III
SYSTEMS OF SUCCESSIVE REGENERATION FELLINGS
AND SHELTER-WOOD SYSTEMS

1. SYSTEMS OF SUCCESSIVE REGENERATION FELLINGS

Under the clear-cutting system, as we have seen, the area to be regenerated is cleared by a single felling, and where natural regeneration is relied on from seed shed by the trees on the area itself, complete restocking is secured in one season as a result of this single felling. This is possible only (1) where conditions of seeding and regeneration are unusually favourable, and (2) where it is not necessary to retain any portion of the old wood for the protection of the young crop against frost, drought, or other dangers.

In the great majority of cases, however, complete natural regeneration will not follow from a single felling, while in the case of sensitive shade-bearers protective cover for the seedlings may be necessary for some years after they appear. In either case part of the old wood has to be retained for a time for the provision of seed or for protective purposes. Thus the old wood is removed not by a single felling but by two or more successive fellings, and the new crop establishes itself from seed shed by trees retained on the area; these trees are termed seed-bearers. In certain cases the new crop may be introduced artificially under the protection of the old one, the latter being subsequently removed in one or more fellings.

The term systems of successive regeneration fellings is accordingly used to denote collectively those systems under which definite areas are regenerated by two or more successive fellings (known as regeneration fellings) extending over a period of years. The nearest French equivalent is perhaps Futaie régulière, but since this denotes even-aged high forest in general it would include the clear-cutting system. Méthode de régénération par coups successives (or progressives) is a term used to denote the uniform system; employed in the plural this term would express most clearly the idea of shelter-wood systems in general. The nearest German equivalents are Schlagweiser Hochwald or Schlagbetriebe, but these terms would, strictly speaking, include also the clear-cutting system.

The distinction between the different systems of successive regeneration fellings lies not in the general framework, which is not peculiar to any one system and is itself subject to various modifica-
SUCCESSIVE REGENERATION FELLINGS

tions, but rather in the method of carrying out the regeneration fellings and distributing them in space and time. The difficulty of devising a satisfactory classification of silvicultural systems applies with special emphasis to the systems of successive regeneration fellings, which show a large number of variations, often merge into each other, and are frequently used in combination. Continental terminology tends to confuse rather than to assist, since the same term is often used by different writers in a different sense, while undue importance is sometimes attached to trivial variations. Following the classification given on p. 2, the systems in question will be dealt with in the following order:

1. The uniform system.
2. The group system.
3. The irregular shelter-wood system.
4. Strip systems.
5. The wedge system.

In describing these systems it is proposed to deal with the uniform system in some detail, as its technique is based on principles many of which apply also to the other systems.

2. ADVANTAGES AND DISADVANTAGES OF SHELTER-WOOD SYSTEMS

Shelter-wood systems are those high forest systems in which the young crop is established under the shelter (overhead or lateral) of the old one; the latter at the same time affords protection to the soil. Shelter-wood systems include the various systems of successive regeneration fellings together with the selection system. As we have seen (p. 25), the question 'shelter-wood v. clear-cutting' has been the subject of much controversy in the past, and it will be of interest to consider the main advantages and disadvantages of shelter-wood systems, more particularly in comparison with the clear-cutting system.

Advantages of shelter-wood systems: 1. In general, though not universally, they aim at natural regeneration whereas the clear-cutting system usually, though not invariably, has to rely on artificial regeneration. Such advantages as natural regeneration may possess, therefore, are more frequently obtained under the shelter-wood systems than under the clear-cutting system.

2. They afford protection to species sensitive in youth to frost, drought, and cold winds; such protection is not afforded under the clear-cutting system except with very small or narrow coupes.

3. The soil is more effectively protected than under the clear-cutting system, particularly where the canopy is opened gradually
and cautiously: there is less risk of desiccation and the invasion of noxious weeds.

4. There is less risk of the multiplication of those injurious insects which habitually breed in clearings.

5. On steep or unstable hill-sides there is less risk of erosion or the rapid run-off of rain-water than under the clear-cutting system.

6. By adopting certain forms of shelter-wood system more effective measures can be taken to guard against damage by storms and snow than under the clear-cutting system.

7. An opportunity is given to the best trees to put on enhanced increment when opened out in regeneration fellings.

8. From the aesthetic point of view shelter-wood systems are usually preferable to the clear-cutting system, particularly if the old crop is removed gradually.

Disadvantages of Shelter-Wood Systems: 1. Shelter-wood systems require more skill and occupy the time of the staff to a greater extent than the clear-cutting system, owing to the necessity for marking trees either for felling or for retention.

2. Work is less concentrated than under the clear-cutting system, and hence felling and extraction cannot be carried out so economically.

3. Damage is done to a greater or less extent by felling trees over young growth and dragging or sliding timber through it; the amount of damage varies with different systems, and can be almost entirely prevented by suitable precautions.

4. In most cases the young crop takes more time to establish than under the clear-cutting system; this loss of time may mean serious economic loss.

5. The rate of cutting and regeneration are more difficult to control than under the clear-cutting system.
IV

THE UNIFORM SYSTEM

1. TERMINOLOGY

The term uniform system, which may be taken as an abbreviation of shelter-wood uniform system, implies a uniform opening of the canopy for regeneration purposes, as well as a uniform or even-aged condition of the young crop produced thereby. The system is also known as the shelter-wood compartment system, sometimes abbreviated to compartment system, denoting that the canopy is opened out for regeneration over whole compartments at a time. The terms shelter-wood system and system of successive regeneration fellings are sometimes applied to the uniform system in particular; it is preferable, however, to regard them as collective terms rather than as applicable to any one system.

In American literature the term seed tree method is sometimes used to denote a form of the uniform system in which the seedbearers are widely spaced over the area.

The French term in general use is méthode de régénération par coupes successives (or progressives). The terms futalé régulière (even-aged high forest) and futalé pleine (fully stocked high forest) are often applied to the uniform system in particular. The term méthode du réensemencement naturel et des éclaircies, first used by Parade, is still sometimes employed (see p. 61).

Among German terms the following may be mentioned:

Schirmschlagbetrieb, dating from the middle of the eighteenth century.

Schlagweise Schirmbesamung, G. L. Hartig, end of the eighteenth century.

Schlagweise Schirmverjüngung.

Dunkelschlagbetrieb, or Hartigscher Dunkelschlagbetrieb, implies a slight initial opening of the canopy, as in the case of shadebearers.

Femelschlagbetrieb, originally applied to Hartig’s uniform system, but now applied more commonly to the group and irregular shelter-wood systems (Bavarian Femelschlag and Baden or Swiss Femelschlag).
THE UNIFORM SYSTEM

*Schirmgroschlag*, a term used by Wagner to denote shelter-wood (uniform) fellings extending over whole compartments as opposed to strips.

2. GENERAL DESCRIPTION

In describing the uniform system it will be convenient to begin with a young even-aged crop of such species as oak or beech and follow it through the different stages of its life until it reaches maturity and is removed to make room for a new crop. In its early stages, up to 25 years, such a crop is subjected to cleanings and early thinnings in which adventitious species such as birch, aspen, and willow, as well as branchy 'wolf' trees, are removed; otherwise the crop is kept in a dense condition in order to kill off side branches and encourage the production of clean stems. The characteristic density of these even-aged young crops may be seen from Fig. 20. Thereafter the crop is subjected to periodical thinnings to remove undesirable stems and promote the development of the better members of the crop. It is important that the thinnings should stimulate good crown development, in order to produce good seed crops later on; but it is equally important that the canopy should not be broken permanently, as this is likely to result in a rank growth of weeds and grass which may prevent natural regeneration when it is wanted.

We may now assume that the crop is approaching the age at which it is desired to fell and regenerate it. If the thinnings have been judiciously carried out, it should consist of trees with long straight sound clean boles and well-developed crowns forming a complete canopy and capable of producing good crops of seed; trees with good crowns will have correspondingly well developed root-systems, so that if the crop is opened out they should be reasonably wind-firm. Owing to the closed canopy there should be no rank weed-growth on the ground, the soil-covering, if there is any present, consisting at most of a sparse growth of shade-loving plants.

The time has now arrived for the regeneration fellings. These consist of two main categories: (1) the *seeding felling*, under which the canopy is opened out in order to afford sufficient light to ensure the survival for a short time of seedlings springing from seed shed by the overhead trees; and (2) *secondary fellings*, under which the mother trees are removed in one or more fellings at suitable intervals in order to admit more light to the seedlings which have appeared. The last of the secondary fellings is termed the *final felling*; this is carried out when the young crop is well established.
Fig. 12 shows diagrammatically the different stages in the progress of regeneration. A crop in which the seeding felling has been carried out is said to be in the *seeding stage* (Figs. 13, 14, 17, 18, 22); one in which secondary fellings have already begun is said to be in the *secondary stage* (Figs. 16, 26); and one which only awaits the final felling is said to be in the *final stage* (Figs. 19, 23, 25).

At one time it was customary to carry out a *preparatory felling* (Fr. *Coupe préparatoire*, Ger. *Vorbereitungshieb* or *-schlag*, *Vorhieb*, *Vorgriffshieb*) shortly before the seeding felling, or in certain cases two or more preparatory fellings extending over a short period, say up to 10 years. The object of these fellings was to promote crown
development and seed production, and to admit the sun's rays in order to hasten the decomposition of the humus layer and produce a good germinating bed by exposing the mineral soil. G. L. Hartig (who first used the term *Vorgriffshieb* in 1834) recommended preparatory fellings in places where seed-years are rare, so that on the occurrence of a seed-year a large area may be ready for seeding fellings. In modern European practice preparatory fellings have been generally discarded. It is now recognized that crown development cannot be secured satisfactorily by a single felling, or even by two or more fellings, carried out a short time before the seeding felling. The correct time to promote crown development is throughout the greater part of the life of the crop, that is, by means of judiciously executed thinnings repeated at fairly frequent intervals from the time the crop is in the young pole stage to the time when regeneration fellings begin. The decomposition of the humus is also promoted by this means, and a further stimulus in this respect is secured by making the last thinning before the seeding felling somewhat heavier than usual. But at the present day preparatory fellings are not generally recognized as a definite stage in the regeneration fellings, and in France *coupes préparatoires* are now commonly understood to mean provisional or preparatory fellings carried out during the process of conversion from one system to another.

It follows from what has been said above that the life of a wood treated under the uniform system—and this applies to shelter-wood systems in general—may be divided into two phases: (1) education or preparation, in which the wood is subjected to early cleanings followed by periodical thinnings extending over a considerable portion of its life and fitting it for the process of regeneration, and (2) regeneration, beginning with the seeding felling and ending when the final felling has been carried out and the young crop is fully established.

The present-day tendency is to pay more attention than was formerly the case to the 'education' of the crop with the object of bringing it into a condition which will favour regeneration when the time comes. This is effected by means of light but frequent thinnings throughout the education stage, these thinnings often increasing in intensity up to the time of regeneration, so that the transition from education to regeneration may be almost imperceptible, and the seeding felling is merely the breaking down of the last barrier that prevents the fecundity of Nature from having full play. Some Continental foresters of long experience maintain that
Fig. 13. Beech under the uniform system. Unopened mature crop on right of path; seeding felling just completed on left by removal of one-quarter of the crop. Lyons la Forêt, Normandy.
Fig. 14. Beech under the uniform system. Seeding stage, with natural regeneration beginning to establish itself in quantity. Spessart, Bavaria.

Fig. 15. Beech under the uniform system. Natural even-aged crop 60–70 years old, one of the oldest crops produced under this system in France. Lyons la Forêt.
in the case of shelter-wood systems generally, at least 50 per cent. of the total production of a wood during its life should be yielded by thinnings.

3. REGENERATION FELLINGS
Fr. Coupes de régénération; Ger. Verjüngungshiebe.

Regeneration fellings, as we have seen, may be grouped into two main categories, (1) seeding fellings, and (2) secondary fellings, ending with the final felling.

The Seeding Felling. (Fr. Coupe d'ensemencement; Ger. Besamungs-hieb, Samenschlag, Angriffshieb, Dunkelschlag; the last-mentioned implies a slight opening of the canopy, primarily for the regeneration of shade-bearers.) If thinnings have been properly executed throughout the life of the crop, by the time regeneration is desired the trees should be in a condition to bear plentiful crops of seed and the soil should be in a receptive condition, free from any excessive growth of weeds or any thick layer of undecomposed humus. The canopy should be closed, since a close canopy means an absence of heavy weed-growth. The trees themselves should, by a long process of selection during the thinning stages, be the best seed-bearers available, the different species being as far as possible in the desired proportion and the trees themselves being the best of their kind, with well-developed but not too spreading crowns and long clean boles. They should have reached the minimum but should not have exceeded the maximum age at which seed is produced in abundance.

The object of the seeding felling is not to stimulate seed-production, but to admit sufficient warmth from the sun to promote germination, and sufficient light to enable young seedlings to survive for two or three years, or until it is necessary to admit more light by a further opening of the canopy. With the majority of species success is best assured by carrying out seeding fellings only in good seed-years, and this rule is very commonly observed. This is particularly necessary (1) where good seed-years occur at long or irregular intervals, (2) where the seed is perishable, (3) where the opening of the canopy is likely to result in a heavy growth of weeds —and particularly in a matted covering of grass—or in the deterioration of the soil. In such cases it is generally advisable to await the ripening or even the fall of the seed before carrying out the felling; this affords a greater supply of seeds and avoids any risk of mistakes in the event of the premature destruction of the seed-crop by storms or other calamities. On the other hand good seed-years need not necessarily be awaited (1) where they occur at frequent and regular
intervals, (2) where seed stored in the ground retains its vitality for some years, and (3) where the opening of the canopy is not likely to result in heavy weed-growth or soil-deterioration before the young crop can establish itself. Under the favourable conditions prevailing in western France, for instance, seeding fellings are often carried out in oak, beech, and Scots pine forests without regard to the occurrence of seed-years.

In carrying out a seeding felling it should be remembered that the ideal of the uniform system is to obtain even-aged masses of regeneration over whole compartments or other areas of some size. In selecting seed-bearers, great importance is attached to lofiness of bole and an even distribution of crown cover. High well-distributed cover admits light to the ground evenly and not in large patches of direct sunlight, and this is an important factor in securing an even crop of regeneration. Hence trees with long clean boles and well-developed crowns should be selected as seed-bearers, trees with narrow or straggling crowns with a tendency to low branching, together with diseased and defective stems, being felled wherever possible. If any low-branching trees have to be retained as seed-bearers or for cover, it is permissible to prune off the lower branches. Small trees and even shrubs forming an underwood should be removed, since these prevent light, warmth, and rain from reaching the ground, and adversely affect regeneration.

Where the uniform system is practised in its ideal form under favourable conditions, advance growth is generally removed at the time of the seeding felling. Solitary saplings or groups of saplings, even if they recover from the suppression which they have endured so far, develop into branchy ‘wolf’ trees and interfere with the regularity of the young crop. An exception to this rule is where large gaps have been created by wind or other agencies and have become filled with masses of promising regeneration of sufficient extent to form self-contained crops. Again, in the case of mixtures of shade-bearing and light-demanding species, promising advance growth of the former may be left while the regeneration of the latter is secured by the seeding felling. Where conditions are less favourable, and advantage has to be taken of the presence of any advance-growth that may appear, we reach the border-line between the uniform system and the group system.

The extent to which the canopy is opened depends on species and on climatic and other factors. In the case of sensitive shade-bearers requiring protection from frost, drought, or cold winds, and species with heavy seeds, the opening should be slight to moderate, whereas
Fig. 16. Beech under the uniform system. Secondary stage well advanced; complete regeneration obtained. Harz Mts., Germany.
Fig. 17. Oak under the uniform system. Seeding felling just completed, one-third of the crop being removed. Forest of Béarn, Normandy.
in the case of hardy light-demanders with light and particularly winged seeds the seed-bearers may be widely spaced, the actual spacing being based on the distance to which the seed is scattered in quantity by a moderate breeze. Examples of seeding fellings applied to different species are given below (pp. 49–59). Where the opening of the canopy is likely to result in a rank growth of weeds or grass, or in the rapid drying or deterioration of the soil, the seeding felling should be carried out with caution. More cover should be retained on hot southerly and south-westerly slopes than on cool northerly slopes, particularly where the soil is dry or shallow. Where there is a matted growth of grass, it may be necessary to hoe or plough the ground at the time of a good seed-year, to enable the seed to reach the mineral soil. The admission of swine for a time before the seeding felling has an excellent effect in breaking up the soil. In coniferous forests the removal of a covering of undecomposed needles (raw humus) is often an essential aid to natural regeneration. In some types of forest, particularly in tropical and sub-tropical regions, the burning of the leaf layer has a beneficial effect on natural regeneration, and some species will not regenerate successfully otherwise. Under favourable conditions one seeding felling is sufficient, but if complete regeneration does not follow, it may be necessary to carry out a second when the next seed-year occurs.

**Secondary Fellings**, sometimes termed *removal fellings*. (Fr. *coupes secondaires*; Ger. *Nachhiebe, Lichtschläge.*) The object of secondary fellings is to remove the overwood and uncover the young crop in order to afford it more light, rain, and nourishment. When the young crop has been fully established as a result of the seeding felling, the overhead cover should not be retained a day longer than is necessary. Under the most favourable conditions an even-aged young crop, resulting from a single seed-year, should cover the whole regeneration area from end to end. Where this happens, in the case of a hardy light-demander the whole of the overwood may be removed in a secondary (in this case a final) felling within a few years of the seeding felling. In the case of a sensitive shade-bearer, however, the young crop should be uncovered more gradually by means of two or more secondary fellings carried out at intervals, in order that it may receive the protection from frost, drought, or other risks which the overwood affords; as the young crop develops it is thus gradually freed from protective cover, and many years may elapse before the last trees of the overwood are removed.

In actual practice, however, conditions are not always so favour-
ABLE AS THOSE JUST DESCRIBED. THE SEEDING FELLINGS MAY RESULT IN SUCCESSFUL REGENERATION IN CERTAIN PLACES AND FAILURE IN OTHERS, IN WHICH CASE ANOTHER SEED-YEAR, OR MORE THAN ONE, MAY HAVE TO BE AWAITED BEFORE REGENERATION APPEARS OVER THE WHOLE COMPARTMENT. IN SUCH A CASE THE SECONDARY FELLINGS DO NOT PROCEED WITH MATHEMATICAL REGULARITY: SOME PARTS OF THE COMPARTMENT MAY BE STILL IN THE SEEDING STAGE WHILE OTHERS HAVE REACHED VARIOUS DEGREES OF THE SECONDARY STAGE, AND IN PLACES EVEN THE FINAL FELLING MAY HAVE BEEN COMPLETED. THUS IN CARRYING OUT SECONDARY FELLINGS THE STATE OF THE REGENERATION SHOULD BE THE CHIEF GUIDE TOWARDS THE SELECTION OF TREES TO BE FELLED OR RETAINED. WHERE REGENERATION IS SUFFICIENTLY WELL ADVANCED IT SHOULD BE FREED FROM OVERHEAD COVER, OTHERWISE IN THE CASE OF SENSITIVE SPECIES IT MAY BE NECESSARY TO RETAIN THE COVER A FEW YEARS LONGER. THE RULE, IN A NUT-SHELL, IS FOLLOW THE REGENERATION. HENCE WHERE DECIDUOUS SPECIES ARE CONCERNED, THE MARKING OF SECONDARY FELLINGS SHOULD ALWAYS BE DONE WHEN THE LEAVES ARE PRESENT, SO THAT THE YOUNG GROWTH MAY BE READILY VISIBLE.

THE LAST FELLING OF ALL IS TERMED THE FINAL FELLING (FR. COUPE DEFINITIVE; GER. ABRIEBSSCHLAG, RAUMUNGSHEB, ENDHEB). IN THE FINAL FELLING ALL REMAINING SEED-BEARERS ARE REMOVED AND THE FULLY ESTABLISHED YOUNG CROP REMAINS. AFTER THE FINAL FELLING ALL BLANKS ARE RESTOCKED ARTIFICIALLY, AS A RULE BY PLANTING. IN THE CASE OF SENSITIVE SHADE-BEARERS IT MAY BE NECESSARY TO PLANT UP BLANKS EARLY IN THE SECONDARY STAGE, IN ORDER TO AFFORD PROTECTION TO THE YOUNG PLANTS.

THE NUMBER OF SECONDARY FELLINGS AND THE INTERVAL BETWEEN THEM VARY GREATLY ACCORDING TO CIRCUMSTANCES. WITH A HARDY LIGHT-DEMANDER LIKE SCOTS PINE, IF COMPLETE REGENERATION IS SECURED IN A SINGLE SEED-YEAR, ONLY TWO REGENERATION FELLINGS ARE USUALLY NECESSARY, THE SEEDING AND THE FINAL, THE LATTER FOLLOWING THE FORMER AT AN INTERVAL OF A FEW YEARS. WITH A SENSITIVE SHADE-BEARER LIKE BEECH, IN WHICH THE YOUNG CROP IS UNCOVERED GRADUALLY, OR IN CASES WHERE REGENERATION ESTABLISHES ITSELF WITH SOME DIFFICULTY, THREE OR MORE SECONDARY FELLINGS, CARRIED OUT AT INTERVALS OVER A NUMBER OF YEARS, MAY BE NECESSARY.

REMARKS ON REGENERATION FELLINGS. WHEN THE OLD CROP IS OPENED OUT IN SUCCESSIVE REGENERATION FELLINGS, THE REMAINING TREES RESPOND BY PUTTING ON ENHANCED INCREMENT (‘LIGHT INCREMENT’). HENCE BOTH IN THE SEEDING AND IN THE SECONDARY FELLINGS CARE SHOULD BE TAKEN TO REMOVE THE DEFECTIVE TREES WHEREVER POSSIBLE AND TO LEAVE THOSE WITH STRAIGHT CLEAN CYLINDRICAL BOLES; INCREMENT PRODUCED BY THE LATTER IS OF GREATER VALUE THAN THAT PRODUCED BY THE FORMER. IN THIS WAY THE QUALITY OF THE REMAINING OVERWOOD BECOMES SUCCESSIVELY
better, until the finest trees of the crop are generally to be obtained from the later secondary fellings and the final felling.

A factor which affects the conduct of regeneration fellings in no small degree is the annual cut or yield, which is usually, though not invariably, fixed by volume. Circumstances must determine each year whether the prescribed volume shall be obtained from seeding or from secondary fellings or from both. When an area is first taken in hand for regeneration, every effort should be made to place as much of it as possible in the seeding stage, and hence at such a time the whole yield will generally be obtained from seeding fellings alone; where seed-years occur at somewhat long intervals it may even be advisable to exceed the prescribed yield during a good seed-year. As regeneration progresses the yield will be furnished mainly by secondary fellings.

In some cases the necessity for adhering to the prescribed yield may give trouble in that it interferes with correct silviculture. Thus if regeneration is backward, silviculture may require the overwood to be retained for seeding purposes or for the protection of the young crop, while questions of management require that fellings should be carried out to furnish the prescribed yield. Again, regeneration may have established itself in great abundance, and may be in urgent need of being freed by the removal of the overwood, whereas this if carried out might mean an outturn largely in excess of the prescribed yield for a year or two, followed by a corresponding drop in the outturn in the years following. Thus it is at times by no means easy to hold the balance between the respective requirements of silviculture and management.

Careless felling and extraction during the secondary and final stages may do much harm to the young growth. The chief precautions to be taken in order to minimize damage are (1) to fell and extract during the winter when there is deep snow on the ground, (2) to lop off the main branches or the whole crowns of trees before felling, (3) to make dragging or sliding paths at intervals through the young growth, and to use the same paths for the extraction of a succession of logs. In broad-leaved forest it is often customary after the final felling to 'cut back' damaged saplings in order to produce a regrowth of straight shoots. The lopping off of the crowns is a usual practice in some of the oak and beech forests of France, the object being partly to avoid damage to the young growth and partly to prevent the boles of the trees from splitting with the fall. For this purpose men ascend the trees with climbing irons and lop the crowns off with an axe (see Fig. 19).
In hilly country, in order to avoid damage by the sliding of timber through young growth, a compartment or a sequence of compartments is often worked over in such a way that regeneration commences at the top of a slope and proceeds in a downhill direction to the export road in the valley. In spite of the fact that considerable damage may be done to the young crop by the felling and extraction of timber, the young crop closes up and the results of such damage disappear in a remarkably short time.

As a precaution against wind damage, fellings sometimes begin in the east of the regeneration area and proceed towards the west. In parts of the Black Forest this procedure was introduced in the early part of the nineteenth century, and it developed afterwards into the shelter-wood strip system.

In modern practice it is sometimes customary to ignore the distinction between the different categories of regeneration fellings, and to regard these fellings as nothing more than a continuation of the process of thinning after regeneration has begun to appear. This idea is logical enough where much elasticity is allowed in regard to the areas in which regeneration is to be carried out and the period during which it is to be established; but where definite areas are set aside for regeneration in a given period of years, the recognition of the separate stages in the progress of regeneration is a great convenience, while there is also a marked distinction between the methods of executing the two main types of felling, seedling and secondary.

4. PERIODS AND PERIODIC BLOCKS
Period: Fr. Période; Ger. Periode, Verjüngungszeitraum.
Periodic block: Fr. Affectation; Ger. Periodenfläche.
Under the clear-cutting system we have seen that theoretically one coupe is cut and regenerated each year, so that if there are \( r \) years in the rotation (i.e. age of felling) there will be \( r \) annual coupes differing in age by one year. Under the uniform system this is impossible, since it requires more than one year to regenerate any given area. Hence, in order to systematize operations and ensure that the whole forest shall be felled and regenerated during the course of a rotation, the plan commonly followed under favourable conditions, such as those prevailing in many parts of France, is to divide the rotation into a number of regeneration periods and the forest into the same number of periodic blocks, each to be felled and regenerated in turn during the course of successive periods. For example, if the rotation is 100 years, divided into 5 periods of
20 years each, and if one whole rotation under the uniform system has just been completed, the normal distribution of age-classes should be as follows:

**AGE OF CROP**

<table>
<thead>
<tr>
<th>Period and periodic block</th>
<th>At beginning of period (present time)</th>
<th>At end of period (20 years hence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>81-100</td>
<td>1 to 20*</td>
</tr>
<tr>
<td>II</td>
<td>61-80</td>
<td>81-100†</td>
</tr>
<tr>
<td>III</td>
<td>41-60</td>
<td>61-80</td>
</tr>
<tr>
<td>IV</td>
<td>21-40</td>
<td>41-60</td>
</tr>
<tr>
<td>V</td>
<td>1 to 20</td>
<td>21-40</td>
</tr>
</tbody>
</table>

* Old crop all removed; only young regenerated crop remains.
† To be regenerated during period II.

**Length of Period.** The period is the estimated number of years required to obtain complete regeneration over a whole periodic block and to establish this regeneration up to the time when the retention of the overwood is no longer necessary; it should begin with the seeding felling and end when the last remaining seed-bearers are removed in final fellings. It is necessary to distinguish between the actual time taken to regenerate small patches of forest and the absolute length of time usually taken to regenerate a whole periodic block. As a rule, the latter is considerably longer than the former, and it is the latter, not the former, which determines the length of the period. For example, in the oak forests of western France, thanks to favourable seeding conditions, the interval of time between the seeding and the final felling over small units of area may be only a few years, but the period is usually fixed at 25 years or more, in order to ensure the complete regeneration of a whole periodic block. The chief factors which determine the length of the regeneration period are as follows:

1. **Seeding conditions.** Where good seed-years are frequent, a shorter period is possible than where they occur at longer intervals.

2. **Light requirements.** In the case of light-demanders a short period is indicated; in the case of shade-bearing species a longer period may be adopted, as there is not the same necessity for uncovering the young crop rapidly.

3. **Hardiness of species.** Hardy species, which may be uncovered rapidly, require a shorter period than sensitive species, which may require the protection of the overwood for many years; of important European forest trees the two most sensitive, beech and silver fir, are also strong shade-bearers.
THE UNIFORM SYSTEM

4. Climatic conditions. Where the climate is mild, the young crop, if it consists of sensitive shade-bearers, may be uncovered more rapidly than in localities subject to severe frost or drought, and the period may be shortened.

5. Soil and soil-covering. Where soil conditions are favourable to regeneration (e.g. sand and gravel for Scots pine, sandy loam for oak, absence of raw humus or heavy weed-growth for most species) the length of the period may be much curtailed. Where the soil is likely to dry up or where heavy weed-growth is to be feared, the canopy may have to be opened with caution during regeneration fellings, and the period is thus prolonged.

6. The question of mixtures. A long regeneration period tends to favour the more shade-bearing against the more light-demanding species: hence, other conditions being equal, a shorter period is indicated where light-demanders are to be favoured than where shade-bearers are to be encouraged.

7. Liability to injury. A long period for spruce is sometimes objected to on the ground that damage done during felling and extraction produces rot in the stems both of young and of old trees: a long regeneration period increases the risk of damage to the young crop and gives more time for the spread of rot in the old trees. This does not occur in the case of silver fir, for which species a longer period may be adopted.

8. Risk of fire. In some coniferous forests, even where hardy light-demanding species are concerned, a few seed-bearers are retained for many years after the young crop is established, as an insurance against fire, and the period is thereby prolonged considerably. This procedure is followed in the NW. Himalaya in some of the forests of Pinus longifolia, which are of an inflammable nature.

In deciding on the length of the period these various factors should be considered in relation to each other, with the object of arriving at a fair estimate of the time required to obtain complete regeneration and to establish the young crop beyond the risk of danger. In Europe it may be said that in the majority of cases the regeneration period varies from 20 to 30 years; this applies generally to oak, beech, and spruce, and often to silver fir if mixed with spruce. Where silver fir forms the bulk of the crop a long period—40 years or more—is frequently adopted, but in this case the system becomes the irregular shelter-wood system (p. 73) and can no longer be called the uniform system. In the case of pure Scots pine the period is generally from 4 to 10 years.

Theoretically speaking, the periodic block should be completely
regenerated by the end of the period. Actually it often happens that owing to various causes regeneration has not established itself as quickly as was hoped, and some areas may be still in the secondary or final stage at the end of the period. In this case there is generally no delay in beginning regeneration in the periodic block next in order, while the arrears of fellings in the previous block are worked off separately. In some cases, if a periodic block is not completely regenerated by the end of the period the remaining seed-bearers are felled and regeneration is completed artificially.

It will be apparent, therefore, that the period represents only an estimate of time, which may or may not prove to be accurate, and which frequently has to be departed from in practice. Hence the idea of definite periods of stated length, although it persists under the favourable conditions prevailing over a part of France, has been abandoned, or has never been recognized, in certain other parts of Europe, particularly in those regions where conditions for regeneration are not of the most favourable or where storms and other calamities are apt to upset calculations. In the latter case a rough estimate of the time taken to regenerate a given area is usually made for the purpose of calculating the yield, but the idea of definite periods for the regeneration of periodic blocks does not exist. In such regions, again, compartments allotted for regeneration may be already partly regenerated with advance growth in gaps, and the regeneration period will represent only the time required to complete the regeneration. In some cases the period—not actually expressed—varies considerably from place to place, according to the nature of the crop, even within the same compartment, a longer period being adopted where shade-bearers prevail than where the bulk of the crop consists of more light-demanding species.

The length of the regeneration period has a decided effect on the form of the young crop. Short periods produce even-aged young crops, while the longer the period the more uneven-aged does the crop become.

**Nature of Periodic Blocks.** There are considerable differences in the manner in which periodic blocks, if recognized at all, are constituted. When the uniform system was developed in France in the middle of last century, the procedure followed was to divide each series (i.e. complete working unit of forest) into as many large self-contained periodic blocks as there were periods in the rotation. These periodic blocks were allotted once for all, each to its respective period. This arrangement, which is still in force in many of the oak and beech forests and some of the coniferous forests of France,
possesses certain advantages. Operations of different kinds—timber fellings, thinnings in pole crops, cleanings in young crops—are each carried out over self-contained areas of some extent; this facilitates supervision of felling and extraction and tends towards economy of working owing to the concentration of such operations in compact areas. In some of the coniferous mountain forests of Austria large self-contained regeneration areas are adopted with the view of justifying the cost of constructing ropeways and other special export works for the extraction of large quantities of timber from one place.

But the formation of fixed self-contained periodic blocks, and their allotment to all the periods of the rotation, has the great disadvantage that in regions subject to storms, insect ravages, and other calamities, this arrangement cannot be maintained for long. From time to time portions of the area are damaged or destroyed, and require to be regenerated; this at once throws out the preconceived arrangement, and if such calamities occur with any frequency the periodic blocks lose their identity and have to be abandoned.

The formation of large self-contained periodic blocks also presents difficulties from the management point of view, in that it usually involves the artificial allotment to definite periods of at least some crops which may be either too young or too old for the period to which they have to be allotted. In the one case they come under regeneration before their time and in the other they have to be retained until they are past maturity; in either case, apart from economic disadvantages, natural regeneration may be rendered difficult. The difficulty as regards the allotment of crops to large periodic blocks according to age can be got over to a great extent by forming scattered periodic blocks, that is, each compartment or even sub-compartment is considered separately and allotted to its appropriate period. This procedure is followed in a good many European forests, and there is a tendency to extend its use in place of the self-contained periodic block arrangement. In introducing the uniform system, it may not always be advisable to allot all crops to definite periods in advance, in which case allotment is made to period I (to be regenerated first), and often to one or more other periods in addition.

The formation of permanent periodic blocks, whether self-contained or scattered, is practicable only where there is little or no risk of serious danger from storms or other calamities; hence this procedure is followed in regions where the climate is not severe, particularly in the case of broadleaved forests, which are less subject
to such dangers than coniferous forests. But wherever such risks are prevalent, the idea of forming permanent periodic blocks, and allotting crops to definite periods in advance, has had to be abandoned. Thus in the coniferous forests of the hilly regions of Central Europe, where severe storms are not infrequent, fixed periodic blocks are not recognized. Instead of this, when a working plan is revised, the areas to be placed under regeneration during the interval between that revision and the next one are decided on according to the state of the crop and marked on the map. Regeneration fellings are carried out in these areas, and by the time the next revision takes place, say 10 years later, certain of the areas may have been completely regenerated, while others are still under regeneration. The latter will be retained as regeneration areas under the revised working plan while new areas will be taken up for regeneration and added to them in place of the areas already regenerated. The same procedure is followed at each revision in turn, so that there are always certain areas under regeneration, though these are periodically changing; this in fact amounts to what may be termed a floating periodic block. This procedure was introduced into some of the coniferous forests of the French Jura and Vosges in 1894, in supersession of the arrangement of fixed periodic blocks. Here it goes by the name of the quartier bleu method, because the areas placed under regeneration for the time being are marked blue on the map, while the rest of the forest remains uncoloured and is termed the quartier blanc. In certain cases the areas to be placed under regeneration next in order are coloured yellow, and are termed the quartier jaune.

Even where there are no serious calamities to be feared, fixed periodic blocks may be impracticable on the ground that natural regeneration may not always be obtainable when and where it is desired, although in certain places it may appear spontaneously in great abundance without deliberate aid from man. In such cases the procedure indicated is to follow regeneration rather than to attempt to force it. Ash and sycamore show this tendency to some extent in England, but it is in the tropics, where the silviculture of the various species has not yet been fully studied, that the principle of the floating periodic block should be specially applicable, and it is, in fact, now being applied to some of the sal forests of India (see p. 57).

Where regeneration takes place rapidly and regularly, periodic blocks are sometimes dispensed with, and an arrangement of annual coupes may be followed similar to that of the clear-cutting system.
Thus in some of the Scots pine forests of Normandy seeding fellings are made in regular annual coupes by area; regeneration generally establishes itself readily, and a few years after the seeding felling the seed-bearers are removed in one or two secondary fellings (see pp. 53 and 54). The yield is fixed entirely by area, but the annual volume outturn is reasonably constant because the secondary fellings follow the seeding fellings with sufficient regularity.

A similar procedure is exemplified in the Aleppo pine (Pinus halepensis) forest of Gemenos on the south coast of France. The rotation is 60 years, and each series contains 60 corresponding annual coupes (compartments). The regeneration fellings are two in number; a seeding felling removing about 50 per cent. of the crop followed by a final felling which removes the remainder 10 years later. Thus two compartments are worked over each year, one by a seeding and one by a final felling. The pine seeds as a rule annually, but since regeneration does not always establish itself readily on the dry calcareous soil of that region, full use is made of heavy thinnings to stimulate regeneration in advance.

The following classification summarizes the methods of adapting the uniform system to periodic blocks or otherwise:

1. Fixed periodic blocks:
   (a) Self-contained.
   (b) Scattered.

2. Floating periodic blocks, usually scattered.

3. Annual coupes by area.

**Numbering of Periods and Periodic Blocks.** When periods and periodic blocks are fixed, the practice in France is to number them I, II, III, &c., and to retain these numbers permanently. Thus in the oak forest of Bellême (Orne), when this system was introduced in 1856, the rotation was fixed at 200 years and divided into 8 periods of 25 years each. This has been adhered to ever since, so that in 1927, for instance, the ages of the crops in the periodic blocks already regenerated were theoretically as follows:

<table>
<thead>
<tr>
<th>Period</th>
<th>Age of regenerated crop in 1927.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I.</td>
<td>1856–1880</td>
</tr>
<tr>
<td>II.</td>
<td>1881–1905</td>
</tr>
<tr>
<td>III.</td>
<td>1906–1930</td>
</tr>
</tbody>
</table>

The year 1927 was the 22nd year of the 3rd period, and in that year the crops in periodic block III should have been in the final stage or already regenerated. In the ordinary course the remaining periodic blocks would be due for regeneration during
PERIODS AND PERIODIC BLOCKS

subsequent 25-year periods, from period IV (1931–55) to period VIII (2031–55).

Sometimes, however, as in parts of Germany, the numbers are altered whenever a new period begins, so that I always represents the periodic block under regeneration, II the next in order, and so on; or in other words, when a new period begins, II becomes I, III becomes II, and so on, while block I, in which regeneration has just been completed, receives the last number of the series.

5. FORM OF CROP PRODUCED

The ideal of the uniform system is to produce young crops as even-aged as possible. We have seen that the crop becomes more and more uneven-aged with the lengthening of the period. A stage is at last reached at which the uniform system gives place to the irregular shelter-wood system; ordinarily the dividing line is reached when the period is between 30 and 40 years, although the form of the young crop rather than the length of the period is the best criterion. With periods up to 30 years unevennesses in the young crop due to differences of age tend to disappear during the pole stage, and by the time the tree stage is reached the crops have all the appearance and characteristics of even-aged crops, with long clean cylindrical boles.

6. UNIFORM SYSTEM WITH ARTIFICIAL REGENERATION

The uniform system with artificial regeneration is sometimes employed for the purpose of introducing new species or increasing the proportion of some particular species already existing in insufficient quantity. Except that the young crop is introduced artificially by sowing or planting, the procedure is similar to that followed in the case of natural regeneration, the canopy being opened gradually or rapidly according to the light requirements and hardiness of the young crop, and the degree of risk of frost, drought, heavy weed-growth, or other injurious factors. Generally, however, a shorter period may be adopted than in the case of natural regeneration, since an artificial crop can be established more rapidly. Artificial regeneration under a shelter-wood is employed most commonly either for the introduction of sensitive shade-bearers or in order to obtain a mixture by combining the artificial regeneration of introduced species with the natural regeneration of existing species. Under certain conditions species which are at least tolerably light-
demanding may be introduced under a shelter-wood, as in the case of oak in the Spessart (see p. 52).

7. ADVANTAGES AND DISADVANTAGES OF THE UNIFORM SYSTEM

The chief advantages and disadvantages of shelter-wood systems in general (see p. 29) apply in the main to the uniform system. The following apply more particularly to the uniform system in comparison with other shelter-wood systems:

**Advantages:**

1. The fellings are simpler in execution than in most shelter-wood systems: the seeding felling in particular involves a straightforward even opening of the canopy over large areas, after the manner of a thinning.

2. Crops of an even-aged type are produced, with tall clean cylindrical boles; in this respect the uniform system, like the other more or less even-aged systems, is superior to the selection system.

**Disadvantages:**

1. Damage to young growth by felling and extraction is greater than in the case of strip or wedge fellings, although by taking the precautions already indicated it may be reduced considerably.

2. The mother trees isolated in seeding or secondary fellings are liable to be thrown by wind, more especially if crown and root development has been insufficiently promoted during the thinning stages. Shallow-rooted species like spruce are particularly susceptible in this respect.

3. In hot situations isolated seed-bearers of thin-barked species like beech are liable to suffer from sun-scorch.

4. In localities subject to frost or drought overhead cover, such as is obtained by the uniform system, is a less efficient safeguard against damage from these causes than side protection such as is secured by the strip system.

5. In localities where damage by storms or snow is prevalent, the even-aged crops produced by the uniform system are more subject to damage than the more uneven-aged crops produced by the group system, the irregular shelter-wood system, or the selection system.

Generally speaking, it may be said that where there are no severe climatic conditions with which to contend, and where conditions of seeding and regeneration are favourable, the uniform system, owing to its simplicity, has a special advantage over most of the other systems. It is not so well adapted for regions where serious damage by storms or snow is to be feared, or where seeding or soil conditions are unfavourable.
8. TREATMENT OF INDIVIDUAL SPECIES AND MIXTURES

In applying the uniform system to individual species, considerable variations in the treatment are necessary in order to provide for differences in light requirements, hardiness, and other characteristics of the species in question. In the case of mixtures the problem of regeneration becomes more complicated. It is the exception rather than the rule to find two species regenerating with equal freedom and vigour; in the majority of cases special measures have to be taken to hold the balance between the two, and if necessary to assist the one against the other. Where one species is more light-demanding than the other, the course most commonly adopted is first to open the canopy slightly and obtain partial regeneration of the more shade-bearing species, then to open it more heavily by the removal of seed-bearers of that species in order to allow the more light-demanding species to regenerate and fill the gaps. If there is a third and still more light-demanding species in the mixture, a further opening of the canopy is made subsequently, seed-bearers of the light-demander being retained somewhat in the form of standards, in order to regenerate any blank spaces remaining.

Although the procedure just described is the normal one, it has to be modified to suit special cases. Thus where one species tends to become dominant at the expense of the others, it is generally necessary to establish the latter first in groups round seed-bearers of the species concerned, or even to introduce them artificially to the extent desired; the dominant species is regenerated afterwards, generally by a uniform opening of the remainder of the canopy.

The following examples will serve to demonstrate the application of the uniform system to individual species and mixtures:

Beech. A shade-bearing with a heavy seed which does not spread naturally to any distance from the parent tree. Full mast-years occur on an average every 5 or 6 years in mild climates such as that of western France, and every 8 to 12 years in most parts of Germany, apart from occasional partial mast-years. At its higher elevations the beech does not seed abundantly more than once in about 15 years. Beech seeds more irregularly than most European species. Partial seeding can be utilized to a greater extent than in the case of more light-demanding species, since the seedlings can persist for some time under shade, and the patches of partial regeneration can be used as a nucleus for more complete regeneration later. The seedlings are sensitive to frost and drought, and do not tolerate acidity or swampiness in the soil. A thick layer of undecomposed
leaves is unfavourable, in preventing the radicle from reaching the mineral soil. Conditions for regeneration are favourable when a light growth of herbaceous or shrubby vegetation is beginning to appear; one of the best indicators of favourable light and soil conditions is the wood sorrel (*Oxalis acetosella*). A thick matted growth of grass, such as may follow too heavy an opening of the canopy, prevents regeneration. *Aira flexuosa*, which is sometimes common in beech forests, is one of the worst grasses in this respect. Such a matted soil-covering may be broken up by ploughing or by the admission of swine.

As a rule the regeneration period varies from 20 to 30 years. Often seeding fellings are made irrespective of the occurrence of seed-years. Where seed-years are awaited, when the flowers of the beech in spring give promise of a good mast a cutting plan is usually prepared in summer so that as large an area as possible may be marked in time for felling to be carried out the following winter.

Generally more than one seeding felling is necessary in order to effect complete regeneration. The seeding felling is a light one, the canopy being opened only to such an extent that the crowns of the trees touch when swayed by the wind. In the beech forests of France 25 to 30 per cent. of the crop is removed, leaving about 70 trees per acre under average conditions (see Fig. 13). Any under-story or undergrowth of shrubs and suppressed trees should be removed. Fig. 14 shows the seeding stage well advanced.

The secondary fellings begin when the young crop is knee high (6 to 8 years old) and should be cautious and gradual. Under the most favourable conditions there are generally at least three, including the final felling. Trees with large spreading crowns should be removed early, as they drain the ground, depriving seedlings of nourishment and thus preventing regeneration.

The final felling should not be delayed longer than is necessary; isolated beech trees tend to become sun-scorched, while the damage done during felling and extraction is intensified where the young crop is allowed to grow too tall. Fig. 16 shows a beech crop in the secondary stage, and Fig. 15 shows a crop 60–70 years old produced by this system.

Hornbeam is a frequent companion of the beech in the forests of France. It seeds freely every two or three years, and regenerates in great profusion; in order to favour the beech, it is necessary to keep the canopy dark enough during the seeding stage to kill off the hornbeam seedlings, which stand less shade than those of the beech.
INDIVIDUAL SPECIES AND MIXTURES

Oak. A light-demanding species which does not spread naturally to any distance from the parent tree. As a rule regeneration springs up more readily on sandy loams than on compact clay soils. The periodicity of good mast-years varies greatly according to the mildness or severity of the climate. In the mild climate of the Adour valley in south-western France, annual seeding of the pedunculate oak is the rule. In Normandy and in western and central France generally, good seed-years of sessile oak may be expected every 4 to 8 years. In the more severe climate of north-eastern France they are far more infrequent. On the plateau between the Moselle and the Meurthe the oak seeds well on an average only at intervals of about 20 years. Writing in 1919, Huffel stated that in Lorraine there had not been a copious mast-year since 1865 and 1868. Under such conditions the uniform system is out of the question. In the Spessart, Bavaria, full mast-years of sessile oak occur on an average every 10 to 12 years. Oak seedlings, though less sensitive than those of the beech, suffer in frosty localities.

Under the favourable conditions prevailing in western France, complete regeneration is not infrequently secured in 6 to 10 years, this being actually the interval of time between the seeding and the final felling. Nevertheless the regeneration period for whole periodic blocks is sometimes much longer, because it takes some years for seeding fellings to be completed over a whole periodic block. In the forest of Bellême it is 25 years, in the forest of Bercé as much as 36 years.

As a rule about one-third of the crop is removed in the seeding felling, about 30 to 50 seed-bearers per acre being left, according to age and size, and there is thus a space of several feet from crown to crown. All undergrowth and low cover should be removed. In France seeding fellings are generally made irrespective of mast-years; when a good mast-year occurs the ground is often thickly carpeted with seedlings, in which case the secondary fellings follow rapidly. Generally speaking there are two secondary fellings, including the final felling, but under favourable conditions a single final felling is carried out a few years after the seeding felling. Figs. 17, 18, and 19 show oak crops in the seeding and final stages. Where frost is feared the canopy is opened more cautiously, both in the seeding and in the secondary fellings. The young crops are kept in a dense condition (see Fig. 20), cleanings being carried out at an age of about 20 to 25 years, and thinnings being begun when the crop is 30 years old or more.

Oak and Beech. This mixture is a common one wherever these
two species occur on the continent of Europe; in fact it may be considered exceptional to find an oak forest without a mixture of beech, which is maintained partly for soil-protection purposes. In localities specially favourable to oak, as in western France, this species usually holds its own against the beech, and a successful mixture can generally be obtained by carrying out regeneration fellings in the ordinary way, as described for oak. Where, as frequently happens, the beech regenerates with greater freedom and tends to outgrow and suppress the oak in youth, care should be taken during the thinning stages to develop a large percentage of good oak seed-bearers. It is also advisable to await an oak mast-year before carrying out the seeding felling, which should be made open enough to effect oak regeneration. The removal of the overwood in secondary fellings should proceed as rapidly as circumstances will permit, and if necessary the young beech should be cut back or topped where it tends to suppress the oak. Where oak mast-years are very infrequent the uniform system with natural regeneration is out of the question.

In the Spessart special measures are taken to increase the proportion of oak by introducing it artificially under a shelter-wood of beech. Both species occur naturally in this region, the oak being of the sessile variety. The proportion of oak obtained by natural regeneration, however, is insufficient, and steps are therefore taken to increase the quantity of this species at the expense of the beech, which regenerates freely, grows more rapidly in youth, and would oust the oak if permitted to do so. The procedure adopted is to open out the crop heavily, about two-thirds of the growing stock being removed, and to introduce oak by sowing acorns under the light cover of the open beech wood, which is retained to protect the young seedlings against frost and drought, to retard weed-growth, and to promote a mixture of beech by natural regeneration. The beech overwood is removed in secondary fellings at intervals of 2 or 3 years, the final felling being carried out within 8 years of the seeding felling and the sowing of the oak. From the time the oak sowings are carried out the young beech has to be uprooted or cut back where necessary to prevent its becoming dominant. The regeneration of a whole compartment is completed in this way in a period of 20 to 30 years, involving as a rule two or three beech seed-years. This method of regeneration is illustrated in Fig. 21.

The effect of a long regeneration period in favouring beech against oak has been demonstrated in the mixed oak and beech forests of the Wienerwald, Austria. Here the uniform system was
introduced early last century with a period of 30 years, the result being that the mixed crops were superseded by almost pure beech; the period was therefore subsequently shortened to 15 years, or in places less, in order to encourage the oak.  

Scots Pine. A strong light-demander with a winged seed which is carried by wind to some distance from the parent tree. As a rule a certain amount of seed is produced almost every year, and good seed-years occur at intervals of 3 or 4 years. In the case of the Scots pine, as of many other pines, crown development is an important factor in the production of an abundant supply of cones.

The seedlings, which are hardy as regards frost and drought, will not tolerate shade. Regeneration generally springs up in abundance on sandy and gravelly tracts, and in dry places a moderate soil-covering of heather or low open bracken or broom is a help rather than otherwise, in preventing excessive drying of the soil. Regeneration is greatly stimulated by the raking off of the needle layer and the exposure of the mineral soil.

The Scots pine is well adapted for the uniform system if care is taken to encourage the development of the crown and the root system by means of regular thinnings at intervals of not more than 5 years; failing this the trees, when isolated by the seeding felling, are apt to be thrown by wind. In applying the uniform system the procedure is simple. The seeding felling consists of a wide spacing of seed-bearers, and a final felling should follow when the young crop is not more than 1 foot high, that is, within a few years of the seeding felling.

Examples of such open seeding fellings and short regeneration periods may be seen in some of the Scots pine forests on the dry sands and gravels of the Seine valley. These forests are of artificial creation, the pine having been introduced to replace the pre-existing poor crops of oak and other hardwoods. The seeding felling consists of the removal of 75 to 80 per cent. of the crop and the retention of 30 to 35 seed-bearers per acre, and the final felling as a rule follows in 3 to 5 years, by which time regeneration should be well established (see Figs. 22 and 23). Where regeneration is incomplete a few seed-bearers may be retained for two or three years more, but it has been found that if regeneration does not appear rapidly it will probably not come in at all, and hence where it fails it is usual to sow up the blanks without delay. The spacing adopted in the seeding fellings was arrived at after actual trials, in the course of which it was found that a closer spacing hindered regeneration. In the forests in question the isolated seed-bearers are frequently
thrown by wind, owing largely to the fact that insufficient attention has been given in the past to the production of wind-firm trees by suitable thinnings. Similar open seeding fellings are practised in the Auvergne.

In the State Forest of Isenburg in Hesse-Darmstadt good results have been obtained with a short regeneration period. Here there are ordinarily three regeneration fellings. About one-third of the crop is removed in the seeding felling, which generally begins where there is already a crop of seedlings on the ground. The secondary and final fellings follow at short intervals, and good results have thus been obtained with a regeneration period varying from 6 to 9 years. The raking of litter by right-holders stimulates regeneration.

**Spruce.** A moderate shade-bearer with a light winged seed which is conveyed by wind to some distance from the parent tree. Seed-years, although fairly frequent, are somewhat irregular; they occur on an average at intervals of 3 to 10 years. The seedlings are fairly frost-hardy but are sensitive to drought owing to their shallow root-systems; in moist soil they sometimes spring up in great abundance. They do not tolerate heavy shade, nor do they recover satisfactorily after suppression. In Central European countries raw humus is one of the greatest obstacles to regeneration; the raking off of the undecomposed needle layer produces conditions favourable to germination and the establishment of the seedlings.

The uniform system is unsuitable for spruce except in localities which are not subject to gales, since this shallow-rooted species, when opened out in regeneration fellings, is too liable to be thrown by wind. For this reason, if the uniform system is to be applied with success it is essential that the conditions for regeneration should be entirely favourable, so that the young crop may be established rapidly. Hence the seeding felling should preferably be carried out in a good seed-year: experience has shown that it should be made cautiously, in order to avoid isolating the trees and exposing them to wind damage. At the same time sufficient light should be afforded to promote regeneration; this can be effected by the removal of one-quarter to one-third of the growing stock. The final felling should be carried out within 4 or 5 years, with or without an intervening secondary felling, and blanks should be regenerated artificially.

In Central Europe the uniform system for spruce has been largely given up in favour of combinations of systems (strip, group, &c.) in which uniform fellings sometimes play a part. Here the
spruce is very commonly treated in mixture with silver fir with or without beech, Scots pine, and larch.

Silver Fir. A strong shade-bearer with a somewhat heavy winged seed, which is conveyed by wind to some little distance from the parent tree, but not so far as that of the spruce. Good seed-years occur on an average every 2 to 10 years according to locality; under favourable conditions seeding is frequent and regular. The best regeneration is obtained as a rule from trees 90 to 120 years of age. The seedlings are sensitive to frost and drought and are readily browsed by deer; they stand a considerable amount of shade, and have good power of recovery after suppression.

The silver fir can be treated successfully under the uniform system. There are often quantities of seedlings on the ground before any seeding felling is carried out, and the secondary fellings may begin forthwith. Where a seeding felling is carried out it should consist mainly of the removal of any under-story and the heightening of the canopy, but with only a slight opening of it. The secondary fellings should be carried out with caution, and there should be several of them extending over a period of several years; the young crop requires protection till it is well established, and the cover should be removed gradually.

Spruce and Silver Fir with Other Species in Mixture. In mixed crops of spruce and silver fir, in many of which beech and Scots pine also occur, the procedure generally followed is to carry out a very cautious seeding felling and allow the silver fir to establish itself; if beech is present it tends to appear in groups round beech seed-bearers. A few years later the canopy is opened sufficiently to enable the spruce to regenerate, spruce and Scots pine seed-bearers being retained and silver fir and beech being removed where possible. As soon as the spruce has regenerated itself sufficiently, the canopy is still further opened in one or more secondary fellings, scattered Scots pine seed-bearers being retained during the final stage to seed up any gaps. The mixture can be regulated by the rate at which the canopy is opened. A gradual opening encourages the silver fir and beech, while a more rapid opening encourages the spruce and Scots pine.

In some of the forests of the French Jura, spruce and silver fir in mixture are treated successfully under the uniform system. Regeneration of silver fir often appears in abundance before the canopy is opened out at all, and persists for some time under the heavy shade. A seeding felling is then made in the interests of spruce, followed by either two or three secondary fellings, including the
final felling. Regeneration is thus completed within 20 years, although the period laid down for the regeneration of whole periodic blocks may be as much as 30 years or more. While it is desirable to complete the regeneration fellings as rapidly as possible, owing to danger from wind, care is necessary to avoid too sudden an opening of the canopy, which may result in the death of the pre-existing silver fir seedlings. Fig. 24 shows successful regeneration obtained in this manner. In the regeneration of silver fir, groups of advance growth are retained, and hence the young crop often has an irregular appearance for a time. Where deer are prevalent the silver fir regeneration may fail to make any headway until the spruce has established itself and formed a protective cover for the fir.

Chir Pine (*Pinus longifolia*). In the NW. Himalaya the uniform system was first applied to the chir pine in 1895, since when it has been extended to various localities with considerable success. This gregarious tree, which is strongly light-demanding, forms extensive forests on hot dry slopes, chiefly between 2,000 and 7,000 feet elevation. The average periodicity of good seed-years varies from 2 to 3½ years according to locality. The winged seed is carried by wind to some distance from the parent tree, and with a suitable distribution of seed-bearers with good crowns natural regeneration usually springs up in abundance on well-drained porous soils with a good proportion of sand and fine mica, where the root-system of the seedling develops well; on stiff clay soils and on shallow soils overlying limestone, where the root-system cannot develop sufficiently, regeneration may fail on hot aspects owing to excessive insolation. Regeneration is stimulated by the burning of the thick covering of coarse undecomposed needles which is often present, but as soon as the seeding felling is made strict protection from fire is essential to success. It has been found in general that a seeding felling by which about 5 to 8 good seed-bearers per acre are retained will effect complete regeneration, but on hot aspects it may be advisable to leave considerably more. So far as the light requirements and the hardiness of the seedlings are concerned, the seed-bearers should be removed as soon as sufficient regeneration has appeared, but since the fire menace is always present, the precaution is sometimes taken to retain a few seed-bearers as an insurance

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Fig. 25. *Pinus longifolia* under the uniform system; final stage. Remaining seed-bearers being tapped for resin. NW. Himalaya.
Fig. 26. Deodar, blue pine, and spruce under the uniform system. Natural regeneration resulting from a spacing of 20 seed-bearers per acre. NW. Himalaya.
against fire until the young crop is reasonably safe from destruction. For this purpose regeneration periods up to 35 years are in force. Fig. 25 shows a crop in the final stage with these ‘insurance’ trees standing.

The striking similarity in habit and environment between the Himalayan chir pine and the western yellow pine (Pinus ponderosa) of North America would seem to indicate that similar treatment would be successful in the case of the latter species. Other Himalayan Conifers. Of other Himalayan conifers the deodar (Cedrus Deodara) and the blue pine (Pinus excelsa) are worked successfully under the uniform system. The blue pine is a strong light-demander from youth upwards; the deodar stands rather more shade and the seedlings require protection from drought on hot dry slopes. Both species are frequently found in mixture, the spruce (Picea Morinda) sometimes occurring with them. The blue pine seeds freely, on an average more than once every two years, and the winged seeds are distributed to long distances from the parent tree. The deodar seeds well on an average once in three years, the winged seeds being disseminated to a moderate distance.

The deodar being more shade-bearing than the blue pine, it is possible to obtain a satisfactory mixture in regeneration fellings by first opening the canopy to about 20 to 30 seed-bearers per acre; when sufficient regeneration has been obtained, a further opening of the canopy to 5 to 10 blue pine seed-bearers per acre should complete the regeneration of the latter species. Fig. 26 shows regeneration in progress in this type of forest. In pure blue pine forest a spacing of 8 to 12 seed-bearers per acre has been found to give abundant regeneration, the number being increased to 20 on hot dry slopes. The spacing adopted in seeding fellings should vary with aspect and other factors, but actually where soil conditions are favourable regeneration often springs up in great profusion under various degrees of spacing. In the case of the blue pine, profuse regeneration generally takes place on the introduction of fire-protection in previously burnt tracts. In the case of the deodar, regeneration is stimulated by the raking of litter, the burning of refuse, or the hoeing of the soil round seed-bearers. Sal (Shorea robusta). The uniform system in one form or another is being extended in the sal forests of India, particularly in the United Provinces. This gregarious tree, a moderate light-demander,

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1 For details the reader is referred to Practical Forest Management by Trevor and Smythies, pp. 125–8, and to The Silviculture of Indian Trees, vol. iii, pp. 1026–9 and 1030–2 (Pinus excelsa) and pp. 1109–14 and 1119–23 (Cedrus Deodara).
tends to regenerate in even-aged masses. Natural regeneration springs up in great profusion in certain places, though the seedlings may die back repeatedly for many years before establishing themselves; in other places regeneration may fail entirely owing to a combination of factors. The plan adopted, therefore, is to take advantage of regeneration already present and to free it, rather than to rely on obtaining it in places where it has not yet established itself. The system as applied varies in detail, but generally speaking areas are allotted for regeneration not only according to the age of the old crop but also according to the quantity of regeneration already present and in need of freeing from overhead cover.

In periodic block I the usual procedure is to leave a shelter-wood for a time as a protection against frost, and to clear-cut everything else. After the extraction of all saleable material the refuse is burnt and regeneration is secured from coppice shoots springing largely from suppressed advance growth which has been cut back. The young crop is cleaned as required, and the coppice shoots are thinned from time to time until only one is left per stool, so that by the time the pole stage is reached the crop is in the condition of even-aged high forest; trees obtained in this way are found to be as good as those obtained from seed. In periodic block II the operations consist of thinnings or preparatory fellings, burning the leaf layer, and hoeing the soil with the object of obtaining seedling regeneration in the state of suppressed advance growth. In view of the uncertainty of obtaining regeneration exactly where it is required, any hard and fast allotment of crops to periods is usually impracticable. The proper course is to follow regeneration and to employ a floating periodic block.

The procedure followed in the case of the sal is also indicated, with suitable modifications, for other dipterocarps of the dry forest type, such as the Burmese *Dipterocarpus tuberculatus*, *Pentacme suavis*, and *Shorea obtusa*.

Tropical Rain Forest. In some of the evergreen rain forests of the Malay Peninsula regeneration under the uniform system is practised with success. This type of forest is characterized by the large number of component species, of which only a portion may be marketable, and by the great luxuriance of the vegetation. The most characteristic trees are the dipterocarps, of which there are over 100 species. Some of the more valuable species regenerate freely, and the seedlings are capable, in varying degree, of persisting for a time under shade, though they die off unless the canopy is opened. Caution is generally necessary in opening the canopy,
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owing to the danger of promoting a heavy growth of grass, weeds, and climbers.

There is usually no difficulty in regenerating the more valuable species if there is a sale for the inferior kinds, otherwise the work is somewhat costly. The procedure generally followed is to open the canopy by removing the inferior species; this benefits seedlings already present and induces further regeneration of valuable species from the seed-bearers retained. Wherever regeneration is established the overhead cover is removed rapidly, and cleanings are carried out where there is a danger of suppression from weeds, climbers, and inferior species.

In order to secure regeneration of the desired species in sufficient quantity, a procedure which has had successful results, particularly in the case of camphor (Balanocarpus Heimii), is to carry out repeated improvement fellings in which inferior species are removed. This induces a dense regeneration of this species, as many as 3,000 young plants having been counted on an acre. The improvement fellings are then followed by regeneration fellings for the removal of the overwood and the establishment of the young crop.

Experiments have resulted in successful regeneration on somewhat similar lines in the evergreen forests of Western India and the monsoon forests of Burma. The cost of weeding the young crop, however, may prove an obstacle to the adoption of this form of regeneration in many localities.

9. APPLICATION OF THE UNIFORM SYSTEM

Systems of regeneration resembling the uniform system as now practised appear to have been known over 400 years ago. In Germany there are records dating from the end of the fifteenth century in which reference is made to regeneration over large coupes, producing even-aged crops. In the Forest Ordinances of the fifteenth and sixteenth centuries, rules are laid down regarding the number of seed-bearers to be retained with the object of securing natural regeneration. Many writers during the eighteenth century make reference to natural regeneration obtained by leaving seed-bearers, and the Hesse-Kassel Ordinance of 1761 prescribes, among other things, fellings similar to those of the uniform system. In Hungary an Ordinance of 1565 prescribes, among other matters, the order of fellings and the reservation of seed-bearers.

In France the idea of coupes by area, leaving a specified number of trees for seeding purposes, took shape at least as early as the
fourteenth century, and led subsequently to the adoption of the *tire et aire* system (see p. 125). The latter system had points of resemblance to the uniform system, which began to be introduced in place of it before the middle of last century. The old *tire et aire* system, in fact, may be regarded as the forerunner of the uniform system. Between the fourteenth and the nineteenth centuries mention is made from time to time, in various ordinances, of the reservation of trees to act as seed-bearers under different conditions. As early as 1520, Tristan de Rostaing, one of the grand masters and head of the Forest Service, recommended a form of successive regeneration fellings to replace the *tire et aire* system. It is clear, therefore, that in France something closely resembling the uniform system of to-day was thought of, if not actually practised, at least four hundred years ago. In the Sihlwald in Switzerland it is believed that regeneration fellings somewhat on the lines of the uniform system have been in operation for five hundred years.

The uniform system in its modern application, however, will always be associated with the name of G. L. Hartig (1764–1837), who as Director-General of the Prussian State Forest Service (1811–37) had a great influence on the silviculture of his time, and strove to introduce regular order everywhere. The first edition of his *Anweisung zur Holzzucht* appeared in 1791, and marked the beginning of a new epoch. Hartig, acting on experience gained in oak and beech forests under favourable conditions of soil and climate in Darmstadt and the Wetterau, advocated even-aged regeneration over areas as little scattered as possible, in order to facilitate the supervision of fellings. He recognized three regeneration fellings: (1) *Dunkel- or Besamungschnitt* (seeding felling), with the seed-bearers almost touching each other; (2) *Lichtschlag* (secondary felling), the canopy being opened to 15–20 paces between crowns, when regeneration is more or less complete, and 10–16 inches high; (3) *Abrisschnitt* (final felling), the removal of the remaining seed-bearers when the young crop is 2–4 feet high. Cotta, in the first edition of his *Anleitung zum Waldbau*, recommended a procedure similar in the main to that of Hartig.

Hartig's influence made itself felt in Germany and in other parts of Central Europe, and his system was applied not only to broad-leaved but also to coniferous forests. It is still in force in many broad-leaved forests, but in the mixed spruce and silver fir forests it has been replaced to a large extent by other systems or combinations of systems, on the ground that the uniform system is impracticable in regions subject to storms.
In 1827 Lorentz\(^1\) recommended the introduction of Hartig's *Dunkelschlagbetrieb* (uniform system) into France; it began to be introduced a few years later, but was not applied on any large scale in practice until the middle of the century, when it was introduced in the oak and beech forests in supersession of the old *tire et aire* system, as well as in certain spruce and silver fir forests of the Jura in supersession of the selection system. The famous oak forest of Bercé (Sarthe) was among the first of the French forests to be treated under this system, which was introduced there in 1846. Parade\(^2\), who had been a pupil of Cotta at Tharanöt, was another strong supporter of the uniform system, which he termed *la méthode du réensemencement naturel et des éclaircies*, a somewhat unfortunate term, since neither natural seed regeneration nor thinnings are peculiar to the uniform system. At the time of its introduction into France from Germany it was referred to as *la méthode allemande*, and undoubtedly its introduction in modern times was due to Hartig's influence, although, as we have seen, something very similar to the uniform system has been known in France for centuries.

In the mild climate of the western half of France the uniform system gives strikingly good results, even with fixed self-contained periodic blocks; the rigidity of this arrangement, however, is recognized by many to be a drawback, particularly in the matter of allotment of age-classes to periods, for which reason there are now indications in some localities of a change to scattered periodic blocks. In the severer climate of north-eastern France the uniform system has proved far less successful for oak owing to the infrequency of seed-years, coupled, in some cases, with adverse soil conditions. It is practised in some of the silver fir or mixed spruce and silver fir forests of the Vosges and Jura, where it has been introduced in place of the selection system owing to the better quality of timber produced and to the advantages of concentrated working; here fixed periodic blocks are still the rule in some forests, although in others they have been abandoned in favour of floating periodic blocks, in order to secure that elasticity which is necessary in regions where damage by storms is prevalent. Far from abandoning the uniform system in these forests, however, the present tendency is to convert from the selection to the uniform system.

In Germany the uniform system is applied frequently to broad-leaved species and particularly to beech, in some cases to Scots pine,

\(^1\) Bernard Lorentz, 1775–1865, Director of the Forest School, Nancy, 1824–30.

\(^2\) A. L. F. Parade-Soubeiroli, 1802–64, Director of the Forest School, Nancy, 1838–64.
and more rarely to spruce and silver fir. In some cases fixed but scattered periodic blocks are adopted, but more frequently the areas for regeneration are selected for a limited period ahead. Germany can show many fine examples of beech crops raised under this system, some, as in the Spessart, dating back to the earlier years of its introduction in Hartig’s time.

In India the uniform system was first applied to the Himalayan forests of Pinus longifolia in 1895, and wherever conditions are favourable it has proved a complete success (see p. 56). India has little to fear from wind damage, and since this factor does not require to be taken into consideration, the uniform system has much to commend it owing to its simplicity. It is now being applied successfully, with suitable modifications, to other Himalayan conifers, as well as to the sal and other dipterocarps (see pp. 57–9).

The success with which regeneration under the uniform system has been obtained in the tropical rain forests of the Malay Peninsula (p. 58) indicates that with modifications to suit local conditions this system may yet become one of the standard systems of working and regenerating certain types of tropical forest. In many parts of the tropics the chief drawbacks to its adoption are the lack of markets for inferior species and the necessity for intensive and costly weeding in the interests of the young crop: under such conditions clear-cutting followed by artificial regeneration with the aid of shifting cultivation has generally proved more successful and less costly.

In Great Britain the chief drawbacks to the general adoption of the uniform system are the prevalence of rabbits, which prevent regeneration, and the excessive weed-growth so often present owing to the open condition of the woods. In the sandy and gravelly tracts of Surrey, Speyside, and elsewhere natural regeneration of Scots pine by uniform fellings has been obtained with complete success, while ash and sycamore often establish themselves in abundance where sufficient light is admitted, owing to the capacity of the young plants for penetrating a heavy growth of weeds. In these cases, however, the work of regeneration requires to become more systematized. The uniform system is being introduced in the Parmoor beech woods in the Chilterns, under a scheme prepared by the Oxford School of Forestry, and the experiment should give interesting results. In the Forest of Dean oak has been regenerated with success in enclosed areas. The best example of completed regeneration is to be seen in Blakeney Hill Wood North, where following an abundant oak mast-year in 1899 an area of about 500 acres was enclosed. Oak regeneration appeared in quantity, and
the seed-bearers were gradually removed, while gaps were planted up with beech. The result is an excellent uniform crop of oak and beech, 376 acres in extent, equal to anything to be seen on the continent of Europe.

10. INTRODUCTION OF THE UNIFORM SYSTEM IN UNEVEN-AGED FOREST

The introduction of the uniform system in uneven-aged or irregular high forest has been in operation since the middle of last century in certain coniferous forests of the French Jura which were formerly worked under the selection system. Conversion from irregular to even-aged high forest has also received much attention in India, where there has been great progress in silvicultural developments during the present century. The advantages of concentrated working and regeneration, as compared with fellings scattered far and wide over tracts of irregular forest, are so great that the future is likely to see a great development of concentrated systems of regeneration, based on the principles of the uniform system, in tropical, subtropical, and temperate regions.

In converting from irregular to uniform high forest, the fellings recognized are generally of two kinds, (1) regeneration fellings in areas allotted for regeneration for the time being, and (2) selection and improvement fellings, including thinnings, over the remainder of the area. Regeneration fellings can seldom be carried out with the precision characteristic of the uniform system itself. In many cases they consist of freeing regeneration which is already present (see under ‘sal’, p. 58), while supplementary artificial regeneration may also be necessary. The resulting young crops are often somewhat irregular, but the irregularity tends to disappear in time.

The selection and improvement fellings are intended to utilize mature timber and at the same time to remove defective or otherwise undesirable stems interfering with more promising members of the crop. These fellings pass regularly over those portions of the area which are not under regeneration, under a definite felling cycle as in the selection system (p. 110). Sometimes, however, crops containing much young growth are definitely allotted to the later periods of the rotation, and here the fellings consist of freeing the young growth from overhead cover, after the manner of secondary fellings.