IX

THE SELECTION SYSTEM

I. TERMINOLOGY

The selection system differs from all the systems previously described in that felling and regeneration are not confined to certain parts of the area but are distributed all over it, the fellings consisting of the removal of single trees or small groups of trees scattered throughout the forest. Fellings carried out in this manner are termed ‘selection fellings’: they result in an uneven-aged type of forest in which all age-classes are mixed together over every part of the area. This completely uneven-aged type of forest is usually termed ‘selection forest’, or ‘forest of the selection type’, whether it has actually been produced by selection fellings or not.

The French equivalent for the selection system is jardinage. The term fourtage, at one time applied to rough-and-ready selection fellings of any kind, is now generally applied to selection fellings in coppice (see p. 143).

The German terms in use are as follows:

Plenterbetrieb, Femelbetrieb, Schleichwirtschaft (selection system).
Plenterhieb, Femelschlag (or -hieb), Blenderschlag (selection felling);
Plenterwald, Femelwald (selection forest). Waldgärtnerei, sometimes applied to selection fellings in small private properties.

There is some difference of opinion among German writers as to the exact significance of the terms Plenter- (Blender-) and Femel-. From about 1760, according to Bühler, the selection type of forest has been termed Plenterwald, or in South Germany Femelwald, and the single stems cut out are said to be geplentert or gefemelt. He also states that the word plentern began to be used all over Germany about 1787, and that it means the cutting out of single trees and also single suppressed and dead stems, whereas femeln applies only to the removal of exploitable trees. Philipp also maintains that in the Femelbetrieb the chief consideration is the question of dimension or utilization, that is, the cutting of trees of a fixed minimum size, and that Heyer first used the term to denote irregular fellings of any kind. Jeitter refers to Bländerschläge as fellings in which explot-
able trees in particular are cut out. At the present day Plenter-
(Blender) and Femel- are usually taken to be synonymous, and
denote selection fellings in general; Mayr, Wagner, and others
adopt this view, which seems to be the rational one under modern
usage.

2. GENERAL DESCRIPTION

Felling and Regeneration. Under the selection system scattered
single trees or small groups of trees are selected over the whole
area and removed; where conditions are favourable, natural regenera-
tion springs up in the gaps so created. Under ideal conditions this
process goes on year after year over the whole forest, the volume
removed being fixed by rules of management; this results in the

![Forest worked under the selection system.](image)

constant maintenance throughout the whole area of an uneven-aged
type of forest ('selection forest') in which trees of all ages are mixed
together. Theoretically a forest worked under the selection system
should contain all age-classes distributed over the area in correct
proportion of stems. Such regularity is seldom actually found, the
age-classes occurring more usually in small groups, resulting from
groups of regeneration springing up in gaps. The appearance of
forest worked under the selection system is shown in Figs. 60 to 63.

The selection and felling each year of scattered trees over the
whole forest would be impracticable except in areas of small size,
and hence in Europe this procedure is usually confined to small
forests belonging to private persons or communities. In forests of
larger size it is customary to divide the area into a number of more
or less equal blocks, in one of which selection fellings are carried
out each year, so that the whole forest is worked over during a
period of years equal to the number of blocks into which the area
is divided. This period is known as the 'felling cycle'. Under this
arrangement fellings are more concentrated, there being an accu-
cumulation of mature trees during the interval between two succes-
sive visits to the same block, so that a larger volume per acre is
available for felling over the annual coupe than in the case of annual fellings extending over the whole forest.

The term 'ideal selection system' is sometimes employed in reference to fellings carried out over the whole area each year, while the term 'periodic selection system' refers to fellings carried out under a felling cycle.

In their most primitive form selection fellings consist of removing all trees which have attained a certain diameter or girth, sometimes with the proviso that any trees required as seed-bearers should be retained. Such fellings are mere 'exploitation fellings', requiring little or no silvicultural skill; they do not ensure regeneration, nor do they provide for a regular sustained yield. Hence if selection fellings are to be raised to the status of a silvicultural system, something more is required than the mere mechanical removal of exploitable trees. It is necessary also to provide for sustained yields by carrying out thinnings among the various age-classes in order to ensure that these are maintained in their correct proportions, that a suitable mixture is maintained if necessary, that young saplings are freed from suppression, and that defective stems of any size are removed wherever they are hampering better ones. Hence wherever the selection system is worked as a true system, thinnings among the immature stems are carried out along with the felling of trees of exploitable size, the whole forming one operation; cleanings are also carried out amongst the younger age-classes, and measures to assist regeneration may extend to the removal of raw humus, the working of the soil, and even sowing and planting in gaps caused by felling or otherwise.

Fellings under the selection system generally involve the removal of the following classes of trees:

1. Dead and dying trees.
2. Trees which are diseased, misshapen, or otherwise defective or lacking in vigour, or of undesirable species, particularly if interfering with better stems or promising groups of young growth.
3. Trees of exploitable size, particularly if defective or lacking in vigour.

In modern practice the tendency is to abandon the idea of an exploitable diameter, and to leave specially vigorous well-shaped trees of any size to put on increment.

In order to secure a correct distribution of size-classes, a plan sometimes adopted is to construct a graph representing, as nearly as can be estimated, their normal distribution, and to carry out the fellings in such a way as to lead gradually towards the normal;
a comparison of the actual distribution of size-classes with the normal curve serves as a guide, the fellings being confined as far as possible to those size-classes which are in excess.

**Group Selection Fellings.** The typical form of selection fellings, in which single trees are removed, is suitable for shade-bearing rather than for light-demanding species, since the gaps created by the removal of single trees are too small for the healthy regeneration of light-demanders, or for the smaller trees to escape suppression from the larger ones standing over them. Hence if the selection system is to be applied to light-demanders, it is necessary to fell trees in groups in order to create gaps of sufficient size to enable regeneration to establish itself. Such fellings are known as group selection fellings, and the modification of the selection system under which this type of felling is employed is termed the 'group selection system' (Ger. horstweiser Femelbetrieb). It is employed to some extent for spruce, and is practised in the larch forests of the Alps and in the Corsican pine forests of Corsica. Group selection fellings have been employed in the coniferous forests of the NW. Himalaya, and in the sal and other types of broad-leaved forest in India, sometimes as a transition towards some more even-aged system.

**The Felling Cycle.** (Fr. Rotation, Ger. Hiebsumlaut.) This cycle should be fixed according to the requirements of each case. If it is very short, involving large coupses, the cultural advantages of the selection system—including cleanings and thinnings—have full play, but work is scattered and therefore costly. If it is very long, involving small coupses, fellings over definite coupses become intensive, larger quantities of timber being removed over a restricted area; this is an advantage from the economic point of view, and it may also favour the regeneration of light-demanders through the creation of large gaps, but the cultural advantages are to a great extent lost, while the accumulation of large trees upsets the correct distribution of size-classes and destroys the character of true selection forest.

In Europe the felling cycle is generally not more than 10 years, and is often less; in France it is usually between 5 and 8 years, seldom if ever more than 8 years, while in the beech forests of the Chilterns in England it varies as a rule between 6 and 12 years. In India and Burma the felling cycle generally varies from 10 to 30 years in the case of selection fellings of a primitive kind.

In Europe a definite felling cycle is sometimes dispensed with in coniferous forests in regions where frequent windfalls necessitate the quick removal of fallen timber in various parts of the forest;
Fig. 61. Spruce and silver fir forest under the selection system. Forest of La Joux, French Jura.
Fig. 62. Forest of spruce and silver fir under the selection system. Forest of Couvet, Switzerland.

Fig. 63. Forest of spruce and silver fir under the selection system. Oberwolfach, Baden Black Forest.
under such conditions a prearranged felling cycle with definite annual felling areas would be inadvisable. This procedure would be difficult, if not impossible, over extensive forests where close personal attention could not be exercised.

3. ADVANTAGES AND DISADVANTAGES OF THE SELECTION SYSTEM

In considering the advantages and disadvantages of the selection system, it must be understood that this refers to the system as applied in its true form with fellings in all size-classes, and not to the mechanical removal of trees which have attained a certain diameter. On this understanding the chief advantages and disadvantages may be stated as follows:

**Advantages:**

1. By maintaining a constant forest cover the continued fertility of the soil is ensured, protection is afforded against erosion, landslips, and snow-slides, and seedlings are well protected against the effects of sun, frost, and cold winds.
2. All seed-years are made use of, and the good crown development of the trees produces good seed-bearers; this promotes conditions favourable to regeneration, at all events that of shade-bearers.
3. Damage by wind and snow is minimized by the uneven-aged condition of the stand, the larger trees protecting the smaller ones, and by the good development of crowns and root-systems; the superiority of this system as regards windfall, however, is denied by some writers.¹
4. From the aesthetic point of view the selection system has a special advantage owing to the absence of clearings of any kind and to the fact that uneven-aged woods have a more artistic appearance than even-aged woods.

**Disadvantages:**

1. Owing to the scattered nature of the fellings, their supervision is difficult and the cost of felling and extraction is higher than under any other system.
2. Cultural operations, such as cleanings and supplementary artificial regeneration, are likewise difficult and costly owing to the fact that regeneration is more scattered than under any other system.
3. Much injury may be caused to the younger trees and saplings during the felling of large trees and the extraction of timber;

¹ Statistics have been produced which show that in some localities a large percentage of the annual outturn in selection forests is obtained from windfalls. While such statistics may be quite reliable, it should be remembered that the selection system is often adopted for protective reasons in exposed situations where gales are frequent; under such conditions the outturn from windfalls is bound to be high under any system.
damage by felling can be avoided to some extent by first lopping off branches, but this enhances the cost and danger of the work.

4. The selection system is the most difficult of all systems to apply correctly in practice owing to the difficulty of deciding on and maintaining the correct distribution of age-classes, and of determining whether or not regeneration is taking place to the extent necessary to safeguard the outturn of the future.

5. From the management point of view, the correct determination of the yield is more difficult and uncertain than in the case of systems aiming at the regeneration of definite areas in a given period of time.

6. The timber produced by the selection system is inferior in quality to that produced by the more even-aged systems: in the first place, the stems are more tapering and branchy, and in the second place, the growth is more irregular, since the trees are under suppression during the earlier stages and are more or less isolated during the later stages, with the result that the centre consists of narrow-ringed and the outer portion of broad-ringed wood; the wood is thus uneven in texture and contains numerous large knots, and the percentage of utilisable timber of good quality is less than in the case of trees grown in even-aged forest.

7. Where grazing is practised the selection system is not suitable, since regeneration takes place all over the forest, and is not confined to definite areas from which animals may be excluded, as in the case of other systems; in practice this objection may be got over to some extent by closing certain blocks for regeneration in rotation, but in this case the true character of selection forest is lost.

VARYING OPINIONS. There are certain points on which opinions differ as regards the merits or defects of the selection system. Among these may be mentioned the following:

1. It is frequently held that fire is less destructive in selection forests than in even-aged forests, since although the younger trees may be killed the older ones survive to regenerate the area. This is not necessarily the case. It is true that young even-aged coniferous crops are often completely destroyed by fire, but on the other hand well-stocked even-aged crops in the pole or tree stage—in which the crowns are well above the reach of any surface fire and the undergrowth is sparse—frequently escape with slight injury. In uneven-aged forests the case is different; with inflammable trees like pine a surface fire may climb up the smaller trees into the crowns of the middle-sized and large ones, developing into an intense crown fire which may destroy the whole forest. Where such a risk
is to be feared it would seem preferable to adopt an even-aged system where special fire-protective measures may be concentrated on young crops, and if necessary to leave seed-bearers as standards over these crops in order to regenerate areas destroyed by fire.

2. The question whether or not the selection system produces higher outturns than the more even-aged systems is one which has been much debated but has never been satisfactorily settled. Figures have been produced to demonstrate the high yields obtained from selection forests, but these have to be accepted with caution, since owing to the difficulty of determining the true possibility it is never certain whether such yields represent only the increment of the forest or include also excess capital removed in fellings. A true comparison between the outturns from selection and even-aged forest respectively will be impossible until figures are available which are based on increment investigations carried out over a long series of years in exactly similar localities. Such figures do not exist at present. It is, in fact, not improbable that whatever the total outturn of wood may be, the outturn of sawn timber of good quality obtained from forests worked under the selection system will be found to be smaller than that obtained from forests worked under even-aged systems.

3. It is sometimes claimed as an advantage for the selection system that it is the most natural one, in that the selection type most nearly resembles virgin forest. If the latter assumption is correct, the implication is that the best way to treat a forest crop is to leave it as far as possible to Nature. But neither the farmer nor the gardener allows Nature to run riot; both take such measures as they can to improve the quality and increase the outturn of their field or garden crops. Why then should not the forester adopt such means as lie in his power to effect the same object in regard to his forest crops?

But in any case the assumption that the selection type of forest is the most natural one is by no means necessarily correct. Certain types of primeval forest, chiefly of evergreen shade-bearing species in the moister tropical regions, maintain themselves in an uneven-aged condition which may or may not resemble that of selection forest; actually, however, virgin forest usually contains a great excess of the older age-classes. The virgin forests of Douglas fir and other coniferous species of western North America tend towards the even-canopied type, or are at most two-storied, and the same applies to many of the coniferous forests of the Himalayan region. There are many types of natural forest in both tropical and temperate regions which regenerate in even-aged masses without the inter-
vention of man, and fail to regenerate successfully in any other way. The real selection type of forest, containing trees of all ages properly distributed, is exceptional even in virgin tropical forest, and requires the careful intervention of man to maintain it; from this point of view, therefore, the true selection type may be regarded as of an artificial rather than of a natural character.

Very divergent opinions have long prevailed as regards the merits of the selection system. Selection fellings have been condemned on many occasions from the Middle Ages onwards. Several German writers of the eighteenth century condemned the selection system because it caused damage in felling and because it removed the best trees; the latter objection obviously referred to fellings of the exploitation type. A Darmstadt Ordinance of 1776 prohibited it altogether, and in 1787 it was laid down in Prussia that even-aged crops should be grown, in order to produce even growth. G. L. Hartig and Cotta, in the end of the eighteenth and beginning of the nineteenth centuries, were definitely antagonistic to the system. The Baden Forest Law of 1833 prohibited the selection system, and this prohibition is still on the statutes, though it is now ignored. In 1883 the French administration directed that the selection system should be regarded as the exception, and that the uniform system should be adopted as a general rule unless there were special reasons against it. Throughout the nineteenth century and up to the present time the controversy ‘selection v. even-aged systems’ has continued, some writers condemning the selection system, others upholding it; at the present day it still has its adherents and its opponents, although the general opinion in most parts of Europe is that it should not be adopted except under special circumstances, such as those mentioned in the next section.

4. APPLICATION OF THE SELECTION SYSTEM

Conditions of Application. Selection fellings, whether in the form of a well-regulated system or otherwise, are generally applied in the following cases:

1. Where, owing to danger from windfall and snowbreak, it is considered advisable to promote the development of individual stems, to secure an uneven-aged form of crop, and to avoid drastic openings in the canopy and the isolation of seed-bearers.

2. To afford protection against erosion, landslips, and avalanches in mountainous regions, to conserve the water-supply in catchment areas and to prevent floods; forests maintained for such purposes are termed ‘protection forests’.
3. In small areas where intensive working and close personal attention are possible, and where there is a small regular local demand for produce of different sizes, as in the case of private and village forests in many parts of Europe, which are frequently worked under this system; as a properly regulated system, the selection system is unsuitable for very extensive areas owing to the difficulty of applying it correctly.

4. Where seeding is rare and spasmodic, and it is difficult if not impossible to systematize regeneration to any extent; in such cases the selection system may be employed to take advantage of any fortuitous patches of regeneration that may appear.

5. On broken, precipitous, or rocky ground where continuous regeneration is out of the question, and where advantage has to be taken of scattered regeneration appearing in places where there is sufficient soil to support tree-growth.

6. Primitive exploitation fellings of the selection type are carried out in tracts, usually of large extent or in somewhat inaccessible situations, where only the largest and best trees, or only one or a few species out of many, will pay for removal; such fellings should, where possible, be regarded as a temporary expedient pending the improvement of communications and the development of markets.

7. Selection fellings are applied in certain mountain regions, particularly the Alps, in conjunction with pasturage; the forest is often of a somewhat open type unlike well-stocked selection forest, and the grazing interferes with the proper application of the selection system.

8. The selection type of forest is often maintained for aesthetic reasons in the immediate neighbourhood of towns and villages.

Economic considerations sometimes limit the application of the selection system even in mountainous regions where its adoption might otherwise be indicated, for instance where it is necessary to extract large quantities of timber from a limited area in order to justify the construction of special export works.

So far as species are concerned, in continental Europe the silver fir is better adapted for treatment under the selection system than any other species. It is strongly shade-bearing, has good power of recovery after suppression, and is sensitive to frost during youth. The most typical selection forests of Europe, therefore, consist of silver fir, often with a mixture of spruce or beech or both.

Application in Practice. The highly organized and difficult selection system practised to-day in Europe arose out of selection fellings of a primitive kind, which are probably the oldest form of high forest
working known, and appear to have been practised by the ancients. In France the only high forest system up to the thirteenth century appears to have been that known as *furetage*, which was applied to broad-leaved forest and consisted of unregulated selection fellings under which single trees were removed here and there. These fellings were difficult to control and led to abuses, with the consequence that cutting by area (*par assiettes*) began to be introduced under government ordinances about the beginning of the fourteenth century. In modern times the selection system, suitably regulated, has been practised to a greater or less extent in the mountain forests of France. In the latter part of last century it received an impetus through the failure of the uniform system when applied rigidly with fixed periodic blocks in mountainous regions subject to storms. In consequence of this failure it was decided that the selection system was the only one applicable to those regions, and an ordinance of 1883 gave effect to this decision. Since then, the more elastic *quartier bleu* method of applying the uniform system has come into prominence, and in some districts the tendency now is to replace the selection system where possible by this modification of the uniform system, except in forests treated primarily as protection forests.

Among the more important mountain forests worked under the selection system in France may be mentioned the silver fir and spruce forests of the Jura and Vosges, the silver fir, beech, and mountain pine forests of the Pyrenees, and the silver fir, spruce, larch, and cembran pine forests of the Alps. The treatment of larch in conjunction with pasturage in the Alps can scarcely be regarded as properly regulated selection working, as the forest is open and park-like, and the grazing interferes with regeneration. The only broad-leaved species worked under the selection system to any extent in France is beech, generally in mixture with silver fir.

In Germany rough selection fellings were practised at least as far back as the Middle Ages. According to Bühler,¹ the oldest mention of a departure from the then commonly practised selection fellings was in 1495, when the cutting of annual coupes was prescribed in the Landesordnung of Württemberg. Bühler quotes Seckendorf (1799) as stating that selection fellings were still common in many places in Germany at the end of the eighteenth century, but that the woods were being ruined thereby. At the present day the selection system, in regulated form, is practised only to a limited extent in the state forests of Germany. It is, however, frequently

practised in small private and village forests, chiefly of silver fir and spruce. Recent statistics show that 10.1 per cent. of the forest area of Germany is treated under the selection system, the percentage being 2.4 for broad-leaved and 7.7 for coniferous forests. In Austria the selection system is common in small private properties in the mountains; in state forests it is worked chiefly for protective purposes at the higher elevations, only dead, dying, and windfallen trees being removed.

In Switzerland the unregulated selection fellings of former days resulted in the serious deterioration of the forests, and the terms *furetage* and *jardinage* fell into disrepute, with the consequence that selection fellings came to be largely superseded by clear fellings in the early part of the nineteenth century. The indiscriminate planting of pure spruce under the clear-cutting system in turn led to the condemnation of that system and its replacement by more natural methods. At the present day the selection system is much favoured in Switzerland, but it is now practised in a highly systematized form having little resemblance to the rough selection fellings which ruined the forests in the eighteenth century.

In England the selection system has long been practised in the beech forests of the Chiltern Hills, but in too many cases the fellings have consisted of cutting out the largest and best trees and leaving the smaller and weaker ones. In many cases the woods have been overworked and brought to a poor condition, with the result that attention is now beginning to be directed towards the abandonment of selection fellings and the introduction of the uniform system.

The problem of working and regenerating the extensive mixed forests of the tropics, in which often only one or a few species are saleable out of a large number, is a very difficult one. In forests of this type rough selection fellings have generally been the rule, a felling cycle being adopted and a minimum exploitable girth being fixed. The constant removal of the best trees of the most valuable species, and the comparative or entire lack of any effort to secure regeneration, must in time reduce the value of forests worked in this way and cause a diminution of future supplies of valuable timber. In India primitive selection fellings of this kind have been in operation for many years, not only in the tropical forests but also in the temperate forests of the Himalaya. In the various tropical Colonies a similar form of exploitation has been the general rule down to the present day. Force of circumstances may necessitate the continuance of such fellings for some time to come, but they should at the
best be regarded as only a temporary expedient, to be superseded by more concentrated systems of felling and regeneration. The true selection system of Europe would obviously be inapplicable in the extensive tracts in question. In India and Burma these primitive selection fellings have already been replaced over considerable areas by more scientific systems, and in future this policy is likely to continue wherever circumstances permit.
Fig. 64. Two-storied high forest. Upper story of oak 110 years old raised by sowing acorns along with field crops: lower story of beech 60 years old introduced by underplanting. Spessart, Bavaria.

Fig. 65. Two-storied high forest. Oak and beech with young under story of beech introduced by natural regeneration. Beech seed-bearers will be removed, leaving only oak in upper story. Spessart.
Fig. 66. Two-storied high forest. Scots pine 100 years old with under story of silver fir 40 years old introduced by line sowings. Forest of Rambervillers, Vosges.
TWO-STORIED HIGH FOREST

Fr. Futaie à double étage; Ger. Zweihiebiger Hochwald.

Two-storied high forest is a form of crop consisting of an upper story with a lower one beneath it, both being of seedling origin. It may be termed an accessory system, since it may originate from various systems, and is not dependent on any particular method of regeneration.

The commonest form of two-storied high forest is that in which a wood, preferably of a light-foliaged species, is thinned heavily when it is approaching or has reached middle age, and a shade-bearing species is introduced artificially as an under story; the two stories are then allowed to grow up, and either they are both felled together or the upper story is removed in one or a series of fellings, leaving the lower one as a self-contained crop.

Two-storied high forest may be adopted for various reasons, of which the chief are: (1) to provide a soil-protective under story to a species which is itself incapable of preserving the fertility of the soil, (2) to enable a sensitive shade-bearing species to be grown under protective cover, (3) to obtain a mixture of species of which one would be outgrown by the other unless given a start, (4) to effect a gradual change of species and of produce, since the standing volume and the yield from thinnings in the lower story increase gradually, until the lower story eventually takes the place of the upper one, (5) to increase production by growing on the same ground two crops of different ages and with different demands on the soil, (6) to furnish substantial early returns by the heavy thinning of the overwood, (7) to provide a soil-protective under story in order to give freedom of action in thinning the overwood heavily without fear of exposing the soil, to allow the best stems to put on light increment and produce large timber.

The last-mentioned idea is frequently put into practice in Germany under the name of Lichtenwuchs betrieb. In the plains of Germany there are many examples of mixed woods of Scots pine and beech treated in this way: during the pole stage the Scots pine is thinned and underplanted with beech, and when the latter has developed sufficiently the pine is thinned out heavily to promote light increment. Similar treatment is frequently applied to oak and beech, the latter being introduced as a soil-protection wood in order
to enable the oak to be thinned out sufficiently (see Fig. 64). Good examples may be seen in the Spessart and elsewhere of oak and beech woods in which an underwood of beech is obtained by natural regeneration, after which the overwood is opened out by the removal of the beech seed-bearers and any defective oaks, leaving an upper story of the best oaks to put on light increment (see Fig. 65). In Great Britain larch plantations are not infrequently thinned out at an age of 15 to 30 years and underplanted with beech or shade-bearing conifers. Among coniferous mixtures, a favourite one in continental Europe is an upper story of Scots pine with a lower story of silver fir introduced artificially, often by sowing, after the pine has been thinned out at middle age (see Fig. 66).

In practising two-storied high forest, care is necessary in the first instance to open the upper story cautiously if there is danger from wind, and to continue to thin it from time to time in order to prevent the suppression of the under story. The chief disadvantage of two-storied high forest lies in the fact that damage is liable to be caused to the under story during the thinning or felling of the upper story; otherwise the system is a useful one when applied for one or other of the purposes mentioned above.
XI

HIGH FOREST WITH STANDARDS

I. PRESENT-DAY PRACTICE

General Description. High forest with standards, like two-storied high forest, is an accessory system, since it may originate from various systems, and is not dependent on any particular method of regeneration. It is produced not by introducing a second crop under an existing one, as in two-storied high forest, but by leaving selected stems of an old crop standing over a young crop established as a result of regenerating the old one. These stems, which are known as 'standards', may be retained, scattered singly or in small groups, for the whole or part of a second rotation. Regeneration may be carried out either naturally from seed, or artificially by sowing or planting.

The chief object of this system is to retain selected stems to put on light increment and produce large-sized timber. Sometimes standards of light-demanders such as Scots pine and larch are retained for a time partly for this purpose and partly to act as seed-bearers for the seeding up of blanks during the regeneration of mixed crops under the uniform or other systems. In certain cases standards are retained for a time over regenerated crops, usually in pine forests, to act as seed-bearers in case the young crop should be destroyed by fire.

Standards should be of species of which there is a demand for large-sized timber; for instance, pine was at one time grown in this way for masts of ships. The selection of standards requires care. Trees suddenly isolated are liable to be thrown by wind or in certain cases to become sickly and die. As a safeguard against wind, standards should not only be of wind-firm species but also possess well-developed crowns indicating a good root-system. In some cases it is customary to prepare trees for isolation by selecting and marking prospective standards many years ahead, so that they may receive special attention during thinnings. In order to prevent the suppression of the young crop, standards should have long boles and crowns well elevated above the ground, and the crowns, although well-developed, should not be too heavy or spreading. Beech is generally an unsuitable standard, as it has a heavy crown and is also liable to sun-scorch when suddenly isolated; in Switzerland, however, beech standards with elevated crowns are retained
for a long time over mixed young crops under the irregular shelterwood system, the height of the young crop being the means of protecting the boles of the beech from sun-scorch. Oak is often retained as a standard, but it is liable to become stag-headed and to produce epicormic branches when isolated; in the Spessart it is sometimes customary for this reason to retain a few small branchy beech, if available, round the oak standards as a protection. Among conifers, Scots pine and larch are frequently retained as standards, for which purpose they are more suitable than most species. Silver fir and spruce are unsuitable; both have heavy crowns and the latter is not sufficiently wind-firm.

Where standards are not likely to survive for the whole of a second rotation, it is sometimes customary to concentrate them along the sides of roads, so that they may be felled and extracted without doing damage to the main crop.

Examples. The system is variously applied. In Hesse-Darmstadt it is well exemplified in Scots pine forests with both artificial and natural regeneration. In the Eberstadt forest, for instance, the pine is clear cut under a nominal rotation of 120 years (formerly 100 years) and replanted along with a temporary crop of potatoes, about 8 to 15 standards per acre being retained for a second rotation (see Fig. 68). When the felling comes round again these old standards are felled along with the remainder of the crop, and new standards 120 years old are selected for reservation as before. The standards selected are the best-shaped and soundest trees, suitable for the production of high-class timber; owing to their tall boles and high crowns there is less interference with the main crop than might be expected in the case of so light-demanding a species. In the forest of Isenburg in Hesse-Darmstadt Scots pine is regenerated naturally under the uniform system, the rotation being 120 years, and a few standards are retained for a second rotation.

In the mixed coniferous forests of Germany and Central Europe generally, it is frequently the custom to leave standards of Scots pine and larch over naturally regenerated mixed crops for part or the whole of a second rotation (see Fig. 67).

In the Spessart, when beech and oak are regenerated under the uniform system it is sometimes customary to leave about 10 oak standards per acre to attain large size. Oak standards are also left in some of the French forests, as in the forest of Bercé, after the completion of regeneration under the uniform system.

Disadvantages. Although the retention of standards for a time may be advisable for purposes of completing the regeneration of light-
Fig. 67. High forest with standards. Young crop of silver fir and Scots pine naturally regenerated; silver fir seed-bearers all removed and Scots pine retained. Private forest, Salmbach, Württemberg Black Forest.

Fig. 68. Scots pine high forest with standards, artificially regenerated by planting along with potatoes. Newly planted coupe on left, young crop 10 years old on right. Eberstadt forest, Hesse-Darmstadt.
demanders or as a precautionary measure in case of fire, there is much to be said against high forest with standards as a means of producing large timber. The standards are very liable to be thrown by wind, and in Scots pine forest instances have been recorded of 90 per cent. of the standards having been blown down. Apart from this, if standards are blown down, or if they have to be felled for any reason before the main crop is due for felling, considerable damage may be caused to the latter. Should the standards be required at any time in case of an emergency, or in order to take advantage of exceptionally high prices, they cannot be felled without the risk of causing damage to the main crop: this is equivalent to locking up capital in such a way that it cannot be released without sacrifice. Standards of broad-leaved species are apt to develop epicormic branches which may reduce the value of the timber. In addition, standards may interfere seriously with the development of the main crop, this being particularly the case where their crowns are low or spreading. In England instances may be seen where large oak trees with low spreading crowns have been retained and underplanted, with the result that the young crop is seriously interfered with or killed outright, and the felling and removal of the standards cannot be effected without causing serious damage.

If a certain proportion of large-sized timber is required, it would seem preferable to set aside a sub-compartment and allow all the trees in it to remain as a self-contained crop for part or the whole of a second rotation, suitable thinnings being carried out to ensure light increment, if necessary with the aid of a soil-protective underwood.

2. THE TIRE ET AIRE SYSTEM

The old French tire et aire system, which was superseded by the uniform system about the middle of last century, was essentially a form of high forest with standards. Although no longer practised, it is of special interest at the present day, since it produced the high forest crops of oak and beech in France which are now being regenerated under the uniform system, while there are various points of similarity between the two systems which lead to the presumption that the newer system was to a large extent evolved out of the older one. It will therefore be of interest to consider the circumstances which gave rise to the tire et aire system, and the chief features of the system itself.

The tire et aire system was originally introduced in place of the unregulated selection fellings (furetages) under which high forest in
France was generally worked prior to the fourteenth century. These selection fellings, under which single trees were taken out here and there according to age and maturity, were difficult to control, and led to abuses on the part of purchasers, for which reason ordinances were passed which sought to replace this method of exploitation by coupes by area (aire). Among the earliest of these ordinances was that of 1318 under Philip V, but probably the most important of them was the Ordinance of Melun (11 July 1376) under Charles V, which may be considered the first Code Forestier of France. This ordinance prescribed, among other things, (1) the formation of high forest coupes by area, 10 to 12 arpents (about 12 to 15 acres) in extent, (2) the retention of 8 to 10 standards per arpent (about 6 to 8 per acre) to act as seed-bearers for the regeneration of the coupes, (3) closure of coupes to grazing for a time, in order to protect the regeneration. For more than a century and a half these coupes by area, from which the tire et aire system was developed subsequently, were made without any fixed plan as to their situation and outturn; only the location of coupes for sale was decided on from time to time and the prescribed number of arpents was then marked out. The reserve of 8 to 10 standards per arpent was probably only a minimum, and in fact an ordinance of 1516 prescribes the reservation of balliveaux in sufficient numbers for seeding purposes.

The want of system in the situation of the coupes led to confusion, and it was therefore decided to make coupes adjacent to each other in regular order, that is, à tire. An ordinance of 1544 accordingly prescribed for high forest the coupe à tire et aire, or coupes by areas in regular succession, as had from time immemorial been the custom in coppice. According to the Ordinance of Charles IX, of August 1573, the age of exploitation had to be at least 100 years, and in the case of oak the rotation actually varied from 100 to 300 years. The reserve of at least 8 or 10 trees per arpent was maintained or even increased, advance growth had to be retained and not removed, and the seed-bearers had to be properly spaced. The good intentions of these ordinances, however, were not fulfilled, since about this time, and for more than a century, administrative abuses brought forestry in France to a low ebb; the staff enriched themselves at the expense of the forests, silviculture was neglected, and the good beginning made with the tire et aire system came to naught. This was the state of affairs when Colbert came into power in 1661.

Colbert’s first act was to suspend all forest exploitation pending
a new reconnaissance by special commissioners appointed to re-
organize the state forests. This reconnaissance culminated in the 
ordinance of 1669, which governed the practice of the *tire et aire* 
system from then onwards. This ordinance maintained the terms 
of the 1376 ordinance in prescribing the retention of standards to 
the number of 10 per arpent, which may be taken as a minimum. It 
did not prescribe fellings in successive contiguous coups, but 
required only that the corner trees of the previous coupe should be 
used to delimit the next one, the controlling forest officer being left 
to determine each year the situation of the coups. It aimed gener-
ally at restocking the ruined forests in 100 years, though as a rule 
the time taken was longer. Generally speaking, the practice followed 
in regard to the *tire et aire* system from 1669 onwards was as 
follows:

1. To carry out fellings in successive contiguous coups in each 
unit of working, beginning with the oldest portions which were 
already partially regenerated.

2. To exploit these coups, already more or less regenerated, 
reserving the better trees as standards in number variable but at 
least equal to that fixed by the ordinance or by the particular rules 
applying to each forest.

3. Where natural regeneration was insufficient, to complete the 
restocking artificially, as a rule by sowing after breaking up the soil.

4. To clean the young crop, usually about 20 years after the 
principal felling, at the same time removing dead and dying stan-
dards and cutting back damaged saplings with the view of providing 
straight vigorous shoots; healthy standards were retained for a 
second rotation in order to obtain large-sized timber.

It is thus evident that the idea sometimes held, that the *tire et aire* 
system consisted of the clear felling of successive contiguous 
coups, retaining 8 to 10 seed-bearers per acre, and leaving the 
resulting regeneration to look after itself, is incorrect. Such a pro-
cedure would not have produced the many fine oak and beech 
stands existing at the present day, and in fact there are places where 
the old *tire et aire* standards still remaining after repeated thinnings 
are so dense that little remains of the under story. It is probable 
that the fellings were more in the nature of secondary fellings over 
areas partly covered with natural regeneration, although in some 
cases artificial regeneration appears to have played an important 
part, particularly in the case of forests which had reached an open 
and derelict state by the time Colbert's Ordinance came into force. 
The appearance of *tire et aire* crops at the present day indicates
that much of the regeneration must have been often of coppice origin. Although the ordinance prescribed cleanings in the young crops, it made no mention of thinnings, and it is impossible to say to what extent, if at all, these were carried out. Records show that thinnings were known and practised in some forests in the sixteenth century. In the eighteenth century they became more general, and among writers of this period Duhamel gave the theory of thinnings almost exactly as it exists at the present day, and recommended making coupes par éclaircissements at intervals of 6, 8, or 10 years. Varenne de Fenille, another writer of this period, regarded these operations as an effective means of increasing production by promoting the increment of the most vigorous trees. According to M. R. Potel, in the forest of Bercé in particular the state of the stands more than 150 years old over large areas testifies to the fact that rules of culture must have been practised under the tire et aire system similar to those prescribed by Hartig in introducing the uniform system. It is therefore apparent that the uniform system is little more than a development of the old tire et aire system, and in fact the chief points in which the former differs from the latter are (1) greater attention to the opening of the canopy for regeneration, (2) removal of all the overwood when regeneration is established, (3) more attention to thinnings to favour the stems of the future and to increase production.

Methods similar to the tire et aire system appear to have been followed contemporaneously in other parts of Europe. In 1454 in the Harz Mountains of Germany, mention is made of a departure from the prevailing unregulated selection fellings, in prescribing the retention of a few seed-bearers in otherwise clear-felled areas. In the early part of the sixteenth century there are German records of an attempt to secure spruce regeneration by leaving 10 to 30 seed-bearers per acre, but this attempt was a failure, as the shallow-rooted seed-bearers were thrown by wind.