet the ever-increasing needs of all.

CHAPTER I.

HISTORY AND EVOLUTION OF FOREST MANAGEMENT IN THE UNITED PROVINCES.

IN this brief review of the history of the forests and the evolution of forest management and working plans since the advent of the Forest department, it has only been possible to mention a few of the salient factors influencing the gradual development of forest administration in these provinces, more especially with regard to the technical management of the forests which has now culminated in the permanent organisation of a special branch for the preparation and revision of working plans and the study of the problems of silvicultural research.

The forests of the United Provinces once extended down from the foot hills and occupied a considerable tract of country in the Gangetic plain, more especially in the districts comprising the old kingdom of Oudh. In the west the clearance of the forest for cultivation was almost complete in very ancient times and the denudation of the Siwaliks was already in progress in the reign of Akbar. In the east, however, the clearance of large tracts of *sal* forest has continued from ancient to recent times and culminated in the policy of land grants immediately after the British occupation. Before this period the *sal* forests of Oudh extended far down into the plains. What now remains is a mere fraction of their original extent and even at the present day the rapid disappearance of the remains of the private forests may be seen in the Kheri and Pilibhit districts.

Early History.

Marriott has prepared a history of the Gorakhpur forests from the earliest times so far as this is possible and the history of Gorakhpur is similar to that of the other divisions of the Eastern Circle.

"The birth of Buddha took place in the 6th Century B.C. at some place either in or close to what is now the north of Gorakhpur district and Kusinagara where he died has been identified by archaeological authorities with Kasia in the east of this district. About the 2nd Century B.C. the then ruling dynasty was overthrown and for a time the country was in a state of confusion. About 400 A.D. the country was visited by a Chinese traveller, Fa-Hien, and again in 635 A.D. another Chinese traveller Hiuen Tsiang passed through it. Both of them wrote descriptions of the country, but exact localities referred to in these writings have not all been identified. The following are extracts from Beal's translation of Hiuen Tsiang's diary (the capital of Kapilavastu according to Beal's notes has been identified with a place about 25 miles north of Fyzabad):—

"From this (i.e., the capital of Kapilavastu) going east 300 li across a wild and deserted jungle we arrive at the kingdom of Lanmo. The kingdom of Lanmo has been waste and desolate for many years. The towns are decayed and the inhabitants few. From this going north-east through a great forest along a dangerous and difficult road where wild oxen and herds of elephants and robbers and hunters cause incessant trouble to travellers we come to the kingdom of Kusinagara.

From Kusinagara going 500 li through the great forest we come to the kingdom of P'o-lo-ni-sse (Benares)".

It is probable that during the flourishing period of Buddhist times large areas of *sal* forest were cleared for cultivation and that this process only ceased with the troubled times following the fall of strong and enlightened government.

Until the 17th Century the country enjoyed no long period of settled rule and no great or permanent extension of cultivation took place. The Ain-i-Akbari, which was completed in 1576, shows only 84,727 acres were under cultivation in the Gorakhpur district, but this by no means implies that the rest of the country was *sal*

forest. Once a *sal* forest has been effectively cleared for cultivation a very long period would have to elapse before such cultivation would revert to *sal* forest, although it would quickly relapse into waste with scattered miscellaneous trees and shrubs.

The control of the Moghal Emperors over Oudh was generally ineffective and it was not till 1791 when Saadat Khan was appointed Viceroy of Oudh that any real attempt was made to control the various local Rajahs who had usurped the reins of government and were continually at war with each other.

The rule of the Nawab-Wazirs of Oudh only added to the depopulation of the country and to the decay of agriculture and further large areas of cultivation relapsed into jungle. Thus throughout several centuries the *sal* forest was preserved because of an unsettled government and troublous times. The advent of the British peace was the signal for a fresh onslaught on the forest and very nearly completed its ruin.

The principal forest bearing tracts of the United Provinces, namely, the forests of the hills, submontane and Tarai, came under British rule after the Nepalese war of 1814—16, and for the next 40 years the energies of the Administration were employed in attempting to open up these jungle tracts with the object of increasing cultivation. The forests were treated to an orgy of destruction in many districts, more especially in Gorakhpur and the eastern districts, but also in the Bhabar forests of Naini Tal, and to a smaller extent in the hills, where serious attempts were made to develop tea gardens and a tea industry. After the mutiny of 1857, the great expansion of the railways developed an enormous demand for timber for sleepers, and all the accessible forests of the province were depleted of their best timber trees for the production of sleepers and other uses. In a very short time the Railways, Public Works, and all timber consumers were threatened with a timber famine, for the surviving forests could not withstand a combination of systematic destruction for the purpose of cultivation, of extensive exploitation, and of entire absence of any

*History
from
1816*

protection. The Government of India gradually awoke to the serious position of affairs, and in November, 1862 a despatch was sent to the Secretary of State, which is illuminating in its description of the very unsatisfactory state of affairs that then existed, and from which the following extracts are taken :—

“It will be convenient in the first place to refer briefly to the past history of forest administration by the Government of India, and to point out the steps by which matters have been brought to their present position.

“In Oudh a superintendent of forests has been appointed since the re-occupation of that province; from the latest information before the Government he is engaged in fixing the boundaries of the tracts of forest that are to be preserved and in preparing for their survey, which is going on at the same time.

“In the North-Western Provinces the difficulty of obtaining timber has been painfully felt for the last fifteen years or more, but the administration of the forests there up to the time of the mutiny was a melancholy failure. A superintendent was appointed in 1854 to the charge of the forests in the Dehra Dun and the west of Rohilkhand, the result of whose bad management was the completion of the ruin of almost all the forests that still contained good sized trees. At present the most important part of the North-Western Provinces forests is under the direct management of Lieutenant-Colonel Ramsay, the Commissioner of Kumaun, who has at last introduced order into the administration. But he works on the wreck of the forests, and it will take many years to restore them to a proper condition.

“It will be understood from this account that until quite the last few years no forest administration has in truth existed. Occasionally questions arose as to the proper system to follow, but they were taken up in that department of the Government of India to which they happened to be referred, and without any methodic or systematic policy. Hence at one time or place, forest management has been directly assumed by the Government, and

at others the idea has prevailed that it is to private enterprise that the Government should look for the successful working of the forests of India. But so long as the supply of timber in the country was generally sufficient for the public works in hand, the question of forest management did not present itself to the Government as one calling for earnest consideration. Latterly, however, while the supply of timber has been steadily diminishing from want of proper conservation, the demand both for State and private purposes has been rapidly increasing; and the enormous requirements of the different railways for sleepers has especially brought the matter into very prominent notice, and has now made the subject of forest conservancy an important administrative question.

“It is in this manner then that the connection between the forests and the Public Works department has arisen. The requirements of this department for Government works in the North-Western Provinces first became so difficult to meet that, as before noticed, a superintendent was appointed to look after the business; he was a Public Works officer. Then the gradually increased demand for sleepers, which has naturally been considered in relation with the railway administration, led further to matters connected with forest management being frequently brought under consideration in the Public Works department, in which the railway business is transacted. The tendency to shift the consideration of forest questions into that Public Department which is most directly interested in the supply of timber, and to which all complaints come regarding the failure of the supply, was inevitable. In like manner the pressure thus exercised had caused the officers of the Government connected with the Public Works administration to be more alive than others to the real importance of the points at issue, and superintendents of forests or timber agents were from time to time appointed to assist in providing for definite or pressing wants. At length the Government of India perceiving the great and increasing importance of dealing with

its forests in a more regular manner, and of concentrating the administrative control, which till then had been exercised in a feeble and desultory manner in all the Civil departments, resolved to bring the consideration of all questions relating to forests before it in one only of its departments, and selected for the purpose that of the Public Works as being the one that actually had most frequently to deal with such matters, and that practically was most deeply interested in successful forest management.

"It will be useful if we here note some of the general principles that should, as it appears to us, be accepted in laying the foundation of a system of forest administration for India. We shall then more clearly lay before you the tendency of the measures that we advocate, and more perfectly enable Her Majesty's Government to correct us if our conclusions are on any point not admitted to be sound.

"And in the first place we may express our belief, that under no conceivable circumstances is it possible that personal interests can be made compatible with public interests in the working of forests, otherwise than under a system of such stringent supervision as would, in fact, reduce those working under it to the position of mere agents of the administration. The length of time required for maturing a growth of timber is so great that no individual can have a personal interest in doing more than realising the largest possible present amount from any forest tract of which he may get possession. In fact, timber is produced of which no man can expect to get more than one crop in his life-time, and the sooner and more completely he realises it the better. The moral or social restraints that are likely to operate to prevent such a course are most especially wanting in India, whether we deal with natives of the country or European settlers. Therefore, we think that the idea of giving a proprietary right in forest to any individual should be abandoned, as the possession of such a right is almost certain to lead to the destruction of the forest;

personal interests, in short, under existing conditions and in this respect are not only incompatible with public interests, but they are absolutely antagonistic.

"We consider also that all Government forest should be strictly set apart and made unalienable; of course, where private rights already exist, or where in the case of the forests of Burma certain rights have been conferred on private parties for a limited time, they must be respected, though it might be good policy to extinguish such rights on equitable terms, whenever it be found possible to do so.

"It appears especially important, at the present time, when the subject of the disposal of waste land has been so prominently brought forward, to mark out and fix the boundaries of the forest which it is determined to conserve, so that it may be definitely determined what is forest, and what is waste land, available for sale. We are sensible that the fact of the existence of a forest in India is, in many cases at least *prima facie* evidence, that the land so occupied is not fit for any other purpose, and it is, therefore, necessary to be very careful about the disposal of waste land containing forest tracts, until it be clearly ascertained that such land is susceptible of being brought under cultivation, that the grant is applied for this purpose, and that it is on the whole better to give the land up to be reclaimed than to preserve it as a forest. We annex a circular that has recently been issued from the Home Department on this subject.

"Of course, it cannot be said that any forest which is now thought to be necessary, or worth preserving, will be held to be so for all time; but the facilities for the destruction of forest are so great, the difficulty of reproducing it so insurmountable, and the general tendency in this country to accept as truth the fallacy that the clearance of forest is of itself necessarily an improvement so common, that it will be important to record forest boundaries, and to set forest land apart in a very strict and formal manner, and it seems even possible that the object might be attained by

an Act of the Legislature. But the exact way of doing this must be a matter for further consideration.

"Having thus secured, as far as possible, that the boundaries of those forests shall be respected, which it is intended to preserve, and having obtained maps and surveys of the whole of them, a solid basis would be got on which to establish an efficient forest administration, the great end of which should be to obtain the largest possible quantity of produce from the forests, consistent with their permanent usefulness. The conditions under which this would be possible would probably be very various in various places, and success could only be looked for as the result of experience, and careful and continued experiment brought to perfection under local management, but under some central control or system of inspection.

"When the forests are once removed out of the category of waste land, and dealt with as a special State domain, there will be a very great step made in advance in obtaining for the forest administration a better defined position. The circumstance that forests have till now been reckoned as waste, and their produce treated as miscellaneous revenue, could not fail to be pernicious, and has very probably conduced no little to the present state of things. A primary object to a collector of land revenue is to remove land from the class that pays no revenue to that which pays, and his tendency will be to sacrifice forest for cultivation. The idea that forest is a thing valuable in itself and, in truth, just as essential to the community as fields of wheat, sugar or cotton, took a long time to spring up, and, in fact, is not even now generally realised in that complete manner that is essential before forest management can be said to stand on a proper basis. The forests, when set aside as such, should be made to assume a distinct plan of their own in the departments producing revenue, and the success or failure of the administration should be made at once apparent from the state of the balance on the forest budget.

"As a first step towards carrying out these important objects we have determined to summon Dr. Brandis from Burma, and to place him temporarily under the orders of the Government of India. Dr. Brandis, as you are well aware, is peculiarly fitted for such a duty. But, in the first instance, he will have to consider the existing state of the forests in different parts of the country, and to submit for our further consideration his views of the best plans to adopt for the purpose in view. It is not probable, therefore, that we shall be in a position to sanction the establishment of any definite mode of forest procedure, or the formation of a regular Forest department for some time to come; in the meantime, we are not committed to any particular course, and before taking further steps we shall doubtless have an opportunity of learning the views of Her Majesty's Government on this important subject.

"We may add that it seems to us that as an officer will be specially required for the general control of forests under the Government of India, so also there should be for the several provinces chief local superintendents, such as Dr. Brandis is now in British Burma. In the minor administrations, where the nature of the forest tracts permits of the work being concentrated, the principal executive officer may readily be general superintendent also. But in a province like Bengal, or in the North-Western Provinces, this could hardly be. The Local Government may probably be best allowed gradually to feel their way to some regular organisation, but of the necessity for system we have no doubt. It is true that occasionally a vigorous control may be exercised over the forests by a local revenue officer as has happened in the case of the Kumaun forests, where the administration of the Commissioner, Lieutenant-Colonel Ramsay, has been in a high degree successful. But such matters are not in their nature an essential part of his duties, and it is indisputable that when the success of the management of such a business is due to the special qualifications and peculiar zeal and activity of an

individual officer, a change that removes him is but too likely to be followed by serious deterioration of system.

“Organisation to be of real and permanent value must not be essentially, or even mainly, dependent on extraordinary personal acquirements or activity; the machinery should be such as will work with average men under the direction of the best of their class. And this is peculiarly the case as regards the administration of forests. Results will be so long in coming, and ruin is so easily and so immediately brought about by the neglect of first principles by a single individual, that as little as possible should be left open to the local executive authorities in this respect.”

The Secretary of State's reply is as follows:—

“The principles laid down by you, in regard to the treatment of the forests, seem to me to be correct, and I cordially concur in most of the recommendations by which in your letter no. 75, now before me, you propose to apply remedy to the existing evils, and to place this branch of administration on a sound and permanent system.

“It is very evident, as you state, that the want of system hitherto existing in all parts of India, but more especially in the Bengal, North-Western and Central Provinces, has been one of the chief causes of the waste and destruction to which the forests have been subjected.

“The present state of the forests, however much to be regretted, is not surprising in a country where forests were abundant, though difficult of access, where timber was in no great demand, and where, on the other hand, land was in great demand for cultivation. Most countries of the world have suffered from similar neglect; and the results have shown themselves, not only in the dearth and consequent high price of timber, but very often in the deterioration of climate, and in the barrenness of land formerly culturable, situated at the base of hills, when these hills have been stripped of the forests that clothed them, which forests condensed the vapours into rain, and gave protection to the country below them.

The subject, however, has of late been more considered, and the conviction has been arrived at, that it required the stability of a settled administration to prevent the present destruction of forests and hand them down in such quantity and conditions as to leave a due supply for future generations. A permanent Government only can be expected to wait long enough to reap the profit obtainable from an article which it takes eighty or a hundred years to bring to maturity. Permanency, as far as it can be obtained, is therefore of the highest importance in any arrangement for the due administration of forests; and Her Majesty's Government, therefore, entirely approve of your proposal to make a separate department at Calcutta for the control of all questions relating to forests in the provinces directly administered by your Excellency in Council. Under the chief officer, whatever designation you may fix on for him, should be superintendents in each province, to whom should be entrusted considerable latitude in the execution of the rules laid down, although he should be bound to adhere strictly to the general principles promulgated by the chief officer at Calcutta. But as regards the provinces under the administration of the three Lieutenant-Governors respectively, upon which you appear to entertain some doubts, it appears to me desirable that the responsibility of practical management should be left in the hands of these officers, under such general rules as you may see fit to lay down, the Inspector or Controller-General of Forests exercising no direct authority, but acting generally as your adviser, and through you of the several Lieutenant-Governors; and Her Majesty's Government are decidedly of opinion that the forest administration of Madras and Bombay should be left, as at present, under the orders of the Governors of these Presidencies.

“It is very satisfactory to me to learn that you have come to the same conclusion as Her Majesty's Government, that individuals cannot be relied upon for due care in the management of the forests, inasmuch as private interests must be opposed, in this instance, to the public interests.

"Your circular, cautioning the Local Governments to be careful that forests are not treated as waste lands under the new arrangement, has received my approval in Despatch no. 23 of the 17th December last. I quite agree with your Excellency that it is very important that, in order at once to remove the forests from the category of waste lands, their boundaries should be established and set apart in some strict and formal manner; but I would suggest to you whether a legislative enactment will be necessary for this object. It occurs to me that inconvenience may arise from such a step, inasmuch as you admit that it may be found desirable to give up land to cultivation which may have been set apart for forests, and *vice versa*; and it seems to me that such questions would be best resolved by your Excellency in Council, acting on the recommendation of the chief officer of the Forest department, and in concert with the revenue officers of the district in which the land is situated.

"With reference to other clauses in your letter, Her Majesty's Government think that the control of the financial operations, as well as the provision of proper means of conveyance to connect the forests with the great lines of traffic through the country, should be wholly vested in the Forest department.

"While alluding to financial considerations, I will observe that, although it is of course to be hoped, and although I firmly believe that a considerable profit will be derived from the forests, when permanently placed under experienced and careful management, still profit is not the only object to be kept in view, and in the state in which many of the forests now are it may not be possible at once to obtain a revenue from them. An outlay even may now be necessary in many instances, and, when necessary, should, I think, be incurred. And it is another advantage of a permanent administration that it will look forward with certainty to the repayment of such an outlay in future years. I may add, too, that the superintendents should be supplied with a sufficient

staff, or it will be impossible for them, and particularly at first, to enforce the rules and give efficient protection to the forests under their charge.

"I await, with interest, Dr. Cleghorn's report on the forests in the Punjab and the North-Western Provinces. I am aware that, in this part of India, the forests of the Government have been especially neglected, and that what remains are chiefly in the hands of private persons; but unless the forest land has been entirely given up to the plough, there may, I hope, be still some portions of the various forests which care and rest may again render serviceable for the production of timber and firewood. The provision of this latter article will, I do not doubt, not escape the attention of your Government, the demand for it, especially in the neighbourhood of hill stations, has much increased, and is likely to continue large in the present difficulty of obtaining coal in India.

"The step taken by you, of summoning Dr. Brandis from Burma, that you may have the benefit of the experience and knowledge of an officer so well qualified to give sound advice as to the arrangements required on this important matter, was most judicious."

These two Despatches inaugurated the birth of the Forest department in the United Provinces (as well as the rest of India), and have been quoted at some length, as they prove so clearly, the serious state that was arising due to the absence of a settled forest policy. Fortunately for India and the United Provinces, a strong forest policy was inaugurated in sufficient time, with the results we see to-day. It is earnestly hoped that those results will be maintained in the future.

A comprehensive account of the early history of the forests and of the work of the Forest department is given in Stebbing's book "The Forests of India," which may be referred to for fuller details.

With the inauguration of a special department to look after the forest estates, it became necessary to organise the personnel. At

first there were no trained officers available, and from 1860 to 1869 the administrative staff was recruited largely from military officers, engineers and others who were fond of a wild and adventurous life in difficult surroundings. And a wild and difficult time these pioneers of forest work certainly had, as the death statistics of the early years of the service abundantly prove. They had first to survey, examine and demarcate the great expanses of forest, to organise their protection against fire and damage, and they had to fight perpetually against the customs and malpractices of generations, incendiarism, uncontrolled grazing, the vested interests of the timber contractors, and all the other influences which had reduced the United Provinces forests to the ruined state in which they were taken over, and from which they have been half a century and more in recovering. The present and future generations owe a great debt of gratitude to this handful of pioneers who in many cases at the sacrifice of their lives rescued the great forest estates of the United Provinces from destruction, and who, with their successors, have assured and built up for the present and future such a splendid heritage.

The detailed history of each Forest division from the earliest times, so far as it has been possible to compile it, has been given in Part I of the various working plans and need not be reproduced here. These histories present a long struggle between the advocates of forestry and their opponents. As time has passed the ideals of scientific forestry have been more and more recognised, but it cannot be said that victory is yet complete or that the country as a whole realises the necessity for an enlightened forest policy.

*The first
working
plans.*

From 1869 began a small but steady stream of forest officers trained first in the French and German Schools of Forestry (and later at Coopers Hill and Oxford), and with their arrival it was possible to make a start in scientific and systematic forest management by the preparation of the first working plans, and between

1875 and 1880 the preliminary work of demarcation and organisation had advanced sufficiently in most divisions and working plans or preliminary felling schemes had been prepared or were under preparation for the forests of Chakrata, Naini Tal, the Western submontane and Bhabar *sal* forests, Kheri and Gorakhpur.

Very considerable difficulties had to be overcome in the preparation of these early working plans, for it must be remembered that the forests were in a semi-ruined condition and far below their proper yielding capacity; the silviculture, rate of growth and other vital factors were only partially studied and the young department had to justify its existence by showing a budget surplus and had also to conserve and build up the timber supplies and bring the forests into a better condition. Working plans were required urgently over large areas, the available staff was limited, intensive working and extensive enumerations were not at that time feasible, and the executive and subordinate staff who had to carry out the markings of the coupes were untrained and often illiterate. Under these circumstances a special system of management was evolved which Recknagel calls the "Indian method," which was simple in execution, was a guarantee against overfelling and for the improvement of the crop, and could be applied rapidly over extensive areas, and although the method has been often held up to criticism, it is difficult to see how any better or more scientific system could have been applied to suit the peculiar circumstances of the time.

This system of regulating the annual yield by volume based on diameter classes, and the time taken for trees to pass from one diameter class to the next, is fully described in Recknagel's "The theory and practice of Working Plans," and in all the old working plans of the province, and need not be described here. This system was adopted universally for all species and for all the forests in the United Provinces which were being managed under sanctioned working plans, and held sway for nearly 30 years, except in some *sal* forests with intensive demand, where the system of

coppice with standards was adopted. Despite its shortcomings, it assured at least a wonderful improvement in the state of the forests, and paved the way for more scientific systems.

In 1896—1900 the *chir* pine forests of the Chakrata and Naini Tal divisions were brought under the shelterwood system, a system eminently suited to this gregarious and light demanding species, and which has proved extremely successful, wherever the regeneration areas have been successfully fire-protected for 20—25 years, e.g., Chakrata. But the holocaust of incendiarism throughout Kumaun in 1921 has done immense damage in many of the regeneration areas of the Naini Tal and Ranikhet divisions and wiped out to a great extent the successful regeneration of the past quarter of a century. All the pine and *deodar* forests of the hills, for which working plans have been prepared, have now been brought under the shelterwood system, and it is safe to state that the only danger to the complete success of the system for these species is fire.

In 1908 the shelterwood or uniform system was first tentatively introduced for the Motipur Working Circle of the *sal* forests of Bahraich division, and considering that this was the pioneer attempt to apply this system to a difficult species such as *sal* whose silviculture at that time was only imperfectly known, the results have been distinctly promising. In 1914 and 1916 the working plans of Haldwani and Ramnagar divisions were revised, and all the extensive and valuable Bhabar forests of these two divisions were brought under the shelterwood system with periodic blocks. In 1914 a system of clear felling and regeneration largely by coppice was introduced for the *sal* forests of Gorakhpur with extremely successful results, and with an enormous and fully justified increase in the revenue. The experience gained in these forests, combined with the increase in knowledge of the silviculture of *sal* which recent research work (discussed below) has made available, justifies a very considerable extension of the adoption of concentrated regeneration in annual or periodic blocks, with a shelterwood, where frost or drought are to be feared or where sufficient

regeneration is not already established, and with clear felling where the above conditions are favourable, and where there is an intensive demand for fuel as well as timber.

This brief review of the gradual evolution of forest management and working plans in the United Provinces would be incomplete without a reference to the evolution of research work. For the first 40 years of the existence of the Forest department in India no attempt was made to organise the conduct of forest research, and thus to co-ordinate 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 organisation, often in the face of powerful opposition. However, a commencement in organised forest research was made in 1906 by the establishment of the Forest Research Institute at Dehra Dun, and from that time onwards research work has been prosecuted energetically. Troup was the pioneer of systematic statistical research in *sal*, *chir* and *deodar*, the three principal United Provinces species; and it is largely due to him that it has been possible to prepare a reliable yield table for *sal*, which has had a profound effect on such important matters as the determination of the rotation, on thinnings, and the calculation of the yield, etc., in recent working plans. Hole's work on the oecology of the *sal* seedling has had important results and greatly affected the technique of *sal* regeneration operations.

By 1918 it was realised that research work, especially silviculture, must be decentralised, and a special research post of

The creation of the Working Plan and Research Circle.

Present management.

Silviculturist on the provincial cadre was sanctioned. This was followed in 1920 by the creation of the Working Plans and Research Circle, and the creation of this special branch has had a marked effect on the preparation and revision of working plans and on greater attention to silviculture, with a corresponding favourable effect on the forest revenues of the province. Previous to the creation of the Working Plans branch, i.e., for the first 40 years or more of scientific forest management, the preparation of working plans had been somewhat haphazard, at least as regards personnel, and it occasionally happened that an officer was put on to prepare a working plan without any particular aptitude for such work. Also in the earlier years, when the sanctioning of working plans was highly centralised, differences of opinion between the local officers and the higher authorities with the Government of India sometimes resulted in unnecessary friction. The creation of the Working Plans branch, working directly under the Chief Conservator of Forests, to a great extent did away with the possibility of such anomalies and difficulties.

The table on the next page summarises by divisions the chief types of forest and the system of management in force.

The area under the shelterwood system is constantly increasing as this system is found more and more applicable to Indian conditions. It is now the opinion of experienced divisional officers that this system can be carried out satisfactorily, once the staff have been trained to the work, that it is easier and far more satisfactory than the old selection system of the past and is conducive to a far greater interest in professional forestry. Wherever the selection system remains in modern working plans the foundations of management have been entirely reorganised and brought up to date; a nebulous yield by area has been replaced by a yield calculated in volume and based on a complete enumeration of the growing stock.

The compilation of yield tables for *sal* has permitted of a more exact determination of the rotation and calculation of the yield.

Summary.

	Shelterwood system.		Selection system.		Simple coppice.		Coppice with standards.		Protection.		Grassland areas.	Remarks.
	Species.	Area.	Species.	Area.	Species.	Area.	Species.	Area.	Species.	Area.		
Western Circle excluding Ohak-rata Lansdowne 896, 679.	Sal Unwork-able.	225,118 34,179 ¹	Hill Sal Misc. Bhabar species.	317,600 63,394	Bamboo	255	Misc. Ehabar species.	45,198	Sal and hill species.	270,016	34,823	
Eastern Circle, excluding Banda, Jhansi and Affore-station 837,516.	Do.	162,589 89,572 ¹	Sal Misc. species. Unproduc-tive.	132,183 14,913 37,748	Sal Unpro-ductive.	36,150 2,090	Sal	43,512	Sal	63,80	209,640 90,199 ²	
Kumaun Circle, 19,11,583.	Chir Oaks Hill Coni. Misc. Chir	450,007 10,230 64,557 3,451 29,028 8,440 ¹	Chir Oaks Sal ..	8,955 16,750 6,800 ..	..	..	..	..	Oaks Kokot and Misc. Oaks and fir	98,132 37,651 8,467	1,206,060 ²	
Chakrata, 105,206	Decdar Oak	37,092 5,977 ¹ 8,046	..	..	..	..	..	..	Misc.	12,256		
Chakrata leased forest 87,925.	Chir Unwork-able.	32,894 8,585 ¹	Decdar	31,824	..	..	..	..	..	..	14,822	
Total whole Pro-vince, 89,38,808.	Sal Chir Decdar Oaks Hill Coni. Misc.	387,707 73,761 517,925 17,045 337,092 5,877 19,276 64,557 8,431 1,125,665	Sal Chir Oaks Decdars Misc. Unpro-ductive.	456,682 8,955 16,750 31,624 78,803 37,748 629,962	Bamboo Sal Unpro-ductive.	255 36,150 2,090	Sal Misc.	43,512 45,198	Sal Oaks Misc.	344,995 105,599 49,907		
											501,502	1,554,474

¹ Not fit for conversion to uniform

² Much of this area to be abandoned.

³ Area of Tulsipur (Gonda) forests.

A brief reference to the gradual development of the afforestation work of the province may also be made.

*History of
afforestation.*

The question of utilising the waste lands in Agra, Etawah and adjoining districts and the establishment of fuel and fodder reserves was the subject of a report in 1879 by Dr. Brandis, then Inspector-General of Forests to the Government of India.

*Report
by Dr.
Brandis,
I. G. F.,
1879.*

In this report attention was drawn to the large tracts of ravine country lying on both sides of the Jumna river and the extent of wastes to be found in several districts of the Doab.

The measures recommended in this report for the encouragement of forest growth on these lands were—

- (1) The exclusion of fire,
- (2) Restriction of grazing,
- (3) The protection from all cutting of wood, and
- (4) Filling up of blank areas by planting and sowing.

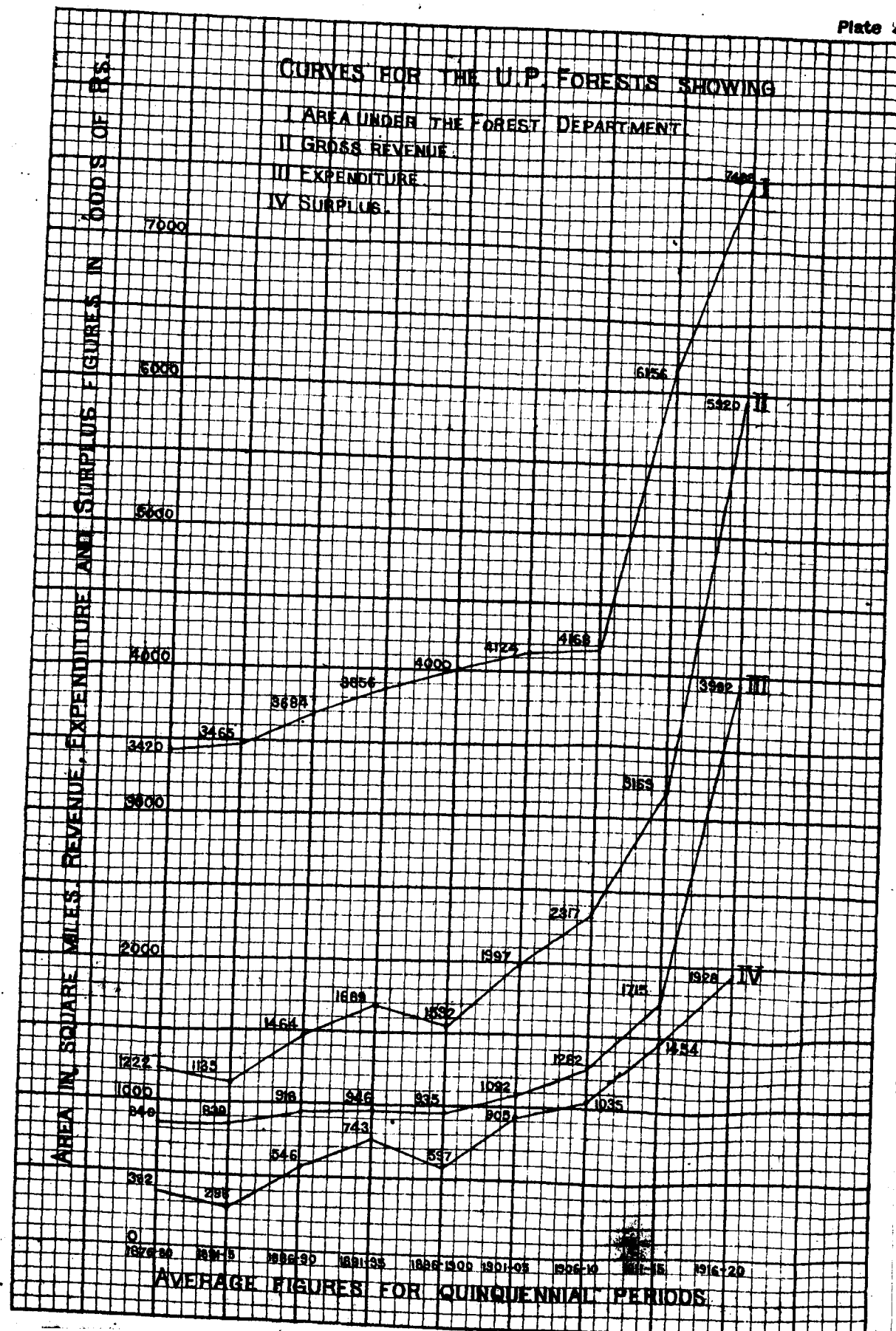
The report recommended the acquisition of suitably situated and sufficiently large blocks of waste land which should not be too far from the markets for the produce. However, the report led to nothing, and no action was taken at that time.

The question was revived in 1884, when Mr. J. F. Fisher, Collector of Etawah, started the "Fisher Forest".

*The Kalpi
Plan-
tation,
1904.*

In 1904 the growing scarcity of babul bark for tanning led to the commencement of the Kalpi Plantation.

Again for a long time no further action was taken in the matter of afforesting the Jumna ravines. But in 1912 Sir John Hewett, the Lieutenant-Governor of the United Provinces, issued a most important resolution, in which he defined the policy of Government in the matter of afforestation of denuded areas, and the establishment of fuel and fodder reserves throughout the province. This resolution was the commencement of a new epoch in the history of afforestation in the United Provinces. An



extract from the resolution will indicate the scope of the work which was contemplated:—

“Among the peasants’ greatest needs are firewood to replace manure, small timber for houses and wood for implements, as well as grazing and fodder for his cattle. It has been recognised with increasing clearness that forestry has an important vocation as the handmaid of agriculture, and that she is called to come down from the hills . . . Sir John Hewett is convinced that a stage has now been reached in the economic development of the province when a systematic examination of the possibilities of afforestation is imperative . . .

“With the agricultural and industrial development of the province a rapidly expanding demand for forest produce, and in particular for fuel, small timber and grass, must be anticipated, and the Lieutenant-Governor believes it essential that action should be undertaken to provide well-distributed areas for the production of these commodities.

“Afforestation is, however, a branch of forestry which differs widely from the management of existing forests, and it is a branch in which the officers of the Forest department have as yet had little experience. The Lieutenant-Governor therefore considers it essential that, before a definite scheme of afforestation is embarked on, a systematic survey of the available areas should be undertaken and that this survey should be combined with a series of experiments on various classes of waste lands with a view to determining the best methods of dealing with different soils, the species best adapted to various conditions and the cheapest and most efficient methods of propagation.”

With this resolution was inaugurated a strong and active policy in afforestation, and the subsequent developments and success achieved are described in the following chapter.

The graphs shows the progress since 1880 of the Forest department in area, revenue, expenditure and surplus. The latter will no doubt be considered by some the final test of success in

Statistics of area, revenue, and expenditure.

management, and provided the estate is maintained in good condition and fellings confined to the calculated annual yield, the extent of the surplus over a series of years is, after all, the amount of the annual profit obtained by Government from the estate. Sums provided by way of capital for the development of the estate or the cheapening of exploitation *ipso facto* have their influence on the revenue and so on the surplus. If development does not take place in due season the surplus will hardly be kept up; if sufficient is not spent on maintenance or if more than the calculated annual yield is cut, financial disaster will finally overtake the management. Government will have consumed the capital of the forest along with the interest and will be left with a derelict property incapable of paying even its own charges for administration, let alone any surplus revenue to the finances of the province.

The lessons of the past have already been set out and are clear for all to read.

It has taken the Forest department over 50 years to build up the estate as it now exists.

From now onwards, with the increase in stocking and improvement in quality, the closer utilisation of the produce and the cheapening of exploitation, matters which are all receiving attention, the surplus should under wise management continue to increase. The foundations have been well and truly laid; the building of the superstructure yet remains to be completed.

The members of the Forest Service can complete this superstructure, but they cannot control the future policies of Councils or Governments of whom they are the servants. If the leaders of the people will only read the history of the past, if instead of following popular clamour they will listen to the voice of wisdom, orderly progress and prosperity will continue. If not, then the condition of affairs so clearly stated by the Government of India in their despatch to the Secretary of State in 1862 will soon recur, without the possibility of a reconstruction, and the country will be left denuded of supplies of timber and firewood for all time.

CHAPTER II.

THE FORESTS OF THE UNITED PROVINCES.

THE forests of the United Provinces are found at all elevations *Topography.* from a few hundred feet above sea level in the forests of the Gangetic plain, to the limit of arboreal vegetation at 13,000 feet on the main ranges of the Himalaya. Consequently the situation of the forests varies from the perfectly level divisions of the plains and the Tarai to the precipitous mountains forming the sources of the Ganges and the Jumna. The forests of the Eastern Circle are all in the plains south of the Nepal boundary, which here runs at a distance varying from nothing to some 30—40 miles from the foot hills. The Western Circle comprises the important Forest divisions which lie along the foot hills, consisting partly of level land sloping towards the plains and partly of the outer forest clad ranges of the Himalaya which here rise abruptly out of the plain to an elevation of some 7,000 feet. This circle stretches from the Sarda river to the Jumna and includes the hill forests of Chakrata. The Kumaun circle includes all the hill country of Naini Tal, Almora and Garhwal intersected with innumerable streams and rivers on all aspects and with every degree of slope from comparatively easy ground to abrupt precipices.

The forests of the United Provinces may be divided into five broad zones:—

- (1) The forests of the Himalayas.
- (2) The forests of the Submontane Siwaliks.
- (3) The forests of the Bhabar.
- (4) The forests of the Tarai and plains.
- (5) The forests of Jhansi and Banda.

In each of these zones the geology and soil are markedly different and must be considered separately.

1. *The Himalayas*.—The United Provinces Himalayan forests are confined to districts of Naini Tal, Almora and Garhwal and an area in Chakrata. In these areas the northern boundary is practically the great crystalline (granite and gneiss) axis of the Himalayas, and although three rivers (the Alaknanda, the Gori and the Kali) have cut through the crystalline axis (and rise in the Haimant and Muth rocks of the ancient Tethys, which are found near Niti, Milam and Lipulek), there are no forests of importance to be found in their upper reaches. Much of the great crystalline axis, which contains the great peaks of the Himalayas, is above the level of forest growth, but wherever the altitudes fall below 12,000 feet the coniferous forests of *deodar* (*C. deodara*), spruce (*P. Morinda*), silver fir (*A. Webbiana*) and blue pine (*P. excelsa*) are to be found frequently mixed with the evergreen oaks.

Between the crystalline rocks and the southern boundary of the Himalaya (the main boundary fault of the Siwaliks) lies a wide stretch of Purana or Pre-Cambrian sedimentary rocks, on which the principal forest occur. These ancient rocks consist of crystalline limestones, quartzites and slates of the Jaunsar or Carbonaceous Series, which, over many hundreds of square miles of country, have been metamorphosed into mica schists, and in which great bands of belts of gneiss and trap and bosses of granite are to be found. The absence of fossils throughout this zone renders it impossible to correlate the different rocks with any degree of certainty, and the geology of these areas has never been studied in detail, except near some of the principal stations, so that many gaps in their geology wait to be filled up. Osmaston in his working plan for the North Garhwal division gives a detailed account of the topography and geology of this tract which comprises the source of the Ganges and its tributaries.

In the great middle belt of Purana rocks are to be found the important forests of *chir* pine (*P. longifolia*), at the lower

elevations and in ascending order the forest of *bunj* oak (*Q. incana*) and blue pine (*P. excelsa*), of *moru* oak (*Q. Dilatata*), of *deodar* (*C. deodara*) and *kharsu* oak (*Q. semicarpifolia*), of spruce (*P. morinda*) and silver fir (*A. Webbiana*).

2. *The Submontane Siwaliks*.—The great boundary fault of the Himalayas runs from end to end of the submontane areas of the province (i.e., between Nepal and Punjab frontiers), and absolutely limits the distribution of the Precambrian Himalayan rocks and the Tertiary Siwaliks; this often inconspicuous fault sometimes running along some small and insignificant ravine forms a stratigraphical break of almost inconceivable duration. This great fault, except for one or two areas, e.g., Lansdowne division, for all practical purposes forms a clear cut northern boundary of the distribution of the *sal*, the occasional patches of scrub *sal* found on the older Himalayan rocks being of no account whatever.

Middlemiss⁷ has classified the Tertiary Siwalik formations into the following zones:—

- (a) Upper Siwalik conglomerate,
- (b) Middle Siwalik sandrock,
- (c) Lower Siwalik sandstone.

Of these (a) and (b) are normally strictly conformable, but are usually sharply separated from (c) by reversed faulting.

The sandrock consists of soft friable sands and occasional clay beds becoming coarser, with small pebbles in the upper layers, and merging gradually into the boulder beds and gravels of the conglomerates. These conglomerates, once loose river shingle beds, have become so indurated with lime that they have become hard, and usually form a very distinctive escarpment (e.g., the Akhiri Danda of Ramnagar and the outer ridge of the Siwaliks at Dehra), and sometimes present a curious scenic effect of great needle-like pinnacles towering up precipitously for 100 feet or more. These two formations were once old Bhabar areas, deposited

⁷ *Memoirs of the Geological Survey.*

at a time when earth movements were gradually increasing the slope and velocity of the upper reaches of the rivers (and thus enabling them to deposit boulder beds where they once deposited sands), these same earth movements finally caught up these river deposits and ridged them up into the ultimate foot hills. The sandrock areas are now clothed with a poor III and IV quality *sal* forest, patchy and open, with a large admixture of *sain*, *bakli* and *khair*, while a high percentage of *chir* is found on the conglomerates. The sandrock of the Saharanpur Siwaliks is characterized by a profuse growth of *chir* pine which under fire protection is spreading rapidly over these denuded areas. The *sal* forest on this tertiary formation varies according to the moisture content of the locality from good quality to scrub, indeed the *sal* is entirely absent from large areas of the hills, its place being taken by zerophytic species, Bhabar grass and bamboo. A detailed description of the geology and vegetation of the Saharanpur Siwaliks will be found in Benskin's working plan for that division.

3. *The Bhabar*.—The "Bhabar" is the term applied to the waterless tract of country at the foot of the hills where the rivers have deposited their loads of boulders, gravels and silt, and formed great cones of detritus. It is characterized by a porous gravelly soil, with boulder deposits sometimes of enormous depth, e.g., the depth of boulder strata at Haldwani deposited by the Gaula river runs to hundreds of feet and the boulder deposits of the small Nihal stream are over 1,000 feet deep. But the administrative boundary between the Bhabar and the Tarai bears very small relation to the true geological boundary, the former is a convenient straight line, the latter a series of sinuosities, bulging out perhaps 10 or 15 miles at the mouth of a river, then curving in almost to touch the foot of the hills where no river has deposited. It varies in width from one to fifteen miles, and although the whole is classified geologically as recent, there are distinct plateaux or river terraces of different ages, each with its characteristic type of forest.

There are two important points to be noted in connection with the Bhabar deposits, which have a controlling influence on the distribution of the Bhabar *sal* forests:—

(1) The large rivers (i.e., the Ganges, Ramganga, Kosi, Sarda and possibly all the big Nepal rivers) have scarcely any Bhabar deposits where they leave the hills, while the small rivers and large streams (e.g., the Nihal, Kalaunia, Gaula and Nandhaur rivers) have enormous Bhabar deposits. At the same time these larger rivers are in every case characterised by extensive boulder deposits appearing in the foot hills in their vicinity (the Upper Siwalik conglomerate) and in the Duns which adjoin their courses before they finally leave the hills, e.g., Dehra Dun, Patli Dun, Kotah Dun and the Khaldunga Dun, while all the smaller rivers have no such duns or conglomerate deposits. The evidence as Middlemiss⁸ has pointed out is conclusive that the real Bhabar deposits of the large rivers have been caught up in the last earth movements of the Himalayan building, and what Troup calls the Dun type is the same as the Bhabar type.

(2) The forest vegetation of the Bhabar is exceedingly variable. In the broad gravelly river beds are found thickets and stretches of *sissoo* (*Dalbergia sissoo*) and *khair* (*Acacia catechu*); on the next level are found forests of *Holoptelia integrifolia*; on the higher level riverain plateaux occur miscellaneous forests, with large number of mixed species of growing economic importance, while on the highest plateaux are found *sal* forests in their best and finest development.

4. *The Tarai*.—Where the Bhabar gravels stop the Tarai begins. A belt of country characterised by numerous springs and swamps, by its malarial and unhealthy climate, and by numerous stretches of heavy elephant grasses interspersed with bands of *sal* and miscellaneous forests, in which *simal* (*Bombax malabaricum*) is an important species. The soil is deep fertile loam, the beginning of the characteristic loam of the Gangetic plain. The Tarai

⁸ Memoirs of the Geological Survey.

produces valuable *sal* forests on the higher and older alluvium, the lower and newer plains being covered with miscellaneous forest or grass.

Apart from a few small patches of forest in the Jhansi division to the south of the Gangetic plain, the United Provinces forests are confined to these four geological formations, the recent deposits of the Tarai and Bhabar and Plains the Tertiary Siwaliks, the Precambrian sedimentary rocks, and the Archean granites and gneisses. A branch of research which is receiving increasing attention is the influence of the geology on the distribution of different forest types, and some interesting examples have already been established. The distribution of forest types on the several river plateaux of the Bhabar have been mentioned above, again, we find that the main boundary fault simultaneously limits the distribution, of the Siwalik rocks and of the *sal* forests, on the Himalayan rocks a well grown area of *sal* is nowhere to be found. The primary factors that influence the distribution of forest types (neglecting for the moment altitude and aspect) are depth of soil, texture and above all moisture content. But these primary factors are undoubtedly intimately connected with the geology, to such an extent that the geology is often an ultimate deciding factor. In the hills the influence of geology is not so clearly traceable since altitude is also important but there are indications that *chir* pine tends to occupy quartzites, the oaks develop best on the slates and limestones, the *deodar* on the granites and so on.

A striking but not unexpected phenomenon is the extraordinary improvement in the soil by fire protection, as shown by the great improvement of the quality class. Thus in the *chir* pine forests in the Almora district which have been successfully fire protected for several decades, we find that while the old crop is poor quality III, the young crop on the same area is quality I. This would follow Schimper's theory, since the monsoon rain is now conserved and the soil keeps moist whereas formerly the rain ran off in torrents. This phenomenon is almost universal in all the older

reserves of Kumaun and will prove a most important factor in the future of the forestry in the United Provinces.

As a consequence of the great difference in elevation, the climate naturally varies from the intense summer heat of the plains to the everlasting snow of the great peaks which form the bastions of the main ranges separating India from Tibet. The plains have a moderate cold weather: frost is almost unknown in Gorakhpur but elsewhere is a factor of much importance in forest management. Indeed in many of the plains divisions frost is the most important factor influencing the management of the *sal*. At low elevations the summer heat is intense during April, May and June and the climate unhealthy. During the rains in July, August and September these forests are intensely malarious, the population leaves the forests and work of any kind is difficult. At medium elevations in the hills, where the bulk of the pine forests are found, the climate is moderate neither very cold in winter nor very hot in summer and work goes on all the year round. At still higher elevations in the zone of the *deodar*, the spruce and silver fir, the winter climate is more severe and snow lies on the northern slopes as late as April. The monsoon is heavy on the outer hills decreasing towards the inner hills until in the remote valleys of the larger rivers an almost arid climate is found. The maximum rainfall is probably that of Naini Tal which averages 90 inches, Ranikhet records 52 inches and the rainfall of Gorakhpur and Kheri averages 50 inches a year. All the important divisions of the United Provinces may be said to have a rainfall between 50 and 100 inches. On the other hand the famine areas of Bundelkhand and Etawah suffer from a chronic failure of the rains every few years.

The main types of forest found in the United Provinces are:—

- (1) Scrub forests of Bundelkhand.
- (2) *Sal*.
- (3) *Chir* pine.
- (4) *Deodar*.

Description of main types of forest growth.

(5) Spruce and silver fir.

(6) Oak.

The
Bundel-
khand
forest.

The forests are scattered over a large extent of country and occur on various geological formations. They differ much in composition and quality and are of the usual Central Provinces dry type. The only species of trees besides the figs, to attain a fairly large size are the *mohwa* (*Bassia latifolia*), *bahera* (*Terminalia belerica*) *salai* (*Boswellia serrata*), *karar* (*Sterculia urans*) of the more valuable species the teak is confined to the forests within a few miles of the Dhassan and Betwa rivers.

Sal.

The *sal* (*Shorea robusta*) is by far the most important forest tree of the province. It grows gregariously in pure woods over considerable tracts of country from the Jumna river to Gorakhpur. The present existing forests are the remains of a once unbroken stretch of jungle extending along the foot of the hills from the Ganges to Bihar.

As Troup has pointed out, and all subsequent research has fully confirmed, the two principal factors that influence the quality of *sal* growth are available *moisture supply and soil aeration*. If either factor is in defect, growth suffers, and the worst type of *sal* crops are found equally on very dry loose soils and on stiff waterlogged clays, and as the conditions of moisture supply and aeration improve so does the growth of *sal*, until we find the optimum conditions of a moist porous fertile loam overlying gravels, with no permanent well water level for considerable depths. If the importance of these two factors is kept in mind, the distribution of the *sal* forests and the variation of qualities becomes in most cases almost self-evident.

Troup has classified the United Provinces *sal* forests into five types (vide *Silviculture of Indian Trees*, vol. I, page 62, adn. seq.), i.e., forest of the (1) Hills, (2) River terraces, (3) Duns, (4) Bhabar, (5) Tarai and Plains.

This classification is not however altogether satisfactory as the Bhabar *sal* forests are entirely forests of the highest river terraces⁹,

⁹ Forest of the Kumaun Bhabar—Forest Bulletin no. 45.—SMYTHIES.

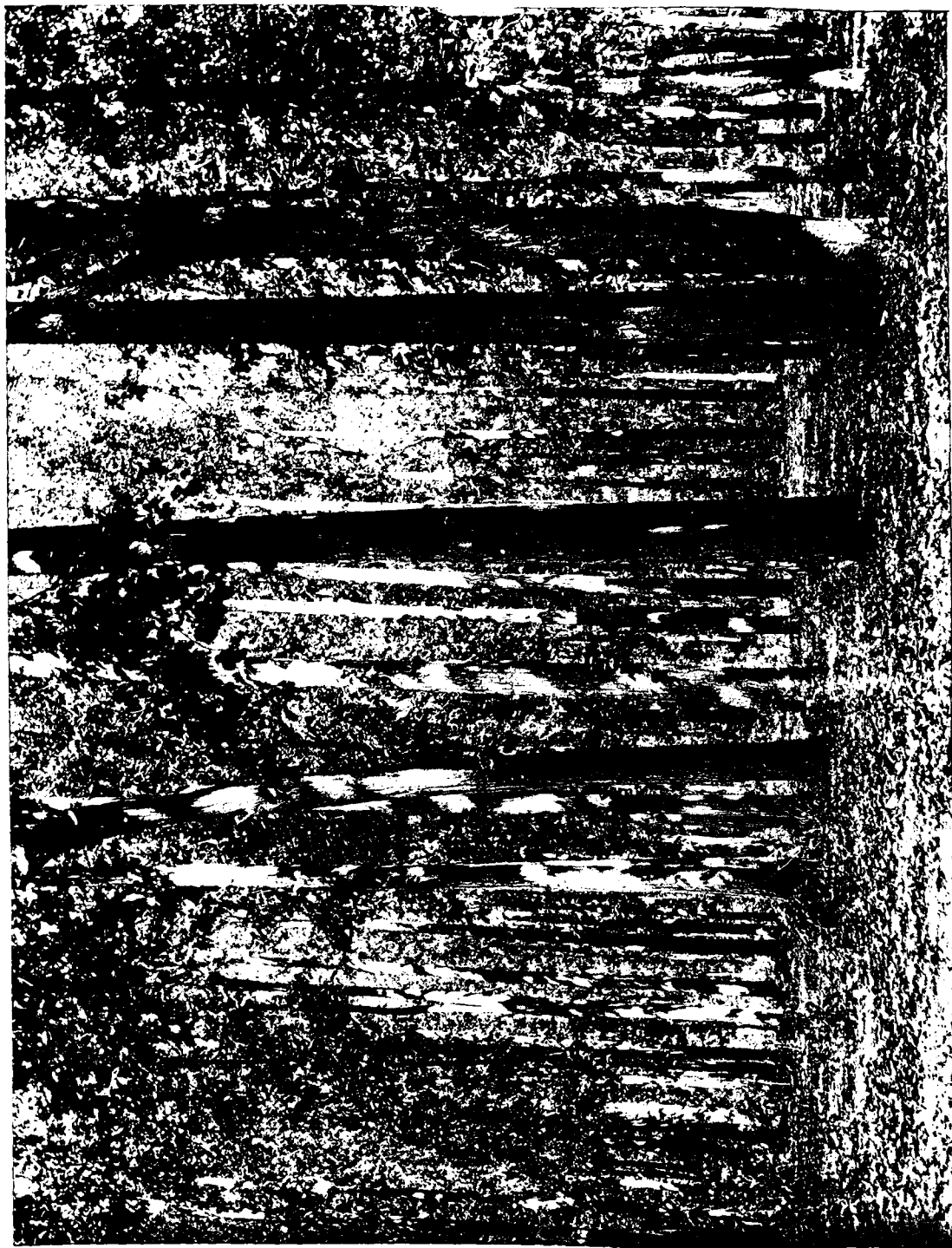


Photo by E. A. Smythies.

Mature Bhabar *sal* forest of good quality.

Photo-Mech. Dept., Thomason College, Rohtas.

and the forests of the Duns are either of the river terrace type or of the hill type. Also some of the most important forests in Oudh, e.g., the "damar" forests of Kheri and Bahraich, are most distinctly old river terraces, although Troup classes these forests (and rightly so) under Tarai and Plains. This classification also does not include one or two special types of *sal* forest, which although not of very great area, are distinctive and important and which Troup never had the opportunity to see, e.g., the landslip type. We may therefore reduce Troup's main types to three, which correspond to well recognised topographical zones, i.e., I.—The Hill *Sal*; II.—The Bhabar *Sal*; III.—The Tarai and Plains *Sal*, and these main divisions will be sub-divided into several sub-types.

The distribution and variation of the Hill *sal* forests bear a close relation to the variations in rock types, already discussed. I.—Hill *sal*.

(1) Forests of the conglomerates and sand rocks.

Howard¹⁰ has given a detailed description of this forest type, and another description is given in the Indian Forester.¹¹ The poor conditions of growth and the broken nature of the ground in this type of forest preclude the possibility of any intensive or scientific system of management; and this type is usually managed as "Protection forest, with Improvement felling."

(2) Forests of the Siwalik sandstone.

The Nahan sandstone formation outcrops over very large areas between the Ganges and the Sarda rivers, and the sub-type of forest which occurs on it comprises the bulk of the hill *sal* forests of the Western Circle.

The sandstone is an old Tarai, ridged up by very much earlier earth movements (probably lower pliocene) than those which upheaved the Bhabar deposits. In altitude this type is met from 1,000' to 5,000', and presents every conceivable variation of

¹⁰ Working Plan of Ramnagar Division, 1916.—HOWARD.

¹¹ Note on Effect of Geology on Forest Types.—INDIAN FORESTER.—SMYTHIES

conditions of soil, moisture, slope, aspect, altitude, and all other factors which influence the conditions of growth of the forest crop. As a corollary, the forest presents an intimate medley of all qualities and types, but speaking generally, the dry and higher ridges and hot steep southern aspects have a poor III and IV quality *sal* crop, mixed with, xerophytic species such as *bakli*, while the more fertile and moister valleys and cooler slopes have good I to fair III quality *sal* crops, with *sain* and *haldu* as the principal auxiliary species. Howard¹² and Troup¹³ have given detailed descriptions of this type of forests, which need not therefore be elaborated further.

This complex admixture of good and bad quality crops affords the most difficult problem in practical forests management that the *sal* forests of the United Provinces present, for while the former could be suitably managed under some system of concentrated regeneration (e.g. shelterwood), the latter is scarcely fit for much more than protection, with improvement fellings, and on the ground it is often difficult to separate the two types. This is a problem that still awaits a satisfactory solution; hitherto this sandstone type of hill *sal* has been managed with improvement fellings, combined with selection feelings of trees over a fixed exploitable girth, annual yields being fixed by area.

(3) One local and exceptional sub-type of hill *sal* forest must be mentioned, which may be called the landslip type. In the neighbourhood of the Sarda gorge there is a remarkable series of enormous landslips, which have come down from time to time some recent, some much older, from the high precipitous hills of Siwalik sandstone, in which the strata is steeply tilted. They afford a perfect example of the succession of forest types described by Troup¹⁴ and in Smythies' note on the Kumaun Bhabar^{15, 16}

¹² *Working Plan of Ramnagar Division, 1916.*—HOWARD.

¹³ *Silviculture of Indian Trees.* Vol. I, p. 62.—TROUP.

¹⁴ *Silviculture of Indian Trees.* Introduction Vol. I.—TROUP.

¹⁵ *Forests of the Kumaun Bhabar.*—SMYTHIES.

¹⁶ *Working Plan of Tarai and Bhabar Estates.*—CHANNER.

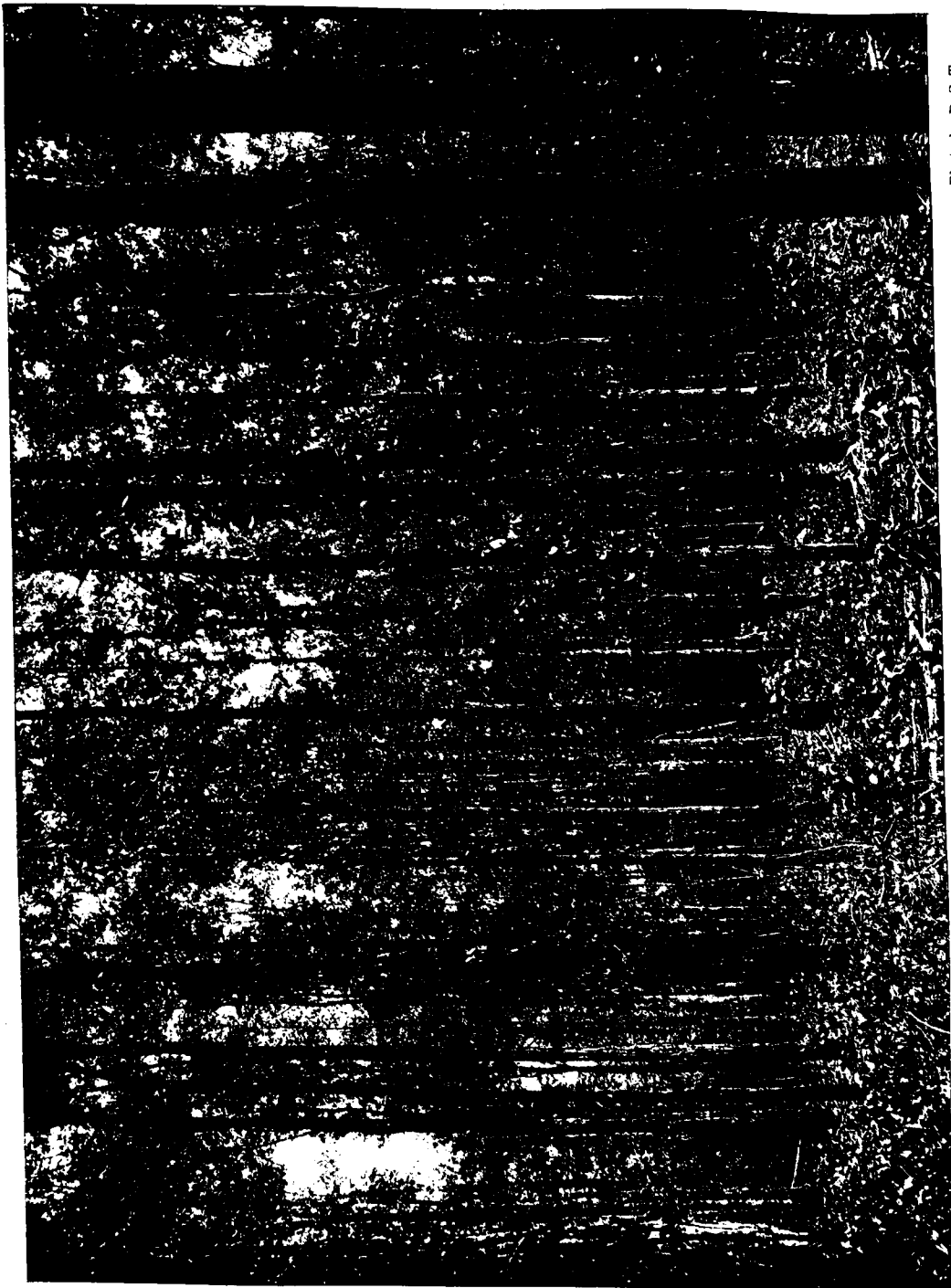


Photo by R. S. Troup.

Finest quality *sal* pole crop, Buxa division, Bengal.

Photo-Mech. Dept., Thomason College, Roorkhee.

THE HILL SAL FOREST.

33

One or two which are still active, are composed of bare detritus, or covered with grasses, *sissoo* and *khair*. Measurements on a slip which came down in the monsoon of 1920 showed a depth of new detritus 20' thick and 400 yards broad at a point more than a mile away from the place of origin, and the *sissoo* and *khair* thickets which originally covered its surface were so buried that only the tops of the trees were showing. The bare surface is again being covered with *sissoo* and *khair* seedlings. Somewhat older slips, where the surface has been stabilised for some time show a forest type which Channer¹⁷ has called the new riverain forest and composed chiefly of *simal*, *haldu*, *kanju*, *jhingan*, etc. On the oldest slips, where a thick covering of rich fertile loam has accumulated, overlying a great depth (up to 80' and 100') of the sandstone detritus, we find *sal* forests of absolutely the finest quality in the zone of the species. When the Nepal Durbar gave the Indian Government a war present of a quarter of a million of B. G. sleepers, it was exclusively from these landslip forests that Collier was able to obtain the supply. Collier has recorded a tree, probably the finest *sal* tree ever felled, with a b. h. girth of 16', and a clear bole of 80' which, when sawn up, gave 96 B. G. sleepers (=340 c. ft.) and 120 c. ft. of M. G. sleepers and scantlings, or a total output of sawn timber of 460 c. ft. In some of the best patches 1,000 B. G. sleepers (=3500 c. ft.) were obtained per acre, without felling any trees below 5' girth.

This sub-type of forest covers approximately 5,000 acres in British territory (and a large area in adjoining Nepal territory), and is mostly managed under a periodic block system of concentrated regeneration.

In the Bhabar tract proper, the *sal* is confined to the highest plateaux, and these plateaux are *not* found where there are Duns and conglomerate formations in the hinterland of the foot hills. There is a very strong presumptive evidence that these plateaux are all that remain of the old Bhabar surface of the land (which

II.—
Bhabar
Sal.

¹⁷ Working Plan of Tarai and Bhabar Estates.—CHANNER.

were not affected by the earth movements) and date from a time before the adjoining streams were rejuvenated by the last earth movement, which enabled them to sweep away large tracts of this old land surface, and in the Bhabar, the *sal* forests are found *only* on these highest and oldest plateaux. This is the type of forest which Troup classified both as river terrace type and Bhabar type. It seems more logical to classify all these areas in the Bhabar and in the Duns in one general type—the Bhabar type, as they are in every way identical. The soil conditions, consisting of rich moist loam overlying a great depth of river gravels and boulder beds, give the ideal conditions for *sal* growth, and these Bhabar forests include nearly all the finest *sal* forests of the province and vary from good I to good quality II.

All these Bhabar type of *sal* forests are managed on concentrated regeneration systems, with fixed or floating Periodic Blocks.

In the Tarai, the *sal* forests are usually confined to flat elevated plateaux slightly above the level of swamps and waterlogged "Chaors"; in the plains, the *sal* occurs where clearances for cultivation and the acts of man have not abolished it.

There are four distinct sub-types:—

- (1) Plains type, as illustrated in Gorakhpur, Tikri, and parts of Bahraich, growing usually on stiff loam to pure clay with light grass and weed growth and generally III to IV quality. This type is usually managed under the Simple Coppice or clear felling system where the demand is intensive and under the shelterwood system where the demand is limited.
- (2) Low level Tarai type,—typified in North Kheri (phanta belt and Low Level no. II. Working Circle), parts of Pilibhit and Haldwani, with very heavy grass growth and usually frost. Usually II to good III quality and managed under some form of concentrated regeneration.

III.—
Tarai
and
Plains
Sal.

- (3) Damar type, an extensive and important type found on high level river terraces or old plateaux which probably mark the original level of the country. This type varies appreciably, from fair I quality on fertile sandy loams to poor III quality on dry sands and stiff clays.

Usually managed under some system of concentrated regeneration by periodic blocks, or some preparatory system with that ultimate object in view.

In several areas these "damars" have been broken up by a network of incipient ravines, which make an undulating surface, and the immediate result is to cause super drainage and extreme xerophytic conditions of growth. Good examples are seen in the forests of Tulsipur, Jaulasal and Jaspur. On such areas the quality of the *sal* forest deteriorates considerably and the type becomes III or IV quality. They present a special problem in systematic management which is being tackled on a large scale in Jaspur (Ramnagar division).

This pine is mixed with *sal* where both species meet and is **even extending its range into the true hill *sal* zone as the result of fire protection.** The *chir* is found at all elevations from 1,500 to 6,500 feet throughout the hills on all aspects either pure or mixed with evergreen oaks. It reaches its maximum development on sandstone or quartzite and is generally of inferior quality on clay soils. These forests are very liable to damage by fire and the new reserves of Kumaun which have recently been handed over to the department consist of an open crop of generally mature trees subject to yearly fire and heavy grazing, with the result that regeneration is generally wanting and the condition of the forests critical. These forests will require careful nursing for a generation before anything like normality is reached. Fire protection is the *sine qua non* of management of these pine forests, for while this tree is fire resistant to a considerable extent, regeneration is impossible with frequent fires, and periodical orgies of incendiarism

Chir
(*pinus*
longifolia)

are even worse than annual fires. Apart from their value as timber, these forests are systematically tapped for resin, the yield in 1918-19 being 93,386 maunds, the nett profit from the industry amounting to Rs. 5,34,398.

The most important species associated with the *chir* are the evergreen oak *Quercus incana* and *Quercus dilatata*, these are utilised for firewood and charcoal where conveniently situated but large areas of this type are at present of no value.

These oaks extend both below and above the *chir* and are mixed with the common trees *Rhododendron arboreum*, *Pieris ovalifolia*, *Symplocos crataegoides* and the climbers *Rosa moschata* and *Clematis montana*.

Deodar
(*Cedrus*
libani. V.
deodara).

The *deodar* is found above the *chir* at elevations of 5,000 to 8,500 feet towards the west. It reaches its furthest point eastward in Garhwal although it is planted in Almora and Naini Tal. It is not known why it should not do well at this latitude but there seems a tendency for the evergreen oaks to extend their area as the latitude decreased at the expense of the coniferous forest of the higher hills. Similarly *kail* (*Pinus excelsa*), the common associate of the *deodar*, is hardly found in Kumaun though it is common in Chakrata. The *deodar* forms pure forests or is mixed with *Cupressus torulosa*, *Pinus excelsa* and *picea morinda*. The timber is very valuable and is the most sought after coniferous wood for railway sleepers and all structural purposes.

The spruce
(*Picea*
morinda)
and silver
fir (*Abies*
pindrow).

At the higher levels from 9,000 to 12,000 feet are found the spruce and silver fir forests, the latter species being the last timber tree met with as the elevation increases. These firs are usually associated with a number of broad leaved trees the most common being *Aesculus indica* and *Acer caesium* and *pictum* higher still the silver fir is mixed with *Betula utilis*, *Rhododendron campanulatum* and *Viburnum* sp. At medium elevations these firs have a maximum height growth of 200 feet and produce a large volume of timber to the acre. As yet they have hardly been exploited for timber. In the same zone are large areas of *Quercus semecarpifolia*,

Plate 5.

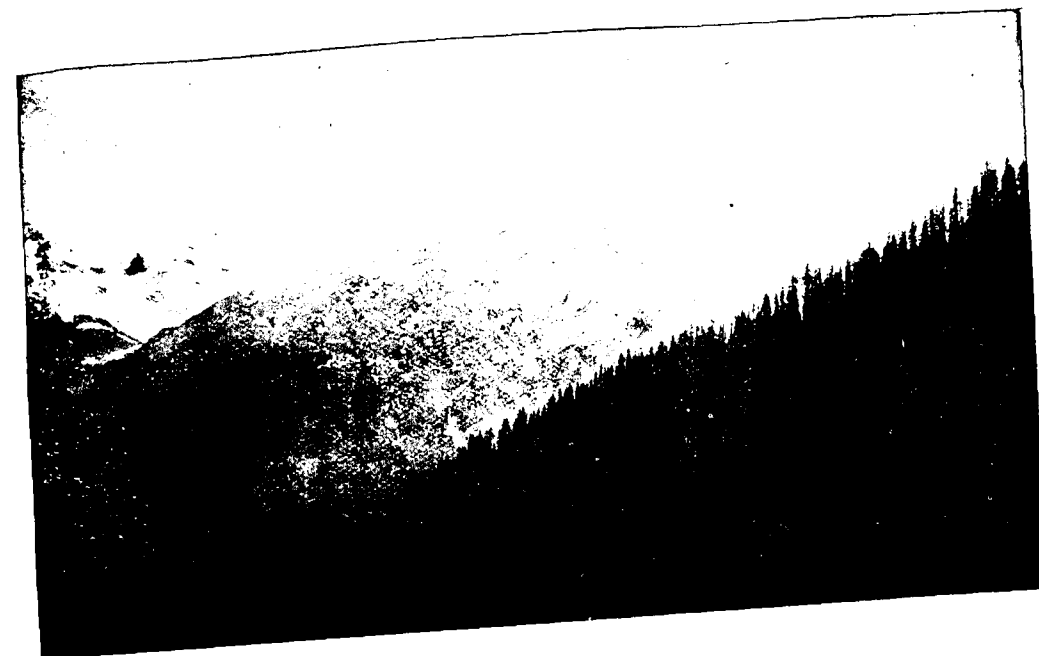


Photo.-Mech. Dept., Thomason College, Roorkee.

Mature Silver fir and blue pine in Kulu division.

Photo by C. G. Trevor.

this oak preferring the southern aspects and the firs the cooler slopes. Still higher the coniferous forest ends, and birch, rhododendron and willow gradually fade away into a country of alpine pasture.

The oaks are chiefly of importance as a source of firewood and charcoal for the supply of hill stations, for agricultural implements and as fodder for cattle. They are distributed into three zones. The oaks.

- (1) The *ban* or *banj* oak (*Quercus incana*).
- (2) The *moru tilonj* oak (*Quercus dilatata*).
- (3) The *Kharsu* oak (*Quercus semecarpifolia*).

The *ban* oak forests of Kumaun have been described as follows by Champion in his working plan for Central Almora. The ban oak.

"Above the *chir* zone, and extending up to the highest peaks is a dense evergreen forest in which the various oaks are the predominant tree species. The distribution of this type seems to depend almost entirely on suitable moisture conditions which are indicated by luxuriant epiphytic vegetation and are met with generally from 7,000 feet upwards. The lower limit coincides with the upper limit of *chir* the dividing line being often very vague, and it may be said that the oak is still the predominant species down to about 6,200 feet though it leaves the drier and poorer ridges to the pine, and extends down the *nalas* in force for nearly another 2,000 feet. *Quercus incana* is the commonest species and reaches its best development between 6,800 feet and 7,500 feet; it runs down the *nalas* to 3,000 feet, whilst at higher elevations it is gradually replaced by other species though occurring even up to 9,500 feet on southern aspects."

This description of the *ban* oak in Kumaun is generally applicable to this species throughout northern India.

This oak grows at higher elevations than *ban* and requires a moister climate and fresher soil. In the United Provinces this species predominates on the outer ranges of the Himalayas in Naini Tal division and also covers a large area in the wet tract of North Garhwal between 6,500 and 8,000 feet. The moru oak.

The
Kharshu
oak.

At still higher elevations this species replaces *moru* and frequently forms pure crops mixed with a few auxiliary broad leaved species and occasionally silver fir on the highest hills of Kumaun. It occurs from 8,000 feet to 11,500 feet and passes directly into the *bugial* or birch-rhododendron formation characteristic of the highest elevations. *Kharshu* occupies extensive areas in Garhwal and to a less extent in Almora. It is a common gregarious tree of the Western Himalayas being found in all the Punjab hill divisions. It is here more associated with the spruce and silver fir than in Kumaun. It has already been remarked that as the latitude decreases towards the east so the oak forest extends at the expense of the conifers. This is probably due to the increased monsoon rainfall, the decreased winter rain and more especially the decreased winter snowfall. The nearer the approach to a European winter climate the better do the conifers seem to flourish.

For a detailed description of the vegetation of the Himalayas the reader is referred to the various working plans each dealing in detail with its own special tract.¹⁸

The representative series of plates in this volume show all the important oecological formations and distinctive forest types of the tract dealt with.

The resin
industry
in
Kumaun.

The gradual development of the resin industry in Kumaun affords one of the most interesting features of forest activity in the United Provinces. Resin is a natural product obtained from certain species of pines by tapping or incising the living tree, which when purified and distilled by heat or steam breaks into rosin (66% by weight) and turpentine (21%). The turpentine passes off as vapour and is condensed to a clear liquid in condensers, the rosin stays behind in the still, and is run into barrels

¹⁸ Working Plan for Central Almora, Ranikhet.—CHAMPION.

Working Plan for North Garhwal.—OSMASTON.

Working Plan for Naini Tal.—SMYTHIES.

Working Plan for Jaunsar.—HOWARD.

Working Plan for Kulu.—TREVOR.

Working Plan for Rawalpindi.—JERRAM.

where it solidifies into a clear yellow or red brown brittle solid.¹⁹ In 1894 some experiments were started by the officers in charge of the Dehra Dun Forest School (Messrs. Gamble and Smythies) in tapping the *chir* pine forests of Chakrata, and a small still for distilling the gum obtained was put up at Kalsi. In 1896 the United Provinces Government sanctioned Rs. 1,000 for starting a similar experiment in the hill forests near Naini Tal and Ranikhet and a small distillery, was started at Bhowali on the Ranikhet cart-road. After a precarious start, the little industry was placed on a profitable basis by 1900 and the zone of tapping operations and the scope of the industry were gradually extended by including in the tapping schemes, additional areas of pine forests in 1903 and 1906. With the gradual reservation of the Kumaun district forests, a rapid expansion resulted yearly from 1911 to 1919. Simultaneously with the increase in output of crude resin, great improvements were made in the distillation of the manufactured products, turpentine and rosin. A long series of experiments, originally instituted by Mr. Clutterbuck in 1908, and carried through for 5 years by the local officers in co-operation with the officers of the Research Institute, Dehra Dun, satisfactorily solved the difficult problem of obtaining first class quality turpentine from *chir* pine resin. By 1917 the French plant installed at Jallo in the Punjab had proved the method of obtaining equally good rosin, and when after 23 years of useful work the Bhowali distillery, which had become too small for the ever increasing output, was given up, and a new and greatly enlarged distillery was erected at Clutterbuckgunj near Bareilly, the improvements evolved at Bhowali, and Jallo were incorporated in the new plant, and a guaranteed standard of high quality of products was assured.

¹⁹ For a detailed description of the method of tapping and collection of crude resin and some details of the methods of distillation and packing of manufactured products, see Smythies' *The Resin Industry in Kumaun, Forest Bulletin No. 26 of 1914*. Since this was published however the methods of distillation have undergone certain modifications, although the basic principles remain the same. See also Chapter XV of this book.

The war illustrated the supreme advantages of an indigenous resin industry, and at a time when rosin and turpentine were practicably unobtainable from America and France, the Bhowali and Jallo distilleries were the salvation of local industries and munition works.

The working results of the Resin Industry in the United Provinces since 1908 show:—

- (1) that the total gross revenue obtained = 64 lakhs.
- (2) That the expenditure (excluding capital expenditure on distillery and plant) has been Rs. 50 lakhs.

Of this total the amount of money spent in Kumaun itself, chiefly among the poorer villagers who form the tapping gangs, and the cartmen who carry the resin, has exceeded 30 lakhs in the last 10 years, i.e., an average of 3 lakhs per annum. Kumaun is a poor district and this sum (which exceeds the total land revenue of the hill patts of Almora and Naini Tal districts), distributed regularly every year among the poorer inhabitants has proved a great boon and undoubtedly the resin industry in Kumaun has chiefly benefitted the local residents. The incendiary fires of 1921 have however done enormous damage to the pine forests and the resin industry, and it is a pitiful commentary on the effects of political agitation that it should result in such wanton damage to an industry which is so helpful and advantageous to the people apart from any profits realised by Government.

The resin industry appears for the present to have passed its zenith. Unlike most industries the larger the scale of operations the greater the total cost per maund of output, because a larger output involves an everwidening range of tapping operations and therefore increased cost of cartage and delivery at distillery site. Partly due to this factor and partly due to ever rising cost of labour, tools and carting, the cost of tapping and carriage per maund of crude resin has increased from Re. 1-9-0 per maund in

1911 to Rs. 3-5-0 per maund in 1916 and to Rs. 5-12-0 per maund in 1919. It was hoped that large scale production would cheapen the cost of distillery charges per unit, but the great increase in the cost of all factory stores, receptacles, etc., have increased the costs of distillation even faster than the costs of tapping and they have risen from Re. 1 per maund in 1911 to Rs. 3 in 1915 and to over Rs. 8 in 1919. During the war years 1916-19 the selling rates for the manufactured goods had increased faster than the rise in expenses, i.e., from Rs. 7 per maund in 1911 to Rs. 11-5-0 in 1915 and Rs. 17-6-0 in 1917, resulting in handsome profits, but such boom prices cannot be anticipated in future, and since 1920 material decreases in the sale values of rosin and turpentine have occurred, which, if they continue to fall, may necessitate the abandonment of the more distant resin tapping areas, with a corresponding fall in output (unless material savings can be effected in distillation charges to counteract the fall in sale values). However there can be little doubt that the resin industry will continue in the future, as in the past, to be a source of steady income to the finances of the province as well as to the ~~inhabitants of Kumaun~~, provided that senseless and wanton orgies of incendiarism do not recur to ruin the valuable pine forests of the hills.

The following extract from an American publication will be of interest to Indian foresters:—

“The possible annual production of naval stores in India seem small, indeed, when compared with the average production in the United States, namely 500,000 tons of rosin and 30,000,000 gallons of turpentine, valued at from \$ 30,000,000 to \$ 50,000,000 annually. It is of great interest to Indian foresters in this connection, as it is to us, that the duration of the American source of supply is doomed to early extinction.” The article quotes from the Capper report the estimates of the remaining period that the present production can be maintained, as follows: Alabama, 5 years,

Georgia 6 years, Florida 8 years, Mississippi 8 years, Texas 10 years, Louisiana 15 years.

"The naval stores belt of India is and always has been under the administration of the Indian Forest Service, and is being developed and exploited, fortunately for the industry, under the French system of working and management, which differs from the American practice mainly in that it allows of a continuous sustained yield over a period of from 30 to 50 years on each stand of timber without serious effect upon the final value of the saw-timber. The American system of working exhausts the naval stores productivity of a stand of timber in from 3 to 5 years and leaves it more or less damaged for saw timber.

Under the wise, far-seeing management of foresters, the naval stores industry of India may with certainty look forward to such development as that now enjoyed by the naval stores of France. The supply will be continuous, uniform and permanent, with a constantly increasing value for the finished output. How different is the situation in America! The naval stores belt is all privately owned and is not subject to technical control from any source. Consequently there is no system of management, little or no advance in refinement of operation, and reforestation, when it occurs at all, is purely accidental. As a consequence, that great American industry, which for the last century has furnished over 80 per cent. of the world's supply of naval stores, will soon find itself put away in that dark closet where hangs the body of the famous goose that laid the golden egg."

The chief interest of this extract is the admission that there will be a definite decrease in American production of rosin and turpentine in from 8 to 10 years, which must effect a rise in prices of these commodities all over the world. It is scarcely too much to say that with the decrease of American supplies, several important industries in India will in 10 or 15 years' time be virtually dependant on adequate supplies produced in India itself, so that,

Plate 6.

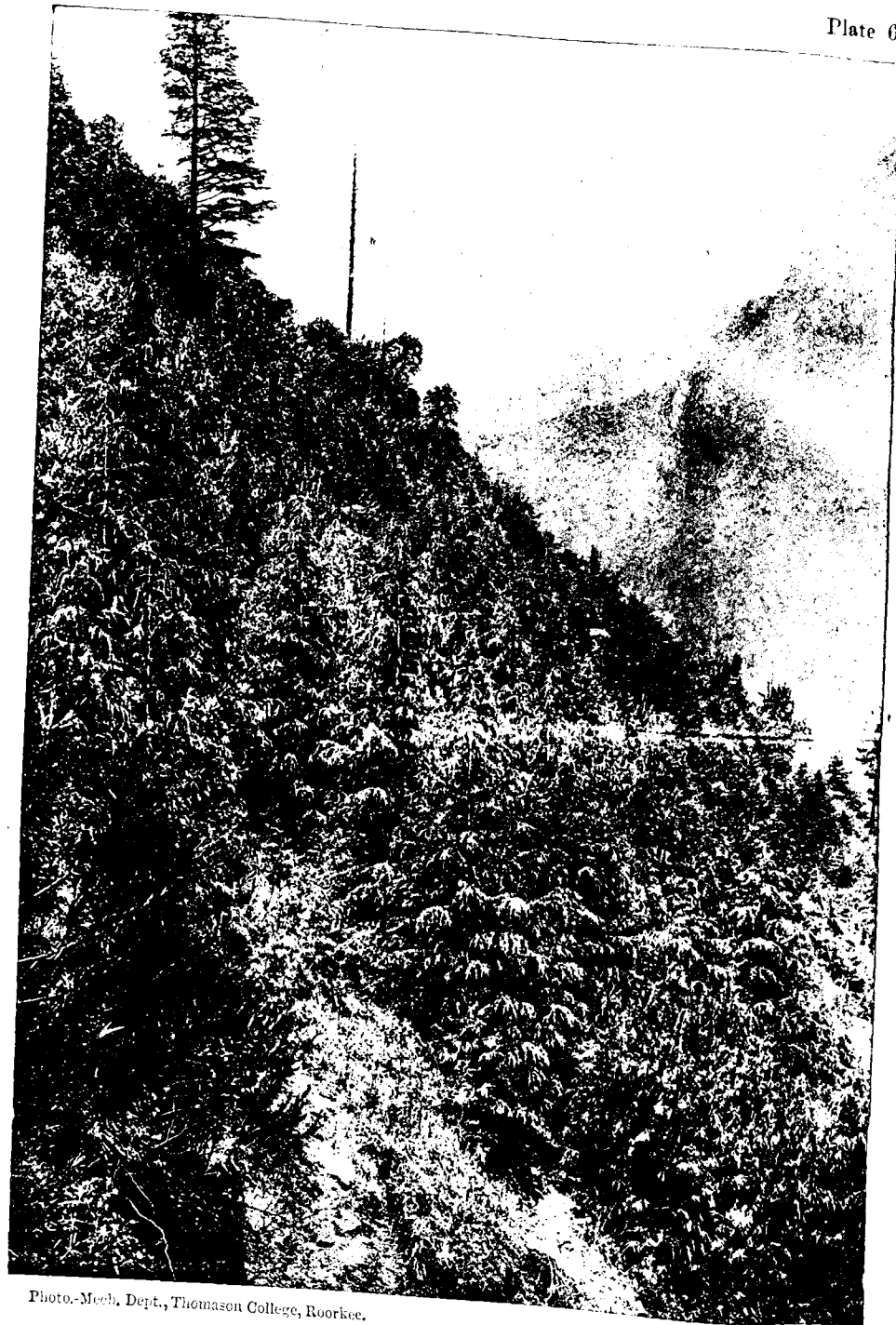


Photo-Mech. Dept., Thomason College, Roorkee.

Afforestation in the hills, deodar plantation.

Photo by R. S. Troup.

despite any temporary set back, it is essential for the Forest Department to continue the exploitation of the *chir* pine forests on conservative lines, both for the sake of future profits and of the local Indian industries depending on these products.

In 1912 the Local Government defined its policy with regard to the afforestation of denuded areas and the establishment of fuel and fodder reserves. In the last quinquennium the reclamation of ravine lands in the Etawah district was reported on and as a result the Etawah division was formed. Afforestation.

In 1914-15 a further inspection of ravine lands in Bundelkhand and in the Agra and Muttra districts was made and a report submitted. In 1914 the lease of the Fisher Forest near Etawah was transferred to Government by the N.-W. Tannery Co. In 1915 the Ordnance Department made over the Kalpi plantations to the Forest Department free of charge.

In 1914-15 about 100 acres of waste land adjoining Cawnpore were taken up and treated experimentally. In 1917 an addition of 125 acres of inferior village land was bought by the late Mr. George Allen and presented to the department for extending the plantations.

In the past 9 years an area of over 9,000 acres of ravine land has been converted into plantations. The policy adopted at present is to stimulate the interest of landowners so that they may be induced to make over land for treatment under present arrangements. The costs of afforestation is borne by Government and is to be recouped from revenue received, the profits thereafter being paid to the owners.

The results to date have been most promising. Bandhing, ditching and surface working of the soil are carried out in advance, and weeding and surface tilling after the sowings. As a result erosion is arrested, good crops of grass are obtained and tree growth is established. *Sissoo* and *babul* (*Acacia arabica*) have done particularly well, and in parts crops have attained an

average height of 19 feet by the third year, and in one area the *sissoo* showed a phenomenal growth of 50 feet height in 7 years.

Plate I shows quite clearly the nature of the country before treatment, and the results obtained by afforestation are illustrated by plates published in the annual report of the Afforestation division, 1922-23, and in Forest Record, Vol. VII, Part VIII of 1920. These pictures are more eloquent than any words and it may be said without fear of contradiction that the afforestation of this inhospitable waste is one of the greatest feats achieved by the United Provinces Forest Department.

In addition to the major afforestation works in the Jumna ravine country, a considerable amount of experimental work has been carried out during the last few years in the afforestation of waste lands included within forest boundaries under widely divergent conditions of growth, and as some of this work has passed the experimental stage, a brief summary may here be given.

(1) *Afforestation of dry Bhabar gravel soil.*

Interesting plantations in the lantana infested areas of Haldwani have been successfully created. The best results have been obtained with *sissoo* root and shoot cuttings put out in March and irrigated for 3 months. A complete crop 12 feet to 20 feet high is obtained in 3 growing seasons. Unirrigated cuttings put out in June have also proved successful.

(2) *Afforestation of abandoned village sites in the Bhabar.*

Successful plantations have been made in the Ramnagar (Rampur Chaor) and Haldwani (Dolpokhra) divisions by sowing and planting *sissoo*, and a system of treatment to ensure success has now been standardised for such tracts.

(3) *Afforestation of grass lands in the Tarai.*

Some interesting large scale experiments, which promise to be very successful, have been carried out in the Lalkua plantation.

(Tarai and Bhabar estates), with a variety of species, chiefly *haldu*, *simal*, *khair*, *sissoo*. This work will shortly be extended in the North Kheri phantas.

(4) *Afforestation of the Pilibhit and South Kheri chandars (frost holes with many damaged sal shoots, which are killed back by frost yearly, usually on sandy soil).*

Experiments have been started to try and grow a shelterwood of *sissoo* which is fairly frost hardy, and likes a sandy soil. If the *sissoo* succeeds, the *sal* is expected to grow up under its shelter without being damaged by frost and hence valuable areas of *sal* forest will be created without any heavy expense.

These plantations by encouraging the growth of valuable species in areas which at present produce no revenue at all, have great potentialities of increasing revenue in the future and the work will be pushed on as funds are available.

CHAPTER III.

THE FOUNDATIONS OF FOREST MANAGEMENT.

General.

EVERY tree, whether isolated or forming part of a canopied crop, is a living entity possessing an individual existence. Its species, condition, age, habit, situation and countless other details combine to make it a tree different from all others.

"The conditions favourable to growth and maximum development vary not only with every species but also with individuals of the same species and these conditions differ for every tree in accordance with the state of the individual and its environment, so that the task of the silviculturist too varies with every tree with which he has to deal.

"Forest management is also necessarily varied according to the forest concerned. All points of difference have therefore to be noted and indicated after the general rules applicable have been laid down. Every forest offers a real and living individuality. It differs from every other forest by its situation, its aspect and configuration; by its soil, by its component crops and also by the character of the surrounding country. There are no two forests any more than two towns exactly alike and it would be a great mistake to suppose that the management of forests adjoining each other or situated in the same region can be built up on the same frame-work or pattern. The forester labouring under so erroneous an impression would lack the very fundamental idea that should guide him, and instead of adapting himself to circumstances would vainly endeavour to force circumstances to suit his silly imaginings.

"The great dangers to be avoided in forest management are preconceived ideas and foregone conclusions. Every rigid system refusing to yield to the varying requirements of different forests

and localities must be equally vicious and more than this it must infallibly result in its staves overlooking some important facts, and indispensable conditions. Indeed it is this very danger of carrying into effect preconceived opinions that justifies us in warning the forester against seeking any perfect solution of the problem before him, the realization of any impossible ideal, and in advising him to confine himself to doing his best to obtain the results required and no more. If, imbued with this spirit, he knows the forest he is dealing with, is careful to conform to the essential rules of forest management, and allows himself to be guided by the true principles of silviculture, by endeavouring to obtain from well-constituted crops and promising trees only such products as the soil can yield, he will scarcely ever fail to draw up a good working plan."

The above masterly exposition of the guiding principles of forest management, written by Charles Broillard in 1860, should be remembered by every Working Plan Officer. It should be the constant endeavour to base the management on true facts ~~apparent sooner or later~~ to every forester, to prescribe only such work as is possible and practicable, and to earn the goodwill and co-operation of the executive staff.

Forests may be divided into two broad classes:—

- (i) Forests managed for profit.
- (ii) Forests managed as protection forests.

The fundamental principles of management in the first named *Forests managed for profit.* class of forests are—

- (1) The attainment and maintenance of the greatest sustained annual yield.

In order to do so two further principles are necessary—

- (2) The attainment of the normal forest.
- (3) The establishment of regeneration to the normal extent.

It is essential to the management of State forests that the forests should supply a steady annual income. It is the duty of the State to produce in perpetuity the largest possible *The sustained yield.*

quantity of the forest produce required for the daily wants of the population, as well as to guarantee an adequate supply of timber for large public works. It is therefore essential that each forest division be worked for a sustained annual yield to meet these demands, and that it should be our aim to produce the greatest possible amount of forest products with the smallest possible forest capital. The attainment of this maximum yield is only possible with complete stocking, careful tending of the growing stock and a proper series of age gradations. The neglect of the principle of the sustained annual yield has had the most disastrous consequences in America. Industries migrated and villages disappeared because there was no more merchantable timber to cut; without a sustained yield the continuity of the forest and the industries depending on it cannot be insured. In Pennsylvania and the Lake States the decay of agriculture, the migration of forest and wood using industries and the decline of previously prosperous villages have followed the destruction of the forests.²⁰ The whole science of forestry is dependent on this principle. Neither silviculture, fire protection nor utilization are by themselves competent to maintain prosperity. Once the principle of the sustained yield has been adopted everything else follows as a matter of course. Good silviculture is necessary to produce the best quality stands and normal reproduction, fire protection is necessary to preserve the growing stock and good utilization to make the most of the prescribed annual yield. In a normal forest the sustained yield will equal the current annual increment of the growing stock, representing the interest on the forest capital.

The
normal
forest.

The normal state of a forest, under a given set of conditions, depends chiefly on the presence in it of—

- (1) A normal increment.
- (2) A normal distribution of the age classes.
- (3) A normal growing stock.

²⁰ Regulation of the cut, Samuel T. Dana, *Journal of Forestry*, March, 1922.

By *normal increment* is understood that which is *possible*, given a certain locality, species and rotation. An abnormal increment may be caused by faulty formation, faulty treatment, injurious external influences, and also by preponderance of certain age classes.

By a *normal distribution of age classes* is understood a series of gradations, so arranged that at all times when cuttings are to be made, woods of the required age are available in such a position that no obstacles to their cutting exist.

The *normal growing stock* is that which is present in a forest in which the age gradations are arranged normally, and show the normal increment. It can, however, also be present (in quantity) in an abnormal forest, if the deficiency of some woods is made good by a surplus in others.

For the strictly annual working and the clear cutting system a forest is, therefore, normal, if it consists of a series of fully stocked woods equal in number to the number of years in the rotation, so that each year a wood of mature age can be cut, and the returns are equal, at any rate in quantity if not in value.²¹

It is a *sine qua non* of forestry that regeneration must follow the fellings and by normal regeneration is understood young growth of sufficient quantity to ensure a normal series of age classes and consequently a future normal yield. In a forest managed under the system of clear felling and planting with a rotation of 100 years $\frac{1}{100}$ th of the area is cut every year and immediately planted up. In the shelterwood system it is essential that the regeneration area be regenerated in the specified period and that the progress of regeneration should keep pace with the progress of the fellings, otherwise the whole structure of the working plan falls to pieces. In selection forests regeneration is supposed to be in progress everywhere and it is exceedingly difficult to say whether normal regeneration is being obtained. It is only by intensive management and frequent revisions of working

Normal
regenera-
tion.

²¹ *Manual of Forestry*, Volume III.—SCHLICH.

plans that a supposed normal forest and normal regeneration is obtained under the system of management.

In continental forestry the principles of the normal forest and normal regeneration are axiomatic and are the ground work of all systems of management, the yield being entirely dependent on them. It is realized that if the normal forest is attained and normal regeneration secured the normal yield must, *ipso facto*, be obtained. In practice normal forests are the exception rather than the rule, even on the continent of Europe, nevertheless the aim of the management is to attain the normal forest within a reasonable time and with as little sacrifice as possible, and the yield is merely the quantity of produce available as a result of the efforts to attain this end²². The whole forest policy of the United Provinces is founded on the principle of the sustained annual yield for forests managed for the commercial production of timber. The best example of progress towards normality is the simple coppice of Gorakhpur.

The
silvicultural
system.

One more point has to be considered and that is the silvicultural system adopted. This system must be suitable to the silvicultural requirements of the species in its special environment and these requirements vary greatly from one locality to another even with the same species. A system applicable under one set of local conditions would be quite unsuitable elsewhere. The universal adoption of the selection system in India in the past without considering the silvicultural requirements of the various species has been attended with failure and the progress of the last few years in all branches of forest management has resulted from the knowledge obtained of the silvicultural requirements of the various species by a few workers who have set out to master this knowledge.

Troup defines a silvicultural system as follows and no better definition could be given :—

“A silvicultural system is a system of forest management applied with due consideration for the silvicultural requirements

²² *European Silvicultural Systems.*—TROUP.

of the species, and aiming at the attainment of the normal forest and the establishment of regeneration to the normal extent.”

Good forest management is neither dominated by silviculture nor by the requirements of exploitation and the tendency of extremists of both schools is to be resisted. Good management consists in a compromise of all factors of silviculture, exploitation, staff and labour, rights and local requirements existing in the area at the time of the compilation of the working plan.

Forest management should be based on the silviculture of the tree with which we are dealing in its special environment and by the requirement of the local conditions and circumstances of every wood.

In previous passages we have dealt with the whole question of the conservation of forests, their direct and indirect benefits to mankind, the penalties involved in their destruction and their relationship to civilization. We shall merely consider in this place the management of such forests as are conserved for the indirect benefits they confer in the prevention of denudation, the protection of stands of commercial timber and the preservation of the water supply. Financial results are of little or no importance in the management of these forests, the reward of success lies in the indirect benefits bestowed on the surrounding country. A large extent of this class of forest exists in India chiefly on the hill ranges. Much more of the land under the Forest Department is really protection forest and should rightly be managed as such, instead of being destroyed by grazing; for example the Tulsipur forests of Gonda division were never meant to be pasture land and the futile attempt to make them so has resulted in 30,000-acres of country being ruined as forest. The protection Working Circle of Ramnagar, part of the Hill Sal Selection working circle of Ramnagar and Haldwani and indeed a considerable proportion of the hills of the outer Himalayan range from the Ganges to the Sarda are in reality protection forests. The Hill Working Circle of Saharanpur division is purely “protection” forest and its

Forests
managed
as
protection
forests.

influence on the topography of the neighbouring plains can be proved from the historic evidences which are set out in the working plan for this division ²³.

The first essential in the management of such forests is to preserve the tree canopy, to increase the density of stocking and to encourage tree growth where none at present exists. In the majority of cases it is in the closing of the forests against grazing that the real means of safety lies.

Forests managed for the purpose of protection perform their functions more effectively the taller and hence the older they are. The yield is, therefore, determined on the physical rotation of the species dealt with and the forests treated under the selection system. The degree of conservatism in the management will depend on the problem to be faced in each case. Under certain circumstances no fellings other than dead and dying trees can be permitted; in others it may be permissible to remove under selection rules practically the yield of the forests as calculated by Von Mantel's formula; always it must be remembered that the preservation of the canopy is of greater importance than financial results.

²³ Working Plan for the Saharanpur Division.—BENSKIN.

CHAPTER IV.

GROWTH AND YIELD.

WHEN a forest area has been successfully regenerated with young plants and saplings, and the forest crop successfully started, the duty and art of the forester lies in nursing up the young crop to maturity under the best possible conditions of growth, so that the objects of management (in India usually the highest volume production of valuable timber, or sometimes of poles or firewood) may be most completely attained.

The objects of statistical research.

The objects of statistical research may be briefly defined as supplying the forester with the data necessary to carry out this duty successfully, and these necessary data may be summarized under the following headings:—

- (a) *The correct density of the crop (i.e. number of trees per acre) at all ages.*—Some species require to be densely grown, (e.g., silver fir and *deodar*). Others require to be very openly grown (e.g., *simal* and *sissoo*), and statistical research affords a clear indication how the important art of thinnings should be carried out, and gives also a figure of intermediate yields that may be expected from these thinnings.
- (b) *Yield and increment.*—Statistical research supplies figures of what may be expected for the final and total (including intermediate) yields at all ages, and hence the annual increment of production.
- (c) *Rotation.*—The figures of yield and increment supply data for ascertaining when the crop is financially ripe, and for fixing the correct rotation; and since the stock per acre, the yields, the rotation, and in fact the whole management of the crop depends largely on its quality,

statistical research has first and foremost to supply a clear definition of quality.

- (d) *The quality classes.*—For species of trees with annual rings, the quality classes are usually defined by the varying heights for definite ages, while for other species, whose ages cannot be readily determined, no really satisfactory basis of definition of quality classes has yet been found, except the maximum height of trees or crops at maturity.²⁴
- (e) *Determination of "reduced equal areas."*—The potential volume production between different qualities of locality vary greatly, and when a sustained equal annual yield is aimed at, it becomes an important matter of practical forest management in a forest of varying qualities to reduce the areas to a common basis of potential production.

Statistical research alone provides the data for this.

- (f) *Volume figures for single trees.*—In addition to the above data, statistical research also supplies complete information regarding the volume and outturn of timber, firewood, branchwood, bark, bole, etc., etc., as well as for determining annual volume yields.

When sufficient statistical data have been collected, the results are summed up in the production of Yield Tables and Volume Tables, which are described below and the methods employed in collecting the necessary data are given in the next section,

This may be divided into two heads—

- (a) For evenaged fully stocked crops, or yield tables.
(b) For single trees, or volume tables.

²⁴ For method of defining quality classes in *sal*, see Smythies' and Howard's—*Types and Distribution of Sal Forests in the United Provinces*.



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

Properly thinned sample plots in III quality *sal* pole crop, Gorakhpur division.

Photo by E. A. Smythies.

(a) *Preparation of Yield Tables.*

The ordinary method employed in India is the usual modification of Baur's method, whereby for each species, large numbers of evenaged and fully stocked sample plots of *all ages and all qualities* are laid out, thinned according to a definite standard, and measured periodically. Each sample plot at each measurement should supply the following data :—

Average age, height, diameter, and volume per tree.

Total (per acre) basal area, and volume of main crop and of thinnings.

In order to obtain this information accurately the following measurements are made *as accurately as possible* :—

- (1) Area of sample plot.
- (2) Mean diameter of each tree in the plot (they are serially numbered).
- (3) Mean diameter of each tree removed in thinnings.
- (4) Height, diameter, form factor, and volume of a number of sample trees, from which the volumes, etc., of the crop and of the thinnings are calculated. *Sample trees are used only for obtaining height, form factor, and volume curves, never for direct calculation of corresponding figures for the plot.* Howard's note on the "Collection and calculation of statistical data" published in 1921 gives such a detailed and complete description, both of the field work and of the calculations, that no further description is required here. But to give some idea of the amount of research work required before a satisfactory yield table can be compiled from the data collected, it may be said that at least 25 plots (most of which have had at least one remeasurement) should be available *for each quality class*, and no satisfactory and comprehensive yield table can be prepared unless each

quality (and especially the best and worst) is adequately represented. When sufficient data are available, the actual method and details of compiling the yield table are described in the note by Smythies and Howard on "Distribution and qualities of *sal* forests in the United Provinces" and need not be repeated here. It is unnecessary to emphasize to trained Forest Officers that every species, every system of management (i.e. High Forest, Coppice or Coppice-with-standards) and every large variation in thinnings requires a separate yield table.

Up to the present, the only Yield Tables published in the United Provinces are for *sal*, in 3 quality classes (by Smythies and Howard), and for *chir*, in 4 quality classes (by Troup). The *chir* yield table will shortly be revised, since in one or two points (notably in basal area and number of trees per acre) it appears slightly defective. Data are also being collected for *deodar*, and *sissoo*.

(b) *Collection of data for single trees, or volume tables.*

The preparation of a volume table for any species is a much simpler matter than the preparation of a yield table and where data for the latter are available, the hundreds of sample trees that must have been carefully measured up will usually afford ample data for the compilation of a volume table. If any additional statistics are necessary (e.g., volume of utilizable bole, or commercial outturn of sawn timber under practical working conditions), such additional data must be collected separately, and with adequate staff, one year's measurements in the felling coupes would supply all the necessary information.

In addition to showing the outturn of timber, fireweed, etc., per tree, a satisfactory volume table should also show if possible the C A. I. as in the calculation of the annual yield of a forest, such information is often invaluable (examples are given below).

Volume tables have from time to time been prepared by various compilers for the following species of economic importance in the United Provinces:—

*Sal*²⁵, *chir*²⁶, *oak*²⁷, *deodar*²⁸, *spruce*²⁹ and *silver fir*³⁰: Data are also being collected for the following additional species *sain*, *sissoo*, *bakli*, *haldu*, *kanju*, *khair*, *simal*, *jaman*.

It will simplify the discussion to divide the uses of the tables in practical forest management—

- (a) in the preparation of working plans, i.e., by the working plans branch.
- (b) in the preparation of outturn of coupes and marked trees for sale, i.e., by the executive staff.

Under (a) the tables will be useful for the following:—

- (1) In calculating the rotation.
- (2) In calculating the yield and increment.
- (3) In the calculation of reduced areas according to quality class.
- (4) In the calculation of the value of the estate.

The following discussion of the subject is taken from Smythies' and Howard's *Distribution and Types of Sal Forest in the United Provinces* as an illustration, as, although it refers primarily to *sal* forests, yet the principles involved are universal to all species and all forests, and reliable yield tables for other species are not as yet available.

(1) *The calculation of the rotation.*

A reliable yield table is extremely useful in helping to determine the rotation. A yield table for *sal* has recently been

²⁵ *Volume Tables for Sal.*—HOWARD.

²⁶ *Silviculture of Indian Trees.*—TROUP.

²⁷ *Kulu Working Plan.*—TREVOR.

²⁸ *Rawalpindi Working Plan.*—JERRAM.

²⁹ *Ranikhet Cantonment Working Plan.*—CANNING.

³⁰ *Kulu Working Plan.*—TREVOR.

The uses of volume and yield tables in forest management.

published and yield tables for *chir* and *deodar* will probably be available shortly, and as these are the three principal species in the United Provinces, the determination of the rotation will in future be greatly simplified. Hitherto in the United Provinces the determination of the rotation in *sal* working plans has at the best been based on an unreliable and uncertain calculation of measurements of diameter increment of single trees in an uneven-aged forest, and at the worst a purely arbitrary figure has been adopted. In the United Provinces working plans the rotation of greatest volume production (for the particular class of produce required) is generally aimed at. In areas of very intensive demand (e.g., Gorakhpur) the produce required will be total wood (timber plus fuel), and the culmination of M. A. I. curve (i.e. where it intersects the C. A. I. curve) for all qualities probably falls between 50 and 60 years. In other divisions where fuel is valueless, the rotation for maximum timber production will be adopted, especially in divisions where much of the timber is exported in the round (e.g., Bahraich). For this class of produce the M. A. I. for all qualities culminates about 75 to 95 years (plus 10 for establishment). Again, in many divisions (e.g., Haldwani, Ramnagar, Kalagarh), sawn timber only is dealt with, but in determining the rotation for sawn timber, an important point must be emphasized. The figures for sawn timber outturn are based on the assumption (vide definition) that there is no heart-rot or hollowiness, and the M. A. I. curves culminate for the different quality classes at 100 years or more. But at such rotations there will certainly be a considerable proportion of hollowiness and rot, and in addition it is probable that the crops will have commenced to open out and become more or less irregular and evenaged; hence for sawn timber outturn it will be dangerous to extend the rotation beyond 80 or 90 years (plus 10 for establishment). In the determination of rotations in working plans, this yield table has certain obvious limitation. It has been prepared for evenaged high forest, and therefore supplies no data for (a) coppice with

standards, (b) selection forest, (c) simple coppice, but in this last case it will for all practical purposes probably be found sufficiently accurate from 30 to 50 years of age, if we ignore entirely the establishment period. It may at least be utilized for simple coppice, until a coppice yield table has been prepared. In considering rotations of *sal* forests, reference should be made to the remarks on this head in the published *sal* yield table.

The same principles will apply in using the data available in *chir* and *deodar* yield tables (when these are published) in determining the rotation.

In the present state of our forests however a careful distinction must be made between "rotation" and "conversion period." This distinction can best be illustrated by the example of the pine forests of Kumaun. Here we find enormous areas of forest which are very openly stocked (often from 6 to 12 trees per acre only) and very overmature. In some cases 75 per cent. of the whole forest is in this state, and it is obvious that the existing crop of the forest will not survive for the period of a rotation. The quicker we can convert these poorly stocked and deteriorating areas into well stocked and vigorously growing crops, the better it will be. But if we converted them so rapidly that at the end of the conversion period there were only young pole and sapling crops, there would be a long hiatus before we could again have commercial fellings for large timber. It is evident, therefore, that the conversion period should be as short as possible, subject to the qualification that at the end of the conversion period the oldest crops will give trees of utilizable size. If for example the yield table indicates a rotation of 120 years as the most suitable corresponding perhaps to crops of 22 inches diameter, then it may be not only justifiable but definitely advisable to adopt, for conversion to uniform crops, a period of, say, 90 or 100 years, giving at the end of the conversion period crops of 18 inches or 19 inches diameter. Although the output per tree will be smaller than from the existing trees, yet the fact that we may hope for 50 or 60 trees per acre in place of

the existing 6 or 12 trees per acre, will result in an enormously increased outturn per acre, and the sooner this desirable result can be obtained, the better it will be.

(2) *Calculation of the yield and increment.*

In working plans or fellings where the yield is fixed simply by area, yield and volume tables naturally are not required. In most of the more important *sal* forests of the province; in which some form of Periodic Block system has been or will be introduced, the yield is usually fixed partly by volume (for P. B. I.) and partly by area (for remaining P. Blocks)³¹. An example of the calculation is given in Chapter V under methods of calculating the yield.

(3) *The calculation of reduced areas according to differences in quality class.*

The enormous difference in yield capacity between different quality classes renders it essential when allotting areas of different quality to the various periodic blocks, or when fixing the annual yield by area, to make due allowance for the difference in yield capacity if a sustained annual yield is required. A ready indication of the yield capacities of different qualities for different classes of produce is given by the M. A. I. curves. Thus in *sal* forests for a rotation of 80 years, the yield capacities for timber production between the different qualities will be (vide M. A. I. for timber)—

	Quality.		
	I	II	III
M. A. I. . .	88	56	32
	1.57	1	.57
	or		
	2.75	1.75	1

³¹ The theoretical application of the yield table to determine the yield of the whole working circle, on the formula. $Y = I \times A \times D$ (where I = M.A.I. per acre of full stock. A = total area, and D = density of stock) cannot be adopted as it involves the unknown factor D , which in our irregular and open *sal* forests cannot be ascertained except by complete enumeration of the whole growing stock.

Hence (taking quality II as unity) the *reduced* area of a working circle is obtained by taking total area of—

	I quality	$\times 1.57$
plus	II „	$\times 1.0$
„	III „	$\times .57$

These factors are given as illustrations, they cannot be adopted universally, since for example every rotation will have a different set of factors or again where firewood and *ballis* below 8 inches diameter come into consideration, it may be necessary to adopt the M. A. I. figures for total wood production and not those for timber production.

An example of the actual calculation is given in Chapter VI.

(4) *The calculation of the capital value of the estate.*

Such a calculation is required for the purpose of Chapter VII of part I of working plans. The annual value of any working circle may be taken as the value of M. A. I. $\times d$ where d = the average density of stocking, provided this calculation makes adequate allowance for hollow trees, and is checked with the financial expectations as calculated in the plan. If both these calculations have been accurately made and are more or less in agreement an additional check on the estimates will be available. Then the capital value of the estate is the annual value capitalized at the appropriate rate of interest. The uncertainty of data will however often make this method of calculation impossible.

(b) *Use of the volume tables in calculating outturn of coupes.*

The custom in the forests of the United Provinces is to mark trees to be felled in the annual coupes in one cold weather, and the trees are felled in the following cold weather. Whether the trees are sold standing to purchasers or worked departmentally, it is important to arrive at the anticipated outturn of saleable material as accurately as possible. In obtaining the estimate of outturn,

the use of volume tables is evident. As sufficient data are collected existing volume tables will be revised and new ones prepared for all the principal species in the United Provinces to show—

(a) total volume of wood (timber plus fuel) down to 2 inches diameter,

(b) total volume of timber in the round down to 8 inches diameter,

(c) volume of converted or sawn timber.

But in estimating sawn timber outturn, an additional factor (which may be called the reducing factor) comes into consideration. As defined, sawn timber figures are based on *best* conditions of conversion and absence of rot, etc., i.e., they represent the optimum figures of practical exploitation that may be expected in the United Provinces forests. For many felling coupes a reducing factor must be applied to allow for—

(1) a certain amount of rot and hollowness,

(2) less intensive conversion.

This reducing factor can only be obtained by experience for each locality, forest or coupe separately, but when once obtained, a standard set of volume figures will prove very useful for obtaining accurate results.

CHAPTER V.

THE ORGANISATION OF THE FOREST UNDER WORKING PLANS.

THE maintenance of the external boundaries of the estate and of the boundaries of such interior private lands as have been excluded from the area of the legally notified reserved or protected forest is one of the first duties of the executive officer in charge. In order to insure that this important work be attended to, it should be prescribed in working plans that a certain proportion of the length of boundary or portion of the estate should be examined annually by a responsible officer, and any defects which may be brought to light rectified. During the course of the revision of the working plan the officer in charge will have frequent opportunity of examining the demarcation and it is part of his duty to see that this is generally in order. Boundaries are demarcated in several different standard ways, the outer line with ditch and stone monoliths is the general standard in the plains, while in the hills natural features, such as ridges or *nalas*, are frequently adopted. The boundary should be clear on the ground, the position of the pillars on the ground and their numbers should correspond with the map, and usually each pillar should be visible from the next one. *Boundaries.*

A forest block is either a natural division of a forest estate or is part of a large tract of forest separated off, either for purposes of the record of forest rights, when it is frequently designated a settlement block, or for other administrative reasons. Forest block bear a local proper name and may be of any size. Some forest divisions, more especially in the hills, are divided into separate entities known as blocks or forests, other divisions chiefly in Oudh are merely divided into compartments. *Blocks.*

Compartment-
ments.

A compartment is a portion of a forest that is as far as possible homogeneous throughout its extent as regards soil, aspect and composition of the growing stock. The compartment is the permanent working plan unit, it must be distinct on the ground and on the map. This latter point is of greater importance than exact homogeneity of the crop it contains, but as far as possible each compartment should be capable of treatment under one and the same silvicultural system and of inclusion in the same working circle. Where this is not so, as in the *chir* and oak forests of Kumaun, the compartment is a geographical unit and the areas occupied by the two species are allotted to the Chir and Oak Working Circles respectively and really form separate sub-compartments. A compartment should be bounded by fixed lines, paths, streams, *nalas*, ridges.

The division of a forest into compartments is the very foundation stone on which is built up the structure of the detailed management. This division into suitable compartments is the first duty of the working plan officer. The size of compartments will vary with the intensity of the management, all the latest plans have considerably reduced the size of the compartment and it is probable that finality has not even now been reached. A reasonable mean in the size of compartments must be maintained: compartments should be neither too small nor too big. If too small, their numbers become excessive; if too big, they are impossible to describe. The old compartments of South Kheri extended over several thousand acres, their descriptions were therefore utterly useless. Compartments averaging 200 to 300 acres may under the present intensity of our management be considered satisfactory. This is about double the maximum in France.

Compartments may be numbered separately for each block as is usual in the hills in Ranikhet and Dehra Dun, or they may be numbered serially throughout the division as is the case in several Oudh divisions such as North Kheri and Pilibhit. It is important

that the subordinate staff should become acquainted with the numbers of the different compartments. These should therefore be numbered on the ground either by small engraved stones, numbered boards, or by painted stencilled numbers on trees. The latter system has been tried with *sal* and found to answer. Compartments are numbered in Arabic numerals 1, 6, 24 and should be shown in black ink on the map.

A sub-compartment is a division of a compartment either permanent or temporary. Sub-compartments are made when it is desired to split up an old-established compartment with a well-known number, or where the composition of the crop, *chir* and oak at different elevations, renders it necessary to allot different portions of the compartment to different working circles, as in Ranikhet. Again, where part of a compartment is *sal* and the rest bamboo as in Lansdowne, sub-compartments would be formed. The boundaries of sub-compartments are not necessarily permanently fixed; they are generally shown by a colour wash on the map and designated with a small letter. Therefore where forest blocks exist a particular sub-compartment would be designated—Bindraban, 31a.

Sub-com-
part-
ments.

A coupe is the area set aside for felling in a single year. It is used more especially in the case of simple coppice and coppice with standards. It is not a fixed geographical entity nor is it a permanent working plan unit like a compartment. Coupes are given a Roman numeral where it is necessary to give them numbers.

Coupes.

The description of compartments is one of the most important duties of the working plan officer, as on this description is based the allotment to working circles and periodic blocks. The description should be concise and should convey in as few words as possible an adequate idea of the composition, quality, age, density, and general characteristics of the growing stock. In the hills a good idea of the contents of a compartment may be obtained from the opposite side of the valley, and this, supplemented with an examination of the interior of the compartment, will enable an

Descrip-
tion of
compart-
ments.

adequate description to be written. In the plains it is not sufficient to walk round the boundary of the compartment; an entirely wrong impression of the contents is often obtained in this way; it is absolutely necessary, in order to obtain a just appreciation of its contents, to traverse the compartment in at least two directions. As the division into compartments varies with the intensity of management, so will the description of compartments vary. In some cases blocks only have been described, and while this is sometimes sufficient to give the executive officer an idea of what the block contains, such diffuse descriptions are useless for working plan purposes. In all areas under intensive management a complete description of compartments or at the least a detailed description of the regeneration area is necessary. Elsewhere, as for instance, in protection working circles, much greater latitude may be allowed, the compartments may be bigger and the description of a general nature. The description of compartments is entered in the compartment history which is the basis of the practical management of the compartment.

The description of compartments is carried out under the standard headings of the text-books as given in the compartment history form, viz.

Soil, situation, aspect.

Allotment to working circles.

Allotment to periods.

Description of the growing stock.

Quality class.

Stock counted.

Prescriptions of the plan.

The soil.

This includes the geology so far as it affects the character of the soil and the vegetation. The nature of the underlying rock has a very powerful influence on the composition of the soil and the vegetation it bears. Trevor ³² records an instance in Kulu where the sudden change in the rock from shales to quartzite

³² Working Plan for Kulu Division.—TREVOR.

resulted in an abrupt change in the forest from *deodar* to *chir*. Smythies ³³ has shown that conditions of soil entirely limit the distribution of the *sal* in the Kumaun Bhabar and profoundly affect the different types of vegetation found in this tract. The existence of the chandars of South Kheri and Pilibhit is attributed to a deposit of sand in place of the usual loam of the Gangetic alluvium.

The most important facts with regard to the soil may be expressed in a few words descriptive of its surface, its composition, its physical state; its depth, and its fertility. The fertility or productive value of the soil, as regards the species which has to be considered, may generally be summed up by such terms as "good" or "very good," "bad" or very "bad," as the case may be. With regard to its surface, the soil may be quite bare and hard, or covered with a layer of leaves, or with vegetable mould apt for the reception of seed, or may be carpeted with moss or grass or overgrows with bushes. The physical character of the soil, its looseness, and the size of the particles forming it are, however, of greater importance as regards forest vegetation than the chemical composition. The soil may be formed of stiff clay, loose sand or agglomerations of stones and boulders; while its hygroscopicity may vary from marshy to dry. But of all the properties of the soil depth is perhaps the most important and is • that which is most likely to vary. Depth of soil is at once manifested by the appearance of the trees. If shallow, the boles are generally short and the crowns low, while the contrary is the case in soils of considerable depth.

The situation includes the relative position and elevation as well as the aspect and slope. As regards elevation, the absolute height above sea-level should be noted generally for the forest; but the height relative to the surrounding country, together with the absence or presence of sheltering land, is of more importance as

*The situation,
aspect.*

³³ Note on the miscellaneous forests of the Kumaun Bhabar Forest Bulletin no. 45.—SMYTHIES.

regards particular blocks or compartments and should be noted. Thus the upper portion of a slope near the top of the ridge may require very different cultural treatment from the lower portion towards the bottom of the underlying valley, although the difference of level above the sea may be slight. The aspect should always be stated where it is well defined; but in hilly ground a single block often faces several points of the compass. The slope may be stated in a single word. A slope is said to be gentle when the inclination is not greater than about 1 in 6; it is steep when more than 1 in 6 but not greater than 2 in 3; it is very steep when more than 2 in 3, and becomes precipitous when it reaches 1 in 1.

*Allotment
to
working
circles.*

The working plan officer enters his provisional allotment to a working circle which may be confirmed or altered as the field work proceeds.

*Allotment
to periods.*

In an exact similar way the working plan officer enters a provisional allotment to periods, based on the description of the growing stock, in the case of a working circle with periodic blocks; and at the conclusion of the field work a definite allotment is finally made.

*Description
of
the grow-
ing stock*

The description of the standing crop should present to the mind of the forester a complete picture of the state of the compartment. In order to do this there are several points to be carefully attended to, viz.—

Component species.

Technical nature of the crop.

Density.

Age.

Origin.

The component species can be described in a few words—

“*Sal* mixed with some few *sain*.”

“*Deodar* mixed with blue pine in the upper part of the compartment and with *chir* along the lower boundary.”

“Pure *chir* pine.”

Auxiliary species if of sufficient importance may be mentioned and an indication given to their abundance :—

“Glades of horse chestnut trees along the *nalas*.”

“A few large *haldu* scattered through the crop.”

It is unnecessary to enumerate in compartment after compartment the numerous auxiliary species of minor importance; but an indication should be given of the vegetation covering the soil, as this is of importance in natural regeneration.

“The soil is covered with a moderate growth of grass with bushes of *Flemingia*.”

“Dense undergrowth of *Strobilanthes*.”

The technical nature of the crop expresses in a characteristic manner what it is; whether a thicket, sapling or pole crop; whether regular or irregular high forest.

The density is expressed by stating whether the leaf canopy is complete or not, close or open and to what extent these different features occur. The age is given when known or ascertainable. The origin of the existing crop should be mentioned whether resulting from coppice, natural or artificial regeneration, so far as any knowledge is available on these points. A note should be made of any serious damage resulting from fire, lopping, grazing, etc., which has left its mark on the crop.

• The following from Broillard's “*Cours d'aménagement*” is deserving of the careful consideration of all working plan officers :—

“As a rule there is peculiar to each crop some special characteristic, some important fact that is more or less obvious which must be observed and noted. Now, it is one thing then another. Experience, and the acquired sense of the forester's art, which has sometimes been termed his second sight, can alone enable him to recognise it. If it has been passed unnoticed, if it is not clearly brought out, if it is not faithfully interpreted in describing the compartment, that description may be lengthy, drawn up with care, specious, but for all that inadequate and deceptive.”

The average quality class of the compartment is recorded and this information used later on for the calculation of reduced areas.

The stock counted is entered if the compartment has been enumerated.

The compartment history.

The last column—prescription of the plan—will indicate the operations which should be carried out at an early date. These notes will be made with regard solely and absolutely to the treatment of the compartment in question. They form a useful guide later on to the executive officer and assist the working plan officer in arranging the fellings and other operations of the plan when he sits down to draw these up.

This will be recorded under the heads just mentioned, maintained for each individual compartment or block depending on the intensity of working. It is intended for use in the field and consequently a copy should be in the hands of the Range Officer in addition to the divisional copy. It will contain for each compartment or block the description of the forest, volume of the growing stock, detailed prescriptions of the plan. Subsequently as work proceeds, notes will be entered showing how and what marking was done, with what idea the markings were carried out, progress of regeneration, artificial help given to the regeneration and the cost thereof, weedings, cleanings, thinnings, etc. In this way a new Range Officer, Divisional Forest Officer or Inspecting Officer going into a compartment can see at a glance the past history of the crop, the work done, the silvicultural ideas of his predecessors, and the result of their marking. Continuity of management is thus obtained and a live interest in each compartment maintained. The compartment history should invariably be put up when the Conservator is on tour and a report on this made at office inspections. The compilations of the compartment history can only be done along with the preparation of working plans, as no Divisional Forest Officer has the time to do it. A sample is given in chapter XIII.

For the proper carrying out of the work of the division a proper set of maps showing the division into compartments, allotment to working circles, periodic blocks, etc., is necessary. The working plan officer will prepare a complete set of maps on the scale 4" = 1 mile or 2" = 1 mile or even 1" = 1 mile, as the case may be, showing the above details. In some cases stock maps, showing the distribution of the species, are necessary where different species are allotted to different working circles as in the case of *chir* and oak in Ranikhet, where the stock map becomes more or less a map showing the distribution of the different working circles. In the case of the Tulsipur forests of Gonda most excellent stock maps showing the distribution of *sal* and miscellaneous species have been prepared. D'Arcy gives a method of showing graphically the nature and composition of the forest as follows:—

Seedling crop	.	.	.	.	0	0	0	0	0
Thicket of saplings	.	.	.	.	o	o	o	o	o
Pole crop	.	.	.	.	+	+	+	+	+
Young high forest	.	.	.	.	x	x	x	x	x
Mature high forest	.	.	.	.	—	—	—	—	—
Overmature or decaying high forest	=	=	=	=	=	=	=	=	=

Jerram in his working plan for the Rawalpindi division has prepared elaborate stock maps on the above lines. It is open to doubt however whether such detailed stock maps are worth the labour expended on their preparation. It is considered that a working plan map showing the general distribution of the working circles; the areas under regeneration, the extensive grass blanks found in the plains, the compartments, blocks or any other permanent features of the plan shows as much detailed as is necessary for all practical purposes.

Coupes will not usually be shown on the general working plan maps on the scale 1" = 1 mile; they will be shown on a large scale map specially prepared for this purpose when this is necessary. In certain cases however under the management of

simple coppice or coppice with standards coupes may be shown on the working plan map.

The working plan map should be printed in black showing the forest boundaries, compartments, roads, firelines, and all *permanent* features of the estate. The outer boundary and the compartment boundaries may be coloured green if this is required but no other colours should be printed. The necessary number of copies can then be coloured by hand and blanks will always be available for revision when this becomes necessary. It is not now intended to issue maps with every revision of working plans as the cost and delay is too great.

CHAPTER VI.

THE ORGANISATION OF THE WORKING PLAN.

THE preliminary working plan report is prepared after consultation with the local executive staff, either by the Head of the working plans branch or under his orders. This report deals in considerable detail with the past system of management and its results, and that proposed for the future. Where any great changes are indicated in the management this report will deal with the division into working circles, the silvicultural system to be adopted, and the method of calculating the yield. It will set out in such detail as is necessary the framework of the revised plan, leaving the details to be filled in by the working plan officer. The preliminary report is forwarded to the Chief Conservator for his approval of the system of management outlined.

The preliminary working plan report.

We may therefore in this place consider the different treatments to which a crop of trees may be subjected and their advantages and disadvantages; when they should be adopted and when avoided. The three main methods—

Method of treatment.

Regular or Uniform High forest,

Irregular High forest,

Coppice,

and their component silvicultural systems will be discussed. The details of each silvicultural system as employed in actual practice are dealt with in subsequent chapters. In determining the method of treatment to be adopted it is necessary to consider the cultural requirements of the species, the demands of the locality, or distant markets, for forest products, and the financial result likely to be obtained. The cultural requirements of the species are paramount; conifers can only be managed as high forest and some broad leaved species will not coppice. In the case

of broad-leaved species which coppice freely, where the demand is chiefly for firewood or small building timber, some coppice systems will generally give the best results; on the other hand, where the demand is for saw logs, high forest is the only possible treatment. As regards regular and irregular high forest the advantages and disadvantages of each are discussed in every text-book. From our point of view the great advantages of regular high forest are—

- (1) The simplicity of the silvicultural operations, of regeneration fellings, thinnings, cleanings, etc. Each operation is done with one particular object in view which the staff can understand.
- (2) The concentration of regeneration, which admits of a knowledge of the exact amount of regeneration being obtained and the adequate tending of this regeneration.
- (3) The closure to grazing of areas under regeneration, if necessary.

These advantages under existing circumstances far outweigh any disadvantages.

These three methods of treatment naturally divide into the standard silvicultural systems as follows:—

- | | | |
|-----------------------|------|---|
| Regular high forest | | I—Clear felling system with natural or artificial regeneration. |
| | | II—Shelterwood system with mostly natural regeneration under a shelterwood. |
| Irregular high forest | | III—Selection system. |
| coppice. | | IV—Simple coppice system. |
| | | V—Coppice with standards system. |

Clear felling with natural regeneration by seed is hardly found in Northern India, it is the system adopted with the Maritime pine in the Landes in France. The only case known is the natural regeneration of mulberry in Changa Manga, which follows the

complete clearance of the crop with the exception of a few reserved *sissoo* standards. The seed is carried by irrigation water and starlings (*Pastor roseus*). Clear felling with artificial regeneration is partially used with *sal* in Gorakhpur. It is the system adopted with *sal* in Bengal and parts of Bihar, with teak and other species in Malabar and Burma and in the *Casuarina* plantations. A definite area amounting to the area of the working circle divided by the number of years in the rotation is clear felled annually and immediately regenerated artificially with or without field crops.

This system differs from the former in that natural regeneration is aimed at and that the regeneration of the crop extends over a period of years instead of being accomplished in one year as in the first system. This system again has modifications; instead of a regular seeding felling, regeneration may be obtained in groups or strips, but none of these modifications have yet been adopted as standard methods; they are all considerably more complicated than the ordinary method. Group fellings have been advocated and tried in the case of *deodar* and the results were very inferior to the ordinary shelterwood felling; strips are advocated by Hole for *sal* and this system is being experimented with on a large scale. It is quite evident however that a strip system could only be adopted on the best sites of the province and so far there is nothing to show that better results will be obtained than under a suitable shelterwood. These modifications are all more difficult to carry out than the standard system; regeneration by groups even with a species suitable to this method of treatment such as silver fir requires very great skill and a long and intimate acquaintance with the compartment under regeneration; the fellings are limited at any one time and do not lend themselves to extensive logging operations such as are proposed for the Punjab coniferous forests. The present need in Northern India is for improved methods of exploitation which involve concentration of the fellings, and so long as the silvicultural requirements of the species are maintained

II.—The shelterwood system.

Silvicultural systems.

I.—The clear felling system.

the greater the concentration and the fewer the number of fellings the better. These modifications while suited to a small forest estate under perfect management, such as the forest divisions of France or Germany, are generally unsuited to the extensive forestry of India. We shall therefore only consider the standard shelterwood system as it is employed in practice. This method is extensively used for *sal* throughout the United Provinces. It is the standard system for *chir*, and the *deodar* forests of Jaunsar and Kulu and the blue pine, spruce and silver fir forests of the latter division of the Punjab are being worked under this system. It is simple and straightforward, ensures good silviculture, normal regeneration, and the improvement of the stocking. The area under this system of management is being continually extended and it is much to be regretted that it was not adopted 30 years ago. In practice it is not laid down that the selection of the seed trees is to be carried out with mathematical exactitude; every advantage is taken of groups of advance growth and the standard system modified to such small extent as may be considered desirable by the forester in charge of the work. In the case of *sal*, coppice reproduction from young stock is considered as desirable as reproduction from seed and every advantage is taken of advance growth, this being retained or cut back as may be necessary.

III.—The selection system.

The theory of the selection system is well understood by foresters; all age classes are supposed to be mixed up together on the area and as the oldest trees are removed in the fellings, so the next age class take their place and a corresponding amount of regeneration is obtained. In practice the selection wood is generally very different from this theoretical ideal. There has been much correspondence in the *Indian Forester* on the subject of the selection system. The advantages and disadvantages of the system are summed up in Hawley's "*Practice of Silviculture*" as follows:—

"The selection method with its uneven-aged form of forest stands in sharp contrast to the other three previously considered.

For this reason it is to be expected that definite arguments in favour of and against can be presented.

"*Advantages*.—1. Affords a high degree of protection to the site and to reproduction and minimises the danger of snow-slides and land-slides. The forest canopy is kept nearly complete, the openings made being small and scattered. No other method affords such perfect protection against the development of a grass and weed cover. Seedlings receive shelter from sun, wind, and early and late frosts. The continuous cover of trees of all ages presents a strong mechanical barrier to the progress of land and snow-slides. Such slides rarely, if ever, start in a selection forest.

2. Can be applied extensively where markets are poor and only trees of large size are merchantable. Poor market conditions hamper the full development of the selection idea, but do not prevent the partial use of the method, for even with the poorest markets it is the largest trees that are saleable.

3. The method best satisfies the aesthetic purpose, due to its picturesque uneven-aged form, and avoidance of anything approaching clean cutting.

4. Windfall is eliminated or reduced to a small figure in selection forests. The individual trees have the opportunity to develop large crowns, compared to trees in even-aged stands and become wind-firm. The small trees are well sheltered by the older ones.

5. Reproduction is relatively easy to secure, due to an abundance of seed trees and to the protection afforded to the seed-bed and seedlings.

6. The selection method is the only one which maintains the uneven-aged form of forest.

7. There is less danger of disastrous fire than in forests of even-aged stands in which the solid blocks of reproduction create enormous fire hazard. In case fire does occur seed trees are always present to stock up the burned area.

8. An ideal method for the small farm woodlot, because it permits annual or frequent harvesting of large timber. Such a

woodlot (of five acres for example) is too small to be effectively organised for annual or short period yield on a clear cutting or shelterwood method.

“*Disadvantages.*—Since the mature trees are scattered throughout the whole stand and are intermixed with reproduction and small trees, logging costs more than under other methods.

“2. Due to the mixture of age classes it is difficult to prevent in the logging injury to the immature trees which form the forest capital.

“3. Grazing cannot be permitted since reproduction is in progress continually.

“4. The timber produced averages lower in grade than that grown in even-aged stands. It is more apt to be knotty, due to the greater crown development of the individual tree. To some extent the site on which the selection method is ordinarily employed accounts for this. Selection forest has been used principally on poor sites in exposed positions and at high elevations as protective forest. On such situations the timber produced under any method is of lower quality than that produced on better sites.

“5. To apply intensively requires great skill on the part of the forester. This results from the complex nature of the age-distribution in the stand.”

This author also deals with the controversy as to the relative productivity of the selection and other systems. The Swiss foresters argue that the principle of the maximum sustained annual yield is compatible with the selection system and Biolley claims to have proved that this is so for the forests of the Canton of Neuchatel.³⁴ Broillard on the other hand writes :—

“The outturn of produce of a forest worked by selection is acre for acre, admittedly less than that of a regular high forest. This inferiority is due principally to the languid growth of some of the trees and the sickly condition of a much larger number

³⁴ La Methode du Controle—*Indian Forester*, July, 1922.—CHAMPION.

and is very marked or insignificant according to the state of the forest concerned. The quality of the produce yielded is also inferior, sometimes even absolutely bad.

The chief causes of this inferiority are—

- (i) the rapid growth of the bigger trees, which in the case of conifers produces soft-grained timber ;
- (ii) the formation of large knots, which are serious defects when they occur in the silver and spruce firs ;
- (iii) the production of various kinds of unsoundness which induce rapid decay in the wood of the species just named. These defects, like the general unsatisfactory condition of the crops, result from the exploitations being spread over too large an area. The consequence is that the damage caused by the felling and export operations is not confined to one locality (in which case it might be easy to repair or mitigate), the commission of all kinds of offences is rendered easy, and the trees that stand out isolated above their neighbours, having their crown exposed to the full force of the wind, are thereby broken uprooted or shaken. Nevertheless, the worst that can be said of silver fir forests worked judiciously by selection is that they are not regular.”

Hawley sums up as follows :—

“Whether the method gives a lower increment than other methods of high forest has been a point of controversy abroad for many years. Some authors contend that the greater the area of foliage per tree and the more complete use of available nutrients, resulting from the mixing of young and old trees with root-systems penetrating to different depths, must work for greater production under the selection method. The argument against this is that the retardation of the growth of young and middle-aged trees, through shading by older ones, more than offsets these items. It is not until the last half of the rotation that trees in a selection stand are completely freed from shading by taller trees. Analysis

of the growth of individual trees show marked contrasts between those grown in even-aged stands.

“Much of the difference in opinion as to the relative production of even-aged and uneven-aged stands arises from unfair comparisons between the two. To gauge the relative production of two methods the same intensity of application must be employed in the management and the two stands must be on the same quality of side. When these conditions are met the production of even-aged and uneven-aged stand should be equal.”

In adopting the principle of Irregular High Forest it is not necessary to follow the theoretical selection wood as illustrated in the working of the silver fir forests of the Alps. Foresters in India and France have modified the selection system to suit the silvicultural requirements of a light demanding species. A comparison of the latest system of management for the Corsican pine with that laid down for selection forests in the working plans for Kulu and Chakrata Cantonment, and the transition system for the North Kheri forests will show that exactly the same conclusions have been arrived at. The shelterwood system has had to be abandoned in Corsica on account of the immense fire hazard; this same system while admittedly the best for the *chir* pine has been seriously hampered by incendiarism, so much so that if this fire damage is to continue the whole system of management for these forests may have to be recast and we may have to return to management under selection principles.

The details of the treatment of the Corsican forests will be of interest to Indian foresters and is reproduced below from Woolsey's French Forests and Forestry.

“The selection system finally adopted is essentially a group selection of cutting where little holes are made in the stand. It is regular enough to warrant thinnings and yet irregular enough to avoid the extreme fire dangers of even-aged stands. An unpublished official description of the system in use is as follows:—

“Since every pine is essentially a light demanding species, in order to obtain natural regeneration light is necessary for the

seedlings. The stand which results from these pretended selection fellings does not necessarily have any similarity with theoretical selection high forest; it is formed of large patches of timber of the same size, often of the same age, which follow each other irregularly. The size of the opening necessary to give all the light required for the development of the seedlings depends on the slope, the total height of the stand, and on the condition of the soil. It cannot be fixed in advance, but the canopy may be freely interrupted, since the entrance of dangerous winds need not be feared.”

“But perhaps the most complete official description of the present selection method is given in the Aitone working plan, Art. 8, dated 30th November, 1907. Here the degree of regularity aimed at is well described:

“The volume of trees 0·35 metre (14 inches) and over in diameter, however realised, shall be counted against the yield. The forest agents shall be free to use whatever method seems satisfactory in estimating the felling. If it consists, however, of the chief or accidental yield, they will have to use the volume tables which are used in estimating the growing stock.

“The fellings will remove:—

- “(1) All trees that are dead, defective, overmature, or completely decayed.
- “(2) Trees measuring less than 0·35 metre (14 inches) in diameter which are not required.
- “(3) Small trees without any future.

“The agents should not lose sight of the fact that the selection method should not be considered as an empirical process in which one is limited to recruit the yield from dead trees, those overmature or of large size . . . It includes the same operations as the method of regular high forest (seed fellings, secondary, final, cleanings, thinnings).

"That which differentiates the two methods is that with the shelterwood system the same kind of operations follow consecutively and are consequently massed in a district . . . while in the selection system these operations are scattered over the whole area of the forest in little spots. It therefore follows that the fellings protect one another, so to speak. Do not imagine therefore that the selection system confines itself to realising large timber alone. It is necessary within the perimeter of each felling area, to practise all the essential cultural operations; to free the young growth, to thin the stands that are too thick, to cut out the trees with no future and never to lose sight of the fact that the really profitable growth is that which takes place in the trees destined to remain until the end of the rotation. At the same time one must avoid the tendency to regularise the stands by allowing any particular age class to dominate a large area just as one must avoid breaking the cover systematically to give it the aspect of a selection forest when managing a regular high forest of good growth."

"Only one official reference to the size of the openings to be made has been found:

" . . . in the stands of Corsican pine it will be best whenever the density of the stand will permit it, to proceed by removing groups of trees so as to cut up the stand into openings of 0.03 to 0.04 hectare (0.074 to 0.098 acres) so that the seedlings of this species will receive the light they require."

The selection system modified in several essential particulars is used with a yield calculated in volume as a transition system, in the *sal* forests of North Kheri, the oak forests of Chakrata Cantonment, the *deodar* forests on very broken ground in Kulu. Elsewhere in the hill *sal* forests where the ground is irregular and the growing stock very varied, this system is used with a yield by area. It is the only system for protection forests. The selection system if properly carried out requires very great skill on the part of the marking officer, and this is hardly realised by foresters who have not actually marked a typical selection crop under this

system. All silvicultural operations have to be done in the same compartment and a nice discrimination has to be exercised as to the tree to be retained or removed; the growing stock in every compartment has to be considered with reference to the normal and fellings made accordingly. Regeneration is in progress over the whole forest and it is exceedingly difficult to realise whether sufficient regeneration is being obtained or not, or to take the measures necessary to induce normal reproduction.

The removal of trees which have reached the exploitable size as carried out in the past, both in the *sal* and *deodar* forests, is no silvicultural system at all. It answered the needs of the day and was perhaps the only possible arrangement under the circumstances of the time, but that time has now past. Its ultimate failure and rejection was foreseen by McIntyre, an officer of exceptional ability, more than 20 years ago when he wrote as follows:—

"It is one thing to cut out mature trees here and there, over an existing advance growth of *deodar*, and quite another thing to regenerate a canopied mature *deodar* forest under which there is no reproduction. If in the latter case we trust to fellings prescribed long in advance, reproduction must be a matter of chance."³⁵

This system differs from high forest in that reproduction is obtained almost entirely from stool shoots. The whole growing stock is clear felled and regenerated by coppice shoots. The system, or its modification coppice with standards, is most suitable for crops managed for firewood or small timber and is largely adopted for the scrub forests of Banda and of Central India, where the site and climate are not capable of producing large trees, and where the indigenous tree growth is mostly scrub. Other examples of the system are the eucalyptus plantations of the Nilgiris, the irrigated plantations of *sissoo* and mulberry in the Punjab and *sal* in most private estates and in several United Provinces divisions. Formerly very extensive areas of coppice existed in France and

IV.—The
simple
coppice
system.

³⁵ Unpublished note on *deodar* in Kulu.

Britain which supplied the demands of the country for firewood; with the advent of coal these copses have largely fallen into decay and either become derelict or have been converted into high forest. Coppice is generally managed on a short rotation; the tendency in France has been towards the lengthening of the rotation, and as this takes place the appearance of the crop approaches more nearly to that of even-aged high forest, until in the case of *sal* in Gorakhpur with a rotation of 50 to 80 years there is practically no difference between the two. The coppice rotation in the Punjab irrigated plantations is 20 years, *sal* coppice in Pilibhit and scrub coppice in Jhansi and Banda grow to 30 years and the latter rotation or longer has been used for *ban* oak. The system for the last species is very well developed in the Dhami State of the Simla hills. The Gorakhpur simple coppice is famous and the technique of this management will be explained in detail in a subsequent chapter. It was formerly not the custom to thin coppice crops but this is now admitted to be absolutely necessary. (Parker in his Changa Manga working plan prescribes three thinnings during the rotation.) In the case of *sal* in Gorakhpur it is prescribed that thinnings will be done in the sixth, eleventh, twenty-first, etc., years. The execution of these thinnings very greatly increases the financial results obtained throughout the rotation, the final crop is vastly improved, and material which would otherwise rot is removed in the intermediate yields and converted into cash. One more point must be mentioned and that is the importance of completing the coppice regeneration by artificial sowing or planting a matter which has not always received sufficient attention in the past. All coppice coupes should be gone over in the first year and the stocking completed artificially.

V.--The
coppice
with
standards
system.

This system is similar to the last except that certain timber trees are retained as standards above the coppice. Coppice with standards has been largely employed for *sal* but has never been properly carried out as is illustrated from the preliminary report for the forests of the Pilibhit division.

"The past method of treatment prescribed coppice with standards, the number of which was to be not less than 60 along the bank of the Chuka river and 70—80 elsewhere. The selection of the standards has been well done and a distribution of age classes has in fact been obtained. At this stage it will be well to consider what the silvicultural result of this treatment will be. With an average of 75 standards to the acre what actually happens is that the heavy thinning to which they are subjected has a most beneficial effect on their growth and development; where they are at moderate distance apart their crowns spread and close up, and a complete high forest crop of fine trees is formed. Where there is a permanent gap in the upper storey a coppice shoot grows up and takes its place with the standards in the canopy. Elsewhere the coppice has not sufficient light to develop permanently and after growing up a certain way becomes suppressed. The ultimate result is indistinguishable from high forest with a second storey of more or less suppressed saplings. Exactly the same result has been obtained in old coppice with standards coupes in Gorakhpur. Further, it is self-evident that this result is bound to occur when the spacing of *sal* in properly thinned high forest sample plots is considered. These figures are appended for comparison:—

QUALITY II.

Average diameter of crop.	No. of trees per acre.	Approximate spacing per tree.
8" 	300	12 × 12
10" 	205	15 × 15
12" 	156	17 × 17
14" 	120	19 × 19
16" 	90	22 × 22
18" 	72	25 × 25

It will be seen that the proper spacing of *sal* of $4\frac{1}{2}'$ girth is 75 trees to the acre and that a crop of 5' trees will average 60 to the acre. It is therefore evident that in order to preserve the coppice, if this is a *sine qua non* of the management, the number of standards must at some stage in the rotation be reduced to about 30 per acre so as not to occupy more than half the crown space of the canopy.

The following are the essential points which must be attended to by the management:—

- (1) The maintenance of the balance between the standards and the coppice, both being considered as of equal importance. Consequently the area occupied by the spread of the crowns of the standards should not exceed half the crown space available.
- (2) The correct distribution of the age classes of the standards. The rotation of the standards is a multiple of that of the coppice and each age class of standards should occupy the same area as it increases in age throughout the rotation. As a necessary corollary each age class of standards must contain more trees when first established than at the end of the rotation, because each individual tree occupies more space with increase in age. In order to keep the area occupied by the standards of a given age approximately constant, it is necessary to reduce their number occasionally.³⁶
- (3) It may be necessary to start with a large number of standards as a protection from frost. If so, these must be reduced to the normal number indicated above as soon as they have fulfilled their object of a forest protection overwood. In certain cases standards are principally retained as a frost protection as in the Nawadia Working Circle of Pilibhit, in which latter case they are removed altogether after 10 years.³⁷

³⁶ *Practice of Silviculture*.—HAWLEY.

³⁷ *Working plan for Pilibhit division*.—HALL.

- (4) The thinning and cleaning of the coppice and the artificial regeneration of blanks as described for the simple coppice system.

A working circle is an area subjected to one and the same silvicultural system and method of treatment and which is exploited by a distinct series of operations. It may consist of one or more felling series. Having decided on the silvicultural system or systems to be adopted, it now becomes necessary to allot compartments to working circles in accordance with the way in which it has been decided to treat them. The broad outlines of the working plan having already been laid down, the working plan officer will consider the question of the allotment to working circles at the same time as he describes the compartments. In order that a working circle may be properly constituted it should contain crops of well graduated ages. As however under present circumstances the distribution of the age classes is never normal, the working plan officer must do the best he can with crops at his disposal and must make the best possible arrangements to obtain greater normality in the future. A working circle comprising as it does forests under one and the same method of treatment need not be in one piece; in fact it is seldom so. The compartments of the Conversion to Uniform Working Circles of Haldwani and Ramnagar are mixed up with compartments allotted to other working circles; the compartments of the Regular Working Circle of Kulu are scattered all over the division. On the other hand the Gola Working Circle of South Kheri division and the Thano Working Circle of Dehra Dun form self-contained blocks of forest. Similarly neither need the periodic blocks be concentrated into one place. The regeneration are both in *sal* and conifers may be scattered over the whole area of the division as is indeed the case in the Dehra Dun and Jaunsar-Bawar plans. On the other hand in the Conversion and Uniform Working Circles of South Kheri and the Chuka Working Circle of Pilibhit the

Constitution of working circles.

regeneration area is concentrated in one place, not because this was particularly desired, but because the growing stock conformed to this arrangement. The circumstances of each division will determine the number and constitution of the working circles, the composition and character of the growing stock and at times the situation of the compartment will determine the allotment to working circles. As a rule all the forests of a working circle must be managed on the same rotation and the yield calculated by the same or very similar methods. For instance forests in which the regulation of the yield is by area and by volume respectively should be kept in different working circles.

The constitution of felling series.

A felling series is part of a working circle comprising a separate series of age classes. Felling series are constituted from the area of the working circle in order to provide a sustained yield of forest produce to one or more markets or to distribute forest works of all kinds over one or more ranges, although the constitution of separate felling series for this latter purpose alone is not necessary. Each felling series is a self-contained unit of management with a separate calculation of the yield and a separate series of all silvicultural operations. Where there is a local demand for the produce, where rights have to be annually satisfied at a reasonable distance from the right-holding villages and local grazing rights have to be met, in these cases comparatively small felling series will be indicated. Beyond what is necessary to comply with the above considerations the number of felling series should not be unduly multiplied. If too numerous the number of separate operations become inconveniently great and the work of a given year is correspondingly scattered.

The standard diameter class.

As all statistical research is carried out in diameters it is necessary that working plans which are founded on the results of these researches should conform to the same standard measurements, and as a corollary the classification of trees for exploitation purposes should follow that adopted in the working plan. As a result of the above considerations the following standard diameter

classes have been adopted in the United Provinces and each diameter class has been given a corresponding colour on the calliper for enumeration purposes, vide the Forest Pocket Book.

Diameter class							
	1	2	3	4	5	6	7
Species	0'—8' white.	8'—12' green	12'—16' red.	16'—20' yel sw.	20'—24' black.	24'×28'	Above 28'

The extent to which the growing stock is to be enumerated having been determined, it now remains to carry out this work. At the outset it is laid down that in working circles organised on a periodic block system, in which the yield is calculated by volume for the regeneration area and by area elsewhere, a complete or very nearly complete enumeration of the regeneration area must be made. In forests where the yield is regulated by area, no enumerations are generally necessary, but in special cases where an accurate forecast of the probable outturn is wanted they may have to be carried out.

The conduct of enumerations.

The actual counting of the trees is done as follows :—

Each recorder is given a book ruled in the standard diameter classes already mentioned, and two or at the most three calliper men work with him. In the plains a couple of linesmen are also necessary. Starting from the edge of the compartment a strip of forest is taken along which the 2 linesmen walk tying bands of dry grass along the line, but keeping pace with the rest of the gang. The recorder takes up his position in the middle of the strip and the calliper men measure at breast height and shout out the species and colour of the trees on the callipers, the recorder entering each tree with a dot under its proper species and colour. After each tree has been measured it is given a spot of whitewash in the case of *sal*, or the bark is marked with a scribe or light axe in the case of suitable species like *chir* or *deodar*, to indicate that it has

been recorded. The marking with whitewash is usually done by separate workmen allotted to an individual calliperman. When the other end of the compartment or enumeration section is reached the line turns and measures a strip adjacent to the one already done. The marks on the trees counted should be placed on the side of the tree facing the direction in which the work will progress so that when working in any strip the marks on the trees of the last strip are clearly visible. In most cases a man carrying drinking water for the gang will have to be provided.

Wherever possible the compartment to be enumerated should be divided by clear physical features such as ridges, nalas or paths into enumeration sections. The ideal section is one that can be counted in one day, so that it becomes possible for the officer responsible for the work to check the work of any one man in one day. Such check is absolutely necessary and the permissible percentage of error is a maximum of 5 per cent. If this is exceeded the work of that recorder must be rejected and the man dispensed with. As a matter of fact, the percentage of error found on checking is normally very much less than 5 per cent. On completing each section or compartment the recorder hands in his results to the working plan officer or the assistant in special charge of this work after signing the form. Recorders usually work in separate sections or compartments, they have however been concentrated in one section spread out in a long line, this was found of advantage on difficult ground as complete supervision by a responsible man was then possible. A standard day's task should be fixed by the working plan officer and the work kept up to this. The custom of recording trees as sound or unsound in the enumerations has been found by past experience to be most unsatisfactory and to have served no useful purpose. Trees obviously worthless should be omitted from the count, trees which fork below breast height are counted as two trees. The recorder must see that the calliper is properly applied to the bole, the rule of the calliper should touch the stem and the measurements

be taken as near $4\frac{1}{2}$ feet as possible, the calliperman stands on the upper side of the tree if on hilly ground, one diameter measurement suffices.

By rotation is meant the predetermined time period during which it is intended to cut over a working circle.³⁸ Rotation really refers to even-aged crops. As regards solitary trees or the individuals of a canopied crop considered singly the age at which they become exploitable varies from tree to tree according to the special environment of each, and in such cases the exploitable size is of more importance than age. Nevertheless in a selection forest a rotation calculated to produce an average exploitable tree must be determined for the purpose of calculating the yield, but this average tree will vary according to the different quality classes of different sites.

The first essential of a rotation is that it produces a crop of trees for which a demand exists and the second that this particular class of crop shows satisfactory financial results. It is useless growing coppice for firewood when there is no demand for this material, nor is it profitable to produce small low class material when the local market demands high class saw logs and is prepared to pay for them.

The text-books deal with the various rotations and the way in which they are calculated; it is only proposed here to give practical examples of how this matter may be considered. It has been shown in Chapter IV how the preparation of yield tables simplifies the calculation of the rotation and renders it a simple matter to fix the rotation showing the greatest volume production, whether of firewood and small timber or sawn scantling.

"The *sal* yield table (in three quality classes) has been given in Chapter VI (Part I) and should be referred to. From the yield table it will be seen that the M. A. I. is practically constant for II and III Qualities between 80 and 90 years (excluding establishment).

The determination of the rotation.

Calculation of the rotation for sal in Dehra Dun.

³⁸ *The Theory and Practice of Working Plans.*—RECKNAGEL.

Moreover, from what has been written in Chapter VI, it is probable that *sal* will not persist as a fully stocked crop to a greater age, and the undoubted factor of rot and hollow more than counter-balances any possibility of price increment.

"A rotation of 96 years (including 10 years for establishment of seedlings) will give the following mean crop diameters:—

Quality II		16"
„ III		13"

"These diameters are the average of the crop; the best trees will be considerably larger, e.g., over 20" diameter on reasonably good sites. It is doubtful if fully stocked healthy crops of a larger mean diameter can be grown under the growth conditions of this locality.

The rotation for this working circle is therefore fixed at 96 years."

Where yield tables have not yet been prepared as for *chir* and *deodar*, as well as in the case of selection forests and standards in a coppice, we are compelled to fall back on the volume tables for individual trees and to make a comparison of the ages, volumes and value of average trees of the different diameter classes, comparing the amount realisable at each age on the one hand by felling the tree and on the other hand by preserving it. By felling the tree its price can be placed out at compound interest; by preserving it the tree would acquire an additional value with increased size. The two figures so obtained for different rotations can be compared, when it is at once seen whether it is profitable to fell the tree or keep it standing to a longer rotation. As an example the method of calculating the yield of the Regular Working Circle of the Kulu plan is given below.

⁴⁰ "From the statistics given in the volume tables it is possible to obtain all figures necessary to the calculation of the rotation for *deodar*. First of all if the mean annual increment in cubic feet of sawn scantling be examined, it will be seen that starting from a

Calculation of the rotation for conifers in Kulu.

⁴⁰ Kulu Working Plan.—TREVOR

diameter of 12" the increment gradually rises from .16 to .30 at a diameter of 18" and .49 at 26" corresponding to a rotation of 120 years. Even now this increment has not reached its maximum but increases to .52 at a diameter of 28" remains the same for 29" and then commences to decline. If the figures of the current annual increment calculated on the volumes of trees on which the yield is based are examined, it will be seen that trees of diameter 12" to 18" having an average volume of 30 c. ft. and being of an average age of 66 years produce an annual increment of 1.27 c. ft. This increment increases to 1.48 in the trees of diameter class 18" to 24" and reaches its maximum of 2.00 in the diameter class 24" to 26". Hereafter it declines to 1.50 in the diameter class 27" to 29" and to 0.43 in the diameter class 30" to 32". As a rotation of 295 years has now been exceeded no useful purpose is served by continuing this investigation. Indeed an examination of the thousands of statistics on which these calculations are based show that the average tree does not attain a diameter greater than 32".

"It is now necessary to consider the bearing of compound interest on the values of trees at different ages. First of all the current sale value of the trees and the amount being received for their cubical contents may be examined. A *deodar* 18" and over but less than 24" in diameter yields 67 c. ft. of the value of Rs. 7.5—a value of 1.79 annas per c. ft. A I class tree 24" to 26" is worth Rs. 22.5 or 3.42 annas per c. ft. and similarly the class 27" to 29" is worth 3.5 annas and the class 30" to 32" 3.59 annas per c. ft. respectively. It is thus evident that the current prices for I class trees are approximately 3.50 annas per c. ft. and it will therefore suffice to adopt actual prices now being received for the trees in considering this aspect of the matter.

"A II class (18"—23") tree enters this class at the age of 80 years and reaches the I class (24"—26") at the age of 110 years: it.

therefore requires 30 years for a tree to pass from a diameter of 18" to one of 24". Now Rs. 7.5 the value of a II class tree accumulated at 4 per cent. compound interest for 30 years amounts to Rs. 24.325 or Rs. 1.825 in excess of the current value of the lowest diameter class of a I class tree, viz., Rs. 22.5 showing that the rate of compound interest received is slightly less than 4 per cent. As however trees of not less than 24" are required in order to fulfil the objects of management (the provision of B. G. railway sleepers) an exploitable diameter of 24" is perfectly justified. But Rs. 7.5 is the value of an average II class tree and not of an 18" tree, the average age of this class should therefore be taken and not the age of entry into this class. The average age of the II class tree is 92 years and that of I class 24" to 26" is 115, so that the average time required for a tree to increase in value from Rs. 7.5 to Rs. 22.5 is 23 years. Now Rs. 7.5 accumulated at 4 per cent. compound interest for 23 years amounts to Rs. 18.485, so that the retention of trees to 24" diameter is fully justified on financial grounds alone.

"Continuing the investigation further it will be seen that 21 years are required for an average I class tree 24" to 26" diameter to grow into an average tree of the next higher diameter class 27" to 29" but Rs. 22.5 accumulated at 4 per cent. compound interest for 21 years amounts to Rs. 50.273, whereas the latter diameter class is only worth Rs. 30. Hence there is a loss of Rs. 20 per tree in retaining trees after they have reached the diameter class 24" to 26".

"Now a diameter of 26" corresponds to a rotation of 120 years. This rotation will produce a *chir* of just about 24", *Kail* of 29", a spruce of 27", and silver fir of 27"; so that with the exception of the last species this rotation is suitable both for *deodar* and its associated species. With regard to the silver fir it is supposed that under regular management the growth now shown will be accelerated, in any case its rotation must conform

to that of the more valuable species comprising the bulk of this working circle.

"The rights also affect the rotation, as only a certain portion from one-fourth to one-third of the forests can be closed at one time. Further, it is not anticipated that regeneration of block no. I can be effected in much less than 25 to 30 years. Another point which will affect this calculation in the second rotation is the quantity of cubic feet per acre produced at different ages. At present only figures for single trees are available, and these are sufficient for present needs; but with even-aged fully stocked woods these single figures will have to be superseded by the correct figures for the volume of crops at different ages according to the quality class.

"Taking all these matters into consideration the rotation of this circle for the present has been fixed at 120 years."

The method of calculating the rotation for the coppice in Changa Manga is interesting as showing what can be done without exact yield tables.

"The following figures show that a rotation of 20 years is more profitable than one of 15 years: An area of 464.3 acres felled at the age of 14, 15 and 16 years, the areas of 14 and 16 years old crop being equal to one another, yielded on the average 2,678 cubic feet stacked of thick and 749 cubic feet stacked of thin firewood per acre. An area of 596 acres felled at the age of 19, 20 and 21 years, the areas of 19 and 21 years old crop being equal to one another, yielded 4,238 cubic feet stacked of thick and 1,323 cubic feet stacked of thin firewood per acre. To obtain a fair and representative figure the areas for which the yields have been taken in the above calculation are situated in 9 compartments in the case of the 14, 15 and 16 years old crops and 11 compartments in the case of 19, 20 and 21 years old crops. They were all in compartments felled for the second

Calculation of the rotation for sissoo and mulberry coppice in Changa Manga.

time. The yield of timber from standards does not affect the consideration of the rotation of the coppice as it is of little importance whether standards are to be grown for 3 rotations of 15 years or for 2 rotations of 20 years. The thin wood is also best left out of account as the figures for it represent the amount which was actually extracted and utilised rather than the maximum amount which could be collected. Taking the area of the plantation at 9,000 acres with a 15 years' rotation the annual coupe is 600 acres, yielding 2,678 cubic feet stacked of thick wood per acre = 1,606,800 cubic feet stacked. With a 20 years' rotation the annual coupe is 450 acres, yielding 4,238 cubic feet stacked of thick wood per acre = 1,907,100 cubic feet stacked. Apart from the fact that 20 years old mulberry wood is worth more than 15 years' old mulberry wood (at present about Rs. 8 and Rs. 6 per hundred cubic feet stacked respectively), the actual outturn with a 20 years' rotation being greater, the 450 acre coupe is worth more than the 600 acre coupe. Further, if the 15 years' rotation were adhered to almost all the mulberry timber which is now produced and which is a very important source of revenue would be lost.

"Since a 20 years' rotation pays so much better than a 15 years' one the obvious question to ask is "why stop at 20 years"? Would not a rotation of 25 or even 30 years pay better still? To answer this question it is necessary to have figures of yields of crops 25 to 30 years' old, which are not available at present. Any one who saw the crops now being felled at 22-23 years' old would admit that they should have been felled some time ago as crops of this age tend to open out very much and there is a constant loss of valuable timber from windfalls. It is not uncommon to find a mulberry undergrowth coming up owing to the thinning out of the cover, and it seems probable that if in Changa Manga a rotation of 30 years were adopted the crops would open out very much and regenerate themselves naturally before the fellings came round, so that a 30 years' old crop would look more like one

CALCULATION OF THE ROTATION FOR SISOO AND MULBERRY COPPICE IN CHANGA MANGA. 97

5 years old in which an excessive number of standards had been left."

Parker could have continued his argument and shown the bearings of compound interest at the rate he adopts for all calculations of the financial returns of this plantation, viz., 4%.

(1) At a rotation of 15 years Y=1,606,800 c. ft. stacked.

Multiplying by Rs. 6 per cent. c. ft.
stacked = 96,408 rupees.

Add 4% compound interest for
5 years, i.e.,
 $\times 1.2167$ = 1,17,299 Rupees.

(2) At a rotation of 20 years Y=1,907,100 c. ft. stacked.

Multiplying by Rs. 8 per cent. c. ft.
stacked = 1,52,568 rupees.

∴ An extra annual profit of Rs. 35,269 is made by lengthening the rotation to 20 years.

All the standard methods of calculating the yield will be found in Schlich's "Manual of Forestry" and in Recknagel's "Theory and practice of working plans." It is only proposed here to deal with such methods as have actually been used in practice and as are recommended as suitable to our work.

*Method of
calcula-
ting the
yield.*

This method is adopted in working circles with a periodic block frame work managed under the shelterwood system. The final yield in the regeneration area or periodic block no. I is calculated in volume and in the rest of the area intermediate yields are realised by area.

*By volume
and area.
Based on
periods.*

$$\text{Yield} = \frac{v + (i \times \frac{p}{2})}{p}$$

Where v = volume of growing stock, of P. B. I.

i = C. A. I. of the growing stock "

p = number of years in the period.

An actual example from the Chuka Working Circle of Pilibhit division is given below :—

P. B. I. Chuka Circle, Pilibhit Forest division.

Diameter class.	Number of trees Sal and Sain.	Volume C. ft.	C. A. I. C. ft.
8"—12" ..	129,835	973,768	114,255
12"—16" ..	85,289	2,132,235	122,816
16"—20" ..	45,505	2,457,270	59,612
20"—24" ..	15,712	1,398,368	..
Total ..	276,341	6,961,626	296,683

$$\begin{aligned}\text{Annual yield} &= \frac{V + (i \times 15)}{30} \\ &= \frac{6,961,626 + (296,683 \times 15)}{30} \\ &= \frac{6,961,626 + 4,450,245}{30} \\ &= \frac{11,411,871}{30}\end{aligned}$$

i.e., annual yield = 380,396 cubic feet = 380,000 c. ft. in round figures.

NOTE.—C. A. I. of trees over 20" diameter is neglected, since these are overmature, and any possible increment will be counterbalanced by probable decrement (windfalls, decay, trees drying up, etc.).

Calculation of the yield of a forest by formulae.

There are two points in forest management in India which have a very material effect in the determination of the yield of a forest. There is first the practical impossibility of enumerating the growing stock of a forest down to seedlings, actually for the United Provinces working plans, enumerations are seldom carried down below trees of 8" diameter. The second point is the relatively high definition of timber, which, for research work generally, and for all forests, where sawn or large timber is the object of management, has been defined as measured down to 8" diameter over bark. Thus in the United Provinces forests generally, the *real* growing stock (V) represents timber over 8" diameter only, and is ascertained by enumerations of trees over 8" diameter (in standard 4" diameter classes), the numbers of trees in each diameter

class being multiplied by a volume factor representing the *timber* content. The following note examines the application of standard formulae to such conditions, for ascertaining the yield of the whole forest. The principal formulae are (1) Von Mantel, (2) Heyer, (3) Hufnagel, (4) Karl or C. A. I. As these formulae are fully discussed in all text-books (e.g., Schlich and Recknagel), it is only proposed here to explain why and how they must be modified to suit conditions given above.

Von Mantel's formula is

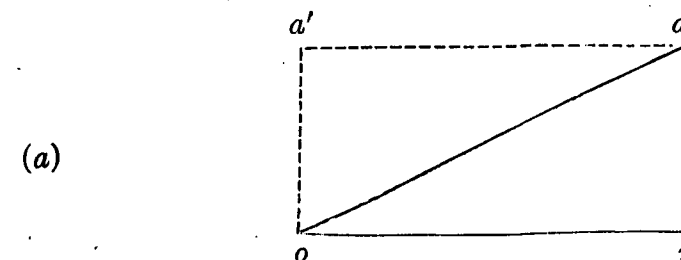
$$Y = \frac{2V}{r} \left\{ \begin{array}{l} V = \text{real growing stock} \\ r = \text{rotation.} \end{array} \right\}$$

Now this formula is theoretically correct only if V represents the whole crop down to seedlings and the wood volume of each tree measured down to 0" diameter. Practically of course this is impossible anywhere in the world, but by measuring trees and wood down to 1" or 2" diameter we get a sufficiently close approximation. However by measuring trees and wood down to such a high limit as 8", a very serious error is introduced, which will be evident from the following :—

Von Mantel's method.

Consider three cases (all for a normal series of age gradations)—

- trees and wood measured to diameter 0" ;
- trees and wood measured to a diameter equal to $\frac{1}{2}$ rotation diameter (or diameter $\frac{r}{2}$ for short) ;
- trees and wood measured to a diameter corresponding to an age X (or diameter X for short, in India usually 8").

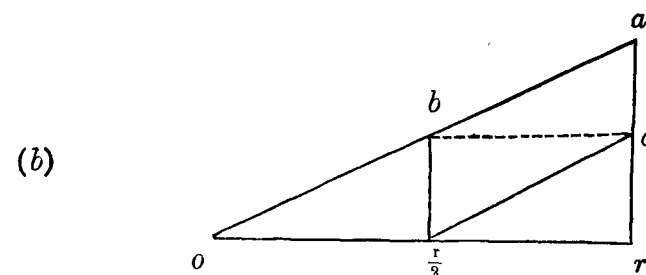


Obviously $V = \Delta aor$

and the yield in r years = figure $oraa' = 2 \triangle aor = 2V$. and meanwhile the areas felled over will have grown up to give the same growing stock = $\triangle aor$.

$$\therefore \text{annual yield } Y = \frac{2V}{r}$$

This is Von Mantel's formula unaltered.



Howard has examined this problem (vide Indian Forester August, 1920), and has modified Von Mantel's formula to read

$$Y = \frac{V}{\frac{r}{2}}$$

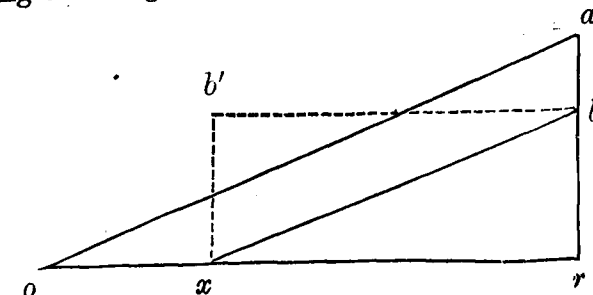
This is based on the statement that by ignoring all trees under $\frac{r}{2}$ years old, V = the figure $a. b. \frac{r}{2} r$.

This is true if the volume of total wood per tree down to 0" diameter is included, *but not otherwise*. For it is obvious that the volume of a crop $\frac{r}{2}$ years old is proportional to the line $b. \frac{r}{2}$ if all wood is included, but is zero if only wood exceeding a diameter $\frac{r}{2}$ is included. In this latter case, the growing stock V is represented by a $\triangle$ on $\frac{r}{2}r$ as base, and if, as yield tables for *sal* indicate, the volume of small wood (i.e., below 8") in a crop remains approximately constant after $\frac{r}{2}$ years old, this V will be the $\triangle \frac{cr}{2} r$.

To apply Von Mantel's formula to this V will introduce a very large error, to apply Howard's modification will introduce smaller but still appreciable error. From the diagram it is obvious that the total yield in $r - \frac{r}{2}$ years = figure $r. c. b. \frac{r}{2} = 2V$

$$\text{and } \therefore \text{annual yield } Y = \frac{2V}{r - \frac{r}{2}}$$

(c) We can now put the problem in general terms, where trees and wood are enumerated and measured down to a diameter corresponding to an age X



The real growing stock V is now represented by $\triangle b \times r$, and as before, it is easy to see that in $r - X$ years, the total yield = figure $rbb' X = 2V$

$$\therefore Y = \frac{2V}{r-X}$$

This formula is approximately true for all values of X , provided that the crop is *both enumerated and measured* down to the diameter corresponding to age X . (This diameter is in the United Provinces generally 8".) To apply Von Mantel's formula to this limited growing stock is wrong, and the extent of the error introduced is evidently

$$\frac{2V}{r-X} - \frac{2V}{r} = \frac{2V}{X} \left(\frac{r}{r-X} - 1 \right)$$

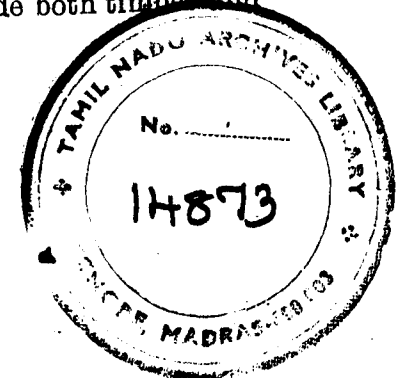
The adoption of this formula pre-supposes the existence of normal crop below age X . If these are in deficit, after $r-X$ years we shall have less growing stock over age X than at present, and hence the formula would then give too large a yield.

Blanford and Simmons have worked out a very useful formula (being a modification of Von Mantel's formula, and a generalised modification of Howard's formula), to calculate the yield where V = the growing stock enumerated to X years of age, but the volume of the individual trees measured to include both timber and smallwood. The formula is

$$Y = \frac{V}{\frac{r}{2} \left(1 - \frac{X^2}{R^2} \right)}$$

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This formula is more conservative than the formula $Y = \frac{2V}{R-X}$ given above, and is therefore preferable to adopt. Howard's formula is obviously a special case of this general formula, where $X = \frac{1}{2}R$, (if $X = \frac{1}{2}R$,) the formula becomes

$$Y = \frac{V}{\frac{1}{2}R \left(1 - \frac{\frac{1}{2}R^2}{R^2}\right)} = \frac{V}{\frac{1}{2}R \times \frac{1}{2}} = \frac{V}{\frac{1}{4}R}$$

Howard's formula has a great practical disadvantage of necessitating alterations in the diameter or girth classes in making enumerations of growing stock for every alteration of quality class and of rotation, which is not feasible in actual practice. For the above formula enumerations can be made in standard diameter classes regardless of quality or rotation. It has been adopted for the calculation of the yield in North Kheri forests, the calculations for which are given below as an example.

In utilising any of the other standard formulae such as Heyer, Hufnagel or C. A. I., a considerable error will be introduced if these formulae are applied to a partial growing stock V representing only trees over 8" diameter, and volume per tree up to 8" diameter. This question has been discussed at length in an article in the *Indian Forester*⁴² and need not be repeated here, but in all cases allowance must be made for the unmeasured growing stock below 8" diameter.

Calculation of the yield for Working Circle (I) of North Kheri on Blanford's formula.

An actual example of the calculation of the yield by this modified formula for North Kheri is given below:—

"From the yield tables for *sal* it will be seen that the M. A. I. for timber in the round culminates at 90 years for high II Quality, that is including the usual 10 years of establishment, and this corresponds with a mean crop diameter of 17". This diameter is the average of the crop, the best trees will be considerably larger, i.e., in the 20"—24" diameter class. Owing to the unsoundness

⁴² *Indian Forester*, December, 1922, pages 626 to 636.

prevailing in North Kheri no argument can justify a longer rotation than 90 years and this is the rotation adopted.

"The yield will be determined by volume for the whole working circle on the following data:—

Area.—47,000 acres.

Quality class.—II Quality.

Growing stock.—All *sal* and *asaina* over 8" diameter have been enumerated in the standard diameter classes. The following tabular statement has been based on the result of these enumerations:—

Diameter classes.	Mean diameter.	Number of trees per acre of forests.	Volume unit per tree (timber plus smallwood).	Volume units per acre of forest.
8"—12"	10	35.56	1.6	56.9
12"—16"	14	13.39	3.8	50.9
16"—20"	18	7.31	7.1	51.9
Over 20"	22	5.90	11.8	69.6
Total	..	62.16	..	229.3

"The calculation of the yield for this working circle can now be proceeded with.

"The formula adopted for calculating the yield from the growing stock enumerated down to 8" diameter is a simple one worked out by Messrs. Blanford and Simmons and is as follows:—

$$Y = \frac{V}{\frac{1}{2}R \left(1 - \frac{X^2}{R^2}\right)} \text{ where } V = \text{the total growing stock (both timber and smallwood) of trees enumerated over 8" diameter.}$$

R = the rotation

X = the age of 8" trees.

"In this case (disregarding establishment period)—

$V = 229.3$ units per acre.

$R = 80$ years.

$X = 32$ "

$$\text{Hence } Y = \frac{229.3}{\left(1 - \frac{32^2}{80^2}\right)} = 6.825 \text{ units per acre.}$$

"Hence the total yield of 47,000 acres = 320,775 units per annum, or, say, 320,000 units in round figures for the whole working circle. It is divided between the two felling series according to the growing stock in each as follows:—

East Felling Series = 146,300 units.

West Felling Series = 173,700 units.

"The yield shown against each felling series should be felled annually, all *sal* and *asaina* of 8" diameter and over felled anywhere within the felling series will count against the yield. *Sal* and *asaina* under 8" diameter and miscellaneous species will not count against the yield. A balance account will be kept for each felling series in the control forms and the surplus or deficit at the end of each year will be carried forward to the next year. A deviation exceeding 10 per cent. of the yield of each felling series will be a deviation from the prescriptions of this working plan and will require the previous sanction of the Chief Conservator of Forests. The figures of volume units per diameter class given in the table above, which have been used in calculating this yield, will of necessity be adopted by marking officers in marking or felling against the prescribed yield. They have no connection with sawn or utilisable output, but one unit represents 10 c. ft. of timber plus firewood."

In the French method of 1883 and in *La Methode du Controle* the proportion of the diameter classes in a normal forest would be fixed as follows with an exploitable size of 24" diameter.

	1883 method.	Methode du Controle.
Small trees under 8" diameter	11	20
Middle sized trees 8" 16" diameter	33	30
Old trees over 16" diameter	55	50

The calculation of the yield employed in the *Methode du Controle* is really based on the real C. A. I. of the growing stock as determined at two subsequent enumerations.

⁴³ "The basis of the whole method is a thorough study of the diameter increment put on by trees during the whole of their lives

⁴³ *La Methode du Controle—Indian Forester—July, 1922.—CHAMPION.*

since this increment represents the results of both the spontaneous and solicited effort on the forest. It is an extraordinary delicate indication of the growth and vigour of trees and as such must form the subject of continuous study on the part of the silviculturist. Hence enumeration, methodical and repeated, is the fundamental operation of the method of control. The modifications to which the growing stock of a forest is subjected are of two classes—increases and decreases. Increases are caused by the increment and by the entry of new individuals, decreases are due to removal either accidental or intentional. It is therefore necessary to make inventories of the material retained (entries) and of material removed (exits). It goes without saying of course that these two operations, the basis of the whole method, must be made in exactly the same manner, and with the same units if their results are to be of any value."

The calculation of the Increment.—This consists in comparing two successive periodic enumerations, taking account of trees exploited.

Let *m* be the volume at the beginning of one period.

" *M* " " the next "

" *E* " of the material removed during the period.

" *A* be the increment.

Then $A = M + E - m$.

This gives the increment of the division as a whole, but it is also carried out for classes and species.

The method has not so far been used in Indian working plans. 1883
It is complicated by a calculation of the growing stock of the old method—
and middle sized groups, based on the theory that these should contain volumes in the proportion of 5 : 3 and that their sum should equal the total volume which would exist if half of the entire area were covered with trees of just exploitable size. If this is so, then

$$\text{Yield} = \frac{v + (i \times \frac{p}{2})}{p}$$

Where *v* = volume of old group

i = C. A. I. of old group

p = 1/3rd the rotation.

If the growing stock is not normal, then various adjustments must be made as described in the text-books.⁴⁴ The method is not at present particularly suitable for Indian conditions and requires yield tables in order to find out whether the sum of volumes of the two groups is normal or not. It also requires the enumerations of the forest in diameter classes varying with each different quality class, which is scarcely practicable.

By area.

This method should be used for forests managed under the clear felling system. Each compartment is given a nett reduced area according to quality and the —

$$\text{Yield} = \frac{\text{Reduced area of the Working Circle}}{\text{rotation}}$$

Coppice felling yields are always regulated by area ; regeneration fellings in P. B. I. may, under certain exceptional circumstances, be regulated by area as is the case in the Chir Working Circle of North Garhwal. This regulation by area formerly existed for P. B. I. of the Conversion Working Circle of Haldwani and Ramnagar but was found unsatisfactory and has been replaced by a volume yield.

Fellings in selection forests have generally been regulated by area sometimes with a volume or tree limit in addition, a most unsatisfactory arrangement.

In protection forests regulation of the yield by area should continue to be the ordinary procedure but elsewhere in forests worked under selection a volume yield should be insisted on. In no case should an attempt be made to limit the yield to a certain area plus a certain volume combined, as this means that either the area is worked over and the volume not obtained or the volume is obtained over part of the area and the rest then left unworked altogether, as the next year a different area has been prescribed for fellings.

⁴⁴ *Theory and Practice of Working Plans* — RECKNAGEL.

CHAPTER VII.

THE CLEARFELLING SYSTEM.

THE system of clearfelling has not as yet been extensively introduced in the United Provinces, but as its introduction in certain favourable localities in the near future appears not improbable, it has been considered advisable to give a brief description and to mention the essential points in its application. The general theory of the system is described in detail in all text-books and need not be discussed here at any length.

When applied to the irregular and usually uneven-aged forests of the United Provinces, clearfelling necessarily implied the felling of a considerable amount of immature material and an important point to be considered, before prescribing clearfelling in any forest, is to what extent this small material will be utilised. Generally speaking, the system should only be applied in areas of intensive demand where preferably even small wood and branches are extracted for fuel ; if applied to forests with a limited demand, or with difficult or costly transport, a heavy and usually unjustifiable sacrifice is involved.

Applicability of the clearfelling system.

A striking illustration of this point is afforded in the Gorakhpur division. A working plan drawn up in 1875-76 prescribed a clearfelling system for the Ramgarh forests but the very limited demand was largely responsible for having the plan cancelled after 2 years. In 1914, nearly 50 years later, a working plan with almost identical prescriptions of work was introduced, the intense demand absorbed every twig and leaf and the plan has been one of the most successful in India.

A second important point is that the successful regeneration (whether natural or artificial) of the area felled over annually can

be guaranteed. Without this proviso, the whole basis and framework of the system is likely to collapse. The classical example of clearfelling with natural regeneration (from seed) is afforded by the maritime pine forests of the Landes but such exceptionally favourable conditions for natural reproduction are extremely rare, and as a general rule the regeneration of clearfelled areas has to be largely or entirely artificial. In India, this usually implies intensive working and an ample labour supply *in the rains*, conditions which are rare in the United Provinces forests. It is perhaps unnecessary to observe that, under the prevailing conditions of the locality the regeneration and young seedlings of the species must be able to grow and flourish with complete overhead light. Thus, for example, the system could never be applied to such a shade demander as silver fir, nor again to *sal* in frosty localities. A working plan officer, then, before applying a clearfelling system to any particular forest, must pay due attention to these three points :—

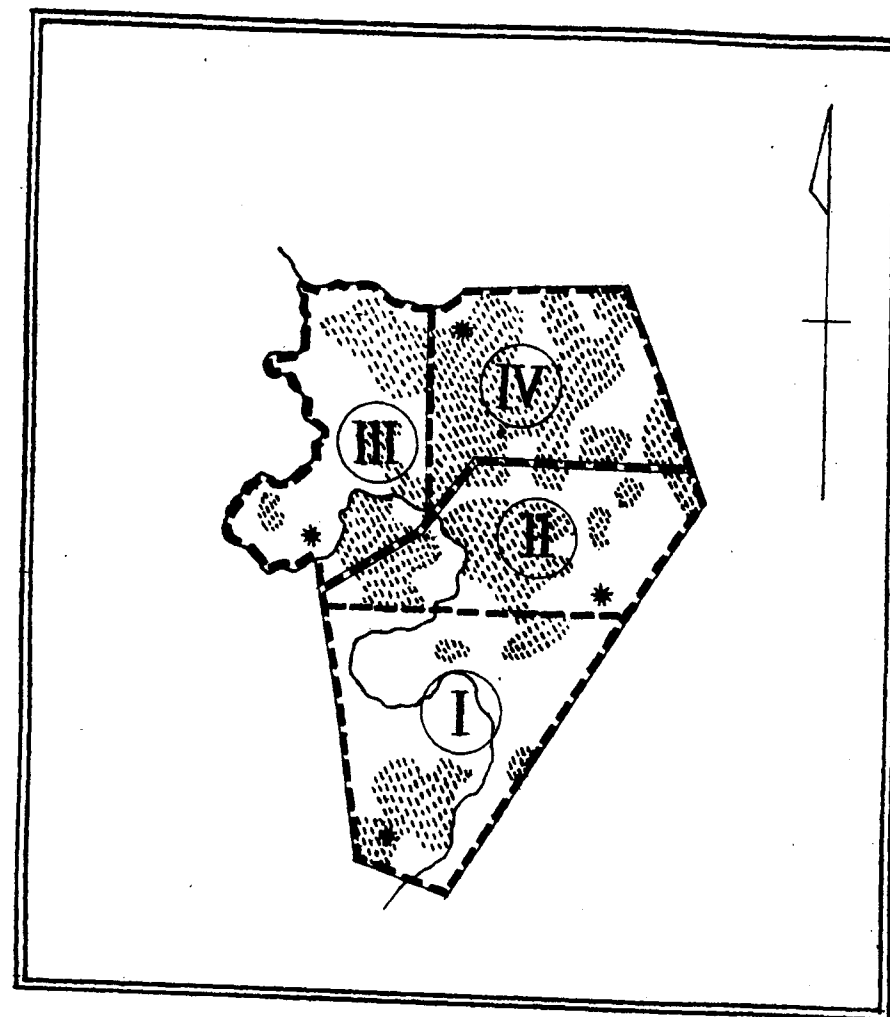
- (1) Suitability to the silvicultural requirements of the principal species.
- (2) The intensity of the demand.
- (3) The *guarantee* of the successful regeneration of the annual coupe.

Applica-
tion of the
clearfell-
ing
system
to U. P.
conditions

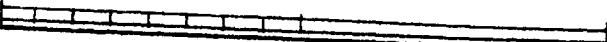
It will simplify the discussion of this matter to give, first and very briefly, the theory of the system as described in text-books and then to quote examples of its application in various forests and under varying conditions in India. The theory then, in the fewest words is as follows :—

If A is the (reduced) area of a forest and R rotation an area A/R is felled yearly, and *immediately regenerated*. The annual yield from the main fellings *is fixed by area*, and is the growing stock on the area A/R . Supplementary regulations should prescribe for (a) cleanings and tendings of the young regeneration.

(b) Thinnings before and after the main clearfellings. These thinnings would also be determined by area. This is the clear felling system in its simplest form. The following illustrations



Scale 1.58 inches = 1 mile

Furlongs  Miles

* Starting point of each Periodic Block.

Dotted shading - Approximate area under Sal.

A square of 1/16th. inch side = 1 acre.

Total area - 1262 acres.

Block I 362 acres.

Block II-IV 300 acres each.

from current Indian working plans show how the system has been applied and modified to suit local conditions.

The best example is afforded in the 1920-21 working plan for the Buxa division, Bengal, ⁴⁵ but is slightly complicated.

Clearfelling in sal.

Demand.—There is a good demand for (a) large *sal* logs, (b) rapidly grown miscellaneous species or "*kokat*" (for planks and tea boxes), (c) firewood.

Labour.—There is a limited but fairly satisfactory labour supply in the rains, and successful artificial regeneration of *sal* and *kokat* can be guaranteed over limited areas. The preliminary conditions for clearfelling are therefore satisfactory. The following description of the system as applied is taken from the working plan:—

Object in view.—The object of the proposals in this plan is to replace the present irregular forests by a series of even-aged woods consisting of the most suitable species in each locality, and at the same time to utilize all classes of produce from the existing crop to the fullest possible extent.

Method of treatment adopted in order to obtain the above objects.—As has been already shown, regeneration must in the main be artificial. From experiments made in recent years it appears that the *Taungya* system promises the best results, and this system is therefore proposed wherever practicable. Selection fellings on present lines will continue in parts of the forest which do not come under regeneration for some time.

This is fixed by area.

Exploitable age.—Fixed at 80 years for *sal*.

40 „ *kokat* timber species.

20 „ fuel species.

Calculation of the annual yield.

General working scheme.—The general scheme is to clearfell the whole forest bit by bit, cultivating field crops for a time, wherever this is necessary, to get rid of harmful weeds or to aerate the soil, and then to sow or plant the species best suited to the

⁴⁵ Working Plan for Buxa division.—SHABBEARS.

locality. This sounds simple and would be so were it not for the following complications :—

“ There are three classes of produce, *sal*, *kokat*, and fuel, which requires a different period in which to mature, and where there is for example, a heavy demand for fuel, which matures in 20 years, it is obviously impossible to restrict the supply by working it on the 80 year rotation required by the *sal* growing over it. Each class of produce must therefore be worked on its own rotation, viz., 20 years for fuel, 40 years for *kokat* and 80 years of *sal*. As all three classes grow mixed together the coupes corresponding to these three rotations will be made simultaneously in the same felling series.

“ In each felling series then, the following clearfellings are prescribed each year :—(A) *sal* to be clearfelled over one-eightieth of the whole area of the felling series, (B) *kokat* to be clearfelled over one-fortieth, and (C) fuel to be felled over one-twentieth. In the *sal* clearfelling coupe all the *kokat* and fuel is also to be felled and in the *kokat* clearfelling coupe all fuel is to be felled so that the above felling areas (A, B and C) actually overlap, the *sal* clearfelling coupe including half the *kokat* and quarter of the fuel clearfelling, and the *kokat* clearfelling coupe including a further quarter of the fuel clearfelling. The actual areas occupied by the different kinds of coupes therefore are—

“The *sal* coupe (including *kokat* and fuel fellings), one-eightieth of the felling-series.

“The *kokat* coupe (including fuel fellings), an additional one-eighthieth of the felling-series.

“The fuel coupes an additional one-fortieth of the felling series.

It is not strictly accurate to call the *kokat* and fuel coupes ‘clearfellings’ because, in the former, *sal* and in the latter *sal* and *kokat* are left standing, but the term is convenient to distinguish the fellings here described from the selection fellings described later.

“The second complication arises from the fact that mature and over-mature trees of the more valuable species as well as *kokat*

are scattered all over the forests. If the programme outlined in the last paragraph (namely, a *sal* coupe moving round the whole felling series in 80 years and a *kokat* coupe moving round in 40 years) were the only fellings affecting these trees, it stands to reason that a tree which is mature at the beginning of the rotation but which happens to stand on the area last to be worked over will be 40 or 80 years over-mature before it is felled, and it may have deteriorated considerably in the meanwhile. To avoid this waste it is necessary to have some sort of selection fellings in parts of the felling series which will not come under regeneration for some time, to remove trees as they become ripe.

“Each felling series is divided into 4 periodic blocks of equal area, numbered I, II, III and IV respectively, and the following fellings are prescribed :—

Clearfellings :—

“(a) *The sal coupe*.—A clearfelling of all species may be made annually over an area not exceeding one-eightieth of the whole felling series, provided that arrangements can be made for restocking the whole of the *sal* bearing area by means of cultivation and the remainder by means of cultivation or otherwise. The only trees to be left standing are groups of immature *sal* or other slow-growing valuable species which in the opinion of the Divisional Officer, are likely to improve during the next 80 years. This felling will begin from the starting-point of Block I.

“(b) *The kokat coupe*.—A clearfelling of all species other than *sal* and other slow-growing valuable species may be made annually over an area not exceeding one-fortieth of the whole felling series less the area of the *sal* coupe, provided that arrangements can be made for restocking the area with or without cultivation. At the same time a thinning in congested *sal* poles and the removal of *sal* of inferior growth interfering with better stems will be carried out. Isolated *sal* trees will be felled to allow of restocking. In areas not fully stocked with *sal*, officers will be guided by the density of the crop as to whether the *sal* should be felled and the area restocked, or whether the *sal* crop should be left and no restockin

*The
fellings.*

undertaken. This felling will begin from the starting point of Block III.

"(c) *The fuel coupes.*—All trees which, in the opinion of the Divisional Forest Officer, will never be fit for anything but fuel may be felled annually over areas not exceeding one-twentieth of the whole felling series less the area of the *sal* and *kokat* coupes combined. These fellings will begin from the starting points of Blocks II and IV.

"The areas prescribed for all clearfelling coupes are maxima and will be limited in practice by the demand and cultivation available. The *kokat* coupe will be felled only if the demand for *kokat* exceeds the supply from the *sal* coupe, and similarly fuel coupes will only be required if the demand for fuel cannot be met from the *sal* and *kokat* coupes.

"*Selection fellings.*—These are prescribed on a 15-year felling cycle over Blocks II, III and IV beginning with Block II, which will, therefore, be worked over in the next five years. At the end of that period the question of selection fellings will have to be re-considered as the working will depend on the extent to which *kokat* clearfellings have been carried out. All *kokat* over the exploitable girth will be removed together with *sal* over 2 feet in diameter unless it is likely to improve in 20 years. At the same time the removal of *sal* of inferior growth interfering with better stems will be carried out.

"*Thinnings and removal of dead sal.*—These two operations are to be carried out at the same time and will be made over one periodic block in each felling series annually. The interval between these operations in any given area is therefore four years.

"Thinnings in the new crop are referred to in Appendix III (3) the thinnings referred to here are confined entirely to congested patches of immature *sal*. This operation is both important and profitable. From the work already done in this direction it is seen that even after a heavy thinning the remaining *sal* poles close up so rapidly that after two years it is almost impossible

to see that any thinning has been made, hence the short interval prescribed. As the areas prescribed for this operation and for creeper-cutting coincide, the marking of the former can be combined with the inspection of the latter and forest guards in charge of creeper-cutting will be able to point out patches of congested *sal* poles which occur only over limited areas.

"Coupes will be laid out early in the cold weather preceding that in which they will be worked. *Laying out the coupes.*

"The yield in this working plan is given in the gross acreage; in laying out coupes; therefore, unproductive areas must be taken as they come and included in the acreage laid off. When large unproductive areas occur they may, at the Divisional Forest Officer's discretion, be distributed over a number of coupes to equalise the outturn.

"The exact position and shape of each coupe is not specified, but the following rules must be observed:—

- (1) The first coupe in each periodic block must be laid out near the prescribed starting point of the block and subsequent coupes made to follow a regular order calculated to finish the working of the block at a point near the starting point of the next block.
- (2) Considerations of economy in fencing and convenience of extraction and cultivation must be kept in view.
- (3) Existing lines, roads and rivers may be used as boundaries of coupes, but all new lines cut as coupe lines must be either true (not magnetic) north and south or true east and west.

"All coupes in which fuel is to be cut will continue to be divided into 70 yard strips by east and west or north and south lines.

"*Coupe statements.*—In the *sal* and *kokat* clearfelling coupes the marking officer will prepare a stock map on the scale of 4" = 1 mile a statement of the trees of each species to be felled, and an estimate of the quantity of fuel available. In fuel coupes

no stock map will be prepared before working, but a rough map on the scale one square inch=1 acre will be filled in with details as to working, stocking, and yield as the work proceeds and from this a stock map will be prepared afterwards on the scale 4"=1 mile.

"For all *sal* and *kokat* clearfelling coupes the Divisional Forest Officer, after comparing the marking officer's stock map with the forest will prepare a statement showing (1) details of trees marked and estimate of timber and fuel saleable; (2) areas to be restocked with each species or mixture of species, and whether by means of cultivation or otherwise; (3) amount of seed of each species required, dates for collecting the seed, and area of nursery and lining out beds required; (4) estimate of the number of cleanings, etc., required and an estimate of the amount of labour and cost, (5) estimate of fencing.

"A copy of the statement will be sent to the Conservator and to the Range Officer concerned.

"No clearfelling will be made in any working circle without some definite steps being taken to ensure restocking. The choice of the species with which the various parts of the coupes are to be restocked as well as the method of restocking is left to the Divisional Forest Officer—firstly, because the choice depends on local conditions and, secondly, because our present knowledge of the silvicultural requirements as well as of the timber value of the various species will be greatly extended during the next few years. Suggestions regarding cleaning, weeding, and early thinnings will be found in Appendix III."

Here we have a complicated example with three separate series of fellings and three rotations in each area, but it illustrates the clearfelling system very well indeed. The extreme importance must be emphasised of the prescription that "one-eightieth of the whole felling series may be clearfelled annually, *provided that arrangements can be made for restocking the whole of the sal-bearing area by means of cultivation and the remainder by means of cultivation or otherwise.*"

*Sowing,
planting,
and
tending.*

In other words, up to a fixed maximum, the annual yield is determined by the area, the immediate successful regeneration of which can be guaranteed.

A simpler example of application of the clearfelling system in *sal* is afforded in the Gorakhpur division. The southern forests have been clearfelled since 1914, but as the regeneration here is almost entirely coppice, the scheme of working has been described in Chapter X—simple coppice.

*Applica-
tion to
Gorakh-
pur.*

In the northern forests, as soon as a railway extension or tramway has been completed (which will automatically enable the potential intensive demand for small poles and fuel to operate) a clearfelling system will also be introduced, and as the regeneration will be partly coppice and partly artificial from seed, it may conveniently be described here. The essential points are as follows:—

Area.—About 36,000 acres of *sal*.

Rotation.—Sixty years, which will produce pole crops of 12" to 13" diameter.

Annual yield.—Fixed by area.

Area of annual coupe.—Six hundred acres. Of this, it is roughly estimated that 60—70 per cent. will be regenerated by coppice, and the balance by artificial sowings.

Fellings.—Everything to be clearfelled and all advance growth cut back.

Cleaning and tendings.—Will be carried out in the young crop at the ages 1, 2, 5, 10 years, and thereafter thinnings at the ages 20, 30, 40, 50 years. Thinnings and Improvement fellings will be carried out in advance of the main fellings in coupes XI, XXI, XXXI, etc., in the first year.

XII, XXII, XXXII, etc., in the second year, and so on.

The thinnings 10 years before the clearfelling will be very heavy. As a point of interest, and to illustrate the intensity of the demand, it may be noted that the cleanings even at ages 1 and 2 are saleable, at 5 and 10 years are remunerative, all thinnings are very remunerative, and the clearfellings from a very indifferent

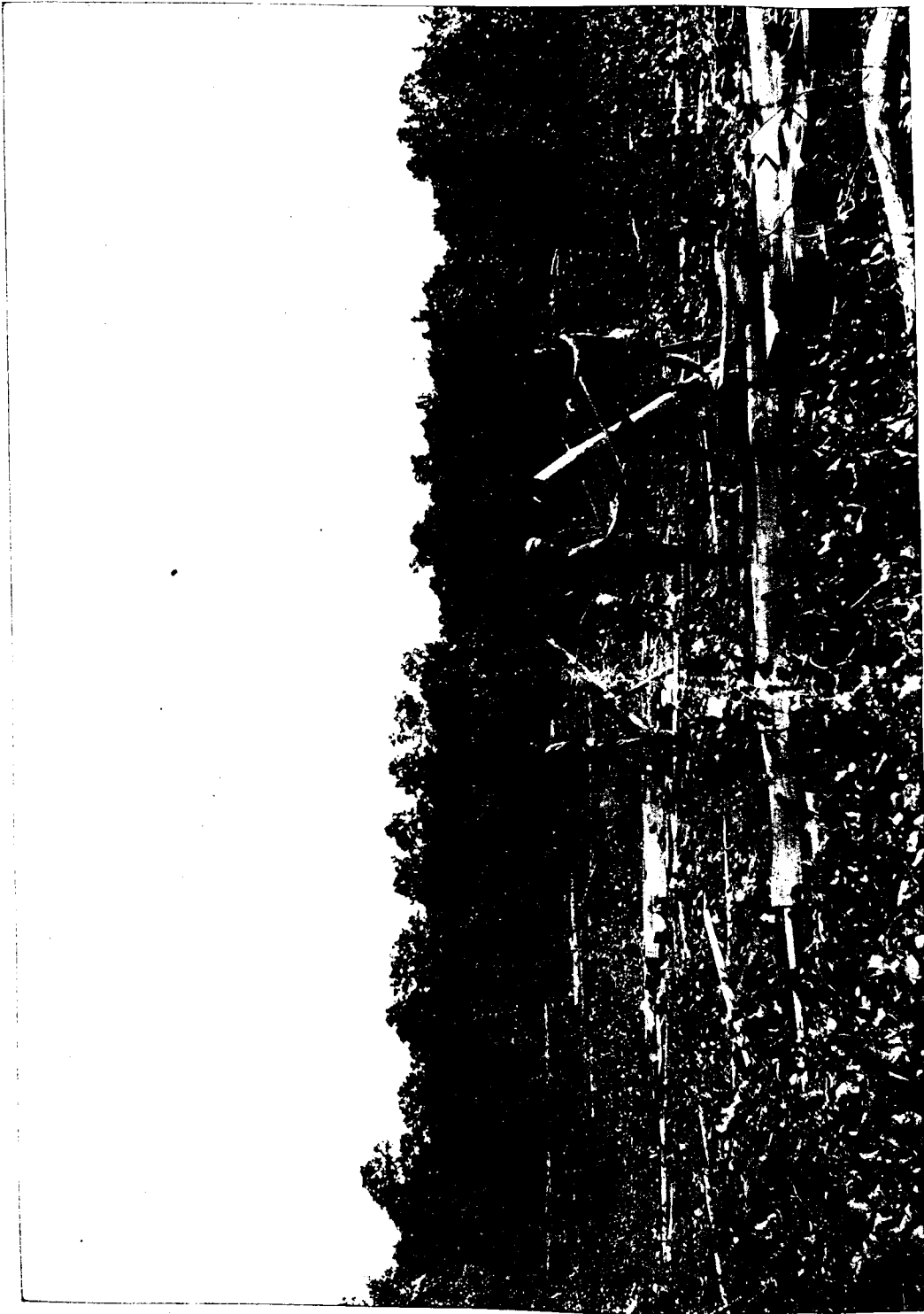


Photo by E. A. Smythies.

Clear felling system in Gorakhpur division.

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

III Quality crop of poles produce a revenue of Rs. 1,000 to 1,200 per acre.

One more example of the clear felling system may be given—the Nilambur plantations.

The system applied is clear fellings with artificial regeneration.

Demand.—There is a great demand for big timber but everything down to small poles is saleable.

Labour.—There is a very good supply of labour and the division has engaged permanent gangs and all the work is carried out departmentally. The gangs are roughly engaged as follows:—

In January and February in thinnings, etc., in March—May in preparation of soil, in June transplanting, in July—October in weedings, and fellings in November and December. A few gangs can always be spared to do extra work as it appears.

Clear fellings suit the silvicultural requirements of teak in this locality very well. Hence the essential conditions for a clear-felling system are very favourable.

Object of management—Is to obtain an equal annual sustained maximum yield.

Rotation—Is 70 years for all qualities, and is the “financial rotation.”

Exploitable size—Varies enormously between the III Quality classes.

Yield—Is fixed by area, by coupes of equal reduced areas.

Fellings—Everything is clear felled (even the undergrowth) and the logs of saleable material alone extracted. The branchwood and unsaleable stuff is allowed to dry on the areas and burnt in March and the unburnt pieces split up and heaped and reburnt. The retention of branchwood, etc., is essential to have a very fierce fire which is absolutely necessary to ensure complete success of regeneration.

Cleanings and tendings—Weeding is done in lines a foot on either side of the rows of plants and the centre 4' is left unweeded

and the uprooted weeds are thrown over it. Pruning is carried out in young plants before the branches develop woody parts.

Thinnings.—While weeding, care is taken to uproot all natural seedlings excepting those which are near the failures in order to reduce the early thinnings into mechanical operations. In the I and II Quality the thinnings start at the age of 5 and are repeated every 5 years to 15, then every 10 years to 45, when one final thinning of the nature of a heavy Increment Felling is carried out. In the III Quality, the thinnings start at the age of 10, and are repeated every 5 years until 25, then every 10 years until 45, after which no further thinnings are made. Three or four thinnings in the beginning are mechanical by the removal of 50 per cent. of trees, i.e., alternate trees in alternate rows.

In these thinnings the idea is to give equal growing space to all the trees left standing without any consideration of the final crop. The final crop only comes into consideration in the last two or three thinnings when the best stems if possible are retained for the final crop with the sacrifice of some spacing because the quality increment is enormous for bigger dimensions. The number of trees retained for the final crop is 35, 50, 70 per acre for I, II, and III Quality respectively.

Cost of formation—Is from 27 to 53 coolie units (one unit 4 to 6 annas) the difference being due to the number of weedings necessary. The 1st Quality area requires three weedings in the first year only, while the 3rd Quality may require a weeding in the 3rd year.

These three illustrations of the application of the clearfelling system to Indian conditions will suffice to explain the general procedure.

In conclusion, it will be useful to emphasise again a few points regarding the conditions required for its successful application. There are some species for which the system is practically essential, i. e., riverain species such as *sissoo* (and to a certain extent

Conclusion.

khair) which cannot regenerate naturally on the site of an old or mature crop. There are again extensive areas of scrub or semi-ruined forests, where the regeneration becomes almost afforestation in which it is advisable to remove the derelicts of the old crop to ensure that the new and even-aged crop develops under the best conditions. For example, the extensive open heavy grass Tarai forests in Kumaun, with *simal* as one of the principal species. Again, certain light-demanding species such as teak and *simal* cannot develop satisfactorily under even an open shelterwood of mother trees, and here again clear-felling is indicated if other essential factors are favourable. And, generally speaking, the clear-felling system is most satisfactory of all systems for strong light-demanders, wherever we have present the three essential conditions: (1) suitability to the silvicultural requirements of the species in that locality, (2) an intensive demand, (3) a guarantee of the immediate successful regeneration of the annual coupe.

CHAPTER VIII.

THE SHELTERWOOD SYSTEM.

WE will now proceed to consider the details of a working circle managed under this silvicultural system and to describe the present technique of the system as applied to the *sal*, *deodar*, *chir*, spruce, and silver fir. It must be understood that in the case of *sal*, spruce, silver fir, and oak no finality has yet been reached and it is probable that the technique now described will undergo considerable modifications as time passes. The system as applied to *chir* and *deodar* has given admirable results and will hardly be improved on. The advantages of this system of management have been explained in Chapter VI, but as laid down in Chapter II each forest is to be considered on its merits and the ~~most suitable system~~ of management to meet its individual requirements prescribed. The standard working plan headings have been taken and dealt with in order.

In this section is described the constitution of the working circle, the details of its area and the distribution of the compartments in relation to the geography of the Forest division. The principal species will be considered and the character of their growth and distribution, the influence of environment on quality and density of stocking, and any other details peculiar to the working circle which it is necessary to mention will be dealt with.

The details of the silviculture of the tree in relation more especially to its regeneration must be commented on in considerable detail. The methods of obtaining reproduction, the spacing of the mother trees in the regeneration area, any modifications of the standard system necessary in the special circumstances of

Constitution of the working circle and character of the vegetation.

The silvicultural system.

the working circle, all these matters must be lucidly explained. In cases like *chir*, where the standard system is well-known and published, papers are available; it is not necessary to repeat such information in working plans. The best information available at the present moment for the different species is given in the form of extracts from existing working plans.

Sal-
(*Shorea*
robusta).

⁴⁶ The system adopted is the uniform or shelterwood system, founded on Collier's Haldwani practice, since modified in the light of experience gained. Mr. Collier's theory is given in the following paragraphs:⁴⁷—"Very little knowledge has yet been acquired as to the conditions which are most favourable to the production of *sal* regeneration or as to the subsequent development of seedlings. Undoubtedly the finest uniform crops of sapling and poles are to be found over areas in which the overwood has been very heavily felled in the past. But while the instances of the kind indicate the desirability of heavy fellings over regeneration already on the ground, yet there is no evidence to show whether this regeneration appeared as a consequence of these heavy fellings or whether it was present at the time of the fellings. Apart from the necessary combination of seedfall and rainfall and assuming that the seed is fertile, the two determining factors in the production of regeneration must be conditions of light and soil. Light depends on the degree of heaviness of the fellings and it would seem an easy matter to determine its influence by an inspection of the forests. The theory that a large measure of light is necessary for the reproduction of *sal* will find support everywhere in the many blanks which are filling up with regeneration, but will fail to account for the absence of regeneration in certain forests. On the other hand there is equally strong evidence to prove that regeneration will also appear in great quantities under extremely adverse light conditions. Light appears to be of secondary importance in the regeneration of *sal* and a heavy

⁴⁶ Dehra Dun Working Plan.—BHOLA.

⁴⁷ Haldwani Working Plan.—COLLIER.

opening of the cover is certainly not necessary to obtain regeneration. In fact over the whole of periodic block I regeneration is present although overwood and underwood have been left intact for 20 years. The other factor is the condition of the 'soil' and by the term 'soil' is signified the surface soil which is solely concerned in the question of reproduction. The quality of the sub-soil can be judged later by the development of the regeneration. An enquiry into the effect of various soil conditions is also difficult, since seedlings will be present in one and absent in another, although little or no difference can be detected between the respective soils. But there is much evidence to show that a soil of loose texture particularly and of good physical qualities generally is very receptive to regeneration. After a successful seed year, reproduction is generally abundant on newly-made soil, e.g., freshly-cut roads, stream-beds, or soil wounded by pigs. The result of experiments coupled with natural evidence taken from the forests indicates that regeneration may be procured in great quantities on a fresh soil. Other experiments undertaken in other divisions were followed by similar results. It is certain that regeneration will directly follow soil-wounding. But soil-wounding over extensive areas will be so expensive as to be hardly practicable. The *sal* gives no indication of a good seed year until April and between April and the fall of the seed, soil-wounding is quite impracticable owing to the great scarcity of labour during the hot weather. It is necessary to discover some other means of assisting the production of regeneration. The writer considers that almost the chief factors in the production of regeneration is the thick layer of leaves which accumulates during the hot weather and decomposes during the rainy season. It is certain that this layer prevents great quantities of seed from reaching the soil. It is often four inches in thickness and a handful of pebbles thrown upon it will demonstrate the effective barrier it must offer against seed. In every *sal* forest it must be noticed that *sal* regeneration is more profuse in blanks

under the shade of miscellaneous undergrowth than beneath the overwood of *sal*, and it is commonly found that in this division (Haldwani) that regeneration is more profuse in the forests unprotected from fire (but immune from cattle) than in fire protected areas. The writer, therefore, prescribes the burning of the leaf layer in unregenerated areas. It will be an inexpensive and easy operation and is likely to be very successful. No harm will result, as throughout the first periodic block there are no areas of high grasses. Nor will the soil suffer injury, as the burning will not be annual but only carried out when a good seed year has occurred. In unregenerated areas the leaf layer will be burnt in the interval between the completion of leaf-fall and the beginning of seed-fall.

"The subsequent development of seedlings is as little understood as the conditions which favour their production. Profuse regeneration may follow a seedling year but die within a few months of germination. The excessive moisture which is usually associated with the earliest life of seedlings is commonly supposed to be the chief cause of mortality. But there are certainly instances in which regeneration survived the rainy season only to die in the following cold weather. No purpose is served by theorising on this seedling mortality, the causes of which are not yet understood. Of the seedlings that survive, the vast majority pass through an 'establishment period' before they show any real progress. The shoot displays no continual height growth, while the root continues to thicken until a vigorous shoot is produced which grows on into a sapling. Many theories have been advanced to explain this phenomenon. The writer has carefully examined many hundreds of seedlings growing under all conditions. Water level may be a factor in the length of the establishment period but it is probably not important, since the seedlings growing along the banks of perennial streams, seem to die back for as many years as seedlings on plateaux in which the water level is deep.



Photo by E. A. Smithies.

Shelterwood system. Sal in Haldwani Division.

Photo-Mech. Dept., Thomson College, Roorkie.

SAL (*SHOREA ROBUSTA*).

123.

"The progress of regeneration that has once become established depends entirely on the condition of light. The *sal* seems to be at once an intense shade-bearer and a keen light-demander. For reproduction will persist for many years under a complete overwood and a dense underwood and will respond to the admission of light in an extraordinary manner. It will be invariably noticed that the most vigorous regeneration occurs in blanks in the forest or in areas in which the overwood is very thin. The development of the uniform crop in the Jaulasal east block (Haldwani) indicates the desirability of heavy fellings over reproduction and there is similar evidence in Kheri, Bahraich, and Ramnagar divisions. The progress of established regeneration seems to vary inversely with the density of the overhead cover, and it is probable that the overwood can hardly be felled too heavily in areas where established seedlings are present in sufficient quantities and in which frost and other forms of damage are not likely to be severe.

"The whole process of regeneration of a wood can therefore be divided into three stages:—

- (a) Regeneration may be obtained without any felling of the overwood or cleaning of the underwood. There is no evidence to show whether the excellent regeneration which occurs in areas which have been felled over heavily in the past existed before the fellings or ensued as a direct consequence of the felling.
- (b) On the appearance of seedlings some degree of light should be admitted by removal of a portion of the underwood and overwood. It is very important that this admission of light should be gradual, since it has been noticed that seedlings which have germinated and spent their first growing season in shade tend to wither off too suddenly exposed to sunlight.⁴⁸

⁴⁸ This opinion has since been modified by research—C. G. T.

- (c) Over established reproduction the overwood can hardly be felled too heavily except in areas in which possibility of frost damage prohibits the absolute clearings of overwood over too wide areas."

Since the above was written much further light has been thrown on the problem of the regeneration of *sal*. An essay in the *Indian Forester* on "Natural Regeneration"⁴⁹ summarises the factors necessary to regeneration and deals with the somewhat divergent views at that time existing. Hole has examined in detail the whole subject of the oecology of *sal*⁵⁰ and has thrown considerable light on the development of the seedling. The *Forest Pocket Book* contains the latest information available in the Research Circle which goes to show that—

- (1) Burning the leaf layer induces profuse reproduction.
- (2) Under a close canopy this reproduction gradually fades away and largely disappears.
- (3) With somewhat heavy opening of the canopy seedlings already on the ground improve greatly, stop dying back and start to grow up.

The last conclusion is not yet absolutely proved, but all the silvicultural experiments tend to show that this is so.

In the particular conditions of Dehra Dun a great deal of the new regeneration will consist of coppice from the great quantity of suppressed advance growth already existing on the ground. This is considered just as desirable as seedling reproduction; consequently where this state of affairs exists all that is necessary is to select the seed trees for retention and to cut everything else. This has been done experimentally with very excellent results as may be seen at Lachiwala.

The silvicultural system therefore resolves itself into regeneration under a shelterwood either by coppice or seed and the retention of the overwood for so long as it is required for seed production or as a frost protection to the new crop.

⁴⁹ Natural Regeneration—*Indian Forester*, October, 1921.—Trowsford.

⁵⁰ *Indian Forest Records*, Vol. V, part IV, Vol. VIII, part II, Oecology of *Sal*.—Hole.

⁵¹ No rigid adherence to the theoretical principles of the regular or shelterwood compartment system will be insisted on. In many cases it may be possible to carry out *in toto* the principle of this system; in many others however owing to the existence of groups or large patches of canopied poles and saplings it will be necessary to regenerate by amalgamating the theory of the shelterwood and group systems. Strip fellings against the sun may also be tried on south and south-west aspects where considered of advantage. Generally wherever practicable a single seeding felling should be made over the whole area to be regenerated, good groups of advance growth or canopied patches of saplings or young poles being retained to form part of the future crop. Within the limitations, the execution of the necessary regeneration felling will be left to the silvicultural knowledge of the marking officer, who will so manipulate the canopy of the mother trees that regeneration is obtained and at the same time an undue growth of weeds prevented. This manipulation of the canopy will necessarily vary according to the species dealt with. It would be absurd to lay down any dogmatic system of management in dealing with species so different in their silvicultural requirements as the *chir* and silver fir. Every species comprised in the Regular and Fir Working Circles will be dealt with according to its own individual requirements.

"The essence of silviculture is to grow each species of tree in the locality most suitable to it. While making every effort to increase up to the desired maximum the proportion of *deodar* in the mixed forests in all localities suitable to this species, no endeavour will be made to grow exclusively *deodar* in forests now occupied by other trees. The mixed character of the crop will be maintained and, taking nature as a guide, the whole area placed in periodic block no. 1 will be regenerated with that species most suitable to the different factors of the locality found in each compartment. In places not suitable to the growth of coniferous

⁵¹ *Kulu Working Plan*.—TREVOR.

trees, walnut and ash will be substituted for the inferior trees now cumbering the ground, and the resultant crop will, it is hoped, be one in which all species are represented, each growing in that portion of the forest most suited to its individual requirements; all together growing up to form an even-aged fully stocked wood, putting on the maximum annual increment and, when mature, yielding a revenue per acre far in excess of anything contemplated in the past.

"The silviculture of the *deodar* has received the most earnest attention for many years past, and during the last seven years continual thought has been bestowed on the most suitable method of obtaining regeneration, and the peculiarities and requirements of this tree from the germination of the seed until the establishment of the young crop. On north, north-east, and north-west aspects at ordinary elevations experience has shown that for *deodar* the ordinary seeding felling, leaving the mother trees equally spaced at an approximate distance of 50 feet will give the most excellent results. The espacement must of course vary according to the size of the mother trees and the aspect dealt with, and this can only be rightly attained by the eye of experience. Two diametrically opposite considerations have to be compromised: (1) the necessity for retaining sufficient trees to keep down the growth of weeds and to produce an ample crop of seed, at the same time sheltering the young growth; and (2) the necessity of removing all cover not absolutely necessary, so that the subsequent fellings of the overwood will do as little damage as possible to the young regeneration. On south, south-east, and south-west aspects the difficulty of obtaining regeneration is much increased and on these aspects the necessity of side shade to the young plant must be kept in view. The case of the Dhamsu Kalaun forest has clearly demonstrated the necessity for side shade in the case of these sunny aspects. The profuse *deodar* regeneration existing throughout the spring and summer of 1915 has largely disappeared from situations devoid of side shade, while where this assistance

has been provided the seedlings are in good condition. In such situations the utmost skill in opening the canopy will be necessary and here regeneration by strips may well be tried. It must be remembered that while *deodar* seed will germinate under any sort of canopy, the young seedlings, must receive sufficient light if they are to flourish, and if this is not provided in due season absolute failure of regeneration will result. *Deodar* is in no sense a shade bearer except for the first year or its life; it requires protection from drought and consequently on certain aspects some extent of side shade, but having once passed the critical stage of the first few years this tree demands ample light. Except where mother trees are left to put on increment there is no object to retaining an overwood once reproduction is fully established, i.e. when it has attained an average age of between 5 and 10 years.

"The *kail* or blue pine is a light-demander and its natural regeneration generally presents no great difficulty when once this is realised. A bright seeding felling leaving the mother trees about 60–70 feet apart is necessary; and experience has shown that even where sufficient light had been provided for the existence of *deodar*, *kail* reproduction was not obtained until the canopy was well opened out. An excellent method of regenerating mixed crops is thus placed at our disposal. It is only necessary to make first a seeding felling suitable for the reproduction of the *deodar*, and thereafter to lighten the overwood so that *kail* seedlings complete the crop. A word of caution is necessary against the clear-felling of large gaps which has at times been perpetrated under selection in groups, for the result of this has been a profuse growth of weeds which has necessitated much labour and expense in sowing and planting.

"*Deodar* germinates under all conditions of light and shade, but the time soon comes when seedling growing in shade must be given plenty of light if they are to survive.

"The great mortality from drought is largely due to the excessive accumulation of humus on the ground. When this cause is

absent it is due to the direct rays of the sun drying up the soil, and on such aspects there can be no question of the value of some side shade and of the light canopy of the mother trees, provided all low-spreading branches have been pruned off, but this side shade must not be allowed to continue too long or harm will result. There should be nothing to keep the rain off the young plants, but a growth of weeds and low shrubs in the regeneration area, provided these are not allowed to swamp the reproduction, appears to be beneficial in collecting the dew and shading the little tree.

*Chir or
chil
(Pinus
longi-
folia).*

“The silviculture of the *chir* is already well-known. It is a greater light-demander than the *kail* and the success of the silvicultural system now adopted has already been proved in practice. It is only necessary to say that a bright seeding felling is generally necessary in Kulu, where this species is growing at an average elevation of 5,000 feet; and that old large crowned trees should be selected as seed-bearers and spaced about 80 to 100 feet apart. For the sake of completeness the following extract from Troup's excellent monograph on this pine⁵² is reproduced below:—“The *chir* pine is one of the most light-demanding of species and under favourable conditions the more light admitted the more successful and complete will be the regeneration. It may be said that in ordinary favourable circumstances 5 to 8 good seed-bearers per acre are ample for effecting complete regeneration; and that a greater number are not only unnecessary, but may even be detrimental to the establishment of a healthy young crop. This statement, however, should not be taken to apply universally. Thus on hot slopes where the soil is stiff and the seedlings are liable to suffer from isolation, protective shade is essential and the demand for such protection may outweigh the demand for light. There are instances in the Rawalpindi division, where the slopes are hot and the soil is clayey, of good reproduction establishing

⁵² *Pinus longifolia*—Forest memoir.—TROUP.

itself under an almost complete canopy. We may therefore qualify the general statement made above by saying that where protection against drought is necessary, the number of seed-bearers per acre may have to be increased very considerably; it may also be stated that on southern slopes as a rule a larger number of seed-bearers are required than on northerly aspects.

“In Jaunsar⁵³ *chir* regeneration is exceptionally easy to obtain, provided the area can be protected for 15 or 20 years from fire. In favourable localities fire protection alone will bring up young *chir* like a weed under almost any degree of cover and light grazing probably assists rather than hinders the process. Anything in the nature of heavy grazing is harmful.

“Although regeneration will spring up under almost any cover in favourable localities, i.e., on north aspects or in sheltered bays, a really heavy opening of the canopy gives the best results. As a hint the seeding felling should leave the mother trees 4 to 7 crowns width apart. About six good seed-bearers to the acre are sufficient, but as some of the mother trees are sure to die it is better to start with about seven to the acre. A secondary felling may be made if necessary, but this will not always be required. So soon as the young growth is three to five feet high the whole of the overwood should be removed, and if a fire occurs, then the area must be artificially regenerated.

“On unfavourable areas, usually hot dry slopes with shallow soil, the above simple procedure cannot be adopted. Fire protection on such areas has often failed to produce adequate regeneration, and yet there is plenty of light. Young *chir* are susceptible to drought, and it is probable that in such places drought and excessive transpiration largely account for the lack of young seedlings. On such areas even light grazing is harmful. Here a heavy opening of the canopy probably does more harm than good, and if the canopy were denser perhaps regeneration would appear.

⁵³ *Working Plan for Jaunsar Bawar*—HOWARD.

It is possible that strips felling against the sun would solve the difficulty, but the regeneration of these unfavourable areas is a question which still awaits solution.

"The ideal seed-bearer for *chir* is a mature tree with a good rounded crown.. The younger trees with pointed crowns usually bear less seed, though in Jaunsar a crop of such younger trees does apparently bear enough to restock an area with seedlings within 20 or 30 years. Abundant seed occurs every third or fourth year.

*Spruce
and silver
fir. (Picea
Morinda,
Abies
Pindrow.)*

"The knowledge of the silvicultural requirements of the Indian spruce and silver fir⁵⁴ is at present very limited, and the possibility of exploiting these species, which now for the first time presents itself, will be utilised to try various methods of regeneration and various amounts of illumination of the soil with a view to the discovery of the exact silvicultural requirements and peculiarities of these trees and the most suitable way of inducing their reproduction. It is believed that it will be found that the admittance of considerable light will be necessary to obtain the natural reproduction of the spruce, indeed all the observations and experiments so far made go to show that this tree requires as much light as *deodar* and it has been observed that while seedlings of silver fir will persist in dense shade, yet their development under these conditions is much retarded, even to such extent that saplings 20 feet in height have been found to exceed 40 years in age. It is believed that at the high elevation at which it grows even the silver fir will require a certain amount of illumination in order to induce its natural reproduction and that once reproduction has been obtained, full light will be necessary for its proper growth and development. Whenever patches of advance growth may be found there is no reason why the principles of the group system should not be made use of, and the advance growth thus found utilised as the nucleus of a future group. Generally as in the case of the Regular Circle, the marking officer will so manipulate the canopy of the mother trees as to obtain natural

⁵⁴ Kulu Working Plan—TREVOR.

SPRUCE AND SILVER FIR (PICEA MORINDA, ABIES PINDROW) 131

reproduction, at the same time preventing the growth of noxious weeds. No precise method of executing the regeneration felling is laid down; it will be enough to prescribe that regeneration fellings will be made, leaving it to the knowledge and experience of the local staff to decide in each and every case the amount of illumination desirable and most suitable manner in which the felling should be carried out."

A periodic block is the part of a forest set aside to be treated during a period or number of years into which the rotation is divided. Each periodic block will be regenerated in its turn during the lapse of one period so that the length of each period should correspond with the time necessary to regenerate a given area of forest under the principles of the silvicultural system with which we are dealing. For instance, a *sal* working circle such as the Conversion to Uniform Working Circle of Collier's Haldwani Working Plan with a rotation of 120 years and a regeneration period of 20 years is in theory divided into six periods, e.g., $\frac{120}{20} = 6$: each of 20 years' duration. With a normal distribution of the ~~age classes the ages of the crops~~ in the different periods would be as follows immediately before commencing work under a new working plan:—

*Division
into
periods.*

I Period	Age of crop	101—120 years.
II "	"	81—100 "
III "	"	61— 80 "
IV "	"	41— 60 "
V "	"	21— 40 "
VI "	"	1— 20 "

Such a theoretical distribution of the age classes hardly ever exists in practice. Collier only allotted periodic blocks I, II, and VI, prescribing special treatment in each case and lumping blocks II, IV, and V together for treatment. Subsequently Collier revised this arrangement, reducing the rotation to 90 years and the number of the periodic blocks to three. No useful purpose is served by an attempt to make a complete allotment to six periods as was

attempted by Troup in his Thano Working Plan: such an arrangement never lasts and is unnecessary. With the frequent revision of plans now possible in the United Provinces it generally suffices to allot the regeneration area and to re-distribute this at subsequent revisions on the lines of the French "*quartier bleu*" system. In Ranikhet, Naini Tal, and Central Almora the *chir* pine is managed on a rotation of 120 years divided into five periods of 24 years, of which only periodic block I is completely allotted. Similarly, the Regular Working Circle of Kulu consisting of *deodar* and its associated species is managed on a rotation of 120 years divided into four periods of 30 years, of which only periodic block I is allotted. The latest *sai* plans with a rotation of 90 years are divided into three periods of 30 years, of which only the regeneration area is usually completely allotted. The number of periodic blocks will naturally vary with the rotation and the different broad age classes constituting the working circle. Thus in the Chuka Working Circle of Pilibhit there is no difficulty in allotting the entire working circle to 3 periods.

Similarly, there is no necessity that the periodic blocks should consist of continuous compartments or of compartments forming together one continuous mass of forest. Circumstances may arise in which this arrangement of self-contained blocks follows naturally as in the Chuka and Thano working circles of Pilibhit and Dehra Dun divisions. As a rule however each compartment will be allotted to its period entirely on its own merits without reference to neighbouring compartments. The oldest crops will naturally be allotted to periodic block no. I for regeneration and the youngest to the last period. This allotment requires a certain amount of give and take; certain crops have to be regenerated out of their turn and provided the working plan officer makes arrangements to equalise the yield in the different periods and exercises his professional knowledge and common sense in the allotment of the regeneration area, nothing more can be expected.

It has been mentioned above that the working plan officer must arrange to equalise the yield in the different periods. This is a matter which has not received sufficient attention in several working plans, where the best quality sites were all allotted to periodic block no. I and the worst to other periods, which must result in the future in a decreased yield. Where the periods are distributed over the whole area of the working circle, consisting of both good and bad compartments in similar proportions, so that the average quality class of the crops contained in the various periods is approximately the same and the area of the several periodic blocks approximately equal, no great necessity for a system of reduced areas arises. In other cases steps must be taken to reduce every compartment to the same standard of productivity. This may be done in a comparatively small working circle such as Chuka by the working plan officer taking the best areas as = 1 and the other compartments as = .8 or .6 as the case may be. The reduced area of every compartment is then calculated and equal reduced areas allotted to each period.

*Reduced
areas.*

It has already been shown in chapter III that the different yield capacity of the different quality classes shown in the yield table is demonstrated by the differences in the M. A. I. It is obviously impossible to adopt fixed figures of yield capacity for different divisions or Working Circles in the province, since variations in the rotation will vary the figures, and also there will be considerable differences if timber production only is considered or if total wood production is reckoned on. And again with close and intensive management the broad quality classes of the yield table may require sub-division into intermediate classes, especially where the qualities of different compartments vary appreciably but not enormously. Every working plan officer will have to consider the peculiar conditions of the area he is dealing with, and from the data and yield tables available, work out

suitable yield capacity ratios. The following figures from the *sal* yield table are given as examples :—

(1) *Timber production only considered.*

		(a) Rotation 80 years.			(b) Rotation 100 years.		
		Quality class I.	Quality class II.	Quality class III.	Quality class I.	Quality class II.	Quality class III.
M. A. I. c. ft. ..	..	88.2	55.6	31.5	85.4	55.6	32.3
Yield capacity ..	..	2.80	1.76	1.00	2.64	1.72	1.00
or		1.59	1.00	.57	1.53	1.00	.58

(2) *Total wood production considered.*

		(a) Rotation 50 years.			(b) Rotation 50 years.		
		Quality class I.	Quality class II.	Quality class III.	Inter-mediate I/II.	Average II.	Inter-mediate II/III.
M. A. I. c. ft. ..	..	168.2	117.0	77.3	142.6	117.0	97.1
Yield capacity ..	..	2.17	1.53	1.00	1.47	1.20	1.00
or		1.43	1.00	.66	..	..	..

The method of using these factors of equiproductive capacity is sufficiently obvious to require no elaborate explanation. The map or measured actual area of a compartment is multiplied by the factor of that quality class to which the compartment has been allotted in order to get the "reduced" area of the compartment. Taking the figures in (2) (b) above :—

Compartment no.	Actual area.	Quality class.	Factor.	Reduced area.
	Acres.			Acres.
1	100	I/II	1.47	147
2	100	II	1.20	120
3	100	II/III	1.00	100
4	100	III	.80	80

It is customary to reduce to unity that quality class which is most abundant in the area being dealt with. The reduced areas so obtained are used in allotment to periodic blocks, to ensure as far as possible that the periodic blocks are equiproductive, though

not necessarily of equal area, so that if the average quality class of the crops contained in the various periods is approximately the same and the area of the several periodic blocks approximately equal, no great necessity for a system of reduced areas arises. In other cases steps must be taken to reduce every compartment to the same standard of productivity. This may be done in a comparatively small working circle such as Chuka by the working plan officer taking the best areas as =1 and the other compartments as =.8 or .6, as the case may be. The reduced area of every compartment is then calculated and equal reduced areas allotted to each period.

This will usually be made by the method of volume and area based on periods, vide Chapter VI. Either special volume tables must be prepared from the provincial tables showing the figures for the average quality of the locality, or the figures for the quality class corresponding most nearly to the average of the working circle may be adopted. Alternately where each compartment has been allotted to a definite quality class as in Dehra Dun division, the figures for that quality class will be used both in calculating the yield and in felling against it.

Under certain circumstances where the yield in volume for the whole working circle is required, Heyer's or Blanford's modification of Von Mantel's formula may be adopted, although the latter is more suited to selection forests.

Extracts from working plans for the different species are given below :—

"No sequence of fellings is laid down; it is only prescribed that in the regeneration area periodic blocks I and VI, the Divisional Forest Officer will carry out fellings when and where he considers them most desirable, subject to the prescribed annual yield. He is permitted to depart from this in any year up to a limit of plus or minus 10 per cent. without further sanction, the excess or deficit being brought forward in the control form.

"There is no hard and fast rule regarding what is overwood and what regeneration. Complete uniformity is not aimed at;

Calculation of the yield.

Methods of executing the fellings. Sal in Dehra Dun.

it will suffice if this is obtained into two rotations. Single trees of any size are not wanted among the future crop but groups of good poles not bigger than about 8 inches diameter covering a sufficient large area may be kept to form part of the future crop if this is considered desirable. Irregular patchy pole crops are not required and should be regenerated. Where the advance growth has been rendered worthless by suppression or by the great frost of 1905, it should be clear felled and allowed to come up again as coppice.

Marking
rules.

"Regeneration fellings (periodic blocks I and VI combined)—

- (1) If the existing regeneration is good, it should be opened out uniformly by removing the overhead cover.
- (2) If the existing regeneration is badly grown, damaged by suppression or by the frost of 1905, it should be cut back. The overwood is not cut back wholesale; 20 to 25 well grown trees per acre properly distributed over the area should be reserved for protection and seed.
- (3) Where regeneration does not exist at present, a moderate seeding felling will be carried out among the dominant and dominating trees, removing at the same time suppressed *sal* and other trees of the main crop.
- (4) In the above three conditions a shelter of miscellaneous trees, such as *sandan*, in the middle canopy will be required for some time after regeneration has appeared. Such trees should not therefore be ruthlessly destroyed.
- (5) As regeneration becomes established, the felling will become heavier until the overwood is entirely removed. Where established large regeneration already exists, removal of the overwood should be drastic and the young crop thinned and cleaned.
- (6) As a rule pure *sal* is not aimed at; seed-bearers of *sain*, *bakli*, *haldu*, *bahera*, *chir*, etc., may be selected, wherever desirable.

- (7) All badly shaped trees in the main crop should be removed wherever they can be spared, remembering that the bad characters of the mother trees are transmitted to their offspring and that regeneration from the best trees in the crop is desired.
- (8) Groups of well-grown saplings and poles of not more than 8 inches diameter and covering an area of not less than one square chain, should be reserved to form part of the future crop, thinned and cleaned. Once it has been decided to keep a group, no attempt should be made later on to regenerate it unless the first selection was obviously faulty.
- (9) In felling trees over well-grown reproduction, every possible precaution such as lopping and skilful felling should be taken to minimize the damage to the young crop."

"No sequence of felling is laid down; the Divisional Officer, subject to such directions as the Controlling Officer may issue, will fell within periodic block no. I when and where he pleases. He is permitted to depart from the prescribed annual yield in any year up to 25 per cent. plus or minus so that the work in hand in any compartment may not be hampered. Any excess or deficit which may occur will be brought forward every year in the control forms. Neither the number of fellings necessary to regenerate a compartment nor the method of executing them is rigidly prescribed. The details of the silvicultural system have already been explained; beyond this it is only prescribed that regeneration fellings will be made.

"The volume being based on the enumeration of all trees 12 inches in diameter and over, it follows that the volume of all trees of this size felled must be counted against the prescribed yield. It is not, however, prescribed that all trees 12 inches and above will necessarily be felled: this must depend on circumstances, and while single trees of any size are not wanted among the future crop, fine groups of trees in the neighbourhood of 12 inches

Deodar.
Kulu
Working
Plan.

diameter covering a sufficiently large area may be retained if this is considered desirable.

"The secondary fellings should in most cases be made when the young crop is from 4 to 6 feet high, as the damage done is then less than when the regeneration is smaller.

"The maintenance of the mixture in mixed woods is prescribed. Pure *deodar* may remain as such, and pure *kail* at suitable elevations should be regenerated with a mixture of *kail* and *deodar*; in all cases a good proportion of *deodar* is to be introduced into the new crop in all suitable situations, but money is not to be wasted on planting trees in places where nature never intended them to grow.

"The proper selection of the mother trees is a matter which of course will receive the greatest attention. As already mentioned in the case of *chir*, the old large crowned trees should invariably be selected, and not the younger conical crowned immature trees which do not produce sufficient seed. In the case of other species this consideration is not of such vital importance but good healthy large crowned trees should be selected and not trees with long stems and attenuated crowns, which will promptly be blown down. Compared to the reduction of seed the consideration of the increment to be put on by the mother trees during the time they stand in the regeneration area is a matter of secondary importance; and it should be remembered that medium-sized trees will do less harm when subsequently felled than trees of enormous size. These latter should generally come out in the seeding felling."

"The areas selected for periodic block I already carry more or less established regeneration and the markings must accordingly aim at regularizing and completing this, and freeing it from overhead cover to allow it to grow up as uniformly as possible. The most difficult question is that of fire insurance, but it is considered that in view of that fact that all the mother trees will carry several resin channels the majority will be killed by a fire sufficiently severe to kill the regeneration, and consequently

Chir.
Ranikhet
Working
*Plan.*⁵⁶

⁵⁶ *Ranikhet Working Plan* — CHAMPION

nothing is gained by retaining them once the regeneration below them is as complete as can be expected or is desired. The following marking rules for periodic block I are accordingly prescribed:—

"1. Where regeneration is absent or deficient, the most suitable trees for regeneration purposes (with long clean boles and good but not too branchy crowns) will be retained with an average spacing of from 23 to 28 yards according to local requirements and the quality of the trees, all the remainder of the overcrop being marked for removal.

"2. Where a choice is possible between straight and twisted trees as seed-bearers, the former should always be selected. The damage likely to be done in felling must also be borne in mind.

"3. Large overmature trees, when standing over sufficient established regeneration will be marked. For this purpose "sufficient" must be taken as meaning not less than plant to every 4 square yards approximately, and 'established' as having a height of not less than 2 feet, and although these definitions cannot be taken rigidly, no large deviation can be permitted.

"Groups of poles under 3 feet in girth will be retained as part of the new crop when they are of fair to good quality and uniformity, and not less than $\frac{1}{4}$ acre in extent. Such groups will be thinned where necessary.

"Inferior groups of immature trees will be considered as overcrop and dealt with under rule 1 (though a somewhat closer spacing should be given), except when the marking officer is of opinion that, owing to bad ground, he is unlikely even with the subsidiary operations prescribed, to increase the general uniformity by making fellings. In such cases only those trees will be marked which are or are likely to become injurious to the surrounding younger crop.

"Broad-leaved species may be retained along damp nalas for protection of water-supply, but will otherwise all be marked."

First
regenera-
tion
fellings in
chir.

"In order to attain the object of management, the following marking rules are proposed:—

"1. Ten to fifteen oak trees per acre will be selected as seed-bearers, the spacing being 22 to 15 yards.

"2. As far as possible sound thrifty trees of medium size and of good height growth will be so retained and trees which are low-branching, unsound, or large and overmature, will be avoided: no minimum girth limit can be prescribed, but ordinarily the seed-bearers should be over 2 feet in girth.

"3. Within the limits of rule 1, the precise number of trees to be selected will depend on their quality as seed-bearers; on the aspect and quality of the locality and on the amount of regeneration (including potential coppice) already existing. Obviously seed trees will not be retained over complete regeneration or over poles retained under the following rule 4 (b).

"4. All other oak will be felled with the following exceptions:—

(a) On ridges and other places where the soil is hard and shallow, and nothing can be expected to replace what is removed: here fellings must be very light until regeneration becomes established.

(b) Groups of young trees under 2 feet girth when of good quality and density should be retained at the discretion of the marking officer when he considers he is likely to improve the quality and uniformity of the crop by retaining them. Such groups should not be less than 2 square chains and will be marked for thinning if requiring it. When in doubt they should be marked for removal, reliance being placed on a new coppice crop.

"5. *Kokat* trees will all be felled with the following exceptions:—

(a) Where their removal will seriously expose the soil, especially on south aspects and poor localities: here a few may be retained both for their own value and for seed production.

(b) Where there is only a small proportion of oak, any deficiency of seed-bearers will be made up from among the better *kokat* species including rhododendron.

(c) In *nalas* and on wet ground, where conditions are unfavourable for *banj*, *kokat* may be encouraged, especially of the following species:—Alder, cherry, hornbeam and birch, and fellings will be made to favour these.

"6. The conversion markings should be made down to the limit utilizable for charcoal, i.e., 1 foot girth for oak and 2 feet for *kokat*."

This is frequently suggested, never prescribed in the regeneration area; the intermediate yields are realized by area and a table of fellings has to be provided. *Order of fellings.*

This most important operation has been standardized in the Kulu coniferous forests where, after the completion of the first regeneration fellings, all rubbish, bushes, inferior trees, raw humus, exploitation refuse and suppressed advance growth are collected and ~~burnt, and the soil placed in a suitable condition to receive the seed.~~ *The burning of slash.* This may necessitate hoeing with the prolonged vine hoe already in use.

Similar methods are already employed in other hill divisions. The heavy slash is piled by hand, the smaller twigs raked together and the whole burnt in heaps starting from the top of the hill.

With *sal* the disposal of slash is of equal importance. The burning of heavy slash *in situ* has been tried and the fierce fire resulting not only damaged the mother trees but destroyed a lot of the *sal* advance growth already on the ground which was wanted to coppice. It is now certain that the bigger slash must be disposed of, preferably by encouraging charcoal burning, before any departmental burning of the regeneration area takes place. A light fire will harm neither the mother trees nor the *sal* advance growth, the latter will be burnt back and coppice vigorously which is what is required.

(Regeneration area—Periodic Blocks I and VI.)

"In the year following the main fellings, the area should be gone over carefully and the following works carried out to such extent as may be required :—

- (1) Removing marked trees left standing by purchasers.
- (2) Cutting back in groups, saplings and poles damaged in the fellings or badly developed.
- (3) Completing the thinning and cleaning in the sapling and pole groups retained as part of the future crop.
- (4) Cutting back all undesirable advance growth with a view to obtaining evenaged groups of regeneration and a homogeneous crop.
- (5) Removing trees and miscellaneous undergrowth interfering with the development of the future crop.
- (6) Lightening the shade of the miscellaneous trees in the middle canopy where this shade is still considered necessary and removing it altogether where no longer required.
- (7) *Climber cutting.*—Climbers should, as far as possible, be poisoned to death once for all.
- (8) Burning the leaf layer in good seed years between the fall of the leaf and the ripening of the seed, in order to stimulate regeneration where it is insufficient or entirely wanting.
- (9) Areas in which the soil has been rendered too stiff by constant grazing or other causes to allow the seed to germinate should be ploughed after burning the leaf layer and if regeneration from seed-bearers is obviously impossible in such area, *sal*, *sain*, *jaman*, *bakli* or *chir* according to the condition of the locality should be sown.
- (10) Small blanks in the regeneration area should be burnt and sown with *sal*, *sain*, *jaman*, *bakli* or *chir*, if necessary after ploughing or hoeing the ground.

Subsidiary silvicultural regulations. Sal in Dehra Dun.

Plate 11.



Photo by E. A. Smythies.

Strip felling, Lakhmanmandi, Haldwani Division.

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

“ Operations (5) to (10) above should be repeated year after year to the extent required, at the discretion of the Divisional Forest Officer until the area is fully regenerated. It is the duty of the Divisional Forest Officer to obtain complete regeneration of the regeneration area and keep it tended when obtained and he should issue orders for carrying out any works he may consider necessary to stimulate or to benefit the young crop.

“ *Sal* should be sown broadcast and the seed covered half an inch with earth. *Sain* and *jaman* should be sown on raised mounds. *Sain* seed should not be covered, but *jaman* seed may be covered about an inch. *Chir* should be simply dibbled in and lightly covered with earth.”

“ It has already been emphasized that, with one or two noteworthy exceptions, far from sufficient attention has been paid in the past to the carrying out of the necessary operations subsidiary to the regeneration fellings. A very high degree of importance is attached to the proper carrying of such work, in fact without it the advocated objects of management will not be attained.

~~“ Whenever necessary and possible, large trees should be lopped before being felled and an expenditure of Rs. 2 to Rs. 3 per acre on this work is fully justified.~~

“ Experience has shown that under the conditions prevalent in these forests, to obtain reasonably complete and uniform regeneration of *chir* a great deal of care is required in encouraging natural seedlings and no small degree of artificial assistance, *which assistance must be given at an early date.* To this end the following works are prescribed in the year after the fellings, or in the case of sowing in the first rains after them, when seed is available :—

- (1) The removal of marked trees left standing, unless their retention now seems desirable.
- (2) The removal of all bad advance growth, etc., too small to have been marked.
- (3) Cutting back of injured stems as far as required for the benefit of the surrounding crop.

*Chir.
Ranikhet
Working
Plan.*

(4) Thinning and cleaning the regeneration wherever required.

(5) Sowing up of blanks devoid of seed trees and as far as possible of areas with few or poor seed trees.

"Owing to the difficulty of seed-supply it is important to make the maximum use of what is available, in which matter there is room for considerable improvement in the present standard of work. The patch method with 5' x 6' spacing and three to four seeds per patch is recommended and the patches are only to be put where the resultant seedlings have a reasonable chance of growing up. Weedings are not usually required."

"On the completion of the fellings, the area must be worked over a second time to effect a thorough cleaning up of the coupe, on the following lines:—

- (1) Any remaining marked trees will be felled unless in view of the results of the fellings, their retention now appears advisable.
- (2) Existing regeneration will be freed by removal of felling debris, and by felling all small *kokat* standing over it, or likely to interfere with its development.
- (3) Damaged or badly shaped regeneration, and all isolated young stems not removed in the main fellings, will be cut back for coppice.
- (4) Groups of young poles retained as part of the new crop will be cleaned and thinned as far as necessary.

"Subsequent cleanings must be done as necessary at the discretion of the Divisional Forest Officer and it is probable that they will have to be made at least once more.

"The cleanings will be followed by the sowing up of all the larger blanks, where natural regeneration seems unlikely to come in; and if sufficient seed is available, sowings to assist natural regeneration even where seed-bearers exist (as on kiln sites) should be made.

"Where *moru* occurs naturally, it should be sown in preference to *banj*, and it may also be tried on cool aspects with good soil at altitudes above 6,000 feet. Owing to the number of pig, birds, etc., in these forests, the seed should be dibbled in."

CHAPTER IX.

THE SELECTION SYSTEM.

*The
system
as
existing
in the
past in
India.*

THIS system as carried out up to a few years ago consisted in fixing an exploitable size and removing trees of these dimensions in selection fellings by area or by a fixed number of trees. Trees of smaller dimensions, if unsound, inferior or actually doing harm, were cut in improvement fellings. Where a number of trees were fixed, a stand table was prepared showing the distribution of the diameter classes, and growth figures were compiled showing the time taken for the trees to pass from one diameter class to the next; figures were also estimated for the mortality suffered by each class as it passes into the next class. The yield was then calculated on the basis of the number of class I (exploitable trees), the number of class II (trees approaching maturity), and the time taken for the latter to pass into class I; the result was a number of trees based on the relative numbers of the trees of the different classes, but without any reference to their distribution on the ground. This yield was then apportioned to certain definite areas in each year of the felling cycle.

Now the mere number of trees of the different diameter classes in the whole working circle gives no idea whatever of whether their distribution on the ground is in accordance with the principles of the selection system. In the area of the annual coupe the class I trees may exist in a crop of open canopy with no regeneration; the youngest age class may be in dense masses and the class II trees may be scattered through the crop either as overwood suppressing the masses of young growth or as inferior specimens mixed up with but probably of the same age as the class I trees. On paper the distribution of the age classes is satisfactory,



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

Artificial regeneration of Sal, Gorakhpur Division, showing adverse affects of side shade on seedling development.

Photo by E. A. Smythies.

while on the ground the removal of the definite number of class I trees prescribed and the neglect to remove class II trees or thin the masses of young growth results in a felling opposed to every requirement of silviculture. This is not an imaginary state of affairs; it has been personally met with on more than one occasion in the *deodar* forests of the Himalayas and is not unknown elsewhere. The result of subordinating silviculture to arithmetic results either in prescriptions of the plan being carried out to the neglect of silviculture or to a silvicultural felling being made regardless of the prescribed yield of the working plan.

It may be argued that the above defects are eliminated when the fellings are entirely by area with no prescribed number of trees. This is so, but another error is introduced in that it is entirely unknown whether the actual yield of the forest is being obtained or not. It is highly probable, more especially in virgin forests that very much more than the true yield will be removed; on the other hand under very conservative management very much less than the yield may be felled. The yield is largely at the mercy of the personal opinions and idiosyncracies of the executive officer in charge and it is not right that the whole future of the forest should be dependent on this.

The present tendency is to convert forests worked under the selection system to evenaged forest under the shelterwood system. Several cases arise, however, in which the character of the growing stock does not lend itself to this conversion or in which the physical aspect of the working circle is too rugged to admit of the production of evenaged high forest. The tendency of even the best managed selection forests is to become more and more even-aged. For the present in Northern India there is no necessity to struggle against this; the future silvicultural system may be left for future consideration and we may confine ourselves to realizing the true yield of the forest and improving the silvicultural condition of the crop. The following extracts from working plans show the silvicultural ideas underlying the present management.

The system as it exists to-day.

*Sal
Ram-
nagar
Working
Plan.*

"The fundamental ⁵⁷ silvicultural idea is a normal series of age classes, mixed in groups of sufficient size; each species growing on the locality most suited to it. Pure *sal* is not aimed at; good *bakli* or *sain* is to be preferred to bad *sal*.

"The object of the fellings is to realise the mature crop of trees and at the same time improve the general condition of the growing stock and complete natural regeneration.

"The selection fellings to be carried out will consist therefore in every compartment of a series of all silvicultural operations necessary to health, growth, and regeneration."

To take another example, we will turn to the Selection Working Circle of the Kulu plan ⁵⁸ :—

*Deodar
Kulu
Working
Plan.*

"These forests will be worked on the selection system, that is to say, the felling of trees will be so arranged that, while providing for the necessary reproduction, an attempt will be made to bring the forests into a more normal condition than they now present. The yield is calculated in volume and the sequence of felling is not rigidly prescribed, the object being that fellings in this circle may be made to fit in with fellings which may be going on in neighbouring compartments of the Regular or Fir circles. Owing to the characteristics of the *deodar* the felling of single trees would not be followed by reproduction, and consequently selection in groups will be adopted. It is also permissible to make a regeneration felling over a limited area should this appear desirable. Trees of any size may be felled in accordance with the silvicultural requirements of the crop, and the volume of all *deodar* trees of 12 inches diameter and over will count against the prescribed yield. When any compartment is being worked thinnings will also be made where necessary. The growing stock of auxiliary species has not been ascertained and the volume of such trees felled will not count against the prescribed annual yield which consists solely of *deodar*."

⁵⁷ *Ramnagar Working Plan Revision*.—TREVOR.

⁵⁸ *Kulu Working Plan*.—TREVOR.

*Oak.
Chakrata
Canton-
ment
Plan.*

"The forests ⁵⁹ will be managed on the 'Group Selection System.'

"The fundamental silvicultural idea of the future management is a normal series of age classes represented by even-aged groups, each species growing on the locality most suited to it. Oak will predominate in the stocking, but conifers will be introduced in groups on such limited areas as are suited to them; good miscellaneous broad-leaved species are to be preferred to poor oak, and are to be encouraged in their own particular environment.

"The object of the fellings to be carried out is the realisation of the mature crop, consistent with the attainment of the normal forest and normal regeneration by groups. The selection fellings will, therefore, consist in every compartment of the most suitable silvicultural operations to attain this object, and will vary according to the nature of the crop from place to place.

"The groups will be of sufficient size to satisfy the light requirements of the different species.

~~"The stock at present consists largely of young to middle-aged~~ oak in uniform groups of varying ages, and the present chief requirement is systematic thinning. Thinnings in these even-aged groups should favour the best trees, and when the group is approaching maturity, the canopy should be opened out vigorously to give plenty of room for the development of large crowns in the mother trees and to promote natural regeneration. Young oak regeneration will stand a fairly dense shade and the protection of the surrounding mother trees should be removed judiciously at first. Only the silvicultural requirements of each group will guide the nature of the fellings; it will not be considered sufficient reason to remove a tree because it has reached a diameter corresponding to the rotation. Natural regeneration, the proportion of age classes in the forest and many other cultural considerations may decide the removal of a tree either before or after maturity,

⁵⁹ *Working Plan for Chakrata Cantonment*.—HALL.

"It will be found that when the present crop is more mature, the fellings prescribed will reduce the number of trees in each group so largely that the forest will take on a more obvious appearance of selection forest, consisting of groups of trees representing all age classes, with older trees having plenty of room to develop large crowns and large increment. Even at present the natural regeneration of oak is promising under the circumstances, and the system of obtaining the regeneration by groups should give it every encouragement, the nature of the fellings allowing the marking officer every scope to obtain it, and putting nothing in the way of the silvicultural necessities of the species.

"Consistent with the system adopted, the marking officer is given every possible latitude in carrying out the fellings, and except that the annual yield is laid down by volume, only silvicultural requirements will determine the extent of the cultural operations in each compartment.

"All trees above 8" diameter have been enumerated and each compartment has been described in the compartment history; so that the marking officer has a good knowledge of his growing stock and the proportion of his age classes. When the stock has again been enumerated after 10 years, a knowledge of the real increment will also be available."

It will be thus seen that the latest practice in India conforms very closely to the modified selection system used in Corsica for a light-demanding species as explained in Chapter VI and is in reality very different both from the theoretical selection system which can still be used for a species like silver fir and the system of removing mature trees by numbers which constituted in India the so-called selection system so largely employed in the past.

It is a live system allowing full play to silviculture and the fellings are regulated by an exact calculation of the yield in volume; which yield may be realised from any diameter classes at the discretion of the executive officer.



Photo. Mech. Dept., Thomason College, Roorkee

Miscellaneous forests of Kumaun Bhabar.

Photo by E. A. Smythies.

The permanent selection forest will always be found in mountainous countries where the importance of the maintenance of an unbroken leaf canopy outweighs all other considerations, or where owing to the precipitous character of the ground no regular working over the whole area of the compartment is possible. The silvicultural characteristics of the species entirely dominate the management as already explained and necessitate very great modifications in the system as applied to different species.

"In forests⁶⁰ of pine, where the trees require bright and abundant light, the selection system always does more or less harm. Under its operation the leaf canopy is very far from being uniform, is often open or breached with small gaps, and consists in places of sickly saplings and poles that can never come to anything. Hence that method has in nearly every case been abandoned with the development of an export trade. In forests of silver fir, on the other hand, the young plant of which species bears even heavy cover for a long time, and shoots up rapidly as soon as it is uncovered overhead, crops worked by selection remain dense and ~~well stocked with trees of all ages~~, provided the annual exploitations are moderate."

This system has lately been very highly developed in France and Switzerland for silver fir under Gurnaud and Biolly, who maintain that the highest productivity of the soil is obtained under this system.

The essence of the "Methode du Controle" is the frequent complete enumerations and calculation of actual increment. The yield is fixed for every compartment separately on the increment per cent. of the growing stock. The advocates of this method even go so far as to turn even-aged high forest into irregular high forest on the grounds that this is more in accordance with nature. The fallacy of this argument has been shown in an article in the "Indian Forester,"⁶¹ and so far as our management is concerned the balance is overwhelmingly in favour of even-aged high forest.

⁶⁰ Cours d'aménagement.—BROILLARD.⁶¹ Forest Management—*Indian Forester*, December, 1921.—TREVOR.

The selection system as a permanent system.

Determination of the rotation.

The length of the rotation adopted must depend on the size of tree required to yield the class of timber most in demand in the market. This again depends on the quality of the site. If 20" diameter is the exploitable size for quality I *sal* sites, it is useless expecting the same size on quality IV sites. Hence the difficulty of a fixed exploitable size, more especially in the case of hill *sal* where the quality varies enormously over comparatively small areas. It is necessary to calculate the size of tree required and the average time taken to produce this tree under the conditions of regular high forest. In selection forest, trees reach the exploitable size at very different ages, depending on the conditions of their environment, and diameter is generally of more importance than age. Hence the rotation adopted will approximate that calculated for regular high forest growing on similar sites.

The felling cycle.

Selection fellings should pass over the area of the working circle in an orderly manner. Where the yield is calculated in volume the extent of the fellings will determine the length of time which elapses before any compartment comes again under felling, although under modern practice no periodicity of the fellings is prescribed and the Divisional Forest Officer may return to any compartment in urgent need of felling. Where the yield is regulated by area, the felling cycle becomes of considerable importance. In the past this has varied from 10 to 30 years; the former is too short for the very extensive area of hill *sal* and protection forest in the submontane divisions and the latter too long. The length of the cycle is frequently taken as that necessary for the trees of the diameter class approaching maturity to pass into the next higher class and for regeneration to become established after the previous felling. In general for the hills of the submontane divisions a felling cycle of 20 years is suitable.

The calculation of the yield.

No calculation of the periodic yield of each compartment in accordance with the principles of the "Methode du Controle" is under our conditions of working a practical proposition. With frequent revisions of working plans and re-enumerations it will in

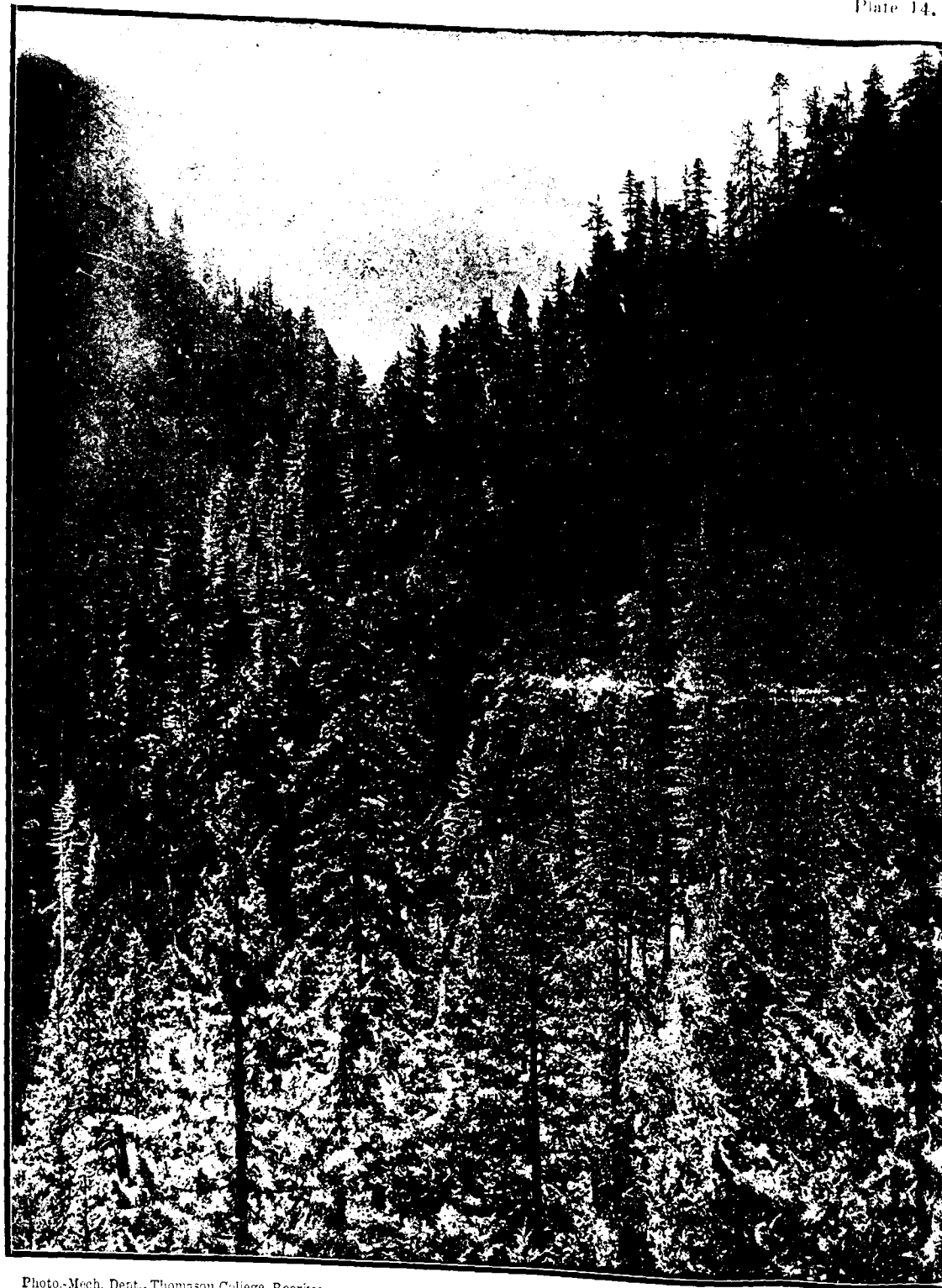


Photo-Mech. Dept., Thomason College, Roorkee.

Mixed coniferous forests in North Garhwal division.

Photo by A. E. Osmaston.

THE CALCULATION OF THE YIELD.

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the future be possible to ascertain the actual increment of every compartment and to calculate the yield in accordance with the above method, but still the yield must be calculated for the working circle as a whole and each compartment felled on its merits. For the present where a volume yield is required, this yield may be calculated by some modification of Von Mantel's, Heyer's or any of the methods described in Chapter VI, depending on the data available. In other cases more especially in protection forests an area yield will suffice.

The execution of the fellings will vary with the species and the silvicultural idea on which the management rests. A general example for *sal* is given as follows:—

The method of executing the fellings.

- (1) Subject to silvicultural considerations, the maintenance of the crop, and the silvicultural idea, the class of tree on which fellings should bear is indicated by the graph in the compartment history showing the actual growing stock compared with the normal.
- (2) Where the crop is mature and regeneration required, the ~~canopy will be opened so as to obtain groups of young growth of sufficient size.~~
- (3) Where mature trees are standing over a younger crop they should be removed in selection.
- (4) All bad trees not actually required for seed should be marked and all dead and dying trees removed.
- (5) All trees obviously out of place, poles or middle-aged trees deforming good regular groups of younger age classes may be felled subject to rule (1).
- (6) Pole crops should be thinned.
- (7) All classes of trees down to 8" diameter count against the prescribed yield.

It will thus be seen that in every compartment every sort of silvicultural operation has to be carried out at one and the same time and to do this well requires exceptional ability.

Order of
the
fellings.

Where the yield is prescribed in volume the order of the fellings will be suggested; the Divisional Forest Officer has a free hand to fell when and where he considers this most desirable so that he can return to any compartment at any time should this be necessitated by any unforeseen circumstance such as fire or drought. Normally once a compartment is taken up this should be completely finished and the fellings pass on in an orderly manner through the whole working circle. Where the yield is regulated by area a fixed felling cycle and fixed annual coupes are laid down and a table of fellings drawn up.

Subsidi-
ary
silvicult-
ural
regula-
tions.

These must be carried out to such extent as local circumstances require. They will follow on the whole the same lines as laid down for the same species under management as regular high forest and the intensiveness of the work done will vary with the value of the crop. In the ordinary protection forest of the outer hills where the quality is generally poor and the fellings light, little or no benefit results from the cultural operations at present carried out and it is a matter for consideration whether in such working circles this work is not better left in abeyance and attention and funds concentrated on the far more valuable *sal* forests managed under the shelterwood system.

CHAPTER X.

THE SIMPLE COPPICE SYSTEM.

THE general idea of the coppice system is well-known to foresters. Reproduction from stool shoots is entirely or almost entirely relied on for the renewal of the crop. Fellings made are clear fellings and the crop is immediately regenerated by coppice shoots supplemented by whatever seedlings are already on the ground. The adoption of this system of management entirely depends on the ability of the species to reproduce itself vigorously by coppice. It is well-known that certain species will not coppice; *Alnus nepalensis* can be pollarded but not coppiced; other species will only coppice up to a certain age and the coppicing powers of the same species vary in different localities or at different elevations. Full details regarding the coppicing power of the species must be available before the detailed management of a coppice working circle can be evolved. Fortunately the *sal*, teak, and most scrub species coppice vigorously and where the object of management is timber of small size and firewood this system is to be recommended, but with *sal* can only be adopted where there is no frost. *Sal* coppice is best developed in Gorakhpur division and a special technique has been evolved which differs from that of the text-books.

The
silvicult-
ural
system.

"Admittedly the Gorakhpur system⁶² is simple coppice because the coppice system is called so on account of the mode of origin of the crop, i.e., it is reproduced from stools, not otherwise. To call it simple coppice is strictly accurate. At the same time its mode of treatment and its method of regeneration differ so sharply from the simple coppice of European forestry that to any one unfamiliar with Gorakhpur the impression conveyed by calling it simple

The
Gorakh-
pur
modifica-
tions.

⁶² Gorakhpur *sal* management, unpublished note—Wood

coppice without a clear explanation of its divergence from European practice would convey a picture to the Europe-trained forester quite unlike what he would see on the ground. "The principal differences are—

- (a) Ordinarily coppice is felled and the shoots come up principally from the same stools as before, i.e., one stool supplies units of the crop in several successive rotations. In Gorakhpur the definite aim is in theory *never* to have the same stool producing a unit of the crop more than once, i.e., at each felling stools from which a pole is felled are discarded and new stools obtained. This involves aiming at a dense underwood of poles from which come the stools which give the new crop. Hence the treatment of the *crop* between establishment and felling differs not only in detail but in principle also from conventional coppice.
- (b) We deliberately adopt a method of felling which forces the shoots to appear at and below ground level. Coming from very young, small stools, this means that the new shoots rapidly become independent of the present stool, especially as the *sal* in nature is inclined to adopt this process itself in being burnt back and dying back during the period of establishment. Hence the crop soon assumes the appearance of high forest, and also some of its attributes. Thinning admittedly helps this, but can be ruled out as it ought to be a routine measure in simple coppice as well. But quite apart from that, if we have successfully obtained our underwood of small poles, without any cleaning, tending or thinning whatever, the forest will soon assume, and continue in the outward and visible form of high forest. In fact almost more so than high forest itself, e.g., Amery's clear felling in Ramgarh, also Domakhand *sal*, which contains trees up to 11' in girth

and sound to the core, which are coppice. Dudhai shows hardly any trace of coppice yet was clear-felled, almost in living memory, whilst zamindari forests show this even more markedly. Notably Nil Ratan's forest north of the South Banki reserve. There is no question whatever that boles of coppice origin in Gorakhpur are as sound as those of seedling origin up to and beyond the exploitable size of a seedling tree."

The whole success of the management depends upon the existence of sufficient suppressed advance growth and small poles and saplings on the ground to supply complete regeneration from coppice shoots. The best trees in the crop which is clear-felled do not usually coppice and reliance is not placed on such trees to produce a fresh crop. Where suppressed advance growth does not exist in sufficient quantity, resort is made to artificial regeneration.

Annual or periodical burning of the leaf layer is done departmentally in order to reduce the evergreen undergrowth and help natural regeneration by seed. This burning does no material ~~damage to the suppressed advance growth~~ already existing. It also keeps the *sal* plants in sufficient health until the clear-felling, when they are all cut back and coppice freely. At the time of the felling or immediately all saleable material has been removed everything remaining should be cut back. In the past in some divisions it has in several cases been the practice to leave the stems up to 6" of 8" diameter uncut; this is the greatest possible mistake and should not be repeated. Such stems have generally grown up under suppression and are most unlikely to develop into anything but worthless trees, their retention causes irregularity in the new crop; they shade the young coppice shoots and are altogether undesirable.

The final clearance of the felling area may under certain circumstances be affected by burning off the twigs leaves and other rubbish. In the case of *sal* this procedure has been carried out in several experimental areas under the direction of the working plans

branch, notably in Dehra Dun, and South Kheri and the results have been excellent. The area is cleared for any artificial regeneration which may be necessary, the coppice shoots spring up from the ground level; the burning fertilises the soil and increases nitrification and the seedlings already on the area are stimulated into active growth; the burning must be done before the coppice shoots appear about the middle of April. Fellings normally will take place during the cold weather but may be started any time after 1st August; the sooner the better, both felling and export to the compartment line should be complete by the 15th April, at the latest and this must be insisted on as is always done in Gorakhpur.

The practice of giving extensions in coppice coupes is contrary to all ideas of good management and should be limited as far as possible. The coupe will be immediately cleaned up, so that the new coppice may start to grow during April, May, and June which is the chief growing season for *sal*. No dressing of the stools is necessary; experiments have shown that this is actually harmful. In Gorakhpur the orders are that the stumps should be left 4"–6" above the ground level; natural drying will probably kill a certain amount of the cambium at the top of the stump but this height of stump is sufficient to prevent the whole of the cambium being dried out as frequently happens with stumps cut at ground level, which then fail to coppice. Shoots are required from ground level and not from the tops of the stumps.

It is essential to good management that all blanks in the coppice crop be completed artificially. In Gorakhpur some of the best sites along the banks of streams contain only medium-sized *sal* trees with little or not suppressed advance growth or seedling reproduction, generally growing mixed with dense evergreens. Here regeneration by *sal* coppice is out of the question and artificial regeneration must be resorted to. During the cold weather following the felling as soon as it is known what areas have to be regenerated artificially, steps should be taken to prepare the soil. It is not intended here

Plate 15.

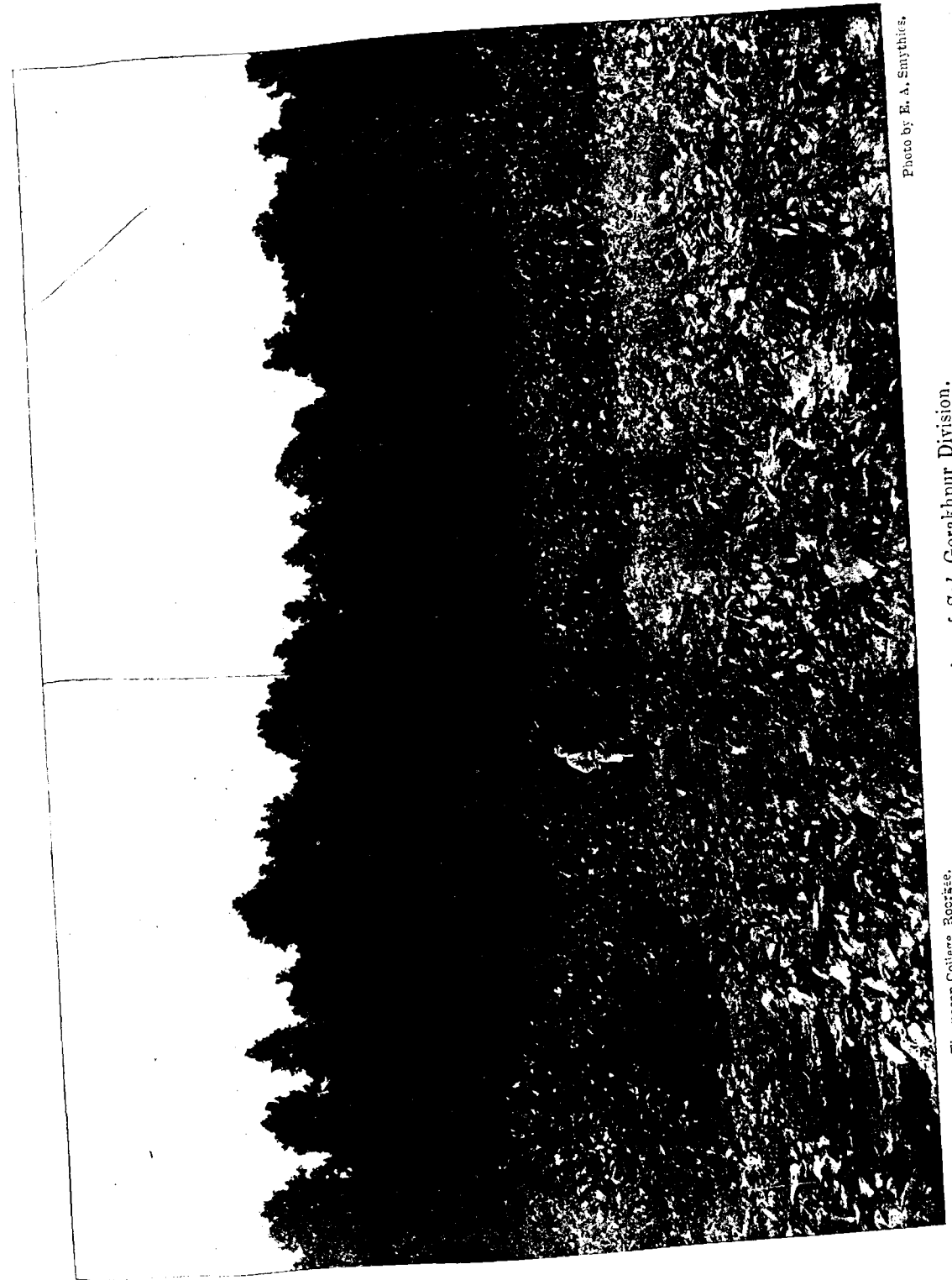


Photo by E. A. Smythies.

Artificial regeneration of *Sal*, Gorakhpur Division.

Photo-Mech. Dept., Thomason College, Rohtak.

THE GORAKHPUR MODIFICATION.

to go into the details of the methods of the artificial regeneration of *sal* for which the reader is referred to the Forest Pocket Book, the article on the artificial regeneration of *sal* in Gorakhpur⁶³ and the essay on artificial reproduction⁶⁴ which is printed as an appendix to this book. It will be enough to state here that teak is the best species for filling up blanks in *sal* coppice where frost is not too severe as it will keep pace with the growth of the coppice, either direct sowings or root and shoot cuttings may be used. The good effect of a summer fallow by inducing active nitrification in the soil is well known and is as valuable in forestry as in agriculture, consequently the soil preparation should be done in the cold weather so that the soil may be aerated and sweetened during the following hot weather months prior to the start of artificial reproduction.

Taungya cultivation promises to give excellent results, but the technique is still more or less experimental and has not yet been standardised, and for this reason a description of the management of taungyas cannot be given here.

Ordinarily with rotations up to 30 years no division into periods is made but with rotations up to 60 years a division of the area into periods is often convenient. For instance in Gorakhpur with a rotation of 50 years it might be convenient to divide the rotation to 5 periods of 10 years, corresponding to the periodical revisions of the working plan for instance—

The division into periods.

Gorakhpur sal-Coppice division into periods.

	I	II	III	IV	V
Age of crop on 1st April, 1922 ..	40-49	30-39	20-29	10-19	0-9
Age of crop on 1st November, 1922 ..	41-50	31-40	21-30	11-20	1-10

⁶³ Article—*Indian Forest*, February 1922—Wood.

⁶⁴ Article—*Indian Forest*, June—July.—Trowsford.

Following on the above division into periods the programme of work would be as follows :—

- P. B. I clear fellings in 10 annual coupes.
- II Final thinning and cleaning in 10 annual coupes.
- III 2nd thinning in 10 annual coupes.
- IV 1st thinning in 10 annual coupes.
- V Cleaning in year 1, 2, 5.

Laying out the coupes.

The rotation having been fixed the next step is to divide the working circle into annual coupes of equal productivity. In order to effect this where the intensity of management calls for this refinement a system of local reduced areas must be adopted. The coupes must be marked on a large scale map and as the fellings come round each coupe should be marked out on the ground with a ditch or path and numbered corner posts so that later on a particular coupe can be located at once. Each compartment should, if possible, contain a whole number of coupes, i.e., a coupe should not usually be situated in 2 compartments but sometimes this is unavoidable. The boundaries of coupes ought to consist of straight lines, or of permanent lines such as roads, streams, ridges, fire lines and the edges of easily recognised grass lands like the chandars of Pilibhit and South Kheri. Each coupe should be accessible to an export line without carts having to pass through an area of young coppice. As far as possible the exploitation of the coupes in the middle of the forest should be avoided as this merely creates a frost hole. Fellings should start on the edge of the forest and proceed in an orderly manner from one side to the other. Where the hot west wind known as the *loo* blows during the summer the fellings should be arranged to proceed from east to west so that the young coppice is sheltered to some extent during its first year.

The determination of the rotation.

This will be done on the lines already explained in chapter VI ; but the power of the stools at different ages to produce vigorous coppice will largely influence the choice of rotation, where true

coppice is aimed at with *sal* on a long rotation as already explained in discussing the Gorakhpur system, this consideration does not hold good.

The yield is invariably regulated by area. Reduced equi-productive areas will be used, where necessary.

The calculation of the yield.

Example—

Gorakhpur Working Plan ⁶⁵

Working Circle no. I (a)

Year of felling.	Coupe no.	Felling Series no. 1.		Felling Series no. II.	
		Ramgarh-Tilkonia.		Bhilampur Banki.	
		Compartment.	Sal area to be worked.	Compartment.	Sal area to be worked.
1914-15 ..	I	3	Acres. 139.52	6	Acres. 115.60
1915-16 ..	II	4	154.20	6	114.40
1916-17 ..	III	1	157.92	6	82.40
1917-18 ..	IV	3	156.26	6	86.64
1918-19 ..	V	3	146.25	6	119.60
etc. ..	etc.	etc.	etc.	etc.	etc.

An estimate of the outturn in timber and fuel will be given. This information is indispensable for the calculation of the rotation and is easily obtained from the records of past fellings or from yield tables.

Where the crop is sold standing, the coupe of the year is divided sale plots each of a suitable size to comprise one sale lot at the annual auctions. These plots are marked on the ground and the crop is then enumerated in the standard diameter classes and the results entered in the sale list. If possible the contractor should be required as a condition of sale to cut everything on the plot with stumps "4"—"6" above the ground level subject to a penalty for not doing so. If this is not expedient, then immediately the contractors' work is over on 15th April the trees not felled by the contractor must be cut departmentally and the stumps put in order. Fellings may continue any time after 1st August, but in many

The conduct of the fellings.

⁶⁵ Working Plan for Gorakhpur division—MARRIOTT.

places will hardly start before October or November. Both felling and export to the coupe lines must, as already pointed out, be finished by 15th April. Only slackness and inefficiency in the divisional management will permit exploitation to continue beyond that date, which means that the coupe cannot be cleaned up and that the workmen and their carts are trampling on the young coppice shoots.

*Thinnings
and clean-
ings.*

As the young coppice comes up it must be cleaned by removing inferior species, climbers, etc., and this cleaning must be repeated as often as is necessary. In the sixth year in the case of *sal* coppice the cleaning will be combined with a thinning out of the coppice shoots and in the eleventh year regular thinnings will commence and be carried out at 10 year intervals during the rest of the rotation; all mention of thinnings in coppice crops is generally omitted from text books. The necessity for thinnings in coppice whether of *sal*, *sissoo* or *babul* has been established and this operation will in future be considered as of equal importance in coppice as in high forest crops and will be carried out at regular intervals.

*Artificial
reproduc-
tion.*

In all coppice coupes the question of completing the coppice crop by sowing and planting must be considered. In Gorakhpur sowings of *sal* have been made before the clear felling but this method has nothing to recommend it and has been given up. Sowings of *sal* are now made after the clear felling with success, and blanks in the coppice are no longer a source of anxiety. The present routine is to hoe up wide strips (1 chain wide) alternating with untouched strips ($\frac{1}{2}$ chain wide); single lines have been found unsatisfactory, and soil preparation 18" deep is very necessary. Wood found that *sal* seedlings which developed a root system less than 13" during the first monsoon invariably died, while those whose roots were less than 18" mostly perished, proving the necessity of adequate soil preparation. The question of doing this artificial work along with the cultivation of field crops has now been taken up. In Changa Manga lines are cleared and mulberry weeded out in order to obtain an admixture of *sissoo* in

the crop. Much could be done to enrich scrub coppice of the Central India type by increasing the admixture of teak artificially. Far too little attention has been paid in many places to this question of artificial regeneration in coppice working circles. It has been the custom to cut the coppice and leave the new crop to grow up as best it could without tending and without any attempt to complete and enrich the stocking. This artificial work is best done the year after the fellings which allows plenty of time for the soil preparation and the satisfactory organisation of the whole work when the extent of coppice failure is quite clear.

For convenience of administration and control a table of fellings showing year by year the different operations to be carried out each coupe should be prepared and given in the working plan. An example of such a table will be found in the following chapter.

*Table of
fellings.*

CHAPTER XI.

THE COPPICE WITH STANDARDS SYSTEM.

The silvi-cultural system.

THE whole system is similar to simple coppice with the exception that a certain number of standards are reserved above the coppice for the production of timber. The system is suitable for all those cases where the objects of management are the production of both large and small material or where simple coppice is ruled out on account of frost. The standards enrich the coppice and with comparatively short coppice rotations materially increase the revenue. The most important silvicultural consideration is the question of the number of standards to be reserved. The defects of the past technique of the system in retaining an excessive number of standards have already been noted in chapter VI. The number of standards will vary with the relative importance of the standards and the coppice, but where such an excessive number of standards are reserved that the coppice is suppressed and rendered worthless the *raison d'être* of the system, which is the production of both timber and small material, breaks down. It may be stated at the outset that in our coppice with Standards Working Circles the standards and the coppice are of equal consideration, and this being the case the standards should not occupy more than one-third of the canopy. *Sal* coppice with standards has been condemned, vide the following silvicultural note appearing in the Indian Forester for April, 1922.

"An examination of an experimental plot in Dehra Dun has again shown that coppice with standards is a poor system for *sal*. The plot has 52 standards to the acre, of an average diameter 9.4" in 1917. The coppice was 12 years old. Quite apart from the slow growth the plot shows obvious signs of suppression."

Plate 16.

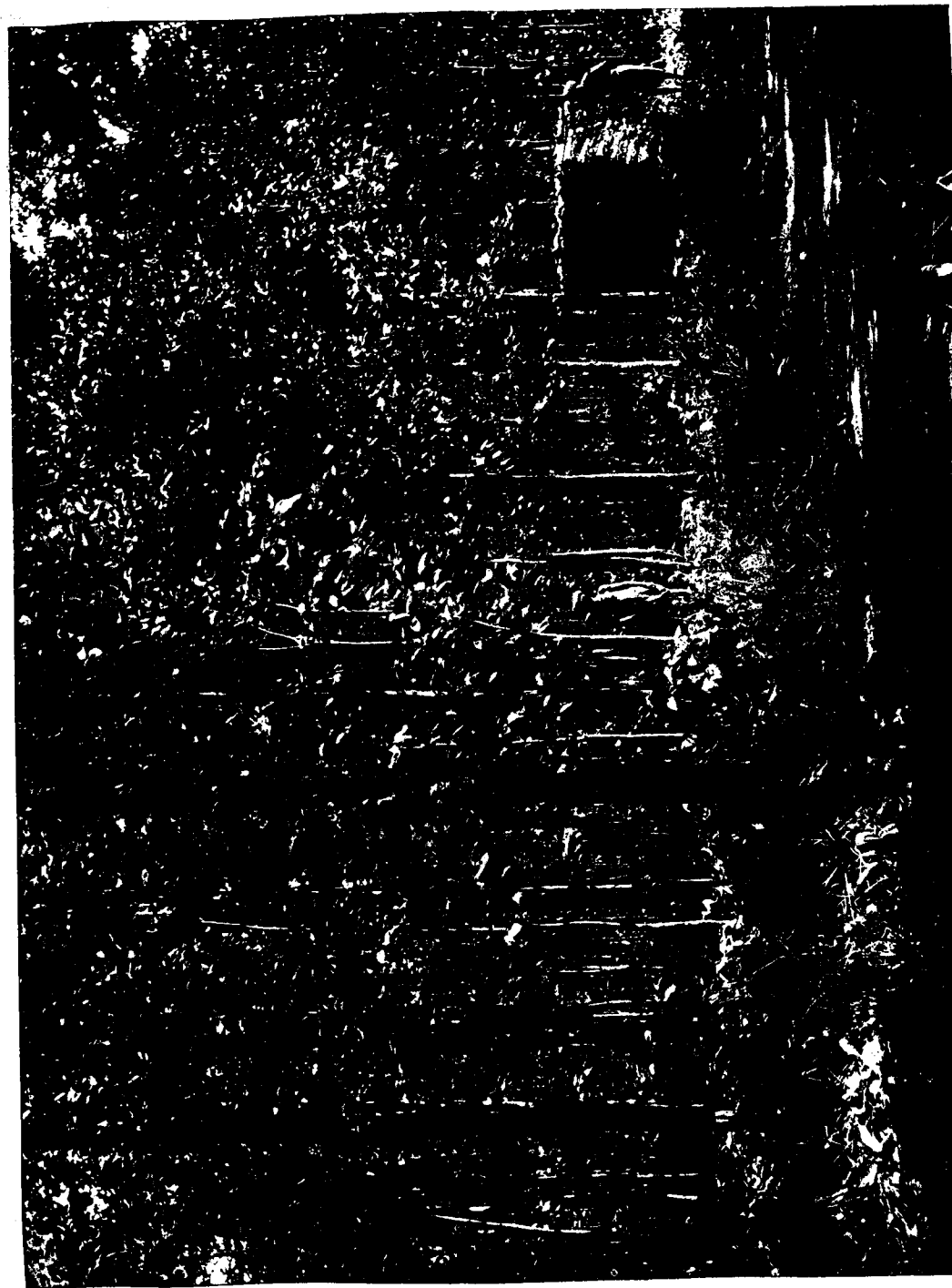


Photo by E. A. Smythies.

Photo-Mech. Dept., Thomason College, Roorkee. *Sal* coppice with standards properly thinned, Gorakhpur Division.

In the above case it is not the system which is at fault, but the silviculture displayed in carrying it out.

Apart from the permanent retention of the standards for timber, they are required for the production of seed, the completion of the coppice crop by natural regeneration so that young stools may always be available, and in some cases to protect the young coppice from frost. This latter point is of considerable importance in the case of *sal* and entirely dominates the technique of the management in Pilibhit and South Kheri.

In these divisions two distinct types of management have been evolved; firstly the ordinary coppice with standards where the standards are a permanent feature of the crop and secondly a system of evenaged high forest regenerated partly by coppice and partly by seed under a temporary shelterwood which is removed as soon as its function of protecting the young coppice from frost and completing the regeneration of the area by seed has been accomplished. The best number of standards to retain may vary in accordance with the amount of protection which the coppice requires in each locality and will also depend on the size and crown development of the standards. Sufficient latitude should therefore be allowed to the forest officer in charge of the markings within prescribed limits. In Pilibhit it is not considered safe to have less than 40 standards per acre during the first few years of the coppice growth. At the other end of the scale it is considered that 75 standards to the acre is a safe maximum when the trees average 8"-10" in diameter. In South Kheri fewer standards are reserved.

We are thus faced with the necessity of starting with many standards which either have to be entirely removed as in the Nawadia and Gola Working Circles or reduced to such number as will not interfere with the proper development of the coppice during the rest of the rotation.

The following table will serve as guide for the maximum number of standards which can be retained in theory but not

exceeded during the coppice rotation of 30 years in a 3rd quality crop. These figures are maximum figures, and are not to be taken as representing in any way the optimum number of standards which should be retained for any particular locality :—

Average diameter of the standards.	Initial number of standards per acre.	Number of standards in the 5th year of the coppice.	Number of standards in 10th year of coppice.
6"	153	123	94
8"	94	79	64
10"	64	55	47
12"	47	41	35
14"	35	32	28

These figures show the impossibility of trying to grow *sal* under coppice with standards when 75 standards per acre are retained throughout the coppice rotation, as has been attempted in Pilibhit in the past, and that it is essential that thinnings in the standards be prescribed if the coppice is to have any chance of success.

For the Dhamela Working Circle of Pilibhit in which the standards will average about 10" in diameter it is prescribed that 60—70 standards per acre will be reserved at the start. In the 5th year of the coppice, the unthrifty standards will be removed and their number reduced to 40—60, and in the 10th year the number will be further reduced to 20—40 standards per acre, which will then be retained till the end of the rotation.

Exactly the same attention must be paid to the coppice as detailed for the simple coppice system. It must be cleaned and thinned in due season and some artificial reproduction work will be necessary and should be carried out.

The Rotation. As a matter of principle the length of the rotation to adopt in coppice with standards is irrevocably governed by two considerations. In the first place, it cannot exceed the age at which the underwood

would cease to reproduce itself completely from the stool; and in the second place it must be long enough to allow the youngest standards (viz., those to be reserved from amongst the underwood when it is cut) to attain a length of bole sufficient to let them be considered as tall trees, and a diameter large enough to enable them to stand being isolated. Determined on these considerations, rotations for coppice with standards would, as a rule, be comprised between 30 and 40 years.

The rotation of the coppice in *sal* coppice with standards is usually taken at 30 years corresponding to a diameter of 6" for quality III. This produces material suitable for *korus*, rafters for grass huts, firewood, etc., for which purpose *sal* coppice is grown. The rotation usually adopted for the standards is two rotations of the coppice or 60 years. Under high forest conditions quality class III stems of this age would average 10" diameter. Grown as standards they should be 12" to 13" diameter. The adoption of such a rotation for the standards renders very easy the correct distribution of the age classes and no standard remains as a standard above the coppice for longer than the one coppice rotation.

Following the same lines as for simple coppice equiproductive coupes will be laid out one each year of the coppice rotation. They should be cut in regular sequence and where the *loo* blows the fellings should proceed from east to west. In some case it may be desirable to keep a narrow belt of trees along the western boundary of the forest.

This is calculated by area, an estimate of outturn per acre is compiled from figures of past yield or from yield tables.

The proper selection of standards is a most important matter. They should consist of the most valuable light demanding species of the crop and should be trees which are capable of putting on considerable increment and increasing largely in value during the next coppice rotation. They must also be capable of bearing comparative isolation and should be as far as possible wind firm species. In *sal* forests the standards will consist of *sal* or *asna*

The Coupes.

The Yield.

The selection of standards.

(*terminalia tomentosa*), failing these *siris*, *haldu*, *bakli* or any useful light crowned species may be reserved. It is essential that the reserved standards be distributed evenly over the coupe. Instances have been noticed where marking officers have retained a group of standards all huddled together and none elsewhere and pretended that they were reserving the correct number ordered. If 50 standards are ordered to the acre the standards should stand more or less about 30 feet apart. One way of getting the right number is to lay out one chain square and select the necessary number of trees in our instance 5, then 10 of these squares will equal an acre and 50 standards will have been reserved. The correct distribution of the age classes of the standards is a matter of very great importance when the rotation of the standards is several times that of the coppice. With a 60 year rotation for *sal* standards in coppice the new standards are all selected from the coppice previous to this being felled. With a rotation of 80 years and a coppice rotation of 20 years there should be in theory 4 age classes :--

1—20 years.	21—40 years.	41—60 years.	61—80 years.
The coppice 6/9th of the canopy.	Class 1 standards 1/9th of the canopy.	Class 2 standards 1/9th of the canopy.	Class 3 standards 1/9th of the canopy.

Now the standards are not to occupy more than 1/3rd of the canopy so that each age class of the standards must occupy 1/9th of the total canopy. In order to comply with this there must be more of the younger and fewer of the older standards and at each felling besides removing the oldest standards; some of classes 1 and 2 must also be cut, a fresh selection of standards must be made from the coppice and the rest of the coppice felled.

The following are the orders regarding the selection of standards :—

- (1) All climbers are to be cut.
- (2) The standards reserved are to be marked clearly with a ring of white or black paint or coal tar.

(3) They are not to be blazed, hammer marked or mutilated in any way.

(4) They will be numbered with paint, measured and entered in a register according to the following example.

WORKING CIRCLE DHAMELA.

Felling series no. I. Coupe XX. Year felled 1910-11.

Serial number of standard.	Species.	Year 1909-10.		Year 1915-16.		Year 1921-22.		Remarks.
		Diam. in inches.	Remarks.	Diam. in inches.	Remarks.	Diam. in inches.	Remarks.	
1	Sal ..	13	..	14	..	16	..	Broken in felling.
2	" ..	8	..	..	..	..	..	
3	Asna ..	6	..	7	..	8	..	
4	Sal ..	12	..	13	Cut ..	..	..	
5	" ..	10	..	11	..	13	..	
6	Haldu ..	18	..	14	..	16	Cut.	
7	Sal ..	8	..	9	..	11	..	
8	Asna ..	7	..	8	..	10	..	
9	Sal ..	9	..	10	Cut ..	..	..	
10	" ..	6	..	7	..	8	..	

(5) The numbers of the standards are to be renewed in each year of felling.

At the commencement of the second rotation of the coppice the final measurements of the standards should be entered up, mature stems will be marked for felling, a fresh selection of stems made and a new form prepared.

- (a) As far as possible it should be a condition of the sale contract that the purchaser should fell everything except the reserved standards. At the conclusion of the work the Range Officer should check the standards.

The conduct of the fellings.

with the register, and certify that they are correct before the purchaser's security money is refunded.

- (b) Everything except the reserved standards is to be coppiced. The retention of stems below 6" diameter to form part of the coppice crop as has been done in the past is a mistake. These stems are generally misshapen, they shade the coppice and spoil the evenness of the crop. In no case in future will anything be retained except the standards. Everything else is to be coppiced.
- (c) All stems should be cut at 4" to 6" from the ground and no dressing of stools is necessary.
- (d) All felling and export to the lines should be completed by 15th April and no extension can be tolerated under any circumstances.
- (e) The purchaser is responsible for any damage done in felling to the reserved standards and he should be fined for careless felling.

Subsidiary silvicultural operations.

It is often desirable to clean up the coupe after the completion of the exploitation by burning whatever slash remains. This burning should never be severe and should be completed by 30th April. If necessary big slash should be collected and burnt in piles and the heaps of ashes sown up with *sal* or *haldu*, the latter broadcast after the break of the rains. As the growing season for *sal* is the hot weather the burning cannot be deferred beyond this date and should be finished earlier when possible. This burning has been found of distinct benefit, the coppice reproduction is not in the least affected, the stool shoots spring from ground level and an ideal seed bed is provided for natural regeneration by seed from the standards.

The first cleaning.

A cleaning will take place in the coupe of the year after the initial felling. This has seldom or never been carried out in the past and the necessity for it has been very obvious in recent coupes. Excellent crops have been partially spoilt by the presence of the damaged and twisted coppice shoots, by standards broken

during the felling and by the presence of the faster growing coppice shoots of miscellaneous species interfering with the growth of the *sal* coppice and sometimes suppressing it. Broken standards should be felled and all damaged shoots, and shoots which have become twisted or whose natural growth has been interfered with should be again coppiced back. It is found that the new shoots grow quickly again and do not suffer much if at all from the loss of the year's growth. The coppice shoots of miscellaneous species which are interfering with the *sal* should be cut back. Generally these are not in sufficient numbers to make this an expensive operation, and ordinarily giving the *sal* one year's start is sufficient to prevent it from becoming suppressed. The operation is therefore generally prescribed for the first year only after the felling, but where it is considered necessary to cut back such species for a second year this must be done. Of such species *rohni* (*Mallotus philippinensis*) and *dudhi* (*Holarrhena antidysenterica*) do most damage and these should be cut out in the coupe wherever they occur. Of other species associated with *sal*, *Eugenia operculata*, *E. jambolana*, *Lagerstroemia parvifolia*, *Zizyphus Xylopyra*, *Bridelia retusa*, etc., should be cut back if they are interfering or are likely to interfere with *sal*, but should be retained if they are filling a blank in the crop. On the care with which this cleaning operation is carried out during the first year after felling depends to a large extent on the state of the future coppice crop, and its importance cannot be over emphasised. It must be completed before the next growing season begins, that it is before the commencement of the next hot weather.

The necessity of the reduction in the number of standards first reserved, under such circumstances as generally prevail in our Sal Coppice with Standards Working Circles, has already been explained; the thinning of the coppice will be equally of importance under this system as under simple coppice. Thinnings

In the sixth year the number of standards will be reduced. The necessities of the existing coppice crop will determine what

standards will be removed but with this reservation, unthrifty standards will be removed first. Where the coppice crop has failed, no standards will be removed. A thinning will be made at the same time in the coppice. This should not be very heavy, and will consist almost entirely of reducing the number of coppice shoots to one per stool. In the same year a cleaning will be made in the coupe, climber cutting and all cleaning operations found necessary being carried out. All coppice shoots of miscellaneous species suppressing the *sal* will be cut back.

In the eleventh year the number of standards will be further reduced to the number per acre ordered to stand throughout the rotation. The best standards should be retained as far as is compatible with the requirements of the coppice, the even distribution of the standards and the suitable gradation of age classes.

In the same year a thinning will be made in the coppice. It will be found that the height growth and density of the coppice crop will vary considerably from coupe to coupe, so the nature of this thinning cannot be indicated beyond saying that the most promising stems should be favoured and given enough room to develop freely for the next 10 years.

In the 21st year another and final thinning will take place in the coppice crop. At this age the coppice will have a diameter of 3"—5" and the ideal density of stocking will be about 400—500 trees per acre. This thinning in the coppice should just be heavy enough to give each pole plenty of room to develop freely during the next 10 years, before it is finally felled at the end of the coppice rotation.

The completion of the stocking artificially as detailed for simple coppice should be carried out.

The following table from the Pilibhit Working Plan⁶⁶ summarises all work to be done in the first ten coupes of the Dhamela Working Circle during the first 10 years of the plan. The roman numbers refer to coupes.

⁶⁶ Working Plan for the Pilibhit Division—HALL

Artificial reproduction.
Table of fellings.

TABLE OF FELLINGS.

Year.	Felling.	1st cleaning	2nd cleaning and 1st thinning	2nd thinning.	3rd thinning.	Remarks.
1	2	3	4	5	6	7
1923-24 ..	I	XXX	XXVI	XXI	XI	In the 1st thinning standards will be reduced to 40—60 and a thinning will be made in the coppice. In the 2nd thinning standards will be reduced to 20—40 and a thinning made in the coppice. In col. 1. 60—70 standards are reserved and everything cleared.
1924-25 ..	II	I	XXVII	XXII	XII	
1925-26 ..	III	II	XXVIII	XXIII	XIII	
1926-27 ..	IV	III	XXIX	XXIV	XIV	
1927-28 ..	V	IV	XXX	XXX	XV	
1928-29 ..	VI	V	I	XXVI	XVI	
1929-30 ..	VII	VI	II	XXVII	XVII	
1930-31 ..	VIII	VII	III	XXVIII	XVIII	
1931-32 ..	IX	VIII	IV	XIX	XXIX	
1932-33 ..	X	IX	V	XXX	XX	

In this chapter chiefly the question of *sal* has been considered but the principles of management laid down apply equally to all species. In the case of inferior scrub coppice, such refinements as the record of the measurements of standards can be dispensed with but this should only be allowed on the sanction of competent authority. Similarly the extent of cleaning and artificial reproduction necessary is open to modification where this may be indicated and laid down in working plans.

Conclusion.

CHAPTER XII.

THE MANAGEMENT OF BAMBOO FORESTS.

IN some cases in the outer hills, the bamboo *Dendrocalamus strictus* covers large areas and constitutes by far the most important forest crops. This is notably the case in Lansdowne division where the bamboos are of fine quality and form the principal source of revenue in the division. The bamboo is mixed with *sal*, *Terminalia tomentosa*, *Odina Wodier*, *Anogeissus latifolia* and a variety of inferior miscellaneous species. Over large areas *sal* is absent, in places it forms groups of high forest. A light overwood does the bamboo no harm and is certainly beneficial in early youth, on the other hand a heavy overwood is prejudicial to the quality and productivity of the clumps; and under the conditions of *sal* high forest such bamboos as are produced are practically worthless. Former working plans for these forests made no attempt to give the bamboo areas any separate treatment or to manage the forest in the interests of the bamboos. Improvement fellings passed over the area entirely for the benefit of the tree growth. Blocks were open and closed to bamboo cuttings under certain rules but as these blocks contained enormous areas of totally undeveloped country, only a fraction of the bamboos were cut and removed. Overcutting took place in accessible places and nothing was done elsewhere. The great areas of the open blocks alone prevented the staff from making any serious attempts to enforce the rules for cutting, which still remain more honoured in the breach than in the observance. The only possible way to obtain some sort of supervision is to have small annual coupes arranged so that every guard's beat constitutes one or more felling series of three or four annual coupes.

The following paragraphs are largely taken from the preliminary report for the Lansdowne division ⁶⁷ but will apply equally to other areas where bamboo forms the most important species in the crop.

The silvicultural system adopted is the treatment of the timber trees comprising the overwood as standards in a coppice and the treatment of the bamboos as the underwood under the best methods of working so far demonstrated by research and experience. Coupled with ordinary fellings of the overwood and the bamboo cuttings hereafter described a certain area of the circle in each range will be brought under experimental concentrated working with a view to the completion of the bamboo crop by sowing and planting and the maintenance of the proper gradation of age classes in the overwood by natural or artificial regeneration.

The
silvicultural
system.

It is also necessary to arrive at some idea of what proportion of the canopy should be occupied by the overwood and what proportion by bamboos. It is suggested that as overwood is of secondary financial importance it will suffice if $\frac{1}{4}$ to $\frac{1}{3}$ rd of the canopy be occupied by the overwood and $\frac{3}{4}$ to $\frac{2}{3}$ rd by bamboos.

The standard rotation for bamboos is four years in the sub-montane divisions. There is no objection in reducing this rotation to three years when the demand is heavy and first class supervision is available for the enforcement of the cutting rules. In the absence of such control over felling and the deterioration of the bamboos will probably result. It is significant that the bamboo has been practically exterminated over large areas of the Saharanpur division by reckless exploitation. The rotation for the standards will vary in accordance with the character and value of the overwood. In Lansdowne the rotation of standards has been fixed at 80 years.

The
rotation.

It is important that a number of small felling series each consisting of three or four annual coupes should be arranged.

Felling
series.

⁶⁷ Preliminary working plan report, Lansdowne—TREVOR.

These small felling areas permit of closer supervision and result in better revenue. Similarly with the overwood this should be divided into suitable felling series of say 20 to 30 coupes, each series being arranged to supply a particular market for railway station.

The yield.

In the case of the bamboos the yield is entirely regulated by area. In that of the overwood, with a rotation of 80 years and a felling cycle of 20 years fellings should pass over the whole areas in 20 years. For a correct treatment of standards in a coppice chapter XI should be seen.

The fellings.

This only concerns the overwood which during the first felling cycle is to be put into the condition of standards in a coppice due regard being paid to the normal distribution of the age classes. The rest of the growing stock not reserved as standards will be coppiced. The only exception to this is where good patches of *sal* occur in the state of high forest and in such cases the ordinary rules of good silviculture in a selection forest will apply. The location of these most important patches is given in the description of compartments.

I.—Felling rules for the patches of *sal* high forest—

- (1) Where the crop is mature and regeneration required, the canopy will be opened to obtain young growth in groups of sufficient size.
- (2) Where mature trees are standing over a young crop they should be removed in selection.
- (3) All bad trees not required for seed should be marked and all dead and dying trees removed.
- (4) Pole crops should be thinned in the upper storey to give room to the best stems to develop.
- (5) The removal of suppressed poles or trees is a matter of no silvicultural importance; if not required to cover the ground they may be felled at the marking officer's discretion; they form part of the intermediate yield the realisation of which is desirable; in several places they can be sold as firewood.

II.—Felling rules for the overwood under ordinary circumstances—

- (1) The best grown trees of any useful species should be selected as standards and they should not exceed 40 stems to the acre equally distributed over the area. Beyond this no definite number of standards is prescribed. In practice the average number of standards suitable for reservation will frequently be less.
- (2) A proper gradation of age classes in the standards is to be maintained and each of the four age classes should in theory occupy approximately equal areas. The marking officer will work with this object in view and do the best he can with the crop he finds in the compartment.
- (3) Having selected the standards all other tree growth should be felled or girdled if unsaleable. All climbers should be cut.
- (4) Fellings should be carried out with the minimum possible damage to the underwood of bamboos, and big branchy standards should so far as possible be lopped before felling.

III.—Felling rules for bamboos—

- (1) No shoots of the last rains are to be cut.
- (2) No shoot is to be cut at more than one foot above the root, except where the congestion of the clumps renders this impossible.
- (3) No removal of roots is allowed, *lathis* must not be cut below the level of the ground.

Artificial regeneration is confined to the regeneration area. It is impossible to give a definite yearly statement of work, but the compartments will be taken up serially in the order suggested for each range as far as practical working conditions permit and the following work done :—

- (1) Filling up all vacant spaces with bamboo by sowing and planting.

Supplementary silvicultural regulations.

- (2) Sowings of any tree species necessary to insure the normal gradation of age classes in the overwood.
- (3) Climber cutting.
- (4) Cleanings of undergrowth and worthless species interfering with bamboos or young standards.
- (5) Weeding of young bamboos to such extent as may be required.

The Divisional Forest Officer will carry out the above work where and when this may be necessary.

The congestion of bamboo clumps.

This matter has been investigated by several officers with considerable experience of bamboos. Congestion is always worse in the more accessible areas and there is little doubt that it is due to the following causes⁶⁸ :—

- (1) Grazing.
- (2) Excessive cutting.
- (3) Cutting the bamboos high.

Grazing.—The bamboo clump by nature spreads outwards, the new culms of the year should arise on the outer periphery of the clump. With the hardening and trampling of the ground and the browsing of the cattle the outer rhizomes are killed, the extension of the clump outwards becomes impossible with the result that new shoots are produced in the middle of the clump which becomes a solid mass of bamboos impossible to work. Such clumps are commercially useless.

Excessive cutting.—The continual cutting of the accessible bamboos of the margin of the clump has the same effect as described for grazing in that the outer rhizomes are killed. These two injurious factors are generally found together.

Cutting the bamboos high.—This is contrary to the rules, but is still done all the same in order to save the bamboo cutters trouble. The result is that a mass of dead stumps collects in the clump which effectively prevent low cutting so that the evil of high

⁶⁸ See also *Silviculture of Indian Trees*—TROUW.

cutting continues until the clump becomes hopelessly congested. This is an evil which can be remedied by better supervision.

The cleaning of congested bamboo clumps has been frequently attempted since Gamble started this work in the Saharanpur division in the eighties. In connection with the revision of the Lansdowne plan the experimental cleaning of congested clumps was carried out under strict personal supervision. It was found that moderately congested clumps could be cleaned up but that the time and cost involved rendered the operation unprofitable.

The cleaning of bamboo clumps.

Dendrocalamus strictus.—Flowers sporadically and some seed is usually available every year. It regenerates naturally but the young plants are destroyed if exposed to grazing. Where natural regeneration has taken place the area must be closed to grazing. No yield will be obtained before the 10th year by which time clumps will have been formed and some thin bamboos will be available. A natural thing out of surplus clumps takes place and the weaker clumps are killed out by suppression. There appears to be no necessity to help this natural process artificially.

Propagation of bamboos.

Bamboos may be propagated by sowing or by planting nursery plants, live rhizomes or offsets otherwise cuttings. The planting out of nursery grown plants when one or two years old or of young forest grown seedlings or of rhizomes is recommended and this operation presents no difficulty. Planting should only be done when the rains are well established.

CHAPTER XIII.

WORKING PLAN CONTROL.

WORKING plans are of no use unless they are adhered to and proper adherence can only be secured by an effective control. This control should be devoted to an examination of the works actually prescribed and carried out and to the control of the actual compared with the calculated yield. At all costs should the elaboration of control forms into accounts forms be avoided and the system of control should be simple and effective.

Apart from a statement showing the actual fellings made in every compartment and a comparison of such fellings, whether by area or by volume, with those prescribed; it is essential that continuity of management should be maintained more especially in the case of areas under regeneration.

Control as adopted in the United Provinces consists of three distinct records—

- (1) The control forms.
- (2) The compartment history.
- (3) The divisional note book.

*The
control
forms.*

The control forms consist of one or more specially prepared forms showing the prescriptions of the plan and the fellings actually made from year to year. These entries are made consecutively, so that the results from the commencement of the plan are at once apparent. The exact nature of the forms varies slightly to meet the conveniences of different modes of work and the exact nature of the entries to be made is given in detail in the working plan in the chapter devoted to control. In working circles with a volume regulation of the yield the same diameter classes and the same volume figures are used both for the calculation of

the yield and the actual fellings made against this yield. Thus if *sal* and *sain* or *asna* (*Terminalia tomentosa*) down to 8" diameter are included in the enumerations and the calculations of the yield, both these species down to the same diameter class will be included in the total of trees felled against the prescribed yield, while other trees which may be included in the annual markings will not count against the total but will be considered as incidental revenue.

Again in cases where the yield is regulated by area, the area felled over is the important entry but in order to maintain a record of the fellings and so that the controlling officer may see what sort of fellings have been done, a list of trees felled is also required.

Similarly when sowing and planting is prescribed a suitable control form is provided for the record of work done and its cost.

The actual outturn of any felling is not an essential for working plan control and is of no use for the preparation of yield or volume tables. It is however of value at future revisions of the plan and as a check on prices received for the coupe, and the information should be included in the remarks column of the control form or in the compartment history. Outturn depends on many variable factors the chief of which is the location of the coupe and facility of export, and it is never a constant of volume marked for felling.

The rules regarding the preparation of control forms and examples of actual forms in use are given at the end of this chapter.

The compartment history is a record of the history of every compartment and has already been described in chapter V. Its proper maintenance up to date is ordered in rule 8 of the control form rules.

*The
compartment
history.*

This should contain matters of divisional importance as opposed to information which only concerns the individual compartment. Such matters as the following would have their allotted place and entries should be made from time to time as necessary.

*Divisional
note book.*

- (1) Details of measurements of type trees and their outturn.
- (2) Details of seed years.
- (3) Sales and outturn figures with special reference to the guaranteed yield, where this system of sale is employed.
- (4) Fungi.
- (5) Insects.
- (6) Research and experiments, etc., etc.

Orders regarding control forms.

1. These orders only apply to those divisions whose working plans have been revised and who have been provided with new sets of control forms. These forms cannot be prepared without reading and understanding the working plan.

2. Four complete sets of forms are prepared in the Working Plans Circle and three sets issued to territorial Conservator concerned. One set is for the divisional office. One for the Divisional Forest Officer in camp, both these sets should be written up annually and the third is the flying set which is submitted by the Divisional Forest Officer to his Conservator. After passing this set will be forwarded to the Chief Conservator.

3. All control forms will be examined in the working plans branch of the Chief Conservator's office and the necessary entries made in the set of forms there maintained. In the event of any further correspondence being necessary the Chief Conservator will address the Conservator concerned.

4. Entries in control forms are to be made year after year in the same form in the space provided, space should not therefore be wasted. If more pages should become necessary forms can always be obtained from the Working Plans Branch and the original set rebound after adding the necessary pages.

5. Control forms will be prepared for the year ending 31st March, unless the working plan definitely prescribes working by the calendar year as is the case in some cantonment plans. The forms will be submitted to the Conservator according to the present orders.

6. The control forms are not accounts forms, they are maintained merely for the purpose of control. Trees marked for felling form part of the yield, whether they are cut by the contractor or not is of no material consequence, consequently the entries in the control forms should be made direct from the auction lists and should show trees marked for felling and sold. Whether the contractor finishes his work in the year prescribed or is given an extension of time is of no consequence for the purpose of control. In order to compare the numbers of trees actually felled by the contractor with the numbers marked, an entry should be made in the remarks column of the forms giving the number of trees or volume actually felled by the contractor together with a note stating what is being done with the unfelled balance. Where fellings are still incomplete on 31st March, a remark to this effect should be made as follows. "Fellings in progress and the full details will be entered in next years form." All trees sold or felled departmentally or given free or felled by rightholders in any one year as may be specifically ordered in the chapter "Control" appear in the control forms. Trees must be shown according to the girth or diameter classes used in the plan and their volume calculated accordingly. Petty fellings outside the area prescribed for felling during the year need not be shown.

7. The special circumstances of each division are dealt with in the chapter "Control" of the working plan and the instructions given therein are to be implicitly followed. Deviations from the prescriptions of a plan, alteration of years of felling, excess fellings over the limit prescribed, require the previous sanction of the Chief Conservator and the authority for such deviations should be noted in the remarks column of the form. The volumes to be entered in control forms are the volumes used for the purpose of the calculation of the yield. The actual volumes used for calculating guaranteed outturn have nothing to do with the volumes to be shown in the control forms.

8. The actual yield of any compartment is entered up in the compartment history when this information becomes available.

The maintenance of these compartment histories up to date and in good order is one of the most important duties of the Divisional Forest Officer. One copy has been provided for the Divisional Forest Officer and one for the Ranger. The Ranger's copy may be considered the working copy. It should invariably be put up when the Divisional Forest Officer or any other officer inspects the Range. All marking officers should look up the entries in the history before commencing marking in any compartment and they should be encouraged to make a note in the history. The Ranger should also be encouraged to take a personal interest in his compartment history and to note therein. During the rains all range compartment histories should be sent in to divisional headquarters and entries for the past years edited by the Divisional Forest Officer and a clean typed copy of the entries approved for the year entered up in the divisional copy. The compartment history is an integral part of the system of control.

Compartment History.

Block Pawalgarh.			Allotment to working circles.	Allotment to periods.	
Compartment.	Area.	Soil situation, aspect.			
1, 2, 3, 4 ..	3,034	The block is generally cut up into steep ravines. These occur chiefly to the west of the Bagra Sot. To the east of this stream the ground slopes gently down to the Sandnigadh. To the north ravines cease and there is a level maidan. The soil in the ravines is generally deep and rich. On the flats it is a loam which has been rendered hard and unfertile by the trampling of cattle. In the ravine country aspects are generally east and west. Only the whole block was described and separate compartment description not available.	Uniform ..	II, III, IV and V.	C 1 and 4. C 2 and 3.

EXAMPLE OF COMPARTMENT HISTORY.

Compartment.	Description of the growing stock.	Quality class.
1, 2, 3, 4 ..	The ravine country covers two-thirds of the block and contains excellent <i>sal</i> forest of the hill type. The <i>sal</i> is generally of three foot and four foot girth classes, but there are many mature trees. The ridges are generally poor and hold only a miscellaneous stock of <i>bel</i> , <i>amaltas</i> , <i>dhauri</i> , <i>bhilawa</i> , etc. The quality of <i>sal</i> in the lower parts of the ravines is first class and very good height growth is attained. Regeneration in the ravines is excellent but is being kept back for lack of cleanings. On the ridges seedlings are very scarce. A fairly pure and dense <i>sal</i> forest occupies the flats to the north. The trampling of the cattle has however so hardened and impoverished the soil that reproduction is totally absent while many trees are stag-headed. The <i>sal</i> is generally of the three foot and four foot girth classes. Along the northern boundary there is a wider strip of dense evenaged <i>sal</i> of the two foot and three foot girth classes. Isolated areas of a red ferruginous soil occur which will not grow <i>sal</i> or any valuable species. In the extreme north-west of the block the Dabka river bed holds an open forest of <i>khair</i> and miscellaneous species.	

STOCK COUNTED							Prescriptions of the plan.
Kind.	DIAMETER CLASS					Volume.	
	1	2	3		5		
							Fellings as prescribed with a view of starting regeneration C 1 and 4. Thinnings, cleanings and Improvement Fellings a prescribed. C 2 and 3.

Miscellaneous notes regarding management.

Year.	

CONTROL

FOREST DEPARTMENT,
CONTROL BOOK OF THE DEODAR WORKING CIRCLE,
Mandali

PROVISIONS OF WORKING PLAN.								
Year in which operations are to be carried out.	Locality to be exploited.			Nature of felling.	Year of Working.	Balance brought forward.		Locality
	Block or forest name.	Compartment nos.	Area in acres.			Block or Forest name and compartments.	Area in acres.	
1	2	3	4	5	6	7	8	9
1921-22 ..	Sangared ..	6 ..	198	Thinnings and cleanings.	1921-22	..	..	Sangared ..
1922-23 ..	Ditto ..	7 (part)	211	..	1922-23	Sangared 6	98	Ditto ..
1923-24 ..	Ditto ..	7 (part)	211	..	..	..	..	Ditto ..
1924-25 {	Dharmigadh	8 ..	} 149	..				
	Sangared ..	9 (a) ..						
1925-26 ..	Dharmigadh	7 ..	264					
1926-27 ..	Ditto ..	9 (part)	145					
1927-28 ..	Ditto ..	9 (part)	145					
1928-29 ..	Ditto ..	10 (part)	174					
1929-30 ..	Ditto ..	10 (part)	175					
1930-31 ..	Mandali ..	9 (a) ..	300					

FORM.
UNITED PROVINCES.
CHAKBATA DIVISION, WESTERN CIRCLE, UNITED PROVINCES.
Felling Series.

RESULT OF OPERATIONS.										Comparison.		Remarks.
exploited.		Trees felled.								Forest.	Area in acres.	
Compartment no.	Area in acres.	Deodar.		Kail.		Chir.		Fir.				
		Diameter class.	No	Class	No	Class.	No.	Class.	No.			
10	11	12	13	14	15	16	17	18	19	20	21	22
6	100	2	760	2	560	2	58	2	112	Sangarad	-98	Could not be completed during the year.
		3	415	3	300	3	9	3	78	..	..	
		4	256	4	118	4	1	4	23	..	..	
		5	32	5	24	5	..	5	..	..	..	
6	98	2	1,123	2	877	2	189	2	218	..	..	Completed during the year.
		3	670	3	420	3	52	3	192	..	..	
		4	312	4	206	4	12	4	31	..	..	
		5	25	5	54	5	..	5	..	..	..	
7 (part)	211	2	2,001	2	3,116	..	..	..	..	..	..	
		3	1,672	3	2,013	..	.	..	..	..	..	
		4	124	4	501	..	..	..	..	..	..	
		5	..	5	22	..	..	..	..	..	..	

CONTROL FORM FOR SUBSIDIARY OPERATIONS,

CHIR

Khunigadh

PRESCRIPTIONS OF THE PLAN.

Year.	Block.	Compartment.	Area.	Nature of work.	Year.
1920-21 to 1929-30.	Khunigadh ..	4 ..	3,195	Subsidiary operations.	1920-21 ..
	Ditto ..	5 ..			1921-22 ..
	Ditto ..	6 ..			1922-23 ..
	Ditto ..	7 ..			1923-24 ..
	Ditto ..	8 ..			1924-25 ..
	Ditto ..	9 ..			1925-26 ..
					1926-27 ..
					1927-28 ..
					1928-29 ..
					1929-30 ..
1920-21 to 1929-30.	Khunigadh ..	12 ..	298	Artificial regeneration.	1920-21 ..
		13 ..			1921-22 ..
					1922-23 ..
					1923-24 ..
					1924-25 ..
					1925-26 ..
					1926-27 ..
					1927-28 ..
					1928-29 ..
					1929-30 ..

ARTIFICIAL REGENERATION, ETC.

WORKING CIRCLE.

Felling Series.

RESULT OF OPERATIONS.

Block.	Compartment.	Area.	Nature of work.	Cost.	Remarks.
				Rs. a. p.	
Kunigadh ..	4 (part) ..	53	Clearing felling	202 0 0	
Ditto ..	8 (part) 4 (part) ..	189	refuse, etc. Ditto ..	316 5 6	
Ditto ..	8 (part) ..	72	Ditto ..	154 0 9	
Kunigadh ..	12 (part) ..	62	Sowing <i>deodar</i> in patches.	372 0 0	
Ditto ..	12 (part) ..	70	Nursery work ..	52 8 0	
			Planting ..	280 12 0	<i>Deodar.</i>
			Weeding ..	112 2 0	
			Nursery work ..	46 0 0	

CONTROL*Non-commercial Chir*

AREA PRESCRIBED FOR PLANTING OR SOWING.						
Year or period.	Area.		Year.	Area of new work.		Kind of work.
	Compartment.	Net area to be planted.		Compartment.	Acres.	
	Acres.	Acres.				
1920-21 ..	Bilori 4, Sura— Barsimi 5 and 7 (parts).	..	1920-21	Bilori 4, Sura— Barsimi 5 and 7 (parts).	89	Sowing patches. in
					120	Ditto ..
1921-22 ..	Bilori 10, 11, Pharkanauli 2, Punarkot 2	..	1921-22	Bilori 4, Sura— Barsimi 5 and 7 (parts).	89	Ditto ..
					120	Ditto ..
				Bilori 10, Punar- kot 2.	22	Ditto ..
					85	Ditto ..
1922-23 ..	Morpateuri 31, Pinath 1 and 2, Chhana 2.	..				
1923-24 ..	Siahidevi 23, Khauriya 1.	..				
1924-25 ..	Sunerakot 2, Bandanidevi 1	..				
1925-26 ..	Panwanaula 16	..				

FORM.*Working Circle, Central Almora Division.***RESULT OF OPERATIONS.**

Species.	Cost of nurseries, including seed.	Original cost of new work, sowing or planting.	Cost of tending.	Cost of replacements.	Total cost of year.	Total cost of compartment completed.	Remarks.
	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	Rs. a. p.	
Chir ..	22 0 0	356 8 0	113 4 0	..	491 12 0	..	All blanks devoid of suitable seed trees, or unlikely to be regenerated naturally to be sown up. Exact area is not prescribed.
Do. ..	36 0 0	478 0 0	146 0 0	..	660 0 0	..	
Do. ..	6 0 0	..	42 8 0	83 0 0	131 8 0	..	
Do. ..	4 0 0	..	73 12 0	64 0 0	141 12 0	..	
Do. ..	2 0 0	37 0 0	..	..	39 0 0	..	
Do. ..	20 0 0	324 0 0	..	..	344 0 0	..	

CONTROL
FOREST DEPARTMENT,
Control Book for the Conversion to Uniform Working

PROVISIONS OF WORKING PLAN.						RESULT							
Period.	Locality to be exploited.			Nature of felling.	Volume to be removed annually c. ft. (estimated only).	Year of working.	Balance brought forward c. ft.	Locality exploited.		Trees			
	Block or forest.	Compartment.	Area in acres.					Block or forest.	Compartment.	3'-4'			
1	2	3	4	5	6	7	8	9	10	11	12	13	
1920-21 to 1949-50	Lachman-mandi.	1	305	Regeneration.	10,000 units.	1920-21 to 1921-22.	.. 1,349	Sudlimath	Part 1	III	1,663	1,663	
		2	164						3	III	431	431	
		3	251						4	III	184	184	
		4	390					Sudlimath	Part 1	III	875	875	
		5	112						Ditto ..	3	III	411	411
		6	147										
	Sunman-thapla. Jaulasal	Not sub-divided.	527										
		1	183										
	Pilapani Sudlimath	2a & 2b	496										
		1a & 1b	301										
		1	515										
	Dulagadh	2	325										
		3	454										
		6	283										
	Chela ..	7	257										
		1	396										
	Guliapani North.	2	312										
		1	91										
	Duan ..	2a & 2b	684										
		1	375										
	Jariakhal	2	285										
		1	280										
		2	710										

FORM.**UNITED PROVINCES.***Circle of the Haldwani Division, Western Circle.*

OF OPERATIONS.										Comparison.		Remarks.	
felled						Above 6'.				Balance carried forward.			
4'-5'			5'-6'						Total volume c. ft. units.	+ Units.	- Units.		
Class.	No. of trees.	Volume c. ft. Units.	Class.	No. of trees.	Volume c. ft. units.	Class.	No. of trees.	Volume c. ft. units.					
14	15	16	17	18	19	20	21	22	23	24	25	26	
fellings in periodic block no. I.													
IV	866	1,732	V	1,310	3,920	VI	1,006	4,024	11,349	1,349	..	Excess sanctioned in Chief Conservator's no. 2721-W.P., dated the 20th December, 1921. Sudhimath compartment, part I area, 490 acres worked. 85 acres withheld for next year.	
IV	189	378	V	88	264	VI	42	168	1,241	3,030			
IV	98	192	V	46	138	VI	11	44	558				
IV	422	844	V	497	1,491	VI	546	2,184	6,743				
IV	468	986	V	353	1,059	VI	518	2,072	4,478				

CHAPTER XIV.

FIRE CONSERVANCY.

THE general policy, technique and details of fire conservancy in the forests of the United Provinces were considered at a special conference held in Naini Tal on the 5th and 6th September, 1922, and the decisions arrived at have been incorporated in this chapter.

The necessity for fire protection in the United Provinces forests generally is unquestioned, but its scope and importance varies considerably in the different forests, and the question of fire protection may be briefly reviewed for the following forest types (1) *sal*, (2) miscellaneous plains, Tarai and Bhabar forests, (3) *chir* pine, (4) other hill conifers, (5) oaks and other hill forests.

An important point to be borne in mind is the steady increase in expenditure on fire conservancy, due largely to the ever-rising wages of labour, and this necessitates the justification in each case of the need and scope of fire protective measures adopted.

(1) *Sal*.—It is generally recognized that fire protection in the past has been of considerable benefit to the *sal* forests, and should be continued, especially (a) in all hill *sal* areas, (b) in all dry plains and Bhabar areas and (c) wherever there is a heavy growth of inflammable grass, etc. In moist *sal* forest with evergreen undergrowth (e.g., Gorakhpur, Tikri, parts of Bahraich), fire protection is not so necessary, but as indiscriminate firing cannot be considered, it is suggested that either protection or controlled departmental burning may be adopted, *whichever is cheaper*. *Sal* regeneration areas must, however, be rigidly protected, once the regeneration has been satisfactorily started. (Controlled burning before a big seed year, to expose the mineral soil, and to induce

Plate 17.



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

Mature *chir* forest killed by incendiary fires, Kumaun.

Photo by W. F. Perree.

regeneration, is, however, a recognized silvicultural operation in the technique of *sal* regeneration.)

(2) *Miscellaneous forests of the plains and Bhabar*.—These occur extensively in Gonda, Kheri, Tarai and Bhabar Estates, Haldwani and Ramnagar divisions. In Gonda they are fire-protected but over grazed, elsewhere they are used largely as grazing grounds (to reduce the grazing incidence in the more valuable *sal* forests), and usually indiscriminately burnt. The possibilities of protecting one periodic block at a time for the general improvement of the growing stock is worth the consideration of Working Plan Officers.

(3) *Chir (pine)*.—It is recognized that fire protection is of paramount importance (a) in resin coupes, (b) in areas under regeneration, where the regeneration is not safely established from the risk of fire. Elsewhere it is admitted that fire protection although advantageous to the forest is not absolutely essential, ~~and might be replaced~~ by controlled departmental burning downhill in April, especially if this course tended to ensure the greater safety of the resin coupes and regeneration areas. Such a policy would be justified if it acted as an insurance against the recurrence of the incredible damage caused by the holocaust of incendiarism of 1916 and 1921. Similarly, early burning of resin areas is worth experiment, as this has been found to work successfully in the Punjab.

(4) *Other hill conifers (deodar, kail, silver fir, spruce)*.—These species are all so tender to fire that their complete protection from fire is considered essential.

(5) *Oaks and other hill forests*.—These forests are seldom very inflammable, their burning is of no benefit to the hill villager, protection undoubtedly improves their condition, and in reserved forests these areas should be protected, so long as this can be carried out economically. Unfortunately the new rules in Kumaun allow the indiscriminate burning of these oak forests.

With these general lines of policy defined, we may now consider the details and technique of fire protection.

A.—MEASURES TO PREVENT OUTBREAK OF FIRES.

(1) *External firelines*.—The following conclusions are based on the assumption that it is illegal to burn or counterfire in *private* forests without the owner's permission :—

- (a) *All firelines must be clearfelled*.—(It is recognized however, that firelines are very seldom automatic in checking a fire, the labours of the fire-gang are essential and the principal uses of firelines are to afford the fire-gang adequate assistance.)
- (b) *Width of firelines*.—No fixed rules can be laid down about the width of firelines or their utility as a protection against fires crossing from outside. Each division must consider the circumstances of each part of its boundary. When the burning of forests outside is not objected to by the owner, a 50' line will ordinarily be sufficient, and the thorough burning of the adjoining forest will be the principal means of protection. Where this is not possible, and the conditions are adverse, no width of fireline will be adequate and it will be necessary to burn a wide strip of forest (without felling). If the forest inside is of the greater value, an endeavour should be made to come to terms with the owner to allow a strip of his land to be burnt on terms to be arranged. Otherwise it will be necessary to burn a strip inside the fireline.

When the conditions are less adverse, firelines of varying width according to circumstances, will suffice. A telephone system will be effective in reducing the width of fireline necessary.

In the hills, if burning of the outer forest is not possible, a well cleared contour path is preferable to a fireline, especially in *chir* forest.

- (c) Although cutting all the grass in most cases is most efficient, the expense has risen so in recent years that each division should consider whether the burning of fire traces will not be reasonably efficient in certain places. This applies particularly to the Eastern Circle where hitherto it has been the custom to cut all grass irrespective of conditions.

It is advisable to experiment with grass mowers in flat country specially designed for our conditions i.e., with high clearance.

Firelines must be burnt before the adjoining forest becomes dry and inflammable.

(2) *Firelines and fire patrols along roads*.—The presence of a road does not necessarily imply the need of a fireline. A well-traced road is preferable to a fireline. Along dangerous and frequented roads it may be necessary to burn a narrow strip on the forest side of the road.

Special fire patrols are only useful on much frequented and dangerous roads, provided that each patrol has a definite length for which he is responsible.

(3) *Camping grounds*.—Each division should make such arrangement for camping grounds as are necessary, and these should be cleared and burnt.

(4) *Publicity. Fire notices*.—The existing notices must be maintained but should include a standard sign consisting of a red star. A pattern of this notice will be devised for the whole province, and will be somewhat larger than the existing notice. In special cases where thought necessary, permanent signs might be erected at suitable spots. Notices at railway stations and in railway carriages on forest lines are recommended.

B.—MEASURES TO SUPPRESS AND CONTROL OUTBREAKS OF FIRE.

(1) *The organization for immediate communication of outbreaks*.—In North Kheri division the telephone system has been most successful in diminishing fire damage and risk, in reducing the time and energy in combating fires, it reduces the annual

expenditure by Rs. 4,000 with an initial expenditure of Rs. 10,000 for a 50 mile installation. It is also of great value in every branch of forest work, e.g., reducing petty correspondence. The installation in North Kheri was erected and is run departmentally with very small amount of professional assistance. Where suitable schemes can be developed, every effort should be made to obtain sanction for the capital expenditure.

Where telephones are not available, where the country is suitable for bicycles, a bicycle patrol is of much more value than a larger number of ordinary fire watchers.

The system of having watchers at look-out points should be developed, and special steel-look out towers may be given a trial.

(2) *The organization for immediate concentration of labour to fight the flames.*—In forests far from villages, gangs of labour required for attending general works in the forest should as far as possible be employed throughout the hot weather. In such cases the cost should be charged to the works concerned. Divisional Forest Officers should consider whether in any case the employment of a gang is mainly for fire protection when the other work which the gang can carry out is not an essential part of the work of the division. In such cases the cost of the gang should be charged to fire protection.

The South Kheri division is quoted as an instance where such a gang mainly for fire protection has been found justifiable.

There can be no special organization for summoning assistance from villages, but in order to render this assistance as little unpopular as possible, the following resolutions of a meeting of Conservators on the 16th August, 1921, on the subject of payment of assistance will be adopted :—

“The policy to be followed should be to pay the ordinary day's wage if demanded. Such day's wage to be decided for each Range by the Divisional Forest Officer. Any rightholder bargaining, or refusing to come to assist in putting out a fire without

extra pay, can be proceeded against under the Act, as this constitutes a refusal.”

(3) *Beating out fires and counterfiring. The general technique.*—General instructions to Range Officers in both hills and plains forests are given as appendix no. IV.

(4) *Internal firelines. Plains.*—It is accepted that in ordinary circumstances counterfiring is as likely to be successful from a narrow line or road as from wide fire line but in the case of large blocks of forest it is advisable to have a few wide lines up to 200' broad because it has been found that under very unfavourable circumstances such wide lines are more efficient than ordinary counterfiring lines and may save a large block from total destruction. With this exception it is considered that a road or a narrow line with a cleared path is sufficient for counterfiring and that all wider interior fire lines might be abandoned.

Existing lines on which a growth of trees and bushes can be confidently expected should be abandoned at once. As regards other lines each Divisional Forest Officer must decide what can be done with due regard to safety. The degree to which the line is used as a road will be an important factor.

No general principle regarding the number of lines can be laid down but the system of counterfiring lines should coincide with compartment lines as far as possible.

In the *sal* and miscellaneous submontane forests of the low hills the same principle of the advantage of narrow counterfiring paths over firelines is accepted. In *chir* forests a few internal firelines not less than 100 feet broad, clearfelled along main ridges are essential, and should be supplemented by narrower lines or scraped paths in special areas (regeneration areas and resin coupes). The usual practice in the hills is to burn firelines from fire traces.

(5) *The protective establishment.*—Fire watchers can only be used at telephone stations or at look-out points (towers or tops of

hills). Ordinarily the establishment will consist of patrols. Fire patrols should only be employed to patrol some definite and important length of road or outer boundary, along which there is special cause to fear that fire may break out.

In the Kumaun hills it is necessary for each isolated block to have a patrol.

For large blocks of forests in the plains, the ticket patrol system is recommended. This system is described in the *South Kheri Working Plan*.

(6) *Arrangements for food, drink, etc., for men engaged in extinguishing fires.*—The supply of water is a most important point. An adequate supply of vessels for water should be kept at each *chauki*, with a reserve supply at range quarters. The staff of forest guards and fire patrols should be supplied with water bottles. The keeping of stores of food is not recommended, but the arrangements for necessary food supplies will be part of the ordinary duties of the staff.

(7) *Prevention of subsequent outbreaks when the fire has been brought under control.*—The prevention of subsequent outbreaks due to smouldering stumps and dead trees is of great importance and must be attended to by the Range Officer himself.

Special attention should be given to smouldering standing dead trees. These must be felled on steep hillsides, and in the plains on the edges of burnt areas. In the plains, water carts have been used for some years with success in North Kheri.

In coniferous forests, trench digging to stop underground fires may sometimes be necessary.

C.—MEASURES TO LIMIT THE DAMAGE DONE BY FIRES.

(1) *Departmental burning, before fire season, of areas whose protection is not essential.*—The departmental burning of unprotected *chir* forests adjoining protected areas (e.g., regeneration areas and tapping areas) is recommended. In many parts of Kumaun there appears very little hope of protecting any areas at

all, unless this is carried out regularly and systematically. It may even be necessary to burn twice a year.

In order to prevent the total destruction of established *chir* regeneration, an annual early burning as soon as it can stand the fire, should be carried out. The department has bitter cause for regret that this was not adopted before.

(2) *Departmental burning of slash, felling debris, etc.*—The removal or departmental burning of felling debris in all forests is a very important measure for the limiting of damage by fires, and should be carried out wherever feasible. Departmental burning for silvicultural reasons should, however, not be carried out in areas containing large quantities of debris without certain precautions as the resulting fires will be so fierce as to damage mother trees and destroy regeneration. In such cases, it will be necessary to collect the debris and burn it in heaps, or otherwise dispose of it to the best advantage.

(3) *Silvicultural operations.*—In *chir* forests, early cleanings ~~and thinnings~~ are undoubtedly useful in reducing the risk of subsequent fires.

Danger from fire is a strong reason for reducing girdling to a minimum.

(4) *Salvage or disposal of grass, fallen wood and other inflammable material.*—It is accepted as a principle that the removal of felling debris in regeneration areas is of greater importance than any probable damage to the young crop, and should be encouraged as far as possible. In the majority of cases, the cutting of grass also is often desirable and should be permitted.

D.—SPECIAL MEASURES AGAINST INCENDIARISM.

(1) *Preventive.*—The conference resolved that effective preventive measures are possible by means of education, and that a very effective measure will be through the schools. The Education department should be approached with a view to starting lectures, supplemented, if possible, by photographs and lantern slides.

It is also considered that in special localities a special officer might be appointed to conduct lectures in schools and villages.

The conference endorsed the resolution (no. VI) of the Punjab conference on the subject of education, i.e., "that the forest education of the agricultural community is of the greatest importance, and that elementary instructions in the utility of forests should form part of the curriculum in all primary vernacular schools in a forest *ilagua*."

The conference also resolved that forest policy in general should be as liberal as is consistent with the maintenance and regeneration of forests, more especially in the matter of minor concessions, such as grass, collection of dry fuel, etc.

(2) *Punitive*.—Criminal prosecution is undertaken whenever sufficient evidence is available to suggest the probability of conviction.

The conference was not in favour of communal responsibility and punishment.

The conference was of opinion that withdrawal of concessions and closures of areas to rights as a punitive measure is a doubtful policy, but it was admitted that in certain cases it may be desirable, such action if adopted must be made effective.

Expenditure under A. VIII-f. For the forest years 1909-10 to 1920-21.
(1st July, 1920 to 30th June, 1921)

Year.	Western Circle.	Eastern Circle.	Kumaun Circle.	Total for province.	Remarks.
1909-10	Rs. 37,208	Rs. 34,270*	Rs. 1,440	Rs. 72,918	*District forests.
1910-11	33,309	34,163*	1,981	69,453	
1911-12	35,306	34,916*	1,921	72,151	
1912-13	36,479	37,520	3,065	77,064	
1913-14	36,679	40,251	3,925	81,855	
1914-15	33,858	40,600	7,621	82,079	
1915-16	43,765	32,778	11,963	88,506	
1916-17	39,572	32,933	7,613	80,118	
1917-18	39,735	29,968	13,436	83,139	
1918-19	44,635	34,149	13,907	92,691	
1919-20	51,539	38,231	17,695	1,07,515	
1920-21	56,721	49,097	33,138	1,38,956	
Total	4,88,856	4,39,876	1,17,713	10,46,445	

Fire protection in the United Provinces for the years 1909-10 to 1920-21 (1st July, 1920 to 30th June, 1921)

Year.	Western Circle.		Eastern Circle.		Kumaun Circle.		Total for province.		Remarks.
	Area attempted.	Area burnt.	Area attempted.	Area burnt.	Area attempted.	Area burnt.	Area attempted.	Area burnt.	
1909-10	1,049,528	6,121	985,103	44,727	186,117*	49,008	2,220,748	99,856	*District forests.
1910-11	1,029,528	1,507	985,885	34,930	247,637*	*479	2,233,050	57,276	
1911-12	1,046,437	27,956	983,279	21,896	261,772*	*6,179	2,299,488	56,031	
1912-13	1,046,473	5,332	1,016,787	49,089	310,770	4,830	2,374,030	59,251	
1913-14	1,046,475	12,003	1,008,112	42,710	397,109	7,800	2,451,346	62,513	
1914-15	1,048,499	231	1,014,113	12,457	375,187	9,567	2,437,799	22,355	
1915-16	1,335,598	31,901	802,294	24,177	533,638	192,400	2,475,530	248,478	
1916-17	1,134,124	374	809,463	6,248	371,113	239	2,314,700	6,961	
1917-18	1,132,152	1,431	810,903	19,931	377,266	1,434	2,320,321	22,846	
1918-19	1,128,874	25,997	803,685	31,278	395,660	3,673	2,329,219	60,948	
1919-20	1,133,015	16,654	803,260	49,686	401,451	33,769	2,337,726	100,169	
1920-21	2,352,198	242,430	*803,314	28,625	404,455*	272,865	2,559,967	548,920	*Figures up to 31st March, 1921.
Total	14,300,901	372,927	10,832,198	365,754	4,270,475	582,563	29,403,574	1,320,544	

CHAPTER XV.

RESIN TAPPING.

IN chapter II a brief history of the evolution of the resin industry in Kumaun has been given. In this chapter it is proposed to describe the details of organisation and methods of tapping and collection of the crude resin in the forest according to modern procedure. The details of distillation, manufacture, and sale of the refined products do not come within the scope of this work.

1. *Method of tapping.*—There are two principal methods employed in the trade for extracting resin from conifers, i.e., the American "box" method and the French "cup and lip" method. That adopted in Kumaun closely follows the French method.

During the cold weather all preparations are made for the coming year's tapping operations; in the new coupes the trees are enumerated and numbered, the various tools and implements required are got ready, and the cups and lips fastened on the trees. This work is now done on contract, and the total cost of buying all implements required, and completely working a new coupe comes to about one-sixth of the cost of working an American coupe of the same size.

In fastening on the lips and cups, a curved cut is first made with a chisel, about 6" above the ground, sloping slightly upwards, and into this cut the lip is fixed. The outer bark is scraped off, and a nail fixed in the centre, and just below the lip, from which the pot is hung (the pot has a small hole in the side for this purpose). Thus all resin which falls on the lip, drains into the pot. The top of the pot is covered with a lid (or suitable shaped flat stone), to prevent as far as possible (1) evaporation of the turpentine oil, (2) inclusion of dirt, etc. The channel



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

Photo by E. A. Courthope.

Chir pine under resin tapping.

is commenced by cutting a groove, about 6" long 4" broad, and not more than 1" deep, with a sharp adze (*basula*). This much is done at the time of putting on the lips and cups.

The real work of extracting resin is commenced about the middle of March, by removing from the top of the cut, a thin shaving, as thin as possible, when the resin begins to exude at once and drains into the pot. This process of removing a thin shaving from the top is called a "freshening," and the cut has to be freshened about every six or seven days (five times a month), throughout the summer as the resin gradually dries on the exposed surface, and clogs the outlets of the resin ducts.

The continued weekly freshening gradually lengthens the blaze, and at the end of the year it should be about 18' long. This length is found in practice to be most suitable, as it gives a good flow of resin and avoids the use of a ladder until the fifth year. Before commencing the second year's work, the nail and pot are removed up to within 4' or 5' of the top of the last year's channel. This ensures a minimum distance for the resin to flow, and this prevents evaporation and solidifying on the way to the pot. As soon as the cups are filled with resin, they are emptied by a collecting coolie into canisters, or old kerosine oil tins. The periodical emptying varies from once in a week to once in a month, according to the flow of resin. The resin thus collected is carried to the forest dépôt and stored in a cool shady place, usually near the cart-road or main line of export, if it is not too far from the tapping area.

2. *The Tapping scheme.* In the pine forests of the Landes of France, there are two methods of tapping i. e. "*gemmage à vie*," or tapping lightly and "*gemmage à mort*", or tapping to death, the object being to tap all trees lightly, so as not to injure them, with the exception of those which are to be felled within the next five years. On these as many blazes are put as the tree will take, so as to extract all the available resin. In Kumaun for the

first 15 years, a system of semi-light tapping was carried out, i.e. as follows :

3 channels put on trees over 6' girth.

2 " " " 4' 6" and 6'.

1 " " " 3' 6" and 4' 6".

trees being tapped for five years, and then given 10 years' rest to enable the wounds to heal up. Experience has shown that tapping to this extent is not at all injurious to healthy trees. The tapping rotation is thus 15 years, five years' tapping 10 years' rest, and again five years' tapping 10 years' rest, and so on.

Experiments started in 1913 in the Naini Tal division showed the advantages of introducing heavy tapping on the trees to be felled within the next five years, and on the revision of the Naini Tal Working Plan in 1915-16, the tapping scheme was revised and is justified and explained in that working plan as follows⁶⁹ :—

"Experience has established the fact that the tapping to this extent does no harm to healthy trees. The channels do not heal up with a 15 years' rotation but the addition of a second set of channels will not harm healthy trees (this has been proved in Suini Range), and with healthy trees the channels will probably completely heal over in about 20 to 24 years. The *chir* is a hardy tree and capable of withstanding severe hacking about without dying, and it is almost certain that the intensity of tapping could materially be increased without killing or injuring trees. Over-mature and sickly trees, which are approaching the limit of life, will undoubtedly dry up more quickly by tapping, but as these are trees which would naturally come out in the fellings they do not affect the main argument.

"The discontinuous method of tapping is however in several ways a disadvantage. It is difficult to draw up a tapping scheme to give an equal annual yield, it is next to impossible to fit in the tapping with the fellings, and as heavy tapping of scattered trees, to be felled shortly, is impracticable, unless the surrounding trees are being tapped lightly at the same time, the profit of heavy

⁶⁹ Naini Tal Working Plan—SMYTHIES.

tapping has to be forgone. Furthermore, the clay pots left in the forests at the end of five years' tapping period are entirely lost, unless (as rarely happens) there is a succeeding coupe in the immediate vicinity. It does not pay to carry pots far.

"It is therefore proposed to introduce a more continuous process of tapping, with a decrease in the intensity for all the *chir* forests of the Naini Tal division. The proposal is practically to adopt the French method of tapping, i. e. one channel per tree, with no rest period. In the Landes the minimum girth is 3', and a new channel is started every five years, the individual channel reaching up to a height of 12'.

"In the Himalayas it is impossible, owing to the configuration of the ground, to tap as high as 12', about 6' to 8' 6" is the limit. To be on the safe side and as this continuous tapping is a new departure in India, it is proposed to fix a minimum girth of 3' 6" and to start a new channel every six years. On the other hand, as many of our trees are over-mature, and of very much larger girth than is ever reached in France, trees of 7' girth may have two channels every six years. If (as may frequently happen on the steeper slopes) the channels become too high in the sixth year for working, this sixth year will remain idle. There seems to be no reason for doubting that what the French maritime pine will stand, the *chir* pine will stand, and we have therefore *a fortiori* ground for holding that tapping to this extent will not be excessive.

"Combined with this continuous, or almost continuous, light tapping will be heavy tapping on trees to be felled within the next five years. In this type of tapping the number of channels is determined by what can be comfortably squeezed on to the tree. In practice 4" to 5" have to be left at the bottom of the tree between channels, or they run into each other higher up. As a general formula for well-shaped cylindrical trees, the maximum number of channels which can be put on is $\frac{4N}{3}$, where N = girth of trees in feet."

This system of continuous or practically continuous light tapping, combined with heavy tapping on the trees shortly to be felled, has now been generally adopted in the Kumaun Working Plans. It is a sound and simple system and thoroughly justified in all areas where the middle and younger age classes are well represented, which ensures that a continuous supply of younger trees become tapable and take the place of the mature trees as they are felled. It is however a very doubtful point if this system of continuous tapping can be justifiably applied to many forests newly reserved in Kumaun, where we find the middle and younger age classes almost totally absent. In such areas continuous tapping will inevitably lead to a hiatus and drop off yield in 20 years when the older trees have been thoroughly tapped, and there are no younger trees to take their place. The total all in cost of delivery of resin at factory site, and the selling rates for the manufactured products are the two dominant factors which limit the scope and radius of tapping in the extensive pine forests of Kumaun, and any reduction in the cost or rise in the selling rate will automatically increase the possible output.

3. *Organisation of the tapping labour.* The resin industry employs a very considerable amount of labour, which is employed (1) in the winter in fixing pots and lips, and making the commencement of channels in new coupes, (2) in the hot weather and rains in freshening the channels weekly, collecting the crude resin from the pots and taking it to the forest dépôts. Labour is also required throughout the year in carrying the stocks of resin from the forest dépôts to the main export dépôts *lohars* in repairing and sharpening tools, solderers for soldering up the tins of resin, potters for making the clay pots or receptacles.

In the early days of the industry, all labour was paid by fixed daily wage—an unsatisfactory system which led to idling and gave the subordinate staff many opportunities of dishonesty. From 1911 to 1918 a system was evolved of farming out the resin coupes to contractors, with a fixed payment per maund of resin delivered. This was a great improvement on the daily wage system and made

possible the great development of resin operations which took place in those years. After a time, however, various difficulties arose, and this all-through contract system was gradually replaced by a system of piece-work payment, or petty contracts at a fixed rate per maund of crude resin delivered by a small gang of 8 or 12 men. This is the system at present in force.

The detailed tapping rules by which tapping labour is controlled, together with a rate list of cost for piece work, is given at the end of this chapter.

4. *The necessity for complete fire protection.*—The *chir* pine is naturally very fire-resisting. But when a fire breaks out in April or May in an area which has been successfully protected for a series of years, whereby the accumulation of dry litter and other inflammable material has greatly increased, the damage done is enormous, even mature tree being sometimes killed outright and all young saplings and regeneration wiped out. The inflammable conditions are greatly increased in areas under tapping, where the resin-soaked chippings, the pots half full resin, and open wounds on the trees all help to aggregate the intensity of the fire. A fire in a resin coupe is followed immediately by a flow of dirty black sooty resin, which escapes to the ground, as the pots are usually broken and then tapping faces more or less completely dry up, and render the area worthless for further tapping during that season. Where the fire has been very intense, and a large proportion of the trees killed outright or seriously damaged, further tapping is rendered useless for many years. In 1921 when incendiary fires swept through most of the resin coupes in Kumaun, the resin yield which should have been 90,000 mds. dropped to about 25,000 mds. in that year, and will also be considerably reduced in 1922. The direct and immediate loss from fires in resin coupes can thus be appreciated and complete fire-protection must be regarded as a *sine qua non* for the resin industry.

5. *Bibliography.*—A brief list of available literature on the resin industry may be given for ready reference—

- (1) Smythies. Some Factors that influence the Yield of Resin from *Pinus longifolia*. *Indian Forester*.
- (2) Smythies. Resin Industry in Kumaun. *Forest Bulletin* no. 26 of 1914.
- (3) Smythies. Working Plan for the Naini Tal Division, 1916.
- (4) Champion. Working Plan for the Ranikhet Division, 1920.
- (5) Troup. Memoir on *Pinus longifolia*. *Forest Memoir*, volume no. 1, Part I of 1916.
- (6) Annual Reports of the Resin Industry, 1917-18 and onwards.
- Statement showing rates for different parts of resin work.*

Number.	Name of article and work.	Rate.		Remarks.
		At	Per	
1	Making chisel ..	As. 8 ..	Chisel.	
2	" adze ..	" 6 ..	Adze.	
3	" (jamura, nail extractor).	" 6 ..	" Jamura "	
4	Making pots ..	Rs. 6 to Rs. 7	1,000	
5	" lids (half) ..	Re. 1-8 to Rs. 3	1,000	
6	Cutting lips from iron sheets.	As. 12 ..	1,000	
7	Cutting channel gauge ..	" 4 ..	100	
8	Fixing lips and pots, 1st year.	Rs. 8 ..	1,000	
9	Fixing lips and pots subsequent years.	" 5 to Rs. 7-8	1,000	
10	Cost of baskets for carriage of lids and pots.	As. 3 to As. 5	Basket ..	
11	Tapping and collection of resin.	Re. 1-4 to Rs. 2	Maunds ..	Higher the output a forest gives lower the rate is paid; generally speaking, the rates are from Re. 1-4 to Re. 1-8 per maund only in one coupe the rate is Rs. 2 per maund and in another Re. 1-10 per maund. Depends upon distance between forest and cart road and roughness of the roads and footpaths. According to distance between cart-road, and rail-head dépôts.
12	Carriage from forest to cart-road.	..	..	
13	Carriage from cart-road to rail head.	..	..	
14	Soldering of tins ..	Rs. 2-4 to Rs. 3	100	

Note.—Bonus to a mate is paid at as. 2 per maund when he gives more than 5.5 maunds per 100 channels at the end of the year, but bonus for March and October is paid without any condition. Mates and coolies are supposed to sharpen their adzes twice a month therefore they are paid at as. 2 per adze along with their bill for tapping and collection of resin.

Rules for resin tapping.

1. The preliminary work of fixing lips and pots is to commence soon after the freshening of the previous seasons has stopped. The latest date for starting this work is the 1st December. All preliminary work must be completed by the 7th March. The first areas to be taken in hand should be those in which new channels have to be started, so that the maximum effect of the new wounding of the area may be obtained before freshening commences.

2. (a) *Provision of all materials.*—Tools and implements required, including the making of earthen pots and lids, of lips, of collecting balties or tins and strainers and the carriage to the coupe or cart road dépôt of the tins to be used in packing of the resin, should be arranged for early.

Tool to be made as under.

- 1 Chisel per 5,000 channels.
- 1 "Jamura" (nail-puller) per 5,000 channels for the areas under subsequent years' tapping.
- 1 "Basula" per 1,000 channels.
- 1 "Balti" per 1,000 channels (the tin is provided with collection tins by Government, but is fitted up by the contractor).
- 1 Strainer for "balti" per 1,000 channels.
- 1 Combined lip scraper and channel measure per 1,000 channels.
- 1 Light ladder per 1,000 channels in 5th year tapping coupes only.

For each channel one pot, lid, and 1½" nail required. For replacing breakages about one pot per four channels is required per annum. Two tins per 1,000 channels are to be allowed for collection purposes. For carriage the number of tins depends on the yield; the number required to be reported by the Range Officer.

(b) *Fixing lips.*—Lips may be either of iron sheets or of tins, if the latter they must be made two fold according to the approved pattern, a copy of which will be supplied on request. The size of the lips must be 6" × 2". In areas under first year's tapping when

fresh channels have to be made, the number of channels to be made on a tree will be known either by a figure stamped on the bark or by the number of cuts made with a timber scribe (risser). In some cases where channels are to be made on trees already bearing old channels the position of the new channel or channels will be indicated by cuts made parallel to old channels with the timber scribe at the points where channels are to be made. Each new channel as far as possible will be put on serially round the stem clock-wise or the reverse, i. e. from right to left or left to right. The position of new channel on such trees must be marked at the distance of $4\frac{1}{2}$ " bark space for the old channel, measuring at breast height. In heavy tapping in regeneration areas, seed-bearers will be tapped on the continuous system. For fixing the lips in the first year tapping areas—cut all the outer bark off the place where the channel is to be placed and the pot is to hang. Then first make this cut with a special curved chisel about 6" above the ground and sloping slightly upwards and into this fix the lip; secondly make the channel. Care must be taken that the edge of the chisel is level, if the outer corners are rounded off the cut does not penetrate the full depth at the ends, and the lip, when fixed, is stopped by the shallow cuts at the corners, and when the channel is made it will be found that the lip does not reach the bottom of the channel in the middle and resin runs to waste in the gap left. Worn chisels should be renovated and chisels should not be made too thick or too wide. Care must be taken particularly in the first year's tapping areas that the cut with the chisel does not slant too much upwards, as in that case the lip when fixed does not project sufficiently to run the resin into pots. About $1\frac{1}{2}$ " above the lip the channel should be started by cutting with an adze a groove about 6" long $3\frac{3}{4}$ " broad and $\frac{3}{4}$ " deep. These full dimensions should be cut as the tree reacts to the effect of the wound before freshening commences, and with a very small wound a good flow of resin will be retarded. In heavy tapping the channels may be cut 2" deep, but this should not be done where very little bark space between

channel has been left, and in no case must the maximum dimensions be exceeded in light continuous tapping. All adzes are to be the original square pattern but must be given a bend in their blades of about 65 degrees to prevent them cutting too deep into the wood. In subsequent years tapping, the lips are first removed, burnt to clear them from old resin and hammered into shape; broken ones are rejected and new ones substituted. The chisel cut is then made at a point about 4—5" from the top of the previous year's channel. The burning of old lips should be done in a place where the forest may not be endangered by fire.

(c) *Fixing the nails.*—Nails must be not under $1\frac{1}{2}$ " in length. They are fixed in the centre, about 1" below the lips and on them the pots are hung. In some cases it may be found easier to put the nails a little to one side or the other, the important point to fix the nails is that the pot shall so hang that all the resin will fall into it from the lip. If pots are hung subsequent to fixing of nails, the latter should be moved again if necessary if the pot is not in correct position.

(d) *Clearing of loose bark.*—This is done best by rubbing bark with the sides of the *basula*. The object is to rub off all loose pieces of outer bark, which would otherwise flake off later during the tapping season and fall into the resin pot; in addition to this, all bark over the length of 6" and width 5" should be cut ("chilloed") leaving at least $\frac{1}{4}$ " thickness of bark at the place where the channel is to proceed during the year. It is desirable that at each freshening bark should be "chilloed" first, then the wood be cut. Experience has shown this prevents the channel becoming deep when freshenings are being made.

(e) *Marking on the bark lines for the channels.*—All channels are to proceed parallel to the axis of the tree or when old channels exist parallel to the existing channel and if, owing to a knot or wound, or the tree being crooked, this results in continuation of the channel being impossible it will be discontinued. To ensure

that channels should proceed as desired in the course of freshening a mark where one does not exist should be cut on the bark upwards in the desired direction on the inner side of the channel, i.e. towards the existing channel.

(f) *Clearing round the base of the trees.*—All the needles and chips of wood and bark to be cleared away from the base of a tree for 3' to lessen the chance of the channel burning in the event of a forest fire. This work will be done at this time and at the close of the season instead of as previously prescribed throughout the fire season.

(g) *Hanging pots.*—The form of the pots is well known and need not be detailed. Care should be taken that they are not too shallow as in this case on some trees they may fill too soon, and resin be wasted. They must not be too broad at the top as they will not fit into the old channels; the practice of cutting notches in wood and bark to allow them to fit in is particularly to be avoided as it increases the time taken for healing over the blaze. The Range officers must understand that the sides of blazes must be kept as much alive as possible.

In first year tapping areas and elsewhere, where new pots are required, these must be made in good time. Old pots will be moved up when lips and nails are moved; they are less liable to damage on the tree than lying at its foot. New pots generally contain dust, and this must be carefully cleared out before they are hung. It must also be seen that the old pots used are as clean as possible.

(h) *Lids.*—Earthenware lids are to be put on all pots. Samples of the semicircular pattern are available in all ranges. All lids must be in position before the first freshening takes place.

3. *Freshening* (chillan).—Not less than a cooly per 1,000 channels must be employed on this work and more must be employed if this number does not suffice to ensure the full number of freshenings per month.

Freshenings should commence from 7th March in favourable localities and from 16th March in colder localities. If it is not considered profitable in any coupe or plot to commence freshening so early as this, special permission must be obtained from the Divisional Forest Officer for a later start.

Freshenings must be continued up to the end of October without interruption and may be continued later if it appears profitable. If in any area it appears profitable to cease freshenings before the end of October, a special permission must be first obtained from the Divisional Forest Officer. Five freshenings must be made per month; even in colder areas at least two freshenings must be carried out in the month of March. Freshenings consist in removing from the channel a thin shaving so as to open up the clogged resin ducts. In this work the blaze must not be lengthened more than $\frac{1}{2}$ " at each freshening, i.e., the strip of bark and wood which is removed at the top of the blaze must not be more than $\frac{1}{2}$ " broad. The shaving should rapidly taper off in thickness and should be only about 6" long. It should not, as is often done, be continued down to the lip, as this in time makes the channel much too deep. Channels should not be made deeper than 1." The channels must be made parallel to the axis of the tree or the existing channel following the guide line (vide rule 2e). The blaze must be clean cut and not torn and jagged, as in that case the resin is held up and coagulates. In twisted fibre trees the lower side of the twist (generally the right side) can rarely be made quite clean and the blaze must not be made of excessive depth or width in the attempt to do this. Adzes must always be kept very sharp (particularly for twisted fibre areas) or the cuts will never be made clean.

Periodical sharpening by the *lohar* is required but coolies must carry a small stone for sharpening the adze.

The tapping period is eight months, i.e. March to October inclusive. This allows for 40 freshenings during the year. At every freshening the blaze is lengthened a maximum of $\frac{1}{2}$ " so that at

the end of first year's work the blaze should be 6" (its original length on 1st March) plus rather under 20" or about 2' in all. In all subsequent years the blaze is lengthened by 18" or so per annum so that at the end of five years the top of the blaze should be 8' in height from the ground.

In the fifth year of tapping, when the channels will be otherwise too high for the tappers to reach, a light ladder should be given to each tapper, which he will carry about with him from tree to tree.

After freshening, the cooly will always clear the lip of any shavings with a piece of iron sheet which he must have with him. This piece of iron sheet is to be shaped so that its breadth is $3\frac{3}{4}$ " i.e., the breadth of a blaze, and that it has in the middle of one side an outstanding piece $\frac{3}{4}$ " depth to gauge the depth of the channels. The first freshening made in the season on an old channel will often require to be a somewhat longer one, i. e., taking more than $\frac{1}{2}$ " owing to the old face of the channel having dried to a greater depth than $\frac{1}{2}$ ". It will be necessary in such cases to cut away the dry wood until the resin bearing wood is reached.

If in some cases of slanting trees or slanting channels it is found that resin will not fall into the pot, it should be guided into it by sticking one or more chips of wood fixed into cuts made with the adzes on the bark at the edge of the channel on which the resin can fall and be guided into the channel and lip to pot.

4. *Collection of resin*—It is necessary that resin should be left as little exposed to air as possible. The keeping of lids on the pots at all times is one means to ensure this. Another means is the constant collection of resin from pots so that the resin be not allowed to remain for any length of time in the pot. The best method is to provide each cooly with a collecting tin and strainer. The procedure is to remove the pot containing resin from the tree, taking the lid off and turning the pot upside down on the strainer in the collecting

tin. While the resin is running out of the pot, he completes the freshening, cleans from the pot any resin that may not have run out of it already, and fixes pot on the tree and replaces lids. It is absolutely necessary that all freshening coolies must collect also, as it undoubtedly results in better work on the part of the coolies. Straining of resin must be done as the resin is collected from the pots into collecting tins or balties. For the strainers wire gauge mesh of four to the inch is the best, but tins with holes cut of equivalent size are allowable if gauge is not obtainable.

Resin when collected must be brought daily to the prescribed dépôt. If a mate or cooly is found to be leaving resin lying in the forest, the Forester, Forest Guard or resin moharrir should report the matter to the Range Officer, who will take immediate steps to warn and punish the mate or remove him if desirable.

5.—*Packing of resin.*

Tins with small holes are provided for this. The resin already strained will be emptied from collecting balties into the small-holed tins. The small holed tins to be filled in the presence of resin muharrir where one is provided: if there is no jamadar at the dépôt, the cooly will fill up the tin himself, but it should be noted that only clean resin should be allowed to pass into these tins, and residue at the bottom of the balti found mixed with dirt to be kept in a separate tin; the cooly or mate has nothing to loose, when he finds dirty resin at the bottom of the balti he will himself keep it separate. In case there is no jamadar at the dépôt the man taking over resin should mark this tin with a separate serial and write "D" to indicate dirty. The resin in small holed tins will take about a day to settle and on the day after filling the resin will be found to have sunk a little in the tin and more must be put in to fill it completely. All tins must be filled completely in this way and no tin should hold less than 20 seers, nett, making the gross weight at least $21\frac{1}{2}$ seers. Small-holed tins when filled with resin must have the holes plugged with clay

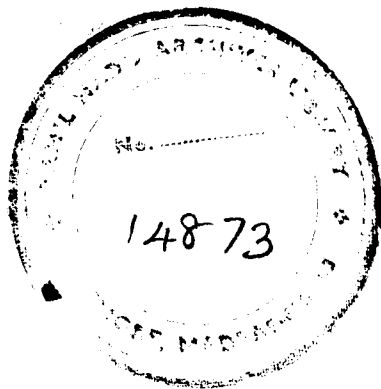
enclosed in a piece of brown paper until the holes are soldered up. Care should be taken that the clay is not allowed to get inside the tin.

All tins filled with resin must always be kept in a shed, which should have a wall or planks on the sunny side.

A strainer must always be available at a packing dépôt for use in case improperly strained resin is received at the dépôt. Another strainer may be used for obtaining the last drops of resin which cling to the shavings, etc., strained off from the resin during the ordinary collection. By putting this strainer with the chip, etc., in the sun, all the resin will be melted off and strain through. Small holed tins when filled with resin will be numbered by the Forest Department resin jamadar with serial and distinguishing number.

Soldering of small-holed tins must be properly done ; in large dépôts a man can be kept permanently employed. For smaller dépôts a man will work several dépôts. More than four days accumulation should not occur except in March and October. Care must be seen that soldering is done strongly and that any defects in tins are repaired at the same time. When soldering is done in sound condition before allowing export, any leaking tins must be repaired before removal. Cart-road resin jamadar will see that in all his dépôts (or in case of check officers in carts checked by them) tins are not leaking. They will insist on immediate repairs of leaking tins. The cost will be chargeable to Government but Range Officers concerned must be informed with a view to the punishment of the solderer concerned, if defects occur frequently.

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APPENDIX I.

PRESCRIBED WORKING PLAN HEADINGS.

Introduction.

PART I.

Summary of facts on which the proposals are based.

CHAPTER I.

The tract dealt with

- Name and situation.
- Configuration of the ground.
- Geology, rock and soil.
- Climate.
- Water supply.
- Distribution and area.
- State of the boundaries.
- Legal position.
- Rights and concessions.

CHAPTER II

The Forest

- Composition and condition of the crop.
- Injuries to which the crop is liable.

CHAPTER III.

Utilisation of the Produce

- Agricultural customs and wants of the population.
- Markets and marketable products.
- Lines of export.
- Methods of exploitation and their cost.
- Past and current prices.

CHAPTER IV.

Staff and labour supply.

CHAPTER V.

Past systems of managements General history of the Forest.
 Past system of management and
 their results.
 Special works of improvement
 undertaken.
 Past yield.
 Past revenue and expenditure.

CHAPTER VI.

Statistics of growth and yield (To include allotment to quality
 classes, mean annual incre-
 ment, current annual increment,
 yield tables, etc.)

CHAPTER VII.

Estimate of capital value of
 the forest.

PART II.

Future management discussed and prescribed.

CHAPTER I.

Basis of proposals General objects of management and
 brief statement of treatment required
 to secure them :—
 (a) As regards the attainment of the
 normal forest and the estab-
 lishment of normal regeneration.
 (b) As regards the Silvicultural
 requirements of the species dealt
 with.
 (c) As regards the yield of timber
 and other forest produce.

(d) As regards the improvement and
 regulation of the water supply.
 Methods of treatment to be adopted.
 Working Circles, their area and distri-
 bution, reasons for their constitu-
 tion.
 Period of working plan and necessity
 for intermediate revision.

CHAPTER II.

Working plan for working General constitution of the circle and
 circle. character of the vegetation.
 Blocks and compartments (permanent)
 Analysis and valuation of the crop.
 Method of treatment (exploitable size,
 choice of species, silvicultural
 system, calculation of the rotation,
 division into periods, allotment to
 periodic Blocks, felling cycle, calcu-
 lation of the yield).
 Method of executing the fellings.
 Tabular statement of felling to be
 made.
 Subsidiary silvicultural regulations
 (sowing, planting, weeding, clean-
 ing, thinning and supplementary
 fellings).
 Other regulations (grazing, protection,
 exercise of rights and privileges,
 collection and record of statistics,
 and control including forms, records
 and maps as required here or
 generally.

APPENDIX.

(Chapters for all working circles.)

CHAPTER.

Miscellaneous regulations (prescribed and suggested).
Roads and other export works.
Improvement of water ways and water supply and methods of exploitation.
Possible development of forest industries, buildings.
Maintenance of boundaries.
Survey and maintenance of maps.

CHAPTER.

Establishment and labour.

CHAPTER.

Financial Forecast and cost of plan.

CHAPTER.

Summary of prescriptions.

APPENDICES.

Only of those appendices required for the elucidation of the plan should be printed therewith.

APPENDIX II.

CLASSIFICATION OF THINNINGS.

(Approved by the Silvicultural Association which met at Dehra Dun from January 10th to 14th, 1922.)

Note.—Ordinary thinning = "*Niederdurchforstung*"; "*Eclaircie par le bas*"; "Thinning in the lower storey."

Crown Thinning = "*Hochdurchforstung*"; "*Eclaircie par le haut*"; "Thinning in the upper storey."

Increment Felling = "*Lichtungshieb*". The literal translation "light felling" conveys a different meaning in English from the German "*Lichtungshieb*."

Classification.

The various trees on an area of even-aged high forest may be classified as:—

I.—*Dominating trees*.—This class includes all trees which form part of the uppermost canopy. It contains the following classes of trees:—

- (1) Healthy trees with a normal crown development and good boles.
- (2) Trees with an abnormal crown development or badly shaped boles.

In this latter class are included:—

- (a) trees whose crown space is cramped by neighbouring trees;
- (b) badly shaped old advance growth;
- (c) trees whose general development has been faulty, e.g., with double leaders, etc.;
- (d) thin and spindly trees;

- (e) diseased trees of all sorts ;
- (f) old seed-bearers.

II.—*Dominated trees*.—This class includes all trees which do not form part of the uppermost leaf-canopy. These are :—

- (3) Dominated trees, which, however, are not yet actually under the shade of their neighbours and the leading shoots of which are, therefore, still more or less free.
- (4) Suppressed trees, that is, trees standing under the shade of their neighbours and with their leading shoots dominated.

(Classes (3) and (4) then may, on occasions, be useful for protecting the soil or helping to clean the boles of their more vigorous neighbours.)

- (5) Dead and dying trees which are of no use either for soil protection or for cleaning the boles of neighbouring trees. Small and very badly suppressed trees may also be included in class (5).

N. B.—Under class (2) some of the trees referred to under (a), (c), (d) and (e) may also occur in the dominated section. There is, however, no need to designate them separately under any class except class (2) as it includes (3), (4) and (5) which usually disappear first in the thinnings.

Thinnings are mostly concerned with the removal of—

- (a) dead and dying trees ;
- (b) trees which are being left behind in the struggle for existence ;
- (c) diseased trees ;
- (d) trees with poorly developed boles or crowns ;
- (e) misshapen trees.
- (f) trees with good crown and boles which are harming more valuable trees.

Thinning may thus include trees falling under classes (2) to (5) either wholly or partly and, more rarely, some trees of class (1).

The essential point about a thinning, however, is that *no lasting interruption of the leaf canopy is created*.

Increment felling.—(Lichtungshieb) includes all trees of classes (2) to (5) even when they are vigorous and healthy and not doing damage to their neighbours, and usually a greater or lesser part of class (1) as well. The essential point, however, is that *a lasting interruption of the cover is created*. This interruption always lasts for a long period and usually for most of the remaining life of the wood. It is therefore usually employed when some form of soil protection wood is to be introduced either artificially, or naturally *cf.*; Eichenlichtungsbetrieb.

Thinnings.

The following kinds and intensities of thinning may be formed :—

I.—Ordinary thinnings (*Niederdurchforstung* or *Eclaircie par le bas*).—

(1) *Light thinning* (A grade).—This is limited to the removal of :—

- (i) dead and dying trees and very badly suppressed boles ;
- (ii) diseased trees, *i.e.*, class (5) and a few of class (2).

This thinning is of little practical use and is seldom made except for the purpose of comparative research with regard to increment.

(2) *Moderate thinning* (B grade).—This consists in the removal of—

- (i) dead, dying and much suppressed trees ;
- (ii) suppressed trees ;
- (iii) spindly trees ; and branchy advance growth which it is impracticable or not desirable to prune or lop, and diseased trees ; *i.e.*, class (5) and (4) and part of class (2).

(3) *Heavy thinning* (C grade).—This consists in the removal of—

- (i) dead, dying and much suppressed trees ;
- (ii) suppressed trees ;
- (iii) dominated trees ;

(iv) diseased, badly shaped or abnormal trees of the dominating class; *i.e.*, classes (5), (4) and (3) and part or all of class (2).

(4) *Very heavy thinning* (D grade).—This usually consists in the removal of—

- (i) all of classes (5) to (2);
- (ii) some of class (1) in such a way that only good trees with nice crowns and well-shaped boles remain as nearly as possible equally distributed over the area and with room on all sides for proper crown development but *there must not be a lasting break in the leaf-canopy*.

In the execution of B, C, and D grade thinnings the following points should be noted:—

- (a) In all cases in which holes would be created by the removal of dominating trees (probably class (2) trees), dominated and even suppressed trees (classes (4) and (3)) should be left to cover the ground.
- (b) In removing *sound* trees of class (2) with badly shaped crowns or boles the operation must be made with due regard to the stocking and condition of the whole crop.

II. Crown thinning (*Hochdurchforstung* or *Eclaircie par le haut*.)

This consists in the removal of dominating trees with the object of caring for and encouraging a certain number of specially good trees. Only two grades are distinguished:—

(1) *Light*.—This consists in the removal of—

- (i) dead, dying and much suppressed trees;
- (ii) badly shaped and diseased trees and stems with double leaders;
- (iii) trees, which it is necessary to remove from a group in order to make those left more or less of even size.

It, therefore includes class (5), a large part of class (2) and some of class (1), but not classes (3) and (4), which are left to shelter the soil and help to clean the boles of the selected trees.

The removal of bad advance growth, etc., if it is likely to cause too great an interruption of the cover, can be spread over more than one operation, but such advance growth should be rendered harmless by lopping or pruning. It is thus practically the same in intensity as a D grade ordinary thinning but leaving classes (3) and (4) instead of removing them.

- (2) *Heavy*.—This grade is applied in order to favour a definite number of selected stems with the object of producing large timber. It consists then, in the removal of all class (5) trees and other trees which hinder the proper development of the selected trees, *i.e.* class (5) and some of classes (2) and (1) but *not* classes (3) and (4).

This thinning is specially suited to crops nearing the end of the rotation.

It has already been stated that the essential point of an increment felling is that it *does* create a lasting interruption of the cover. More trees are removed than in the heaviest D grade thinning; in other words, the selected trees are left more or less isolated, and classes (3) and (4) are not left to cover the soil. The soil, therefore, is not supporting as many trees as it could support and, although the increment per tree is large, there comes a stage when the reduction in the number of trees more than counterbalances the increased increment per tree. Exactly when this point is reached is certainly not known in India. Experiments were being performed in Europe but the problem was not by any means solved in 1912 and probably is not solved yet. Moreover, other points such as the quality of the wood, the value of any underwood, etc., come in. This subject is still quite in its infancy, and the classification of these increment fellings is only inserted to make the table complete and not because there is any

likelihood of such a felling being made in the near future in India. Moreover, these grades are only experimental and the second is known to be too heavy, as it passes the stage at which the increased increment per tree is counterbalanced by the decreased number of trees.

The grades are :—

(1) Light.

(2) Heavy.

If the basal area of a wood (excluding classes (3) and (4)) is measured after a D grade ordinary thinning then the light increment felling removes 20—30 per cent. of that basal area and the heavy increment felling removes from 30—50 per cent.

The term “predominating trees” is not used here. The best of the dominating trees are sometimes designated as “predominating” but the distinction is needless as naturally whenever any dominating trees are felled the worst are taken and the best left.

APPENDIX III—(1).

NATURAL REGENERATION.

“ Instead of the thorn shall come up the fir tree.

Instead of the briar shall come up the myrtle tree.”

In an earlier essay it has been shown that the foundation of all good forestry lies in the intense study of nature, dominated by a love of trees and a desire for knowledge. Approached in any other way silviculture becomes a tedious task to be delegated as far as possible to ignorant subordinates, with the usual deplorable results. Without an inborn appreciation of the growth of trees no one can become a master of this art. Without a master's skill no system of management can reach perfection. In the processes of natural regeneration the art of silviculture reaches its zenith. Every tree differs in its requirements, every aspect and species requires different treatment. Here a group of advance growth is retained and freed to form part of the future crop, there existing saplings are cut away as undesirable.

Three factors govern the successful regeneration of a forest crop :—

(1) Soil.

(2) Light.

(3) Moisture.

All these factors are inter-dependent, they must exist in suitable harmony one with the other and when these conditions are fulfilled natural regeneration follows as a matter of course.

The art of the forester in this branch of his work consists in developing his practice so as to bring about this happy state of affairs as far as possible by the usual processes of nature.

The first factor that must be suitable is the soil, that is to say the chemical, physical and biological conditions of the soil must all be favourable. Every forest soil probably contains the limited quantities of nitrates, phosphates, lime and potash necessary to plant life. The availability of these chemical substances will largely depend on the physical properties of the soil. Excess of such substances as humic acid in the soil is very prejudicial to plant growth, but such excess is due to physical causes which can be overcome by good husbandry. Adverse physical soil conditions may be ameliorated, stiff clay will be improved by the maintenance of a close forest canopy over a series of years and the consequent admixture of humus with the soil followed by suitable cultivation. Similarly a light sandy soil can be improved by the natural adding of decaying vegetation which will increase its water holding capacity.

If suitable physical conditions cannot be obtained by the proper manipulation of the canopy, then more drastic steps must be resorted to and the surface soil stirred up to produce a good tilth and to amalgamate the humus with the mineral soil. Finally in order to obtain abundant natural regeneration the bacterial flora of the soil must be prolific and the process of nitrification active. A soil in good heart will naturally be well aerated and will contain an active bacterial flora. Given active nitrification in the soil, obtained no matter how, natural regeneration presents no difficulty. Henrik Hesselman has shown in the reports of the Swedish Institute of Experimental Forestry, that a lively nitrification in the ground is essential to profuse reproduction. His researches have shown:—

- (1) In the fairly dense mixed coniferous forests of central Sweden, where the ground covering consists mainly of moss, clear cutting, shelterwood cutting or merely chequerboard cutting can produce lively nitrification.
- (2) The preparation of the soil with the Finnish plough or any other machine that causes a mixture of the

humus covering and the mineral soil produces a formation of nitrates, even when the wood is so dense that nitrification does not otherwise occur.

- (3) Mouldering brushwood and old rotting timber require or produce nitrification in the ground, even under circumstances in which the formation of nitrates does not occur on the clearings.
- (4) Where the covering of raw humus is somewhat more developed, chequerboard cutting, shelterwood cutting or clear cutting does not by itself produce a formation of nitrates. The formation of ammonia, however, is substantially increased. But the formation of nitrates can be produced either by a preparation of the ground with machines or by the burning of brushwood.

His conclusions are summarised as follows:—

“If we go through our experience of the factors that favour regeneration, we find throughout that in a very notable manner they coincide with the nitrification of the humus nitrogen. Where the nitrogen of the humus covering is transformed into nitric acid the regeneration proceeds easily and the young pine and spruce plants develop, well provided they do not have to compete with an uncommonly luxuriant grass and herb vegetation. Where the nitrogen of the humus covering is not nitrified, natural regeneration is rendered difficult and the spruce and pine plants grow slowly.”

Hole has shown that proper soil aeration is absolutely essential for the full development of *sal* seedlings and by soil aeration he implies an adequate supply of oxygen in the soil. The researches of the Agricultural Experimental Station of Cornell University have shown that vigorous nitrification takes place in sealed flasks as long as there is supply of oxygen and that there is an optimum

mixture of this gas (one containing 35 to 60 per cent. of oxygen) for nitrification. Further "when the supply of oxygen becomes limited and anaerobic conditions are produced, denitrification sets in and this continues until practically all the nitrates are destroyed." Therefore it is clear that all these factors of the soil are interdependent one on the other. Without a proper supply of oxygen active nitrification will not occur and where the latter condition is not fulfilled adequate regeneration will not take place. We have already seen the conditions under which nitrification can be increased in coniferous woods by ordinary forest operations.

The Dehra Dun experiments of Hole have further shown that when rain water rich in oxygen is held in contact with ordinary forest soil, the oxygen is rapidly exhausted and the supply of CO_2 is increased. An increase in the CO_2 dissolved in the soil water necessarily means an increase in soil acidity detrimental to active nitrification. He has also proved that a water culture solution containing an excess of CO_2 and a deficiency of oxygen has a directly toxic effect on plant roots. The advocates of the soil toxin theory also have shown that such toxins cannot exist under conditions which bring air, and therefore oxygen, into contact with toxic solutions.

The extent to which nitrification is going on in the soil is frequently apparent from the vegetation found on the ground. In Sweden Hesselman states: "Where the humus nitrogen is transformed into nitrate, there appear nitratophilous plants such as raspberry. *Epilobium angustifolium*, *Arenaria trinervia*, etc." In Kulu, Trevor writes: "There can further be no doubt that the presence of shrubs and plants of the natural order Leguminosæ is especially desirable and the presence of *Indigofera Gerardiana* has been observed to improve the vigour of young *deodar* growing in its vicinity." In Kulu a growth of raspberry and *Indigofera* follows a fire, indicating active nitrification, and profuse regeneration of pine and spruce is frequently a feature of such old burns.

It may safely be said that an excessive deposit of needles is inimical to the regeneration of all coniferous trees; indeed the same thing has been found in the Kelheim State Forests of Bavaria and is well known in Kulu, in both places steps are taken to get rid of this deposit. Seed germinates readily in this loose humus, but the seedlings cannot survive the hot weather in May and June; their slender roots cannot penetrate down to the mineral soil and consequently with the drying out of this raw humus they perish. The effect of clean mineral soil in stimulating regeneration is well known.

Collier states regarding *sal* in Haldwani: "The other factor is the condition of the soil and by the term soil is signified the surface soil which is solely concerned in the question of reproduction. There is much evidence to show that a soil of loose texture particularly and of good physical qualities generally is very receptive to regeneration. Results of the experiments with soil wounding indicated that regeneration may be procured in great quantities on a fresh soil."

In order to produce conditions of soil suitable for the regeneration of *sal* Collier propounds the system of burning the ground leaf cover after the fall of the leaves in March, more especially when a good seed year is expected. To any one acquainted with the leathery nature of the *sal* leaf and with the struggles of the seedling root to penetrate this almost impermeable stratum in order to reach the mineral soil, the advantage of this procedure will be obvious.

This work has been done experimentally over considerable areas in Ramnagar and Haldwani and this combined with the admission of sufficient light, in accordance with Hole's researches, is at present the foundation on which a system for the natural regeneration of *sal* is being built up.

In the case of the Himalayan conifers Trevor has standardised the methods of soil preparation to follow the first seedling felling, having come independently to exactly the same conclusions.

regarding excess humus which Hesselman has now proved to be correct. His method is described as follows :—

“After the completion of the first regeneration felling all rubbish, bushes, inferior trees, raw humus, exploitation refuse and suppressed advance growth will be collected and burnt, and the soil placed in a suitable condition to receive the seed. This may necessitate hoeing with the pronged vine hoe already in use.”

The collection of the exploitation refuse is done by hand labour, the larger branches are thrown on to piles and the smaller chips and the raw humus raked up with iron pronged rakes and the whole burnt in small heaps. A wonderful reproduction frequently follows this treatment.

All practical methods of obtaining suitable soil conditions have now been dealt with. It is not only necessary to obtain this ideal in the first instance to admit of complete germination and early growth, but in the case of *sal* equally important to maintain suitable conditions so that the establishment of the seedlings may be obtained at the earliest possible date and the period of dying back largely reduced or done away with entirely. This natural dying back must be due to various factors unfavourable to growth, as under garden conditions with perfect soil, full light and sufficient moisture, *sal* does not die back at all and develops straight away into healthy saplings. This supposition is still further supported from an examination during the monsoon rains of *sal* regeneration under a fairly heavy canopy and a dense soil covering of decaying vegetation. In spite of a superabundance of moisture and heat generally considered favourable to growth, the *sal* seedlings were in a most miserable condition and it was self-evident that they were growing under some unfavourable condition of soil, light or moisture. Research is now being made to discover exactly what this adverse factor is so that the process of regeneration may be modified accordingly. How important this matter is may be realised from the fact that *sal* regeneration eight years old which has received constant attention and yearly weeding does not as yet show any sign of upward growth.

Granted suitable soil conditions the next factor necessary for successful regeneration is light. The varying light requirements of species are well known and sufficient importance is devoted to this matter in text-books dealing with European forestry. But in India in the case of many species considerable doubt still remains as to the conditions of light suitable for their reproduction.

Light and moisture are intimately bound up. Side shade from the south for instance may be responsible for a more or less constantly wet soil and is often the injurious factor in such cases rather than a deficiency of light rays for photosynthesis. Light is therefore in this essay used as a relative term meaning not merely “light” such as is measured by a photographic exposure meter but in addition the inseparable factors of soil and moisture conditions which are directly caused by fellings in the overwood for the purpose of admitting light to the soil.

In the case of the *deodar* it has been stated that this species is a shade bearer but this is not so. Many years of investigation into this matter have brought out exactly what are the light requirements of this tree.

“*Deodar* germinates under all conditions of light and shade but the time soon comes when seedlings growing in shade must be given plenty of light if they are to survive. It has been stated that the group system is suitable for the *deodar*, but this system is only suited to a shade bearer, and so far from falling into this category the *deodar* must be classed among the light demanders. A gap 100 by 80 feet with seed bearers around, clear felled : S. W. aspect, 6,000 feet elevation, was completely regenerated in 1914 and promptly fenced. Vigorous seedlings now survive in the upper half which received most of the light, but in shady places round the edges they have all died away. We have thus in the experiment eliminated every cause except the factor light, and it is want of this alone which must have caused the death of the seedlings. Another somewhat similar group in a different locality

confirms this observation; and a comparison of group and shelter-wood fellings is entirely in the latter's favour. Innumerable instances can be given of the influence of light on growth; in the Jutlikawala plantation the height of *deodar* growing in the full enjoyment of light was double that of plants growing under only a light overwood of *kail*."

Similarly in the case of spruce, which is reputed to be a moderate shade bearer, it has been found that this tree in the Himalayas is not a shade bearer at all but requires as much light for its reproduction as the *deodar*. Troup has aptly summarised the light requirements of the *chir* pine as follows:—

"The *chir* pine is one of the most light demanding of species and under favourable conditions the more light admitted the more successful and complete will be the regeneration. It may be said that in ordinary favourable circumstances 5 to 8 good seed bearers per acre are ample for affecting regeneration; and that a greater number are not only unnecessary, but may even be detrimental to the establishment of a healthy young crop. This statement however should not be taken to apply universally. Thus on hot slopes where the soil is stiff and the seedlings are liable to suffer from insolation, protective shade is essential; and the demand for such protection may outweigh the demand for light. There are instances in the Rawalpindi division, where the slopes are hot and the soil is clayey, of good reproduction establishing itself under an almost complete canopy. We may, therefore, qualify the general statement made above by saying that where protection against drought is necessary the number of seed-bearers per acre may have to be increased very considerably; it may also be stated that on southern slopes as a rule a larger number of seed-bearers are required than on northerly aspects.

"Opinions regarding the light requirements of the *sal* still differ. Collier writes regarding the natural regeneration of this species under the shelterwood compartment system in Haldwani.

"The whole process of the regeneration of a wood can therefore be divided into three stages:—

(a) Regeneration may be obtained without any felling of the overwood or cleaning of the underwood. There is no evidence to show whether the excellent regeneration which occurs in areas which have been heavily felled over in the past was present before the fellings were made or ensued as a direct consequence of the fellings. But even if healthier seedlings are produced under a light overwood and little or no underwood it would still be inadvisable to open out the cover in anticipation of a seed year. If a successful regeneration year followed the fellings and cleanings immediately excellent results might be obtained. But if no seed year occurred for several years the exposed and fresh soil would most certainly deteriorate and become stocked with grass so that future attempts to procure regeneration would be difficult. Since it is quite certain that plentiful reproduction may be obtained under the most adverse conditions of light the safest method of treating unregenerated area is the maintenance of a complete overwood and underwood and the burning of the leaf layer. It may be also noticed that the overwood in these selection forests is rarely dense but is generally in a condition resembling that of a European overwood which is in the state of a light seeding felling.

(b) On the appearance of seedlings some degree of light should be admitted by the removal of a portion of the underwood and overwood. It is very important that this admission of light should be gradual since it has been noticed that seedlings which have germinated and spent their first growing season in shade tend to wither if too suddenly exposed to direct sunlight.

- (c) Over established reproduction the overwood can hardly be felled too heavily except in areas in which the possibility of frost damage prohibits the absolute clearing of overwood over too wide areas."

On the other hand Hole's researches go to show that the *sal* seedling requires full overhead light for its proper development. These opposite doctrines must somehow be harmonised and a silvicultural system for the natural regeneration of *sal* worked out. This investigation is now well in hand.

Blanford has also shown in dealing with the teak in Mohnyin (Burma) that burning of the soil covering and intense light are necessary for the natural regeneration of this species. He relies on the seed already dormant in the soil for his reproduction and clear-fells the whole of the overwood. Hole's experiments at Dehra also confirmed this silvicultural fact.

In all methods of regeneration under a shelterwood it must be remembered that two diametrically opposite considerations have to be compromised—(1) the necessity for retaining sufficient trees to keep down the growth of weeds and to produce an ample crop of seed, at the same time sheltering the young growth from drought frost or hot winds; and (2) the necessity of removing all cover not absolutely necessary, so that the subsequent fellings of the overwood will do as little damage as possible to the young regeneration.

A compromise is therefore necessary and in the exact degree of compromise lies the art of the forester.

The different light requirements of different species in a mixed crop may be used by the skilful forester to manipulate the proportion of species in his new crop. This is done in Europe with the spruce and the silver fir; the same idea has been employed by Trevor in the regeneration of a mixed crop of *deodar* and blue pine.

"It is only necessary to make a first seeding felling suitable for the reproduction of *deodar*; and thereafter to lighten the overwood so that *kail* seedlings complete the crop."

It is thus apparent that an exact knowledge of the silviculture of trees is absolutely essential if success is to be obtained in natural regeneration. Given this knowledge it is perfectly easy to devise a system of management in concordance with the silvicultural peculiarities of the tree and the nature of forest being dealt with. Even treated under different systems of management the fundamental silvicultural requirements of the species must still dominate the technique of regeneration. The management of *chir* pine, blue pine, and *deodar* under the shelterwood compartment system has now been standardised. Work on these lines is being carried out for *sal*, spruce and silver fir and the regeneration of teak with clear felling is well understood. Much still remains to be learnt, but once systematic attempts are made to regenerate a definite area with some definite species, results will be obtained in due course by any careful forester.

The correct treatment of the soil and the correct admission of light are both within the competence of the forester, but the third factor moisture can only be influenced by him to a moderate degree.

It has already been shown that the character of the fellings will influence the moisture conditions of the soil and to this extent the latter factor can be controlled by the forester, but acts of God such as unusual prolonged droughts are beyond his control and the losses they cause must be accepted as inevitable. Similarly no silvicultural technique can do away with the hazard of hail-storms which may ruin delicate seedlings.

It has been supposed by some that a dense canopy of mother trees prevented seedlings from dying of drought. As a matter of fact the reverse is the case; *deodar* seedlings under dense shade have actually died of drought while seedlings growing in the open have continued to flourish. Under heavy shade there is no dew, whereas in the open there is plenty; a slight fall of rain has no effect on plants growing in the shade whereas those in the open obtain the benefit of every shower. For these reasons all low

spreading branches are pruned off the *deodar* mother trees as a routine measure in areas under regeneration. While heavy shade is injurious to the regeneration of all species other than dense shade bearers such as silver fir, a moderate amount of high shade, more especially side shade to ward off the hot sun, is beneficial and in some cases absolutely necessary.—“In the hills, on south, south-east and south-west aspects the difficulty of obtaining regeneration is much increased and on these aspects the necessity of side shade to the young plants must be kept in view.” It is believed that the constant soddenness of the ground during the rains under a fairly heavy canopy of *sal* trees is most injurious to *sal* seedlings and that this evil effect would be mitigated by a heavier felling in the overwood and the admission of more sun and air to the ground. Excess of damp is also fatal to *deodar*, under such circumstances the seedlings fade away or are destroyed by a fungus believed to be *Peridermium*. In areas of deficient rainfall moisture can be conserved by soil cultivation but this belongs more to the province of sowing and planting which will be dealt with in a subsequent essay.

The principles of natural regeneration are of world-wide application, the skill of the forester lies in adapting these principles to a multitude of different species or to a mixture of species growing in the same crop; in manipulating the canopy of the mother trees so as to obtain regeneration of such species and in such proportions as he may desire and at the same time to restrain a superabundant growth of weeds.

It is not sufficient to obtain complete germination; this is only the first stage towards success. The young seedlings have now to be nursed up to the sapling stage. Weedings will be in many cases absolutely essential and on the thoroughness of this work success will often depend. This dense weed growth in a clear felled area will absolutely destroy untended teak seedlings and the same is true of moist coniferous forest where only a moderate opening of the canopy produces a crop of herbs which will

effectually smother any young tree. In most cases a certain amount of sowing and planting will be necessary to complete natural regeneration and there should be no hesitation in carrying out this work to such extent as may be necessary. In Kulu after burning the slash it is a routine measure to sow up the burnt heaps with *deodar* seed and the results are magnificent. Surplus plants are removed from these heaps when 1½ years old and planted out. Every endeavour is made to complete the regeneration in as short a time as possible, as every year that passes after the execution of the seeding felling makes success more difficult and expensive. Artificial sowing and planting is also necessary when it is desired to increase the proportion of a valuable species in a mixed crop and this cannot be effected by natural means. French forestry inclines perhaps too much to natural regeneration and German practice to artificial planting. The happy mean between the two schools will give the best results and the good forester will aim at getting the bulk of his new crop by natural means and should then not hesitate to assist nature to his utmost ability by completing the crop artificially. Working on these lines very considerable success has been obtained, and as time passes it is hoped that more and more attention will be given to the various silvicultural operations which are necessary to obtain natural regeneration, that research will indicate to us the correct treatment of the soil to ensure a complete reproduction and maintain this in health and vigour, and that the light requirements of more and more of our principal species will be elucidated and their methods of natural regeneration standardised.

The young seedlings will now be growing up and in the next essay their subsequent treatment will be dealt with.

“TROWSCOEED.”

APPENDIX III—(2).

ARTIFICIAL REPRODUCTION.

By "*Trowscoed*."

In a previous essay the conditions of soil, light and moisture requisite for natural regeneration have been fully dealt with. Exactly the same conditions govern the success of all artificial sowing and planting and in addition several further factors have to be considered.

Artificial reproduction naturally falls into three divisions, firstly the filling up of gaps in areas being regenerated naturally, secondly the restocking of a clear felled area and thirdly the creation of a forest by afforestation.

The question of artificial versus natural regeneration has been the cause of acute controversy for the last 50 years or more. Men of eminence in the profession have taken the most extreme views and schools of forestry have arisen diametrically opposed to one another. The most orthodox French opinion has advocated the advantages of natural regeneration even at the cost of many years' delay, on the other hand the Saxon school declined to have anything to do with natural regeneration preferring to clear fell and plant.

The mind of the forester will always be influenced to some extent by the school of thought in which he was brought up and, however broad-minded he may be, he will probably have a preference for that style of silviculture with which he is best acquainted and of which he has become a master.

In recent years this controversy has continued with respect to the effect of planting in reducing the vitality of an artificially raised crop when handled under a long rotation. Toumey states

in his work "Seeding and Planting": "It is generally acknowledged that the artificial stand as compared with the natural is more quickly established and more uniform in distribution and in the size of the individual tree. The growth during early life is also more rapid. It appears however that it is more sensitive to external harmful influences and that the trees begin to fail or fall off in increment at an earlier age than in stands that have arisen from natural seeding."

"Where natural regeneration is possible the trend of present day forestry in Europe is away from pure stands and artificial regeneration towards mixed stands and natural seeding. In Saxony where spruce has been planted in pure stands for successive generations a change is now being made towards natural regeneration and mixed stands. It is believed by many that the repetition of the same species rotation after rotation ultimately exhausts the soil."

Believing as we do as a general rule in the superiority of natural over artificial means and considering that the best practice is likely to be that which approaches most nearly to the regime of nature we welcome this trend of modern thought, and consider that there can be no question but that the art of silviculture finds its highest expression in the successful natural regeneration of a mixed crop. Nevertheless under certain circumstances clear felling and planting is the only satisfactory system of management giving the most valuable crops and the best financial results. This is probably undoubtedly so in the teak forests of Burma where this method combined with the cultivation of field crops has given good results out of all proportion to those obtained by natural means. A similar method of treatment has been adopted for the Bengal *sal* forests which is described in detail in the Indian Forest Record by Messrs. Glasson, Russell, Shebbeare and Teague. It is still open to doubt however whether it will be possible to obtain the labour necessary to regenerate the normal area by these means and it is probable that the regeneration of the Goalpara *sal*

forests can only be obtained by natural seeding. It must always be a confession of failure when natural regeneration cannot be obtained where it is required, more especially in the case of gregarious species like *sal* and the conifers.

Under the conditions which prevail in Britain clear felling and planting is almost the only system worth considering and the planting of teak in Nilambur is probably the finest piece of work done by the Forest department in India. Bourne goes so far as actually to root up natural teak seedlings which come up between his transplants and his thinnings are reduced to almost a mechanical operation.

Even Blanford's system for the natural regeneration of teak in Burma has been superseded by artificial regeneration which is considered to give superior results.

The two extremes of silvicultural practice in India are well illustrated by comparing Collier's system for the natural regeneration of *sal*, in which regeneration commences in the second period or forty years before the end of the rotation with Bourne's practice with teak in Nilambur in which complete regeneration is obtained in one season. In our own practice, after a long and intimate acquaintance with both natural and artificial methods in the regeneration of the Himalayan conifers, the following conclusions have been forced upon us so far as these species are concerned :—

- (1) That natural regeneration is always superior to artificial work.
- (2) That artificial sowing and planting is essential to the complete and rapid stocking of the area under regeneration.
- (3) That reproduction whether natural or artificial should be obtained within the shortest possible time after the first regeneration felling.

Following on these results a technique was developed embodying the best points of both schools of thought and aiming at

natural reproduction wherever possible supplemented immediately by artificial work, undertaken largely for the purpose of augmenting the proportion of *deodar* in a mixed crop of *deodar* and blue pine. The Kulu working plan, considering the requirements of silviculture to be paramount, is founded on this practice. Other authorities, however, are of the opinion that the requirements of exploitation are of prior importance and advocate a system of clear felling and artificial regeneration on the Saxon lines. Before a system of forest management can be founded on these principles it will be necessary to show that artificial reproduction on the suggested scale is a practical proposition; so far as our experience goes, the artificial regeneration of clear felled areas in the hills especially on warm aspects has been a work of the greatest difficulty. There is little doubt that such a system will succeed on favourable aspects after burning the slash, but whether the system is suitable for general adoption is another matter.

As an example of the third division of our subject the afforestation of the ravine lands of Etawah may be mentioned. In this case the whole forest was destroyed several centuries ago, since when the conditions of climate and water-supply have entirely altered. The conservation of the limited rainfall becomes the first essential to success. To this end the work is governed by the well known rules of dry farming; the soil is deeply ploughed and ridged to prevent run-off, and the ridges are constantly weeded and the soil loosened to diminish evaporation. In the area treated denudation ceases, the jagged outlines of the ravines become rounded off and a mixed crop of *babul* and *sissu* covers the ground under which a plentiful supply of good fodder grass springs up. A desolate waste is in this way turned into a fuel and fodder reserve of inestimable value to the surrounding agricultural population.

The Landes in France is an instance in which afforestation has turned a fever stricken waste into one of the richest provinces of France. The reclamation and forestation of these sand wastes is perhaps the best possible illustration of the benefits of forestry

to the individual, to the community and to the nation. Instead of dreary wastes of sand and swamp 1,611,421 acres of Maritime pine forests give a net annual revenue of £675,500 and provide a livelihood for the local population.*

The Eucalyptus plantations of the Nilgiris and the irrigated *sissu* plantations of the Punjab show how the face of nature can be transformed by the art of the forester and a barren country turned into a productive garden.

It is now necessary to consider the technique of artificial regeneration in all its aspects, to discuss methods of sowing and planting and the various factors which make for success in these operations.

If artificial reproduction is to be undertaken at all it is absolutely necessary that every detail of the proper technique should be given minute attention, that constant personal supervision should be exercised and that the work be organised on a businesslike footing. Large sums have been wasted by inattention to these matters. Success in this work is almost entirely a personal matter. With exactly similar advantages one man will succeed and another fail. The latter will plead drought, frost, hail, excessive rain or some other vicissitude of nature entirely beyond his control, when as a matter of fact his failure is entirely due to own incompetence. There is only one way of judging the capacity of the forester and that is by the results he can command. The successful man is one who can grow crops at a profit, no scientific knowledge is of any value if it cannot be applied to this end "Two centuries of forest culture in Europe have conclusively demonstrated that successful artificial regeneration is chiefly a matter of soil management."

The following are the factors to be considered :—

- (1) Selection of suitable species.
- (2) Soil preparation.
- (3) Seed supply.

* *Studies in French Forestry*, by T. S. Woolsey, 1920.

- (4) Nursery work and direct sowing.
- (5) Planting.
- (6) Tending.

(1) *Selection of suitable species.*

This point is obvious but has only been too frequently neglected in the past. Innumerable instances are known to almost every forester of the planting of species unsuited to the locality. Large sums of money have been wasted on planting *deodar* on bare hillsides in the eye of the sun in positions where the work was foredoomed to failure. The planting of larch in Britain under entirely unnatural conditions has resulted in widespread epidemic disease, and not even warned by past experience the planting of exotics to the neglect of indigenous species still continues. As a general rule it is best to employ species natural to the locality to be planted, if these are of sufficient value, and to defer the wholesale introduction of other species until experiments have shown that good results can be obtained. In any case attention must invariably be paid to the soil and climatic requirements of these exotics in their natural environment.

Given suitable silvicultural conditions the most valuable species should always be selected as the costs of formation usually are constant for all species. If teak can be grown successfully it is useless to plant other species unless these are required to form a mixture with the teak. This tree is one of the easiest to manage, it grows very rapidly in early youth and even outside its natural habitat has been found to be a very valuable species for planting work. In Gorakhpur, after exhaustive trials with many trees, teak has been found by far the best for filling up blanks in the *sal* coppice, and a plantation of indifferent quality 40 years old in this division has been sold for over Rs. 1,000 per acre, giving better financial results than the native *sal*.

A species may show very fine results at the start but later on may be a financial failure. *Sissu* is the only species for the

first afforestation of the Punjab irrigated plantations but later on it is destroyed by the fungus *Fomes lucidus* and mulberry very fortunately takes its place. It is doubtful whether the *sisso* plantations of the Kumaun Bhabar will be more than a temporary success and every effort should be made to introduce under the *sisso* species of more permanent value.

(2) *Soil preparation.*

Whether in the nursery, in direct sowings or in planting, the preparation of the soil is directed to the production of a good tilth to provide the factors most favourable to germination and the rapid development of the seedling. On the latter frequently hangs the success or failure of the whole work. Given the best, or at least suitable conditions for germination and growth, the exact nature of the method of soil preparation employed is of minor importance. This will vary with the requirements of different species, the nature of soil and the costs permissible. It is useless being able to point to success regardless of the cost; success is only attained when the area has been stocked with trees at a cost which will give satisfactory financial results. Wood in his article in the *Indian Forester* for February, 1922, has given an instance of the soil preparation on growth. In the old Gorakhpur nursery the soil was dug to a depth of 1' in June and *sal* sowings made, resulting in an average annual height growth of 1' 1½" over a period of 8 years. In the new nursery the soil was dug to a depth of 1½' in December and *sal* sown in the following June resulting in an average annual height growth of 1' 5" over a period of 4 years. *Sal* root and shoot cuttings have been a failure under forest conditions, they have only succeeded under nursery conditions with intense soil preparation. Smythies records an instance in the Motipur plantation of Bahraich where a typically xerophytic vegetation of *Egle Marmelos*, *Dyospyros* and *Odina Wodier* has been turned into *sal* forest by intensive soil

preparation and direct sowings. The success of *deodar* sowings in heaps of burnt slash has already been commented on and similar results have also been obtained with teak. The success of the taungya system in Burma and Bengal is entirely due to the efficient cultivation of the soil obtained by the growing of field crops combined with the provision of the full overhead light so necessary in the case of teak. A mulch of dry earth has enabled *chir* pine seedlings to survive on a particularly dry area where otherwise they invariably died of drought and this method had been extensively employed in the dry teak forests of Bombay. Many species require very special conditions of soil for their germination; *Alnus nepalensis* in Kulu, *Dalbergia sissoo* and *Acacia Catechu* in the sub-montane tract and *Populus cuphratica* along the Indus all require fresh river alluvial deposits for their reproduction, and a similar soil with an absence of weeds must be provided in raising these trees under artificial conditions. In the United Provinces it has only lately been discovered that absolutely clean soil is essential for the germination of *Adina cordifolia*. This tree has been raised on mounds in the Bhabar but only with considerable difficulty as the minute seed is easily washed away. Profuse natural regeneration has been obtained accidentally in an area under experimental regeneration of *sal* after making a heavy felling and burning the slash, the resulting ashes giving exactly the conditions required for the germination of this tiny seed.

In the case of the afforestation of the Etawah ravines everything depends on proper soil preparation. On the flat uplands the whole ground is deeply ploughed and ridged 10 feet apart to prevent run-off and the sowings of *babul* and other species are made along the ridges. The cultivation of 3 lines of cotton plants between the ridges has now been commenced both with the view of improving *sal* conditions, diminishing weed growth and reducing the costs of afforestation by the profits on the cotton. Intensive weedings and soil loosening form part of the standard practice; everything possible being done to conserve moisture and

increase the rapidity of early growth in this almost desert country.

A perfunctory soil preparation is most generally attended with failure. Dibbling teak in Burma, patch sowings of *sal*, broadcast scattering of miscellaneous seeds in the Saharanpur coppice coupes have generally utterly failed either from this cause or from subsequent neglect of weedings. In Etawah complete failure involving the loss of a large sum of money was the result of employing an incompetent officer. Innumerable instances could be given of the importance of adequate soil preparation; enough has been said to show that the success or failure of artificial reproduction is very largely dependent on this cause.

(3) *Seed supply.*

It is manifest that to obtain success in this work good seed must be used. This is insisted on by every authority on the subject. Seed may appear perfectly good and yet not be worth sowing. The first seed that ripens is frequently unfertile and useless. The seed of *Anogeissus latifolia* which is collected before the end of March is worthless; *sissu* seed should never be collected off the ground and the same remark applies to the other species and is especially true in the case of small seeds. Thus in 1919, seed of *Anogeissus Holoptelea* and *Dalbergia* collected by sweeping up the seed on the ground gave very poor results. In the Afforestation Division it is a standing order that *sissu* seed is always to be collected off the trees and never from the ground. Some of the larger seeds such as teak, *Gmelina*, *sal*, *Odina* may be collected off the ground after they have fallen. *Babul* seed, which has been eaten by and passed through goats, has been found to have a very high germination per cent. Some seeds such as ash only germinate in the second year, *babul* does the same in years of deficient rainfall when the seed remains dormant in the soil. Some of the larger seeds such as teak require special treatment to induce early and even germination, without such treatment many seeds fail

to germinate the first year. There are many factors which influence the fertility and vigour of seed, the most important of which may be briefly summarised.

(1) In a good seed year the seed is invariably better, the germination per cent. greater and vitality higher than in a bad seed year. This has been proved to be the case many times with the *deodar* where in a good seed year the success of artificial reproduction is much greater than in years of poor seed supply although there is no apparent difference in the seed.

(2) The complete ripeness of the seed is vital factor, seed should be collected when ripening is at its maximum, early and very late seed should be avoided.

(3) In many species (*e.g.*, *sal* and *sain*) the size of the seed varies considerably; the fertility of large well developed seed and the vigour of the resulting seedlings is a well established fact.

(4) Recent investigations have shown that variations in the characteristics of the mother tree due to soil and climate may be transmitted through the seed. Thus in Etawah local *babul* seed is useless for afforestation work on account of its deep rooted habit, and to obtain the best results the seed has to be obtained from the Hamirpur district where the tree has developed a shallow rooted system owing to water-logged soil conditions.

In the Etawah district plantation areas the spring water level has sunk in the last 300 years from about 60 feet to over 100 feet as the result of erosion, and the rain water now penetrates the surface soil to a depth of a few inches only; below this the soil is absolutely dry and compact until the spring level is reached. There is absolutely no natural regeneration from seed, and it is thought that the isolated trees are the offspring of coppice stools of great age whose roots have kept pace with the sinking spring level. Roots have been dug up at a depth of 102 feet. This deep rooted character of the Etawah *babul* seems to have been transmitted to the seed. The intense soil cultivation prior to afforestation increases the surface seepage sufficiently to enable the ordinary

shallow rooted form to develop, but it is insufficient for the deep rooted form which fails to pass the dry strata in its endeavour to reach the spring water level.

Zederbauer has shown that seed collected from suppressed or sub-dominant trees produces plants less resistant to disease than the seed collected from dominant trees, but also that individual characteristics of the mother tree, such as unusual divergence from the typical form of the species, may be transmitted through the seed (Toumey, "Seeding and Planting" in *The Practice of Forestry*). The researches of Champion on the subject of twisted fibre in *Pinus longifolia* tend to show that this defect in structure is transmitted through the seed. The Almora plantations were certainly made with seed from twisted *chir* and many of the trees now show twist. It is of the greatest importance that all afforestation with *chir* pine should be carried out with seed obtained from straight fibred trees.

Similarly in the case of *deodar* and *kail* seed required for afforesting high elevations should not be obtained from mother trees growing at low elevations, as it has been clearly shown from extensive experiments in France and Switzerland that the height growth of Scotch pine and spruce obtained from Alpine seed commences earlier and is completed sooner than that of plants from low land seed, and that the latter have difficulty in maturing their wood before the advent of the winter. Also that at ordinary elevations the height growth of plants obtained from mother trees growing at such elevations is much greater than that of plants from Alpine seed.

Sowings of *kail* at 9,000 feet in Kulu, with seed obtained from trees growing at medium elevations, failed as the seedlings were killed by the winter cold. It is probable that better success would have been obtained if seed from trees at the maximum elevation of 10,000 feet had been used.

The cause of failure of many of the Swedish-Scotch pine plantations has been attributed to the use of German seed and

much better results have been obtained with larch seed from Scotland than with Alpine seed. For planting on dry areas in the United Provinces teak seed should be obtained from dry localities in Bombay or the Central Provinces in preference to seed from trees growing in a moist climate.*

(4) *Nursery work and direct sowings.*

The importance of good nursery work has lately been insisted on in Bengal, where planting is usually preferred to direct sowing, and the technique of nursery work has been standardised. The authors of the Forest Record already quoted rightly insist on a good site, proper lay out and shading of the seed beds for those species which require this treatment. Their work aims at producing by early sowing, intensive tending and adequate watering plants fit to put out at the beginning of the rains. Coniferous seedlings in the United States are raised on similar lines and in many cases shading the seed beds by lath screens in order to protect the young seedlings from wind and sun has been found to be necessary and is now part of the routine. The question of transplanting in the nursery has given rise to a certain amount of controversy. In Bengal the young seedlings are pricked out as soon as they are big enough to handle. In Jaunsar *deodar* plants are tended in the nursery for 2 years and 7 months and twice transplanted before being put out in the forest. In Kulu no transplanting in the nursery is ever done and seedlings are put out direct in the forest when 18 months old thereby enormously reducing the costs of planting. It is believed that the present excessive costs of planting in Britain could be reduced by using small seedlings instead of large expensive transplants and that better results would be obtained. It is significant that the consensus of opinion in Bengal is that the only safe and successful way of planting is to put out small seedlings.

* Toumey—"Seeding and Planting." *The Forest Pocket Book*.

In other parts of the Indian Empire direct sowing is preferred to planting. In Burma teak sowings are made at a stake 6' x 6' with field crops. In the Punjab plantations a line of *sissu* is sown in a step in the ridge and watered by percolation from an irrigation ditch. In ravine plantations of the United Provinces direct sowings are made along the top of the ridges. In Gorakhpur the *sal* sowings are made in strips on the flat. In waterlogged areas mounds must be used and *simal* plantations in the Tarai made in this way have given very good results. Each locality will develop its own standard methods of doing the work. Costs must of course be kept down to a reasonable level and this fact will influence the method to be employed. The advantages and disadvantages of direct sowing and planting have been frequently discussed. The subject is summed up by Toumey as follows:—

“The history of artificial regeneration shows that direct seeding is the rule and planting the exception in the early development of forestry in every country. Direct seeding finally gives way to planting. This, in turn, has often been carried to excess. At the present time, the foresters generally concede that the particular circumstances of each case should determine the form of artificial reproduction to practise. Planting is generally conceded to be the quickest, safest and easiest known method of re-stocking. Its economic application, however, must always be a determining factor in its employment. In favourable localities with excellent soil conditions and with acceptable species, direct seeding is usually less expensive. Under the following conditions, however, planting is much more certain and, on the whole, less expensive than direct seeding:—

- (a) On swampy lands, unprotected areas, sites overgrown with weeds, or grass, and open, heath covered places.
- (b) Under an open stand of intolerant trees where the soil is liable to become quickly overgrown with herbaceous and shrubby growth.

- (c) On suitable soil such as shifting sand and water-eroded places; also on lands subject to inundation.
- (d) On lands superficially hardened; on thin, exposed soils; and on light sandy soils.
- (e) On lands in mountainous regions subject to slipping under the action of weather and water.
- (f) In repairing of failed places in both natural and artificial regeneration.

“Frombling believes that in Europe the advantages of planting and the disadvantages of seeding have been overstated. He believes that dense sowings have a great advantage over plantings, because in the former case competition for space results in the suppression of the poor individuals. When the young stand is crowded the death of numerous individuals results in a welcome exclusion of the weak. As no planting compares in density with a successful stand from seeding, the latter is more fully composed of hardy and vigorous individuals due to the weaker being crowded out. The following principles are set forth by him in reference to seeding and planting:—

- (a) Only a dense position in early life enables a stand, no matter of what species, to produce the best results.
- (b) Since in planting the spacing must always be wider than in seeding, the latter is preferable in principle.
- (c) Special conditions often make the planting necessary if they do not, direct seeding or natural regeneration should be employed.

“Direct seeding is better adapted for the reforestation of recently cut over and burned areas than for afforestation. It is never practicable on sites having a dense ground cover. It is often used on very rocky ground where planting is difficult. In Saxony the direct seeding of Scotch pine and Norway spruce is seldom practised. In Prussia Scotch pine is often regenerated by direct seeding, some foresters advocating direct sowing and others planting even on the same quality of sites and under similar

conditions. In Scandinavia, where more than one-fourth of the total artificial regeneration is by direct seeding, coniferous forests are re-established by this method at less cost although there is more or less danger of failed places, of irregular height growth, and the overcrowding of seedlings.

"The present low average cost of direct seeding on the National Forests, including cost of seed, rodent poisoning, and the preparation of the ground, viz., \$4 per acre, has resulted in a high percentage of total failures and too few plants per acre on sites where failures are not recorded. The present unfavourable results from direct seeding emphasise the necessity for using the best seed and giving more attention to soil preparation.

"The most important considerations upon which the choice between seeding and planting should be based are the following:—

(a) The difference in cost.

(b) The difference in the time required for the stand to close.

(c) The difference in the quality of the stand."

In India, given a site suitable both for sowing and planting, the cost of formation and maintenance of the plantation till established will determine the method to be employed. In Kulu both direct sowing and planting of *deodar* are extensively used and there is not much to choose between the two systems. Some trees such as *babul* and *chir* pine cannot be transplanted at all and in such cases direct sowing must be resorted to. Teak is sown in Burma and planted in Nilambur and the exponents of the two methods will both no doubt maintain the superiority of their own practice. In conclusion we have only to remark that provided equally good results are obtained and that the cost reduced to a similar standard for both methods are similar there is no practical difference between direct sowing and planting.

The time of sowing must now be dealt with. Teak seed in Bengal should be sown early in April after special treatment to accelerate germination. The seeds of the *Dipterocarps* and some

of the oaks germinate on the trees or immediately they fall to the ground and must be sown at once. Other seeds ripen during the winter and hot weather and do not germinate till the break of the rains. These should be sown either before the break of the rains or immediately after the first rain. *Deodar* seed can be sown either in autumn or very early spring, sowings of *kail* and spruce need not be made till the following June. *Chir* seed is sown in June after soaking the seed in water. "In temperate climates were it not for the danger of being destroyed either by animal life or by adverse climatic conditions while lying on the ground over winter, direct seeding in the autumn would be acceptable for all autumn maturing seeds. All species which naturally germinate in the spring can be sown either in the autumn or the spring. Seeds which can be easily stored with little danger of deterioration and at small cost are sown in most localities in the early spring. Because of their rapid deterioration when stored, birch, alder and fir seeds are often sown in the autumn."

(5) *Planting.*

In planting work several factors influence the degree of success obtained. The more adverse the local conditions of soil and climate the greater must be the attention devoted to the protection of the site and the establishment of the plantation.

(1) *The size and age of planting material.*

The planting stock will usually consist of nursery raised seedlings or transplants as planting wild stock is generally unsatisfactory and these wild plants are usually no cheaper than nursery stock. It should be a rule to use the smallest stock which will succeed on the site to be planted. The chief advantages which result from the use of small stock are as follows:—

- (1) It is usually much less expensive.
- (2) The cost of handling and planting is considerably less.

(3) There is less interruption in growth due to the lifting, transport and planting of the stock.

(4) The root system is less liable to injury.

On the other hand, where the planting site is exposed, subject to drought or rank growth, larger plants should be used than on the best sites. The age of the planting material will therefore vary with the site and the species and in most cases cost limits the size of the stock that can be advantageously used in forest planting.* Transplants have a better developed root system but it is doubtful whether this advantage compensates for the enhanced cost of the plantation wherever it is possible to use seedlings. In Bengal where planting is preferred to direct sowing the management aims at producing nursery plants ready to plant out at the beginning of the rains when 4 to 6 months old. In Kulu, as already mentioned, *deodar* are always planted out when 1½ years old and transplanting in the nursery is not done.

(2) *Methods of planting.*

As a general rule the quicker the plantation can be established the cheaper and more satisfactory will the work be, and labour is more economically employed in forcing the plants in their early stages than in keeping them alive once they have had a setback or in replacing a number of casualties. It is often more economical to employ a more expensive method of planting if thereby casualties can be avoided and more vigorous growth obtained.† It is not proposed to discuss the various standard methods of planting as these are well known to all foresters. It is necessary, however, to emphasise the bad effects of doubling up the roots in planting and the disastrous consequences of setting the plant with the collar too deep in the soil. We are only too familiar with both the above faults. When planted the young trees should stand a little above the level of the ordinary soil so that they sink

* Toumey—*Seeding and Planting*.

† *Indian Forest Record*, volume VIII, Part IV

naturally to the correct level, they should never be planted in deep holes below the surface level under the mistaken view that they will obtain more water in this way, and the soil must be well firmed about the roots and not merely stamped down round the collar, neglect of this is another frequent cause of failure. When all other methods fail and the area must be restocked, basket planting may be made but satisfactory financial results can hardly be expected with this costly method. The planting of *sisso* root and shoot cuttings is now extensively done with satisfactory results. The cost of setting out the plants is cheap and the growth obtained faster than with seedlings. Attempts to grow *sal* in this way have however failed.

(3) *The time of planting.*

As regard temperate climates Toumey writes:—

“From extended studies by Engler on the periodicity of root growth in silver fir, white and Scotch pine, beech, oak birch and maple, it was ascertained that the development and production of roots are not continuous. Root growth is interrupted by periods of repose which do not exactly correspond with those when the shoots are at rest. The growth of the roots of coniferous species was entirely suspended from November to March or April, while root growth in the deciduous trees did not appear to undergo complete arrest in growth even in mid-winter. However, the period from February to beginning of March is the least favourable for root growth, due to the low temperature of the soil. In general root begins its rapid development from a few days to several weeks before its buds start. *For this reason spring planting is more successful when conducted at least one or two weeks before the buds begin to swell. The new root growth will not be injured or broken off in setting the plants.*

“It was found that the roots undergo a cessation of growth in summer due to drought, but in October there is a new period of activity, which is much more intense and more prolonged in

deciduous species than in the conifers. It appears from these investigations that the autumn planting of the broad leaved species should be just before this new period of root activity begins. It also appears that deciduous species, because of the greater growth of the roots in late autumn, are more acceptable for autumn planting than are spruce, pine and other conifers.

"Almost without exception the most favourable time for planting is the spring, two weeks or more before the buds begin their growth. At this time the roots are active and become quickly established. When plants are taken from the nursery at this time and immediately set in the plantation, there is very little interruption of growth and the conditions are favourable for maximum success. In the spring plantation of deciduous species, it is particularly important that the trees be set before the leaves start their growth or even before the buds have appreciably swollen. When the planting is delayed until the leaves have started, they invariably wither and die on the trees and the later foliage which results from the unfolding of the dormant buds is usually ragged and open. Most conifers on the other hand can be successfully planted after the new growth is fairly well advanced. They do better however when set before the new growth has started."

In India the chief planting season for most species is the beginning of the rains. In Bengal the best time for planting is the end of May or the beginning of June for localities above 5,000 feet, the middle of June up to the middle of July in the middle and foot hills, and the same period in the plains except that it is safe there to plant up to the end of August. As a general rule once the rains have properly set in the sooner planting is finished the better, as the more established the plants become during their first rains, the more able they will be to survive their first hot weather. *Deodar* should be planted as early in July as the rains permit and the same applies to *sissu* root cuttings. Walnuts both in Bengal and in Kulu is planted out in the cold weather and ash in Kulu is treated in the same way.

(4) *The spacing of plantations.*

The spacing of the transplants will vary in accordance with the rapidity of growth of the species employed. The plants must be set sufficiently close to produce a closed canopy at an early age and to form a fully stocked plantation of well grown trees. The disastrous results of planting at too great intervals are only too obvious throughout Britain. At the same time the costs of formation require that the plants be not set closer than is absolutely necessary to produce good results. The planting of larch 6' x 6' has lately been advocated in Britain to reduce the very excessive cost of formation under present conditions and when it is considered that this method only requires 1,210 plants per acre compared with 2,722 required for planting 4' x 4' the economy is manifest. With a fast growing species we consider that a spacing of 6' x 6' will give perfectly good results. This is now the distance laid down for teak in Burma. *Deodar* should be planted 5' x 5'. It is better to set the plants square than in rows where the distance between the rows is 10' or 15', this delays the closing up of the plantation and produces unbalanced trees.

(6) *Tending.*

"It is becoming more and more clearly established that for the conditions generally prevailing in the United Provinces (the four months of growing season in the rains followed by four months of dry cold weather, and by four months of hot weather) the success or failure of the plantation depends to a very great extent on the conditions of growth during the first year, and more especially during the first four months of the growing season. A seedling that does not develop adequately during the first monsoon has small chance of surviving the following hot weather.

"Tending of direct sowings and plantations is absolutely vital if failure is not to result. This factor is unquestionably of supreme importance in afforestation, and to its neglect in the past must be

ascribed most of the failures in plantation work, with which the United Provinces forest areas are dotted. It has been proved in the plains (Etawah), in the Tarai (Gorakhpur, Kheri, etc.), in the Bhabar (Haldwani, Ramnagar) and in the higher hills (Chakrata, Naini Tal), that failure without rains weeding is almost inevitable and success with rains tending under normal conditions is almost certain. On the other hand with *chir* pine plantations on bare hillsides near Almora, and *sissu* on light gravelly soils with mild weed growth in Ramnagar, success has been obtained without rains weeding, and again in the Bhabar where labour and supervision in the rains are very difficult, various alternative schemes, e.g., early sowing and planting with irrigation, have met with success. But generally speaking nothing can replace or give the same results as rains tending."*

In Bengal the authors of the *Forest Record* write :—

"The amount of tending necessary depends on the rate of growth of the species and on whether the intervening spaces are occupied by well cleaned field crops or by jungle. Under a good field crop practically no special tending of the forest plants is necessary except the loosening of the soil about their roots, at any rate in the case of fast growing species, provided that two years' cultivation can be arranged for. In the case of *sal* grown with field crops, some forking or weeding may be necessary and climber cutting will have to be done in the third year. If the area is not under field crops jungle must be kept sickled back well away from the plants, two weedings will be necessary during the first rains, one in the second and one in the third. In the case of *sal* even more weeding will be necessary.

"Weeding and cleaning is best done at the beginning and the end of the rains. If only one cleaning is to be given it should be at the end of the rains. It is a good plan when making this final cleaning to spread three or four inches of cut jungle over the forked up 'thali' as a mulch and to cover this with a thin layer of earth.

* *The Forest Pocket Book*, 1921.

Only such jungle as will decay quickly should be used. Illami (*aggaratum* sp.) forms an excellent mulch and is plentiful. Mulching is particularly advisable on dry ridges into which the roots have not penetrated to any great depth so that the trees are likely to die off through lack of moisture in the dry weather.

"The result of this tending is that most of the small trees go away with a straight leader and form symmetrical trees such as are not always seen in plantations set out with one or two years-old seedlings."

Troup in his *Silviculture of Indian Trees* gives instance after instance of parallel sowings, weeded and unweeded, where the former lines succeeded and the latter failed altogether. The ending of *sal* sowings in Gorakhpur is described as follows :—

"During the rains weeding and working the soil is done generally three times in all. *Weeding is absolutely necessary* or the young seedlings get completely smothered in grass and weeds. Working the soil need not be done with the first two weedings but should be done with the third and final weeding which generally takes place in September. Very good results have been obtained where only weeding and no special working of the soil has been done, as the weeding in itself necessitates some working of the soil. If no weeding is done the sowing is generally a failure. After this tending during the rains it is generally not necessary to do anything more until the next monsoon, provided the work and specially the third weeding in September has been properly done. The cost of this tending during the first year is about Rs. 12 per acre of actual area worked over."

Trevor insists on the importance of weeding coniferous sowings in Kulu: "It is absolutely essential that direct sowings be properly weeded. Where heavy herbaceous undergrowth is present weeding should commence on 1st June, and be repeated a second time during August. In other places where the undergrowth is not aggressive one weeding in August will be sufficient. Very heavy weedings cost up to Re. 1 per acre. The average cost

of weeding 500 acres consisting of both heavy and light work has been found to be 8 annas an acre."

Sissu root and shoot cuttings must also be tended by loosening the soil during the rains. The final soil loosening at the end of the rains is perhaps the most important operation in the plains.

Attention to all these details of management combined with close personal supervision of the work and continued observation as to the best methods to be employed for each and every species will ensure success in artificial reproduction. In many cases already in Burma, Bengal, Nilambur, the irrigated plantations of the Punjab, the afforestation work in the United Provinces and in several hill divisions, standard methods have been adopted on which it would be difficult to improve. Still in other places much remains to be done to bring this branch of our work up to the necessary standard of efficiency. With the increasing intensity of management of the *sal* forests of the United Provinces, much more artificial reproduction will have to be undertaken for the completion of areas under regeneration, but with the knowledge already obtained this development of our work need give no cause for anxiety.

"TROWSCOED."

APPENDIX III—(3).

THINNINGS.

Whether as the result of artificial or of natural regeneration a time arises sooner or later when thinnings become necessary in every forest crop. In the case of conifers this operation may be delayed for a considerable number of years, whereas in the case of teak thinnings may be necessary when the crop is one or two years old. As we have already seen in the case of natural regeneration every species will require different treatment and the forester carrying out this operation must have a clear understanding of the habits and growth of the trees with which he is dealing.

A thinning consists in lessening the crowded condition of the best trees in a canopy so as to favour their development. In the case of most conifers it is essential that thinnings should commence early so that good healthy stems with crowns of sufficient vigour to withstand snow should be produced.

"The first thinnings must be executed without thought of the value of the produce extracted, the sole object being the future of the crop." In dense coniferous reproduction or in line sowings this work may commence with the pruning knife when the plants are about two or three feet high. Later when the crop is six feet or more in height and has covered the ground with a complete canopy the first thinning may be carried out. This is equally important in the case of conifers and *sal* and a neglect of this necessary work has resulted in the deformation of extensive areas of sapling crops. The most practical way of doing this work is with an intelligent forest guard who is given a stick of a certain length with the order that this stick has to pass between all the trees left standing. Where the stick will not pass between two

trees the best one is kept and the worst marked for felling. The guard marks the trees to be removed and a gang of coolies working with him cuts them down. The stick may be of any length ordered but for sapling crops under 6' diameter, to which crops alone this method is intended to apply, a 4 foot stick is recommended for conifers and a 3 foot stick for *sal*. The final spacing of the trees left standing will be about $1\frac{1}{2}$ times the length of the stick used. Extensive areas of various species have been thinned in this way in many divisions of Northern India and the method can be recommended with absolute confidence.

It has been stated that thinnings are undesirable or unnecessary in the case of *sal*; a mass of figures go to show however that thinnings in *sal* are absolutely necessary if a reasonable rotation and increment is to be maintained. Two plots in Haldwani have been under observation for 28 years. One was never thinned and the other was thinned once in 1884 and never again. The increment for the first 50 trees in each plot (stretching from 18" to 60" girth) shows—

For unthinned plot = 7.5" per tree.

For thinned plot = 13.7" per tree.

Assuming this rate of increment spread over the rotation (and the large difference in limits of girth in each plot makes this justifiable) it shows that in 120 years—

An unthinned crop would attain 2' 8" girth.

A thinned crop would attain 4' 10" girth.

How much more the latter increment would have been accelerated by subsequent regular thinnings is proved by the slowing down of the increment curve of this plot while neighbouring regularly thinned plots show accelerated increment for every thinning. Exactly similar results are shown by the two Chaukhamb sample plots in Lansdowne, situated side by side and measured annually since 1902. The thinned plot only had one thinning in that year and the immediate stimulus to increment is at once apparent from the graph attached—Plate 13. The old Dehra Dun sample plots

which extend over a period of 24 years with one thinning only show a rapid increment for the first five years after the thinning, after which the effect of the thinning began to wear away and the increment became very slow towards the end. Averaging the measurements of hundreds of trees in five different localities and calculating the rotation on the periodical increment on the 5, 10 and 24 years subsequent to the first thinning, rotation for a 5 foot girth *sal* works out as follows:—

On the 5 years period 89 years.

10 years period 117 years.

24 years period 154 years.

A comparison of the condition and appearance of the thinned sample plots with the unthinned forest around them is sufficient to convince any forester of the necessity of thinning this species. Thinnings are universally admitted to be necessary in European forestry, they are essential to the Himalayan conifers and absolutely necessary in the case of teak and *sisu*. It is therefore unreasonable to suppose that *sal* is alone in not requiring thinnings and the figures given above clearly prove that this tree follows the same fundamental rules as other species.

The opinion has been expressed that a growth of epicormic branches on *sal* indicated an excess of light but this is entirely a wrong assumption. The formation of epicormic branches both in the *sal* and the European oak is an indication of ill-health and is generally due to the crown of the tree being unable to obtain sufficient light to support normal growth, resulting in all the dormant buds on the stem being called upon to put forth leaves to assist the crown in supplying sufficient nourishment to the stem and roots. Epicormic branches are also produced after a fire by injured trees for similar reasons, namely to increase assimilation with a view to repairing the damage done by fire. Healthy *sal* trees with normal crowns do not produce epicormic branches even when growing as standard in a coppice and the properly thinned sample plots are singularly free from this defect.

Thinnings permit of the realisation of the legitimate intermediate yields, they shorten the rotation and improve the quality of the final crop. They are essential under all silvicultural systems and their neglect in working *deodar* under selection in Jubbal has been most unfortunate. Innumerable instances can be given where thinnings in *sal* and oak worked under selection are the crying silvicultural need of existing crops.

The degree of the thinning will vary with the species being dealt with. It is impossible definitely to describe what constitutes a correct thinning, but the experienced silviculturist will know exactly what degree of density is desirable in each and every case and will act accordingly. The golden rule is to begin early, thin moderately and repeat as often as necessary. The art of thinning can only be acquired by experience, observation and thought, but there are now fortunately plenty of trained foresters, who are quite competent to do this work under the direction of a Divisional Officer, who knows and can explain exactly what he wants. McIntire in speaking of *deodar* has stated: "I have come to the conclusion that in thinnings one should be guided entirely by the condition of the canopy formed by the dominating stems. The removal of the suppressed poles occupying little or none of the space in the canopy appeared to me to be quite a minor consideration." Again Broillard writes: "Pine woods require early thinning, failing this the trees languish." Where snow break or strong winds are to be feared, the sole method of preventing loss is by thinnings which prepare the trees for an isolated condition and strengthen their stems and root systems.

Thinnings promote not only diameter but height increment. Chavegrin is positive on this point: "It is believed that trees grown under crowded conditions are more rapidly drawn up and attain greater length of bole. The error of this assumption has been long since revealed by research. In truth trees of the same age growing in a dense crop are far behind those standing in rational freedom, the greater the number of stems per unit of

area, the more patent is their inferiority in height." Again Gazin states: "In trees suitably spaced the height increment is proportionate to the diameter, which latter is subserved by subsequent thinnings." Experiments carried out by the forest branch of Munich University went to prove that "when thinnings were carried out freely, the development in height was relatively much greater than the diametrical increment and at any rate during a certain period in the growth of crops, the heaviest degree of thinning produced the loftiest and cleanest boles." The whole science of thinning is crystallised in the words of the International Congress of Silviculture in 1900. "All struggle between neighbouring stems must be avoided, for it is always at the expense of growth that it takes place. The formation of the stems of the prospective crop, in as large numbers as possible, must be assisted by gradual freeing beginning at an early age. When they are formed they must be successively thinned out to enable them to develop their crowns and root systems."

It must not, however, be presumed from what has been written above that heavy thinnings are necessarily advocated. The method of thinning different species will vary considerably; the pines, live in a canopy, open but evenly distributed, quite a different style from isolated trees. The *deodar* grows in a moderately dense wood, but the individual crowns must be given sufficient room for their proper development, if too crowded they become attenuated, the trees develop a sickly appearance, and increment practically ceases. The silver fir loves tranquillity, it amplifies its foliage slowly and never much; it likes coolness and freshness and suffers from the introduction of sun and wind, it loves a close canopy and this must at all costs be maintained. In the case of spruce it should be remembered that the production of clean stems is essential if the highest price is to be obtained for the produce. The Indian spruce has longer fibres than any other spruce in the world, and there is a great future for clean slowly grown stems of this species. The wood should therefore

be kept close and even, and thinnings carried out in a careful and regular manner, gradually reducing the number of the dominating stems by freeing the best and most vigorous crowns among them but remembering always that the crop is one united whole, inter-dependent and inter-responsible.

Bagneris asserts: "To obtain the full benefit of thinnings they must be repeated whenever the crop becomes too crowded to allow of the normal expansion of the crowns; observation shows that they should be more frequent during the period of height, growth, and that they should preferably occur after equal intervals, in general every 10 years up to the 70th year or less according to species."

It cannot be too often asserted that thinnings must be made in the canopy of the dominant trees. Suppressed trees may be removed by all means if there is any demand for them, but their removal has no effect on the silvicultural condition of the main crop. In some cases in dealing with the *sal* it may be desirable to retain the suppressed trees to conserve the moisture content of the soil to the maximum. Howard has made an attempt to classify thinnings, *vide* proceedings of the Indian Silvicultural Conference, 1918. His grade A and B of ordinary thinning, *éclaircie par le bas* are of no value whatever as a silvicultural operation. His grade C is too drastic in that it involves the removal of all classes of trees save the dominant and the thinning of the latter. This prescription is certainly modified by his two qualifications:—

- (a) In all cases in which holes would be created by the removal of dominant trees, dominated and suppressed trees should be left to cover the ground.
- (b) In removing sound dominated trees with badly shaped crowns or boles, the operations must be made with due regard to the stocking and condition of the whole crop.

APPENDIX IV.

STANDING ORDERS FOR RANGE OFFICERS.

*Fire protection in the plains,
Beating out fire and counterfiring,
The general technique.*

Beating out fires and counterfiring.

*Preliminary
organisa-
tion.*

On receipt of a fire report the Range Officer should send immediate intimation to the Divisional Forest Officer. He should send messages out in all directions for labour, warn the neighbouring Range Officers, issue orders for the rapid conveyance of necessary tools, water utensils and water carts to the scene of the outbreak and then proceed thither with all available labour. In the absence of the Range Officer the senior official present will perform his duties and continue to do so until relieved by the Range Officer who should then take entire charge of the operations. It is essential that the Range Officer should invariably carry his range map when going to fires, for he will find that it will prove of substantial help to him in working out on the spot his general plan to fight the fire. Especially will he find this to be the case when he does not possess sufficient knowledge of the locality. Instances are known where such an imperfect knowledge coupled with the absence of a map have resulted in the adoption of wrong measures. Where communications by telephone is possible the Range Officer should be accompanied by a cyclist-patrol carrying a portable telephone whose duty it will be to transmit the Range Officer's messages from time to time to the Divisional C. O., furnishing the latter with full details and thus keeping him in constant touch with the progress achieved.

It would have been better to incorporate these essential provisos into the main rules and not lay down that all trees other than the dominant trees should be removed. Again in his definition of crown thinning it is prescribed that dead trees and part of the dominant trees will be removed but that the dominated and suppressed trees will be left to shelter the soil. It is contended that a correct thinning by which is intended a compromise between '*éclaircie par le haut*' and ordinary grade C thinning will involve—

- (1) the regularising of the canopy by thinnings among the best dominant trees;
- (2) the removal of badly shaped dominant trees in favour of well grown dominated trees;
- (3) the thinning out of the dominant trees in favour of the dominant trees or alternatively for the benefit of other dominated trees retained as part of the crop.

The removal of suppressed trees is a matter of expediency depending largely on local markets for the produce. Wherever possible they may be cut, and in coniferous forest their retention is undesirable but, as already noted, under certain circumstances in the case of *sal* they are better kept, to shelter the ground.

Trees top-broken by snow have a great power of recovery and should not be removed merely because they have lost their leader. Unless broken in half or otherwise irretrievably damaged they should only be removed under the ordinary rules for thinnings.

The question of the correct manner of executing thinnings has been studied for many years, and after carrying out this operation over many thousand acres and seeing the deplorable results of a neglect of this most important work, the writer is in entire agreement with the words of the eminent authorities already quoted: opinions which may be aptly summed up in the words of Cannon:—

"The health, the life of the crop lies in judicious reiterated thinnings."

"TROWSCOEED."

Unless the Divisional Officer or any attached gazetted officer, arriving at the fire, specifically takes over control from the Range Officer the latter should continue to direct operations.

On arrival at the scene of the fire the first duty of the Range Officer is not to snatch an extinguisher from the nearest man and begin working like a coolie, but carefully and calmly to study the situation. It is very necessary that every Range Officer should cultivate the habit of facing the position calmly, fully realising that his must be the master mind to direct and control operations. The importance of this point cannot be over emphasized for mental confusion and panic on the part of the Range Officer lead to chaos and disaster. It is better that a few more acres should be burnt while a sound plan of attack is being evolved than that the attack should be carried out in a haphazard manner leaving much to chance.

The factors that should claim the Range Officer's first consideration are:—

- (a) *Direction of wind.*—It is necessary correctly to differentiate between the general direction of the prevailing wind and the several, often deceptive, currents created by the fire itself. Having arrived at a decision on this point it will be possible to decide on measures immediately necessary.
- (b) *The possibility of beating out the fire without resorting to counterfiring.*—It is seldom necessary to counterfire during the winter months, for at this time of the year fighting a fire presents no difficulty. But during the fire season proper the conditions are entirely changed. When, however, the character of the forest burning is such that there is but little or no grass, the wind is not strong and the fire is making but little headway there is no necessity to counterfire. In such circumstances it is only necessary to advance directly upon the fire and beat out the flames. A golden rule in fighting a fire is

Plan of attack.

not to counterfire unless it is absolutely essential to do so. It should be borne in mind that reckless and needless counterfiring does more harm than good. No counterfiring should be done except with the approval of the Range Officer or the officer in charge of operations.

- (c) *If a counterfire is necessary where should such be carried out.*—When the fire has assumed a wide frontage and is advancing rapidly with the aid of a strong wind through forest containing heavy grass and much dry debris and the flames are such that it is dangerous, if not impossible, for men to battle directly against the conflagration the need for counterfiring becomes immediately clear. It is then necessary to choose the most suitable, usually the nearest, road or fireline from which to counterfire. This road or fire line, should be selected in the direction, in which the fire is advancing and should, if possible, be sufficiently ahead to allow the act of counterfiring to be completed in good time so that the two opposing fires may meet some distance away in the interior of the burning compartments.
- (d) *Staff and labour immediately available and the most effective manner of distributing them.*—A correct idea of the staff and labour at once available is necessary so that definite tasks over definite sections of the perimeter of the fire may be allotted. The Range Officer should keep with him two or three messengers mounted on ponies or cycles to convey his instructions to subordinates.
- (e) *Arrangements for drink and food.*—It is of the greatest importance that immediate and adequate arrangements should be made for supplying regularly the fighting gangs with drinking water. If it is anticipated that the

fire is likely to last several hours arrangements for food should also be effected.

- (f) *Allocation of labour expected to arrive at the scene of the fire.*—Besides the men who have already reached the outbreak gangs will arrive from time to time. In order that the services of such men may be utilised without loss of time definite orders should be issued regarding their allocation and duties. Members of the range staff should on arrival solicit orders from the Range Officer.

The first step to take is to send the major portion of the fighting gang in the direction in which the wind is carrying the fire. All the men should be equipped with extinguishers. Subordinates, preferably those with experience and local knowledge, should be placed in charge of the main fighting body and they should be ever on the alert to see that the men are distributed in the best possible manner along the fire frontage. Men engaged in beating out a fire require constant and unremitting supervision. The spacing between individuals should be suitable and there are times when crises arrive and have to be coped with promptly by efficient handling of labour. Often in a crisis even seconds count and decisions must be quickly made. Subordinates should, for the sake of example, assist the men in beating out the fire and the more energetically they work the more will the men strive to co-operate. It should never be forgotten that a good example is of the utmost value in fire fighting operations. Every endeavour should be made to prevent the fire extending to protected grassy areas and naals holding heavy grass as such, when once on fire, assist enormously in spreading the outbreak. A few men should be deputed to follow the main body and deal with possible subsequent petty outbreaks near the edge of the burnt area.

While the main fighting gangs are engaged against the flames ahead a sufficient number of men under subordinates should be deputed to beat out the fire in the less important directions. Usually this operation is not a difficult one

Beating out a fire without counter-fire.

as the flames, lacking the influence of the wind, travel but very slowly and can rapidly be extinguished. Nevertheless, it is essential that this work should be executed with thoroughness, for any section of the perimeter incompletely dealt with may suddenly burst into flame with a change of wind. As these rear gangs beat out the fire they should sweep a strip, six feet wide at least, quite clear of inflammable material along the edge of the burnt area to guard against subsequent outbreaks. All smouldering logs or pieces of wood on or near such a strip should be completely extinguished, but if time does not permit this to be done they should be rolled or thrown well inside the burnt tract. Burning trees, especially old hollow stems, along or near such swept strips should be felled in the direction of the burnt area and completely extinguished. Burning stumps near the strips should receive attention and care should be taken to see that no fire remains in them. Fire in stumps is apt frequently to be overlooked. Sometimes stumps continue burning for days, the smouldering fire persisting in working its way deep into the wood and even below the ground surface to the dry decaying roots. In order that the work of extinguishing burning logs and other timber may be done thoroughly these minor gangs should be supplied with sufficient water. The mere plastering of mud over the burning parts does not act effectively; indeed, this measure is deceptive for though it may temporarily cancel all signs of smoke the fire continues alive inside. It will frequently be found necessary to use axes and cut deeply into the wood to get at the fire so that it may be properly put out with water. The function of these minor gangs is therefore not only to extinguish the fire but to devote their energy towards rendering the cleared strips effective and doing everything possible to prevent subsequent outbreaks. They should not be employed, during the progress of the fire, in the interior of the burnt area to extinguish burning timber, etc., as such work comes properly within the duties of those specially deputed on post-fire operations.

Theoretically, the best time to start a counterfire is when the wind has somewhat abated, but such a favourable circumstance is not always present and it becomes imperative to take immediate action and begin the counterfire. The point at which counterfiring should usually be begun is that nearest the advancing fire. One of the cardinal principles of counterfiring is that the operation should be executed under complete control. It is therefore necessary to have a sufficiently large labour force before undertaking a counterfire, especially since this operation is done against the wind; if the measure is attempted with an inadequate number of men it is almost certain that the counterfire will become uncontrollable and spread the general conflagration instead of checking it.

Counterfiring.

The counterfiring party should consist of three distinct groups of men each performing different functions. The first group should contain men equipped with suitable grass-cutting implements, the second should be comprised of those to whom the grass is supplied, usually in the form of sheaves, and who should run along with their lighted sheaves developing the counterfire, while the third and considerably the largest group should be made up of individuals armed with extinguishers. The latter should follow the second group and prevent the counterfire from crossing the line selected for the operation. The members of the second group should not go too far ahead of those following them. Much vigilance should be exercised by the third group because it sometimes happens that the counterfire fanned by a high wind and encouraged by the presence of heavy grass, grows rapidly in intensity throwing its flames high into the air and carrying burning material on to and even across the counterfiring line into the neighbouring compartment, there to begin another fire unless such material is immediately extinguished. When the first attempt at counterfiring has failed and the fire threatens to develop an uncontrollable frontage the wisest procedure is to fall back on to the next selected line and to begin a second counterfire without loss of time. If it is eventually concluded that circumstances are so

adverse as to make successful counterfiring from roads and narrow firelines impossible the safest course is to collect all available labour, retire to the nearest wide fireline and there counterfire with the hope that the additional width will hold out a greater prospect of success.

Post-fire
opera-
tions.

The fire having been brought under control it is necessary to attend to the large quantity of burning material in the shape of trees, logs and smaller timber which will usually be found scattered throughout the affected tract. Old, dead, hollow trees require particular attention and unless felled and the fire burning in them completely put out constitute a special source of danger. The whole of the burnt area should be divided into definite units of work and a subordinate with a gang deputed to each to extinguish all burning and smouldering material therein. Such subordinates and labour should camp at the scene of the fire, the Range Officer seeing that adequate arrangements are made for their food. It is important to extinguish all smouldering material in as short a time as possible, especially if the fire has occurred during the *sal* leaf-fall. At this particular season the leaves are shed in such large quantities that they soon form a new and thick inflammable layer on the ground which is likely to be set alight by any smouldering wood and another fire, though a slow one, may start and travel to an adjoining unburnt tract. It is thus very important that the swept strip round the whole of the burnt area should be kept as clean as possible. Instances have been witnessed where, during the time of heavy leaf-shedding a series of fires have occurred in patches on the site of the original outbreak. If the Range Officer cannot himself stay at the scene of the fire it is at least necessary that he should visit the area daily until he has thoroughly satisfied himself that all smouldering material has been properly extinguished.

Fire protection in the hills.

1. The idea is ingrained in the local people that burning of the forest late in April or in the first half of May will produce a

good new and early crop of grass. The needles of *chir* fall about this time and undoubtedly suppress the grass and render the hill-sides difficult and even dangerous to cattle. The villagers' time-established remedy for this is burning the forest and when no restrictions exist burning is resorted to everywhere at this season.

2. With established customs such as these the policy of the Forest department must at present be to arrange our protective measures so that an adequate area of forest, either "Open Civil" or where necessary reserved, can be burnt at the season that the people wish, without unduly endangering the forests which it is desired to protect.

3. As the result of experience gained more particularly in the bad fire seasons of 1915-16 and 1921 the following remarks may be made:—

- (i) In *chir* forests firelines with *chir* trees standing on them are practically useless as the needles fall at the season when the efficiency of the fire lines is required to be at its highest. The needles are in such quantity particularly in a dry year that after their fall even clearing of a narrow path to counterfire from the fireline is a very slow operation.
- (ii) *Banj* and rhododendron stop a fire to great extent, there is little grass and debris under them. They are to be encouraged along the edges of the firelines. One drawback to them is however that they generally have several dry branches stumps, wounds, or hollows and these burn and smoulder for a long time. In fighting fires therefore arrangements have always to be made for putting these out.
- (iii) Counterfiring should only be allowed by villagers under the orders of a forest official.

In a cold weather and when the forest is damp, fires in *chir* forest can be often put out by beating, together with short counter-fires either on ridges, in *nalas*, horizontally or sloping. In the

hot weather and when the forest is dry, only at the very commencement can a fire generally be controlled by beating and counterfiring must be early resorted to by the staff. In almost all cases counterfiring must be on ridges or in *nalas*, straight up and downhill or along the top of a ridge. Counterfiring on the horizontal or any thing approaching it on the side of a hill will sometimes serve to stop a fire with small flames from coming up hill but this will be difficult. Such a counterfire will generally be useless to stop a fire coming downhill. It may be temporarily of use to delay a fire in order to enable effectual measures to be taken elsewhere but sooner or later burning cones and debris will fall downhill. Even if a fire is ringed in and the running fire has been put out, the watch of a horizontal fireline at the bottom of the burnt area is very difficult and for days danger exists and at any time burning material may fall and the fire break out again lower down.

Ridges undoubtedly are the best place to locate counterfires though high winds may cause difficulty at times on them.

Often when the wind is very strong the best thing is to collect the supply of labour and rest the men and wait until the conditions improve, it is useless to wear out men by attempting the impossible. In selecting a ridge for counterfiring local knowledge is essential as it is useless to take a counterfire a mile or so down a ridge to find that it ends in precipitous ground, down which the line cannot be completed. The man or men with most local knowledge must go ahead and direct the party who clear the strip from which the counterfire is made.

Nalas are useful for counterfiring only when broad or damp or when filled with broad leaved growth. If narrow and dry, burning debris will roll down from the burnt side and bounce across to the protected forest and spread the fire. It is also difficult when flames are at all intense to prevent the fire, when counterfiring, from crossing to the wrong side of a narrow *nala*.

Another point is whether counterfires should be carried out uphill or downhill. Generally all work progresses better in the hills from the top to the bottom and counterfiring is no exception. In working uphill if work is unexpectedly slow and the fire spreads along the hill across the line of the counterfire, the whole work on that line is useless and a fresh start has to be made further along from the bottom again. If working from the top and the fire spreads along the hill below and across the line of counterfire, there is always a good chance of successfully slanting the counterfire along the hill downwards and outwards to ring in the spreading fire.

The greatest drawback to counterfiring downhill is that every one moves too quickly downhill and once down no one wants to go back, even a few paces, and great care has to be taken to have a reliable official to keep back men to put out stumps and make all safe behind.

In laying out the line of a counterfire always avoid having trees just on the edge of the burnt area, clearing round them when necessary and preventing the fire from reaching them. Also try and prevent dry trees or stumps from catching fire close to the edge of a counterfire, a few minutes extra work in this way will save hours of watching afterwards and reduce the likelihood of the fire breaking out again.

Wooden rakes save much time in clearing the ground for starting a counterfire, but they must be well made so that constant replacing of teeth is not required. All watchers must have these rakes and there should be spare supplies at each Forest Guard's and firewatcher's *chaukis*.

(iv) When the running fire has been put out, danger is by no means past and the extinction of burning stumps, watch of tall burning trees etc. has to be arranged. It has been found that burying burning stumps with earth is dangerous though under control it may be of temporary use.

The stumps are not often put out by the earth but continue to smoulder and being buried are not seen until burning strongly when the earth falls in, a strong wind may fan the embers into flames and sparks may spread the fire again. Only on water can complete reliance be placed and for this reason a supply of kerosine oil tins must always be kept at Forest Guards' and firewatcher's *chaukis*. The Range Officer must see that all Forest Guards have at their *chaukis* a sufficiency of tools such as rakes, phowras, axes and *daratis*. In hot weather and particularly at the season when unprotected forest is being burnt and the atmosphere is not clear it is difficult to observe and locate fires. Range Officers must arrange for continuous and permanent watch to be kept by fire-watchers from prominent points with a good view. *Chaukis* should be constructed at these places and men made reasonably comfortable and there should be two men for such a post if it is isolated. When a fire has broken out notice must be sent to the nearest Forest Guards who will arrange to inform the Range Officer at once and any other neighbouring forest officials or gangs of men working in the forest, and send notices to reach rightholding villages from which help is required. All guards should be provided with a supply of the printed notices for calling out help to a fire and these should be delivered, if possible, to a *malguzar* or in his absence to some leading resident of the village. If the latter will sign the notice he should be asked to do so and the messenger can return the notice to the official who sent him. If no one will sign the notice the messenger will, after reading out the summons, stick it up in some prominent place in the village, e.g. in the *malguzar's* door post. It should not be assumed that people will come to a fire without notice, although it is true they are bound to do so as soon as they become aware of it. Unless a notice is served, it is always difficult to prove that the villagers were aware of the fire.

all but the smallest of fires the organisation of the labour supply is a most important duty for a Range

Officer or the senior official present at a fire. When any official senior to the Range Officer is present the latter will refer when possible to the former for orders, but it will generally be most satisfactory to leave the executive control to the Range Officer under the control and advice of the senior official. The official controlling the fighting of a fire is not expected or wanted to work like a cooly except at critical moments when personal example is of great value. Generally he has to save his strength and get the maximum he can out of the others working on fire. One of his first duties is to arrange for the summoning of the necessary help from contractors and right holding villages, etc. He should limit his demands in this respect according to the circumstances and should not unnecessarily oppress the people by summoning them from long distances. In some cases distant villagers might be summoned for the day after the fire to take their share in putting out stumps, etc., this would give such people a chance of coming with less discomfort. Another important point is the provisioning and water supply for workers. Men should always be sent off for water at an early hour and easily consumed food should be sent for when necessary. The cost of food will be borne by Government in all cases.

- (vi) Regarding the payment of labour employed in putting out fires, a roll should be taken of all those present when the running fire has been put out or ringed in. This should be done as the men were either appointed to a particular part of the boundary of the burnt area to watch and put out stumps, or sent with messages for help, or to fetch food, etc., or in the event of their having done a fair share of work and not being longer required, when they were allowed to go. The people

would be told that payment for work done would be dependent on the circumstances of the fire and would be decided by the orders of the Divisional Forest Officer. The regulations for payment are based on the resolutions of the meeting of Conservators on the 16th August, 1921, which will be followed.

4. The measures that are required to carry out the policy defined in paragraph 2 above are :—

(i) The fixing of the boundary of the forest to be protected outside which burning will be done annually—

(a) When the forests have been long under protection as in the case of old reserves this boundary will be as hitherto the boundary of the reserved forest. At present there is generally at the best only a very narrow strip often not properly cleared, called a fire line round the boundaries, with the result that it is not safe to burn the open civil forests outside them in April and May. Here what is required is the clearing of a proper fireline wholly inside our boundary. The width will vary somewhat with the locality, the minimum at present is to be 50' and the maximum 100'. Range officers will report in detail what clearing is required and from what portions of the lines the material can be used for fuel supplies or failing this, what parts they can get cut free of cost by villagers in return for the free grant of the material (not to be counted against their rights allowances). They will give an estimate for the cost of the remaining work.

When the boundary is along a cart road in the strip 50' on either side, cutting is not allowed without reference to the Public Works department, nor is such cutting desirable as it might endanger the road and would in any case remove all the shade.

In such places therefore all we can do is to keep the strip clear of needles and inflammable matter, patrol it in the fire season and warn travellers. This will not generally affect the possibility of burning the outer forests, as in the case of a cart road it would generally be possible to burn downwards from it, and in some cases even it could be done from a bridle path.

(b) For the new reserves proposals must be sent in on the lines of the preceding paragraph. Where there has been ample open civil forest left outside the reserves, it will suffice, as in the case of the old reserves, to make the fire protection boundary along the reserve boundary, cutting the strip inside the reserve. The maximum and minimum width to be as already stated.

(ii) Interior firelines where they already exist in the old reserves must be cleared of all *chir* trees. In some of the higher levels trees on fire lines have not been cleared in *banj* forests, or having been cleared, *banj* has been allowed to grow up again. Regarding these places reports are to be made giving suggestions. Where firelines have not been permanently located and cleared, reports should be made giving proposals. It will not be possible to clear all in one year so the degree of urgency should be stated, to show the order in which they will be undertaken, the possibility of using produce and getting work done free or the estimate of cost to be sent in.

Trees must be cut as close to ground level as possible, this is important as high stumps will take long to disappear and give much trouble in burning lines.

(iii) Dead trees or trees with large dry branches adjoining fire lines must be cut, this again may take time but is an essential operation, and is to be reported on.

(iv) Range Officers will also report on the measures they propose to carry out under the three preceding subsections, what outer forest it will be possible to burn in conjunction with the villagers in April and May in the coming season. See the people and let them know and explain the policy to them. We want to make burning possible and cheap, so their co-operation is required, but they must burn *with* us and under the control of our staff, otherwise fires will occur.

(v) Firelines both exterior and interior will be burnt as early in the season as possible, they should generally be completed by the end of February. Needles will fall on them later on, and fire patrols must keep clear strip on the line as broad as the length of the line under their control permits. This work has often been overlooked by Range Officers while others have demonstrated that if kept at work firewatchers can do this quite well.

Outer unprotected forests, including open civil, can be burnt outwards so far as it will burn without giving trouble at the time that the exterior fire lines are burnt, but the main burning will be done in April or May when the villagers want to do it. They will be told to ask the Range Officer to arrange dates for them to burn it under control of the Forest staff.

(a) Care must be taken over the number of men called out to fires, definite limits as to number cannot yet be fixed.

(b) Opportunity should not be lost to impress on villagers accustomed to burn "C" class forest adjoining reserves, that they are required to give notice to the Range Officers of the date on which they wish to burn. The rules regarding this are laid down in G. O. no. 76/XIV-51, dated the 11th January, 1918, copies of which have been issued to all *patwaris*.

JB
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