REPORT

ON

THE GROUP SYSTEM OF NATURAL REGENERATION

IN

GERMANY

AND

ITS APPLICATION TO INDIAN FORESTS

BY

M. R. K. JERRAM,

Deputy Conservator of Forests, Punjab.

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PREFACE.

The following notes are the result of a tour in Germany in the autumn of 1912, made with the object of studying the practical application of the group system to certain German forests, its results, and the possibility of applying the principles of the system to coniferous forests in the Punjab Himalayas. Full detailed description of the forests visited is not given, being considered unnecessary; remarks are confined, in so far as is compatible with intelligibility, to matters of practical interest to Indian Forest Officers. A general description of the theory of the system is considered unnecessary, as most present-day Indian Forest Officers are acquainted with it. Reference may be made to Mr. Fernandez's pamphlets, which give a full account of the sylviculture of the system, as applied to certain forests in Bavaria and the Black Forest. He does not, however, discuss the management of the system, a matter of considerable practical interest to Indian Forest Officers, which I have endeavoured to deal with in these notes, in such a manner as may afford them some assistance. I have throughout applied the term gap or regeneration gap to the space cleared in a group felling, since to apply the term group to such a cleared space, as is often done, is obviously wrong.

KELHEIM, BAVARIA.

There are two forest divisions here, Kelheim Nord and Kelheim Sud, but the conditions are sufficiently similar in the two to make a common description of both sufficiently accurate for the object in hand.

The forests occupy limestone hills and the slopes are generally moderate. They consist of mixed forests of Spruce, Beech and Silver Fir. There is also a quantity of oak but it is subject to a special treatment which is only of academical interest to Indian Forest Officers and is therefore not dealt with here.

Management.—The nominal rotation is 120 years, and the regeneration period 30 years. (The rotation is being gradually reduced to 100 years and the regeneration period to 25 years.) The rotation chosen is that at which the sale price per unit of volume culminates. There are then four periodic blocks, but the division into fixed periodic blocks is, as will be seen later, hardly recognised except for the purpose of calculating what portion of the total volume and increment of the forest shall be cut annually. The forest is divided into compartments averaging about 150 acres and these are allotted to the different periods, *i.e.*, the yield is regulated according to the method of area and volume combined (Schlich, Volume III). The volume and increment of the existing crop is ascertained from yield tables and, in the case of the more irregularly aged woods, by means of sample woods, and the volume which may be cut annually calculated therefrom. This volume is always cut regardless of the area covered.

As explained above the necessary number of compartments are allotted for felling in the next 30 years. This division into compartments is made not only for the purpose of regulating the yield, but also for the purpose of facilitating the control of the regeneration. Each compartment is a separate regeneration unit, in fact a small periodic block in itself. Operations are not carried out in each compartment allotted to the 1st period every year nor is the sequence in which these compartments should be taken up laid down at the time of making the working plan; for this reason and on account of the irregular periods of the recurrence of the fellings and their varying intensity (explained below) it is clear that the regeneration period of 30 years is a purely nominal one and that many compartments are regenerated in a considerably less period and generally all in a

somewhat less period. No attempt being made to comply with any theoretical mathematical requirements in laying down the initial size of the regeneration gaps, the extent of their subsequent periodical increase, their initial distance apart, and the number of operations required to join them up (*vide* subsequent remarks on the group system in the Punjab), it might seem that, with the necessary inaccuracies which are bound to occur in calculating the yield, regeneration operations would be in danger of being advanced or retarded beyond what they should be to ensure the whole regeneration being carried out in the proper time. This however is prevented first by the division into compartments which makes it easier to apprehend the extent to which regeneration operations have proceeded, and secondly by ten-yearly revisions of the working plan. At these revisions not only are the yield recalculated but the compartments to be regenerated in the next 30 years are laid down anew (hence the remarks above about there being no division into fixed periodic blocks).

In practice, however, it only occasionally happens that a compartment originally laid down to be operated on in the first 30 years is not actually taken up in that period; it is clear that only in very exceptional circumstances would a compartment the regeneration of which had been started in the first ten-year period be relegated to another period in the rotation at the next revision. The compartments allotted to the current period of working are gone over at the commencement of each year by the Divisional Officer who then draws up a plan for the years' working, showing what compartments shall be operated upon and in what manner the operations—shall be carried out.

Sylviculture.—The manner of making the fellings is guided first by the necessity for giving the Beech and Silver Fir a start over the Spruce, which on this limestone soil is quicker growing, and secondly by the necessity for taking the fullest advantage of seed years, the occurrence of one of which may entirely regulate the manner of felling for the next five or six years. Neglect of the first consideration results in a pure Spruce crop which is not desired. For the purposes of explanation only, the operations may be divided into three:—Primary operations—Secondary operations,—and Final operations.

Primary operations.—If necessary first make a thinning over the whole compartment to set free the crowns of seed-bearers and increase their fertility (Kelheim Nord). (The yield obtained thereby counts against the Final Yield.) Search out the clumps of Beech advance growth and give them more light by cutting a few trees round them. Start making regeneration gaps by felling the biggest trees in groups. The biggest trees are generally selected and it is found that the dominated trees which remain and are thus set free put on a very considerable increment during the regeneration period. In Kelheim Sud the original gaps are theoretically supposed to be 20—25 yards in diameter; formerly they were made larger. In Kelheim Nord the initial gaps are, in the absence of advance growth, usually very small; frequently only one tree is taken, leaving a gap perhaps only five yards in diameter. The advantage of making small gaps in the first instance is that Silver Fir and Beech being considerably more shade-bearing than the Spruce thereby get a start. If regeneration is required in a hurry much larger ones can be made. I have seen one initial gap (or rather strip) about 150 × 40 yards in extent which has been successfully regenerated, but the result is pure spruce; the gap was clear felled except that a few suppressed beech were left for protection until the regeneration had been obtained.

Secondary operations.—Enlarge the size of existing groups or make fresh groups. When once seedlings appear on the ground trees are felled much more freely and the subsequent felling areas are generally of ever increasing dimension.

Final operations.—Join up gaps by felling intervening trees, remove any shelter belt which may have been left on the windward side of the compartment. Sowing and planting is resorted to if necessary to regenerate the compartment completely.

As has already been stated the occurrence of seed years exercises a great influence on the manner in which the fellings are carried out and the following rules are applied in modification of the above.

Seed years.—Make fresh gaps.

Non-seed years.—Thinnings or opening out advance growth.

Years following on a seed year.—Make fellings so as to assist the growth of the crop of seedlings obtained from the seed year. The requirements of this operation may supply the full yield for five or six years, the other less essential operations being postponed.

No attempt is made to take up the regeneration of a whole compartment at once by making gaps all over the area; on the contrary, such a procedure is particularly avoided; the initial gaps are made on the leeward side of a compartment to avoid damage by wind, or from the top of a hill and worked downwards to avoid damaging the young crop by dragging the produce of the felled trees through it. It is generally found necessary to increase the size of a gap every four or five years, but no rule can be laid down. Should the new crop for some reason or other fail to come up within a reasonable time or be destroyed, sowing or planting is resorted to as soon as the soil shows signs of becoming unsuitable for natural regenaration; this however very seldom occurs. In felling particular care is taken not to damage the young crop. Trees are first felled outwards at the corners of a group, and the other trees are then felled on the top of them. The operations throughout have given the most splendid results in the way of natural regeneration, this being due in part no doubt (Kelheim Nord) to the fact that the present forest officer has been in the division for nearly 30 years, and there has thus been absolute continuity of action following a fixed plan and based on a thorough knowledge of the crop and its requirements for a whole regeneration period. Natural regeneration is indeed generally even thicker than required and cleanings in quite young (10 years old) crops are therefore carried out. Thinnings are made in the compartments not included in the current period. The idea is to make light thinnings at frequent intervals.

FREUDENSTADT, BLACK FOREST, WURTENBERG.

There are two divisions here, Freudenstadt and Steinwald. The following is a description of Freudenstadt Division, but applies for the most part to Steinwald as well.

General.—The forest is 5,000 acres in extent, covering the summits and slopes of hills between 1,800 and 2,700 feet above sea level. There is a lot of nearly flat ground and the slopes are usually not what we should regard as steep in northern India. The species are Spruce and Silver Fir, with a small admixture of Scotch Pine and Beech.

Management.—The rotation in the past was that of the highest annual income, namely 120 years. At the last revision of the working plan, the financial rotation was worked out and was found to average 100 years for the different species (90 years for Silver Fir and Spruce and 130 years for Scotch Pine). As however 50 per cent of the woods are over 80 years old, the previous rotation of 120 years has been maintained for the present. Working Plans are made for 20 years and revised every 10 years. The procedure (Judeich's method) is to go over the whole forest and make a description of compartments noting what area if any in each should, for sylvicultural reasons only, be brought under regeneration during the next 20 years. The total area to be brought under regeneration during the next 20 years having been thus determined, the volume standing on the same is ascertained from yield tables (*N. B.* It is also noted what proportion of the area in each compartment to be regenerated in the next 20 years should be regenerated in the first period and second period of 10 years respectively.) This volume divided by 20 gives the annual yield, and this yield is cut annually regardless of the area covered; thus the yield for a period of at least 10 years is equalised (*i.e.*, until the next revision). A compartment may be regenerated in as little as 20 years or as much as 40 years. The management is in fact governed entirely by sylvicultural considerations,

and it is clear that the method adopted does not provide for the equalisation of the yield, except for short periods. The control is, it will be seen, less regulated by fixed rules even than in Kelheim. It may be mentioned however that the normal felling area and yield are worked out in order to ascertain to what extent they differ from the actual, and presumably the system would be modified if this deviation were found to be very great. As a matter of fact the actual felling area (for the current period) is 25 per cent more than the normal felling area given by the formula:—

$$\frac{\text{total area}}{\text{rotation}} \times \text{length of period.}$$

But the annual yield is slightly less than the yield calculated according to the Austrian method with the normal growing stock to be established in $\frac{1}{3}$ rotation. This is due to the already mentioned excess of mature woods. It is clear that the system cannot have much application for India, where we are usually bound to have a sustained annual yield and have not the data to calculate how far we are going astray by the above method.

Sylviculture.—The method of regeneration is in a few places the same as the Kelheim method. More generally, it is a sort of hybrid operation resembling Wagner's Strip System (Appendix II) more than any other recognised method. Owing to the great danger to the forest from storms it is considered essential to expose as small an area as possible to this danger at one time, and therefore the gaps are made very close together and only a narrow strip (200 metres or less in width) is operated on at once. In order then to cut the full calculated yield it is clear that the gaps will be joined up and the regeneration of the above small areas proceed much more rapidly than is ordinarily the case. So rapidly indeed is the operation carried out that it is impossible to obtain full regeneration from nature and supplementary planting operations have to be carried out on a considerable scale. The combined result of both in bringing about an early protection of the soil is not nearly as good as that obtained in Kelheim from nature alone. The local forest officers however say that natural regeneration cannot be expected here as good as that in Kelheim owing to the absence here of lime in the soil. It is also admitted that the soil is not as good as it might be owing to the scanty amount of Beech and the ill effects of exposure during the working of the shelter-wood compartment system, which the present system supplanted. Considering the exposure of the soil, which the present system entails, and the cost of planting, the selection system would seem to be preferable to the existing one if wind danger makes the genuine group system inadmissible. The groups are generally clear felled, but occasionally Scotch Pine are left standing in a gap to give seed. On steep slopes the system generally becomes the strip system pure and simple, as the group system is considered to result in too much damage to the regeneration owing to the timber (whole trees are generally exported) being dragged through the regeneration gaps.

Pfalzgrafenweiler, Black Forest, Wurtemburg.

The forests resemble those at Freudenstadt and the previous sylvicultural system was also the same, namely the shelter-wood compartment system.

The present system, which is practically Wagner's strip system, was introduced six years ago. The system differs only from Wagner's in the direction of the fellings which are from east to west, and in the fewer points of attack on the fellings taken up at once; both these modifications are introduced on account of the wind danger. As in Freudenstadt, planting generally has to be resorted to to supplement natural regeneration, but not to such a great extent owing to the better quality of the soil. The fact that planting has to be resorted to as much as it does must however be held to constitute to some extent a failure of the system as here applied. The forest and its management has many features of peculiar interest, but they are not of much practical importance to the Indian Forest Officer.

Forbach Black Forest, Baden.

General.—The division consists of 12,500 acres of Silver Fir, and Spruce Forest with a small admixture of Beech and Scotch Pine. The forest greatly resembles, both in appearance of the forest growth and configuration of the ground, the coniferous forests in the Punjab Himalayas; that is to say the age classes are very much intermingled and the slopes are very steep and rocky.

Managemant.—The rotation is 120 years, the lowest rotation with which the particularly large timber, which it is here desired to produce, can be obtained. The first investigations made to determine the yield are the same as those already described for Freudenstadt Division (Judeich's method). A large number of checks are applied to th however with the object of regularising the yield more or less. There is no need to describe these checks as none of them would be possible in India. One of them consists in estimating the area occupied by each age class, a very uncertain operation even in this small area one would imagine when the intermixture of the age classes is considered. The estimated yield has been steadily rising in the last 20 years. The forest is divided into compartments averaging about 100 acres in extent.

Sylviculture.—In the words of the forest officer in charge, it is not desired to put into operation any fixed sylvicultural system. An inspection of the fellings shows that this principle, or lack of principle, has been followed in practice. The regeneration fellings vary from place to place from pure selection to group, strip (generally started in several places in one compartment) or even a regular sequence of regeneration fellings.

The management and sylviculture have a very haphazard appearance from the Indian point of view. They may——and in so far as one can see do——work well when a small area of forest is put in charge of a thoroughly efficient forest officer who remains in it the greater part of his lifetime and is able to look after it as he would his own garden; but it is hardly necessary to say that such methods would be impossible to apply in India. Until lately the selection method was of almost universal application but it is now being abandoned, except on the very steep slopes, in favour of other methods which give the young crop more light, as in many places it has failed to give altogether satisfactory regeneration. The regeneration is generally excellent in the gaps and strips, which are now being opened out. A VIII e, and A VIII g, works cost together rather less than 4 annas per acre per annum for the whole forest. Half of this is the cost of planting operations, one quarter the cost of collecting and burning felling refuse, and one quarter the cost of cleaning, pruning, etc.

Application of the Group System to Coniferous Forests in the Himalayas.

It is obvious to anyone acquainted with Indian conditions that the Kelheim system cannot there be put into force without considerable modifications. The system requires the presence for several years of the same officer for carrying out the marking, a condition which is lacking in India, and the possession by that officer of a thorough knowledge of the whole periodic block under working and its varying condition from year to year, knowledge which it is impossible for the forest officer in India to have. It is clear that in India operations must be more guided by rules, thus lessening the danger from inefficient management (inefficient by force of circumstances) and of course at the same time the opportunities for expert management.

In the Punjab the dangers from inferior skill in marking, from non-continuity of action, and from over cutting owing to the manner of calculating the yield, being recognised, an attempt has been made to make the system almost mechanical. The number of operations in which regeneration should be carried out, the original size and distance apart of the regeneration gaps, and the increase in size of the gaps with each felling are all laid down. After division

into periodic blocks the first periodic block is divided into sub-periodic* blocks equal in number to $\frac{\text{regeneration period}}{\text{number of regeneration operations}}$ and fellings are carried out in sequence in one of these blocks each year, regeneration gaps at fixed distances apart being made in one year over the whole of such block.

The extent of the annual fellings is limited by the boundary of a sub-periodic block, but it is further limited by a stem check. All the trees above a certain size in the first periodic block are divided into diameter classes and enumerated; the number of trees in each class is divided by the number of years in the period and the result plus or minus a small percentage as a margin is the maximum or minimum annual yield. To make the method clear to those who are not acquainted with the Punjab an example of its application is given in Appendix I. It is not of course intended to be understood that the method is applied in practice absolutely mechanically as shown in the example. The marking officer does not go round with a tape measure; and certain fellings in addition to the group fellings proper are recognised as necessary; but the devisors of the method do apparently intend that in so far as possible regeneration gaps should approximate in size and distance apart to the measurements laid down. The method has the following objections:—

(1) Impracticability of making gaps of approximately fixed dimensions, and a fixed distance apart and increasing them by a fixed area in irregularly stocked forests on precipitous slopes.

(2) Neglect of the sylvicultural requirements of the crop owing to fixed intensity and fixed period of recurrence of the fellings to each gap.

(3) Stem check is likely to act in opposition to sylvicultural requirements, *e.g.*, sylvicultural requirements may necessitate the yield in one year being taken out in the form of a small number of large trees and in another year in the form of a large number of small trees.

(4) Excessive loss of revenue due to the mechanical removal during the earlier operations of small trees, instead of as under the Kelheim system, leaving such trees till the end of the operation to increase in size, removing in the meantime the bigger ones.

Personally I do not think the group system applied as it is at present in the Punjab can ever work satisfactorily. It is easy however to pick holes in proposals for applying an intensive system of working like the group system to the peculiar conditions in India where the charges are enormous, the forests scattered over large areas of most difficult country and the controlling officer and his assistants changed every few years; to suggest anything markedly better and at the same time practicable is not so easy, and to devise a practicable method not open to severe criticism is impossible. It is therefore with considerable diffidence that I make the following suggestions as to how a working plan on the group system might be drawn up for a coniferous forest in the Himalayas. I may say at the outset that I consider it quite impossible to devise any method by which group fellings can be marked by any officer who is not an efficient sylviculturalist—the present system in the Punjab seems to bear the stamp of such an attempt—it must I think be accepted as an axiom that at present markings must be done in almost all instances by officers trained in Europe. My suggestions are as follows:—

(1) The present system of dividing the forest into periodic blocks would be retained, also the number of operations for completing regeneration would be laid down, thus necessitating the further division into sub-periodic blocks as at present; but the number of operations laid down would be only held to apply to the sub-periodic blocks as a whole, and would not be used as a regulator to determine how quickly the initial gaps should be joined up.

*Called, I think wrongly, Annual coupes. The Annual coupe is really the actual area felled each year, *i.e.*, $\frac{\text{area of sub-periodic block.}}{\text{No. of operations.}}$

(2) The sub-periodic blocks would be felled in sequence as in the present Punjab method, but their boundaries would not necessarily limit the extent of a year's fellings, the yield being regulated by volume as explained later. The sub-periodic blocks would be further divided into compartments, as is done at present, to facilitate control.

(3) The above limitation should be sufficient to control the system, and the marking of the fixed annual yield should be done on the Kelheim method, *i.e.*, on purely sylvicultural principles. The maintenance of a Forest Journal showing where, how, and on what principles the markings were done each year would be essential.

(4) Since, when marking on purely sylvicultural principles, all parts of a sub-periodic block will not be gone over at each operation, it is clear that 3 regeneration operations, at present considered sufficient in the Punjab, will not suffice. There should be *at least* five operations in a 30 years regeneration period. This has the disadvantage of increasing the size of the sub-operiodic block, *i.e.*, the area which the marking officer must go over each year.

(5) The yield would be ascertained by means of a sample wood or woods. Instead of applying the usual method of selecting and measuring small sample plots in a large number of woods (a method which must be inaccurate in the forests with which we have to deal owing to the impossibility of selecting a *small area* which is really representative) one large area (or one for each type of forest where there are two or more very different types dealt with, *e.g.*, a dry zone and a wet zone) of, say, 500 acres would be selected. This sample wood of course might be any shape and comprise parts of several compartments or forests; it should be part of the ar which will fall into the 1st periodic block. In this wood all trees, except such as it was not intended to cut in the 1st rotation, would be measured up in 2" diameter classes. The measurement would be done again after an interval of 5 years. The volume would be obtained from sample trees felled and measured up in each class. From the data thus obtained the total volume and the increment during the regeneration period of the 1st periodic block would be calculated, and the annual yield would be obtained by dividing the total volume plus the correct proportion of the increment by the number of years in the period. For the first 5 years of the working plan, unless the above operation had been carried out beforehand, we should have to work from volume figures alone making an estimate of the increment. There should not be much difficulty in getting the above operation done in the Punjab now that the local Forest School is turning out so many trained foresters and guards; in any case it would not be such a laborious operation as enumerating the greater part of the stock over the whole forest as is done at present.

(6) The increment per cent in the different diameter classes could also be worked out and would assist in deciding the rotation.

(7) The working plan should be revised at least every 10 years. This is very important not only because a new sylvicultural system is being introduced, but also because such revisions provide the best check on over or under cutting. In the past we have endeavoured to make ourselves safe against over cutting by fixing the yield well on the safe (?) side. The result under the old selection system has often been to make our sylviculture suffer for our lack of confidence in our estimates, in that owing to the yield being fixed considerably below what it should have been we cannot get over the ground and return to our felling area often enough to complete regeneration operations. The proper method is to cut boldly what our calculations show us we should cut—subject of course to making our fellings in accordance with sylvicultural considerations—and to rely upon revisions at sh

intervals to put right mistakes in our calculations. Supposing we make a mistake and the yield is really 10 per cent less than we calculate ; even then at the end of 10 years by making a small re-distribution of compartments and spreading the excess over the remainder of the rotation, assuming a rotation of 100 years it will only be necessary to reduce the yield about 11 per cent below the past yield, or about 1¼ per cent below what it should have been from the first, not a very serious mattter. Moreover, whereas it is important to regularise the yield over short periods for the purpose of contracts the regularization of the periodic yields is of considerably less commercial and financial importance.

Merits of the Group compared with the Selection System in Himalayan Forests.

The group system was introduced into the Punjab because in the opinion of many forest officers the old selection system was failing to give regeneration. It was recognised that the introduction of the new system must result in a considerable temporary loss of revenue, owing to the felling of immature and perhaps unsaleable material in the first periodic block. This loss has evidently been more serious than anticipated since in the Punjab Annual Report for 1911-12 it is contemplated going back to the selection system, and it is stated in justification of this course that several forest officers with the necessary experience are of the opinion that regeneration can be obtained as well by the selection as by the group system. That absolute confidence however is not placed in the latter opinion is shown by a further remark in the report that it will be advisable to maintain the selection-in-group system—a temporary expedient adopted originally until group working plans could be made—until the results of the group system in Chamba are seen. It is, of course, only possible for those with an intimate knowledge of the forests in question to decide which is the best system to apply to particular forests ; but it is advisable that the general merits of a system should be realised before it is put into operation, and I venture to call attention to the following defects of the selection system as applied to India which may have been overlooked. In the first place it is a mistake to suppose that the selection system is a simple one. It offers more scope than any other system for intense forestry, and is therefore correspondingly difficult to put into operation with really satisfactory results. To obtain satisfactory regeneration one must be constantly returning to the same area to complete operations already begun. Probably 5 to 10 years is the maximum period which should elapse between each operation. It is necessary that at the first operation the marking officer should have a clear and correct idea in his mind of the course which the regeneration fellings should take and that the marking officers at subsequent operations should realise his idea and act on it. This is true of other systems, but the necessary continuity of action is less likely to be attained in the selection system owing to the ease with which past operations are overlooked or misunderstood.

One can hardly miss a regeneration area in the shelter-wood compartment system but one may very easily miss many little gaps that have been made in the canopy in a Himalayan forest worked on the selection system. Further no one has ever yet devised, and almost certainly never will devise, a method of ascertaining under Indian conditions how the real forest worked under the selection system differs from the normal one, nor of bringing it into a more normal state that it already is. I say ' under Indian conditions ' because the above is claimed to have been done for certain European forests, *e.g.*, the forest of Couvet in the Juras ; but the methods adopted depend chiefly on estimates and no one who looks into them could think of applying them to India. Thus the best we can hope to do under the selection system is to maintain the forest in its present state. But under the selection-in-group system, which means that groups are selected for felling instead of single trees, it is impossible even to do this and to provide for the regularization of the yield, unless we alter the present method of calculating the yield. The reason is clear; the yield is calculated as a certain number of trees of a certain class or classes, but it is impossible in selecting groups for felling in accordance with sylvicultural requirements to ensure that the trees falling in each class shall be in the proportion laid down. This difficulty can be got over by felling the volume increment calculated as suggested under the group system, and if it is

decided to retain a selection or selection-in-group system, it would seem advisable that the yield should in future be calculated in this manner.

Some notes on German Forest Management.

The following observations were made in the forest divisions enumerated above and also in the division of Salmünster, Prussia. They are inserted here as they may have some interest for Indian Forest Officers though they have nothing to do with the group system.

Natural versus Artificial Regeneration —The old views on this subject have lately undergone considerable modification and the superiority of natural over artificial regeneration from the financial point of view as well as on account of the superior hardiness of the natural seedlings is now recognised in places which were previously strongholds of the 'save time and plant or sow' policy. An example of this is to be found in the mixed oak and beech forests in Salmünster, worked on a rotation of 180 years.

The best time to remove each tree of the parent crop is so perfectly understood that natural regeneration is obtained with a facility and profuseness which is astonishing to anyone who has been dealing for some years with Indian forests. And yet less than 20 years ago artificial regeneration was carried out at a cost which with interest at 3 per cent would amount at the end of the rotation to many times the value of the mature crop at present prices.

In Kelheim Nord in the exceptionally dry summer of 1911 practically all the young Silver Fir plants but hardly any of the natural seedlings died.

Thinnings.—It has occurred to many Forest Officers that it should be possible to obtain figures showing to what intensity thinnings should be carried out in crops of different ages in order to obtain the maximum increment. Experiments have been initiated on these lines at least in Switzerland, Prussia, the Punjab and possibly in other places. At the last Punjab Forest Conference it was decided not to extend the experiments owing to their doubtful value and the quantity of more important investigations which required to be carried out. The general opinion amongst practical German Forest Officers appears to be that such experiments have very little value, and even in Salmünster, where they have several sample thinning plots maintained by the Prussian Research Institute, the officer marking thinnings takes nothing else into consideration but his own views of the sylvicultural requirements of the crop.

Rotation.—In none of the seven divisions which I visited in Germany was any sort of financial rotation (*i.e.*, rotation in which rate of interest is taken into consideration) in operation; and in only three divisions (Wurtemberg) was the financial rotation taken into consideration at all in so far that it was worked out in order to ascertain how far it was being departed from. I did not, however, visit Saxony, where I believe the forests are almost invariably worked on a financial rotation, combined however with clear-cutting and planting up.

All the German Forest Officers with whom I have discussed the matter and who had any definite views on the subject were of the opinion that the working out of a financial rotation has no practical value, calculations made for 100 years or so ahead on the data given by present prices and the present ratio of the value of money to natural products being recognised as fundamentally inaccurate, there being indeed a constant tendency over long periods of time for the value of money to fall and that of natural products to rise. Of course the more irregular the system of regeneration the more uncertain are the calculations for a financial rotation, and it is interesting to note in the irregularly worked forests in Germany how often the rotation is founded on the growth of single trees.

APPENDIX I.

Diagramatic representation of the group system as applied in the Punjab.

Let area of forest=24,000 acres.

„ rotation=120 years.

Let regeneration period=30 years.

Then No. of periodic blocks=4 and area of a periodic block=6,000 acres.

Let No. of regeneration operations=3.

Then No. of sub-periodic blocks=$\frac{30}{3}$=10.

And area „ „ „ =600 acres.

Area to be clear felled in groups each year=$\frac{600}{3}$=200 acres.

Let width of the 1st gap=60′ then area occupied by 1st gap (and by each subsequent extension of the same)=3,600 sq. ft.

And the number of such gaps to be made in each sub-periodic block=$\frac{200 \text{ acres}}{3,600 \text{ sq.ft.}}$=2,420.

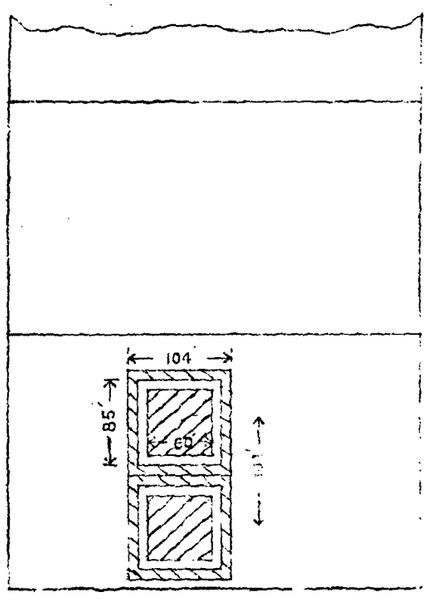
A mathematical calculation will show—

(*i*) That the side of the gap after the 2nd felling=85′.

(*ii*) „ „ „ „ „ 3rd felling when the gaps are joined up=104.

(*iii*) That the distance apart of the groups centre to centre also=104′.

Part of 1st periodic block.



2nd sub-periodic block to be felled in the years 2, 12 and 22.

1st sub-periodic block to be felled in the years 1, 11 and 21.

Regeneration gaps (enlarged)

1st gap felled in year 1.

2nd gap felled in year 11.

3rd gap felled in year 21.

APPENDIX II.

WAGNER'S* STRIP SYSTEM.

This system is of recent origin and probably unknown to the majority of Indian Forest Officers, so I think a short description of it here is advisable. It is generally associated with the name of Wagner, the first person to bring it into public notice,* though its principles have been applied for some years by various forest officers. It differs from the ordinary strip system in the principles it takes into consideration in deciding the direction of advance of the fellings, and also the manner of advancing them.

Felling direction.—In the old strip system fellings were generally made from east to west to avoid damage by westerly gales. Wagner, however, takes many other considerations into account in deciding on the felling direction, considerations affecting not only the parent crop and the regeneration on the cleared strip but also the regeneration which should be appearing on the strip about to be felled. A most important influence is exercised, he considers, on regeneration by light rain brought up by the west wind and falling in a slanting direction. Its importance lies in the fact that it frequently comes in the spring and summer when young plants are in most need of moisture, and that it is often so light that it does not pass through the leaf canopy of the mother crop and therefore unless special measures are taken the regeneration will not benefit. Taking this into consideration as well as the other recognised climatic effects of exposing a crop to the different points of the compass, Wagner then enumerates the advantages and disadvantages of each direction of exposure as follows :—

East.—In frosty weather the early morning sun exercises an adverse effect on the regeneration and the rays being slanting, the effect is exercised for a considerable distance under the shade of the parent crop. The light west rain not only fails to reach the ground under the parent crop but also, owing to the slanting direction of its fall, a large portion of the cleared strip lying to leeward of the parent crop.

South.—Drying up effect of the midday sun on the cleared strip and also, as the rays always slant considerably in Europe, on a narrow strip under the parent crop ; light west rain will only fall on the cleared strip and cannot assist regeneration under the parent crop.

West.—Full advantages from the light west rain. It falls not only on the whole of the cleared strip but also, owing to its slanting direction, on a wide strip of ground lying under the parent crop. On the other hand full exposure to the westerly gales, and of the cleared strip to the midday sun.

North-west.—The advantages of west with less exposure to gales, and to the sun.

North.—The effect of the light west rain is felt on the cleared strip only, but on the other hand there is full protection from the sun and gales.

The above considerations decide Wagner in choosing a north-west to south-east direction for the fellings unless there is great danger from storms, in which case he chooses a north to south direction. Modification of this is necessary in hills where the wind is often diverted from its original direction.

Method of felling.—Seedling fellings are made on the first strip to be taken in hand to induce natural regeneration, and subsequent operations consist in extending these fellings (on the same strip), a very gradual and irregular advance of the strip into the forest by fellings of the same nature, and a very gradual advance of the rear boundary of the strip by a clear felling on that boundary over such width as may be completely regenerated.

Application to Indian conditions.—The system is much easier to control than the group system, but in an irregular crop it results in an even greater sacrifice of immature material, a consideration which will probably put it out of the question. Moreover, the peculiar climatic conditions which give it its chief advantages in Europe are for the most part not found in India in so far as I am aware. It may be noticed that a system which is easy to control, whilst it lessens the opportunities for mistakes and the evil effects of non-continuity of action, also lessens the opportunities for taking the fullest advantage of the ever-changing phases of nature. Compare for example this system with the group system as practised in Bavaria.

* 'Wagner, Raumliche Ordnung im Walde' obtainable from H. Laupp'schen Buchhandlung.

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