IV. Plan or Scheme of Management of the Woods of the Novar Estate for twenty-five years, from 1899-1900 to 1923-24. By Colonel F. Bailey, assisted by John J. E. Meiklejohn, Factor, John D. B. Whyte, Assistant-Factor, and William Mackenzie, Forester.

SITUATION, GEOLOGICAL AND CLIMATIC CONDITIONS.

The estate of Novar, owned by Mr Munro Ferguson, is situated on tbe north-western shore of the Cromarty Firth, between the river Skiack and Evanton on the south-west and the town and river Alness on the north-east. The woods, some scattered blocks of which lie but a few feet above the sea at high tide, rise on Cnoc Duchaire to a height of 1172 feet and on Cnoc Fyrish to a height of 1460 feet. The mass of them forms a continuous stretch of forest, covering well-drained slopes which face the Firth and extend inland to a distance of three or four miles. The general aspect of the woods is south-easterly ; but in the northern portion of the estate they drain into the Alness river and there have a generally north-eastern exposure.

The principal rocks of the district round Novar are various crystalline schists, which form the higher parts of the parishes of Alness and Kiltearn. These are succeeded, to the east or south-east, by conglomerates and sandstones of Old Red Sandstone age. The conglomerates are developed chiefly in the hills immediately to the west and north-west of Novar House — the highest point being reached in Caishlan (1715 feet). The low grounds between Alness and Evanton are underlaid chiefly by sandstones. The superficial accumulations of the district consist in the hilly ground principally of a gravelly and sandy till. The same deposit covers considerable areas in the low grounds, but it is frequently over-laid or replaced by sheets and mounds and ridges of gravel. The ground below a level of 90 feet or thereabout is chiefly gravelly and sandy, or alluvial. These low-lying deposits appear to be relics of three old raised beaches, of which the uppermost occurs at a height of about 90 feet, the middle one at 50 feet, and the lowest at 25 feet above the present sea-level. Along the margins of the streams alluvial flats occur as usual. ^

' This statement of the geological characteristics of the locality was kindly
furnished by Professor James Geikie.

The slopes are for the most part moderate and suitable to forest growth; but, owing mainly to the action of wind, the crop, especially the Scots fir, becomes stunted at altitudes above 700 or 800 feet in exposed situations and above 1000 feet in more sheltered places. This effect is specially observable in the higher parts of Creag Ruadh, Cnoc Fyrish and Cnoc Duchaire. The soil is for the most part light and of moderate but sufficient depth, rendering

the locality eminently adapted to the growth of coniferous woods. Over portions of the ground the development of the younger crops is marked by great vigour, of which the following instances may be noted, viz. : — In Black Park Corner, the dominant stems of larch and Douglas fir, in mixture fourteen years old, attain an average height of about 40 and 39 feet respectively ; in parts of Temple Park, larch, Scots fir and spruce, aged fifteen years, reach a mean height of 31, 28 and 25 feet respectively; in the eastern part of Cnoc-an-Eiliknaidh, larch and Scots fir, aged fourteen years, run to a mean height of 28 and 20 feet ; while in Lower Assynt Belt, larch, Scots fir and spruce have grown in eleven or twelve years to heights of 32, 25 and 24 feet respectively. The trees composing these crops have, generally speaking, good girth and a flourishing appearance ; but although actual disease is not prevalent among the larches, their foliage and bark are not everywhere in a healthy condition. The above have been selected for mention as being among the most promising of the young crops on the estate ; but the rate of developmenj, of the majority of the younger woods, at moderate altitudes and where the larches are not seriously injured, by disease, is very satisfactory.

At Cromarty on the Black Isle, the mean annual temperature, as recorded at an elevation of 60 feet above sea-level durinc a

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period of forty years, is 46° -6. The lowest mean monthly temperature, which occurs in the month of January, is 38°-5. The mean monthly temperatures in March, April and May are respectively 39°-5, 43°-9 and 49°; while in September, October and November they are 53° 1, 47° -2 and 42°. The readings at Chanonry, on the eastern side of the Black Isle at an altitude of 40 feet, are almost identical with the above. Severe spring frosts in April and May, and autumn frosts in September, are experienced about once in five years, and caused considerable damage to young larches both in the spring and in the autumn of 1896.

The mean annual rainfall, as recorded during a period of twenty-five years, at Ardross near the northern limit of the Novar Estate,

at an altitude of 450 feet, is 37-78 inches; while at Invergorden, at an altitude of 25 feet, it is 25*85 inches. The rainfall is well distributed.

The prevailing winds are from the south-west and west; but damage by storms, which proved disastrous during the years 1893 and 1894, appears to be always caused by gales blowing from directions lying between north-west and north-east. '

GENERAL DESCRIPTION OF THE WOODS.

The total area^ of woodland on the estate, including ground temporarily unstocked, is as follows, viz.: —

A. Included in the Working Plan.

Acies. Acres.
Older conifers — aged 47 to 122 years, 56
Older hardwoods— aged 50 to 90 years, 1813
6

1. Total of tJie older woods, 924

Younger conifers — aged up to 19 years, 1819
Younger hardwoods— aged 5 to 20 years, . 989

2. Total of the younger icoods, 3732

3. Temporarily unstocked, ,

Total included in the Working Plan,

B. Excluded from the Working Plan.

Older woods, 89
Younger woods. 50
Temporarily unstocked, 56
Rabbit warren, . 70

Total excluded from the Working Plan,
Grand total.

265
3997

Details of the above areas, which are indicated by distinguishing colours on the map, will be found in Appendix A ; and a description of each wood, with suggestions for its treatment, is given in Appendix B.

1 The areas given throughout the Report were furnished by the Estate Office, having been, with few exceptions, taken from the Ordnance Survey Area Books,

A. Area included in the Working Plan.

1. THE older woods.

The older woods are stocked as follows : —

(a) Conifers.

Scots fir, in about tliree-fifths of which larch are scattered, ...

Scots fir and larch in more equal proportions,

Scots fir and larch, with some hardwoods, or with some spruce and hardwoods,

Scots fir with a few hardwoods,

Larch with spruce, ...
Larch with hardwoods, ...

Pure larch, ...
Itliscellaneous crops of poor quality.

Total,

Acres.

45

Acres.
6.57

70
4
— 119

6
68
18

The age of these woods ranges from 47 to 122 years, the average age being 84 years ; and the result of a careful estimate, made ^ in respect of each wood, is that the average crop per acre, taken over the whole ground now stocked, does not exceed 117 trees of from 12 to 13 cubic feet each, or say 1500 (quarter-girth) cubic feet of timber, down to a diameter of 6 inches in the case of larch and of 7 inches in the case of Scots fir. This does not represent one-third of the amount that fully stocked woods, in this locality, ought to carry at 84 years of age.

The presence in parts of the estate of fine specimens of all the principal species serves to indicate the class of timber that the ground is capable of producing, though the trees now standing on a considerable portion of the area are, generally speaking, shorter and of a rougher quality than might have been grown in denser woods. But to the gales, which have cleared the crop from parts of the ground now bai'e of trees, may in great measure be ascribed the thinly stocked condition of many of the standing woods; while the growth of the Scots fir has been checked by squirrels, which have irretrievably ruined a number of extensive areas in which that tree forms the main element of the crop. At the same time there is reason to believe that in some places, at

^ By Mr J. D. B. Whyte, assistant-factor, and Mr William Mackenzie, forester.

least, many of the most promising trees were removed during the course of thinning.

As before stated, Scots fir growing on the higher ground, in comparatively cold and exposed situations, is stunted in its development; but the timber of such trees is hard and tine-grained, and is, no doubt, of a very durable quality. Scots fir appears, as a rule, to form an

unusually small heartwood, which in many instances does not occupy more than from one-third to one-half of the diameter of the stem at its base ; it appears to develop most freely on the more open side of the tree. Except in Clash-na-buiac, Dail Gheal and Bog-a'-Phibbaire, the larch trees now standing are for the most part afiected by red-rot. Of the total area (868 acres) occupied by the older conifers, 518 acres, or about five-eighths of the whole, are closed, the remaining woods being grazed by farmers' flocks. The more lightly stocked portions of Evanton Wood, which have been closed for three years, show a very promising natural growth of Scots fir and larch ; and a portion of this wood, which has been closed for one year only, is already beginning to fill up with natural seedlings of these species. A similar growth is to be seen in most of the thinly stocked parts of the older coniferous woods from which sheep and cattle are excluded, and where the growth of brackens and other herbage is not too dense for its development. This is notably the case in Black Park and Contullich, which were closed in 1898; but part of Evanton was closed earlier than any of the other woods. A fair but irregular growth of natural seedlings is found also in woods open to grazing, wherever the young growth is protected from sheep by coarse herbage — Inchcholtair Wood may be cited as an instance of this. In this light and favourable soil, natural seedlings of both Scots fir and larch spring up readily in heather of considerable height and density, but very few of them are to be found in grass.

(b) Hardwoods.

Of the older hardwoods (56 acres), about 17 acres contain a considerable proportion of oak, and in about 37 additional acres that tree forms one of the constituents of the crop. The average age of these woods ranges between fifty and ninety years. They are estimated to contain, on an average per acre, 65 trees of 11 cubic feet each, or about 715 (quarter-girth) cubic feet of timber, down to 5 inches in diameter. These very thin crops are, as might be expected, generally speaking of poor quality, and they do

not occupy the ground to advantage. They are, for the most part, unlikely to improve sufficiently to warrant their being left standing longer than necessary, though selected trees may remain as standards, to be subsequently under-planted with shade-bearing species, where they stand at all densely. The area closed to grazing is 20 acres. In Dail Gheal Belt there is a very satisfactory natural undergrowth of beech from one to fifteen years old.

2. THE YOUNGER WOODS.

The stock of the younger woods is composed as follows : —

(a) Conifers.

Acres. Acres.

Scots fir and larch, in more or less equal proportions,

with, frequently, a small admixture of spruce, . 759
Scots fir and larch, in which spruce, silver fir and

Douglas fir are more strongly represented, . . 261

1020

Scots fir, in 175 acres of which larch occurs in small

proportion, 526

Larch, 195

Spruce, with a few larch, ... 4

Douglas fir, pure, or mixed with larch, silver fir,

Scots fir and hardwoods, ... 10

Larch, spruce, Douglas fir, Scots fir and hardwoods ;

about half the area mixed by single trees and

the remainder by groups, 43

Miscellaneous mixtures of conifers and hardwoods, . 5

Experimental area, ... 6

Old nursery, ... 4

10

Total. . 1813

A glance at the above statement shows that the principal tree in these woods is the Scots fir, larch occurring either as a pure crop or mixed with the Scots fir in varying proportions. Spruce, silver fir and Douglas fir are found for the most part in mixture with Scots fir and larch ; but in a comparatively small area only has the error been committed of mixing numerous species together on the same ground. The age of these plantations ranges from one to nineteen years. As a general rule they are progressing satisfactorily, and examples have been given above of really phenomenal development. In places, however, the crops suffer damage by ground game, from deficient drainage or other causes ; and most of the young crops of pure larch are suffering more or less from cancer.

The worst of the diseased larches have been cut out from part of Assynt Hill, as well as from Cross Hills and Novar Mains ; side branches have been shortened where interfering with lower growth in Toll Belt, Novar Mains, Fyrish Upper Belt, Temple Park and Cnoc-an-Eiliknaidh ; and hardwoods have been pruned in Toll Belt. With these exceptions, no thinning or pruning has been done in these woods.

(b) Hardwoods.

The small area (6 acres) of young hardwoods consists of alder, willow, horse-chestnut, beech and other species, from five to twenty years old. Of this area 1| acres are closed, and the remainder is open to grazing

3. AREA TEMPORARILY UNSTOCKED.

Of the unstocked area (989 acres), about one-eighth part was bared by the storms of 1893-94; and from the remainder the crop has been removed during the course of the annual fellings, but replanting has not yet been carried out. Over a considerable proportion of the ground, isolated trees or small groups of trees have been left for ornament ; and these are gradually being over-thrown by wind. More than one-third (381 acres) of the area is now open to grazing, but the rest of the ground is closed. Vigorous natural regeneration of Scots fir and larch from adjoining woods is seen in places, notably in Inchcholtair.

The small-sized, unmarketable wood (tops and branches) has, unfortunately, in many places, been left on the ground after felling, and has no doubt for a time encouraged the breeding of injurious insects ; it now adds greatly to the risk of damage by fire. Between 700 and 800 acres are more or less covered with " brush " of this sort, which should be gradually burnt ofi' as the work of planting progresses. Such dangerous accumulations of debris should not be permitted in future.

B. Area Excluded from the Working Plan.

An area of 195 acres in the vicinity of Novar House has, by desire of the proprietor, been excluded from the Plan, and an additional area of 70 acres has been fenced off as a rabbit-warren. It would be possible at anytime to frame a separate Working Plan for these areas, with a view to their serving in the most effective manner possible the object on account of which they have been excluded from the present Plan,

PRINCIPAL INJURIES TO WHICH THE WOODS ARE SUBJECT.

The attacks most to be feared are tliose by storms, larch disease, squirrels and ground game.

Storms.

The estate has suffered very severely from violent gales, blowing, usually, from directions ranging between north-east and north-west. During the years 1893-94 these winds did great damage, overthrowing no less than 55,000 trees, or more than half the number now estimated to stand in the older coniferous woods, and causing an immediate loss of £2000, owing to a fall in prices consequent on the Hooding of the market. The woods which suffered most were Cnoc Duchaire, Moultavie Belt, Contullich Wood, Cnoc Fyrish, Creag Ruadh, Cnoc-na-Coille, Meann Chnoc, Badger Hill, Dail Gheal, Evanton Wood, Blackrock Brae and Inchcholtair. As

a precaution against the recurrence of such serious calamities, the outer margins of all woods, especially on the sides from which experience has shown that danger is most to be feared, should be strengthened by permanent shelter-belts, comprising Austrian, Corsican, Mountain or Cembran Pines, Norway Maple, Sycamore, Beech, Birch, or other wind-firm trees, according to locality. Intermediate belts should also 'be established within the larger woods, running in a direction perpendicular to that of the dreaded storms; and the outer trees on all sides should be left standing while fellings are in progress. The stock in permanent shelter-belts should be maintained by planting or sowing in all openings left by the gradual disappearance of the old trees.

Larch Disease.

Larch cancer acts as a terrible scourge in many of these woods. In places — as in the lower part of Cnoc-na-Coille — trees seventy years old show marks on their boles of the disease, which is, however, no longer active ; but the older larch crops appear, as a rule, to have escaped serious injury. Among the younger woods, disease is particularly prevalent in Cross Hills, where larch has been planted in a moist hollow, and in the 138-acre block of pure larch on Assynt Hill, especially towards its western end. The disease has also a strong hold on the young trees growing on ill-drained ground in Toll Belt ; and few, if any, of the young larch woods are entirely

free from it, The three woods mentioned all lie on warm southern slopes, at elevations ranging from 50 to 900 feet above the sea.

It is a noteworthy fact that in parts of Claisdruim and of Contullich Belt, where self-sown larch, six to fourteen years old, stand in dense masses on the ground, the young trees suffer very little from disease, the bark having, generally speaking, a peculiarly healthy appearance. In parts of the lower portion of Temple Park and of the centre of Cnoc-an-Eiliknaidh, both of which have been previously noticed as carrying crops of remarkable vigour, aged respectively fifteen and fourteen years, the side-branches of larch are dead to a height of 8 or 10 feet; and these dead branches are sometimes loaded with spore-bearers of the fungus, while the stem and higher living branches appear quite healthy. This looks as though the fungus might have attacked the lower branches after their death ; but the matter requires further observation and study. Throughout the plantations it is noticed that the stems of young trees standing in a free position, and in a generally thin crop, are frequently attacked by disease, the power of which seems to depend rather on unfavourable local conditions than on the degree of density of the crop. For example, in the open, breezy Acharn plantation, where the soil is unfavourable, the young trees are badly diseased; while, as before mentioned, the dense, self-sown crops in Claisdruim and Contullich Belt are comparatively healthy. It may turn out that fairly dense crops of healthy young larch can be raised on this estate, if none but the most suitable localities are selected for them.

Two years ago an experiment was tried in the low-lying Cross Hills plantation, where disease had attacked almost every stem, of making a thinning among the yoimg trees, then twelve

years old and of good height, by removing those of them which were most diseased ; and the crop was under-planted this year with spruce, silver fir and Menzies fir. It remains to be seen whether the effect of this thinning will be to cause a more vigorous development of the remaining stems, and thus to enable the best of them to contend successfully against the fungus ; but Cross Hills is a locality very unfavourable to the growth of larch. An experiment in under-planting with silver fir has also been commenced this year in the western, the most diseased, portion of Assynt Hill, where the crop is fifteen years old, and where it is not easy to account for the violence of the attack.

In such badly infected places, it is impossible to deal effectually

with the pest by merely cutting out the diseased stems, as this would leave too thin a crop on the ground ; here simultaneous under-planting is necessary. But in comparatively healthy young woods, like parts of Cnoc-an-Eiliknaidh, Temple Park and others, it is desirable to check the further progress of the attack by at once removing, during the winter when the spores are inactive, all diseased stems from the least infected areas ; and the enemy's advance may be met thus until the proportion of attacked trees becomes too great for this treatment, when, again, simultaneous under-planting must be resorted to. Such thinning and under-planting would not, ordinarily, in healthy woods, be done before from the twentieth to the twenty-fifth year of the crop's age; but the progress here made by the disease necessitates application of the treatment at an earlier stage. It would be an advantage if all parts of the diseased thinnings which cannot be utilised could be burnt. In plantations such as the two last-named, where larch occurs either as a . pure crop or as the principal constituent of the stock, it might be worth while, as an experiment, to clear of larch, at intervals of from 200 to 300 yards, strips of ground about 25 feet wide, running in a direction approximately from north to south, and to plant these up with Douglas fir and rapidly-growing species of hardwoods ; this might have some effect in impeding the distribution of the spores.

The prevalence of larch disease on the estate necessitates consideration as to wliether the continued planting of larch otherwise than as a disseminated species is justifiable. The temptation to run some risk by growing it in pure crops up to a certain age is considerable, in view of the high prices obtainable for the timber, and of the fact that thinnings, consisting of badly diseased twelve-year-old stems, which were sold as " sheep-net stickings " from Cross Hills in 1897, realised a profit of £6, 2s. per acre. But this was an exceptional price; similar produce would not now bring in more than half the amount. There can be little doubt that at present the wisest general rule will be to restrict the raising of larch to localities which are not unfavourable to it, and to limit the number of plants to a small proportion of the stock, evenly distributed among the principal species. Any of these trees which may survive to the end of the rotation will add materially to the value of the final crop, while even if the majority of them should be lost, their disappearance would not seriously impair its density. But experiments in the growing of young larch as a pure crop, and as a

principal species mixed in various degrees with sliade-bearers, should be continued on a limited scale, plots for this purpose being selected on northerly or north-easterly aspects, as remote as possible from existing sources of disease, and sepai-ated from each other by considerable stretches of ground stocked with other species. In these plots the raising of larch should be studied by A^aried treatment, pure crops being ultimately under-planted with shade-bearers. Should these experiments give satisfactory results, larch will no doubt again be grown on a more extensive scale.

Squirrels.

Allusion has previously been made to the injury done by squirrels, which, unfortunately, are very numerous, in spite of the endeavours made to keep them down by shooting. The forester killed forty-one in Cnoc Duchaire in a single morning. They gnaw the tender portions of the bark of Scots fir, commencing their depredations in some cases when the trees are about seven years old, and they continue to attack the upper part of the stem and branches of trees which have reached a considerable age. They also eat out buds, and thus interfere with the development of the crown. The crops of Scots fir in Cnoc-na-Coille, Inchcholtair, Caistel Breac, Badger Hill, Lealty Belt, Baddan's Belt, Cnoc Duchaire and Contullich Wood, covering in all about 400 acres of ground, have been practically ruined by squirrels, a large proportion of the trees having lost their tops, the stems being scored with deep wounds, and the timber being greatly reduced in value. Young crops, aged fourteen and fifteen years, have also been severely attacked in Cnoc-an-Eiliknaidh, Broom Hill, Temple Park, Assynt Hill and other woods. The only way of dealing with these destructive animals appears to be to shoot them ; but this would prove a much more effectual measure if neighbouring proprietors could be induced to make common cause against the enemy.

Ground Game.

A wire netting to keep out mountain hares is maintained round the higher or north-western boundary of the main block of woods ; but the following areas have not the benefit of this protection, viz. : — on the west — Inchcholtair and Blarvorich; on the east — Cnoc Duchaire, Baddan's Belt, western part of Claisdruim, Dalreoch, Ardoch, Lealty Belt and Acharn. The young plantations are not specially protected by wire netting, trapping and shooting being relied on to keep down the stock of rabbits. Whether this method is adopted at a greater or a less cost than would be involved in fencing has not

been calculated in connection with the present Plan. But, as might be anticipated, a great deal of injury is done in places; and if the young crops are to be efficiently protected without resort to wire netting, strenuous efforts on the part of the gamekeepers must be

sustained. The plantations in parts of which serious damage was noticed are the following, viz.: — Blackrock Corner, Assynt West Belts, Contullich Belt, Contullich Wood, Toll Belt, Black Park, Temple Park, the Old Nursery, Dalreoch, Cnoc-an-Eiliknaidh, Badger Hill, Evanton Wood, Assynt Hill and Cnoc-na-Croige.

In some places, notably in Blackrock Corner, Assynt West Belt, Assynt Lower Belt and Contullich Belt, even the largest of the larches, eleven or twelve years old, have been freshly gnawed by rabbits; and it does not seem improbable that the wounds thus made may expose the attacked trees to the dreaded disease.

Some plants have been cut down by hares in Ardoch Wood and Blarvorich, while roe-deer and blackgame have done serious damage in places.

Other Sources of Injury.

Spring and atitumn frosts, as previously stated, cause occasional damage to young crops, but on the whole this is not usually of a very serious nature.

Of insects, those most to be feared are the Pine Weevils {Hylobius abietis or Pissodes notatus), which have attacked crops from one to four years old in Cnoc-na-Croige, Black Park, Bullockeshan, Contullich Wood, Evanton Wood, Blarvorich and Cnoc Fyrish ; the Pine Shoot Moth (Retinia resinella) is also doing considerable damage in Bullockeshan; and the Pine Beetle {Ryhirgus inniinrda) injures both young and old Scots fir on many parts of the estate, — as, for example, in Claisdruim, Cnoc Duchaire, Contullich Wood and Lealty Belt. Measures to meet these attacks must be taken, not only by the destruction of the insects, or of their eggs or larvje, in the manner suggested in volume iv. of Schlich's "Manual of Forestry," but, especially as regards the weevils, by selecting the felling-areas of successive years in such a way as to enable the new crop on each such area to attain the age of four or five years before the crop adjoining it is felled and the ground restocked.

The young silver Jirs are badly attacked by disease. In Allt Duack some trees of this species, six or seven years old, which threw out fine shoots last year, are now very unhealthy looking, the stem and branches being covered with plant-lice and some of the terminal shoots being dead. Silver firs of like age in Fyrish Lower Beit are also showing similar signs of failure; and the same phenomenon has

been observed on neighbouring estates, where trees up to at least

forty years of age have been attacked and killed. It has been noticed that death, which often occurs with some suddenness, follows two or three consecutive years of attack by lice.

Specimens of affected plants were submitted to Professor Bayley Balfour, who has kindly given the following opinion : —

" I have no hesitation in saying that the aphis is not the primary cause in the case of the diseased silver fir. The trees ai'e covered besides with fumago, and their whole aspect is that which is very common in the case of trees which are grown in an unsuitable situation. I have seen plenty of trees in the state of those you send me, and like those you describe in your letter, and in every case I am satisfied the ailment is a constitutional one — the result of unsuitable environment. I cannot but think that Professor Schwappach was far wrong when he advised extensive planting all through Scotland of the silver fir. The aphis of the silver fir is, Dr MacDougall tells me, a different one from the ordinary spruce aphis."

If this view be correct, endeavours must be made to ascertain what the unfavourable factors of the environment are. If similar conditions were found to prevail throughout the estate, all attempts to grow silver fir must be abandoned, and this would be very regrettable, as the tree is a very desii'able one for the under-planting of larch and Scots fir. But healthy individual trees of all ages are found in places on the estate as well as elsewhere in the neighbourhood.

Insufficient drainage keeps back the crops in parts of Dail Gheal, Badger Hill, Cottage Wood, Evanton "Wood, Cnoc-na-Croige, Toll Belt, Acharn Wood, Dalreoch, Claisdruim, Baddan's Belt and Blarvorich. This should be seen to.

A dense growth of brackens, and in places of whins, broom, raspberry or juniper, which covers an area estimated at 1000 acres, forms a serious impediment to the progress of the young crops, and renders the restocking of the ground both difficult and costly.

In Dalnahaun and Dail Gheal damage has been done to some of the standing trees by the wire ropes used with the traction-engine during the removal of logs. Trees which may be thus injured during future felling operations had better be felled and taken out before the engine leaves the wood.

Fires have not in recent years caused serious damage to woods on the estate ; but during the current year about 70 acres of heather in Creag Ruadh were burnt. Measures should be taken to reduce

the risk of conflagrations in coniferous woods by establishing belts of hardwoods along the lines of greatest danger, and by reinforcing them with interior lines where such appear necessary.

PAST MANAGEMENT.!

All woods which have now reached the age of ninety-five years or upwards were planted by General Sir Hector Munro, who also

brought much waste land on the estate under agriculture. Most of the remainder of the older woods were planted by Mr Hugh Munro between about the years 1830 and 1850, from which latter year and up to 1881 no planting was done. In 1881, extensions were resumed by the present proprietor, who has planted the whole of the younger woods, covering an area of 1819 acres. The estate has, on the whole, been fortunate, in that out of five successive owners. Sir Hector Munro, Sir Alexander Munro, Mr Hugh Munro, Colonel Munro Ferguson and the present proprietor, all but Sir Alexander Munro, Colonel Munro Ferguson and the Trust which followed his death have been extensive planters; but the breaks which occurred render it impossible now to arrange for continuous fellings throughout the whole of the period that must elapse before the oldest of the younger woods has attained the felling age.

The fine old Scots fir trees, such as may still be seen in parts of Dail Gheal, Meann Chnoc, Cnoc Fyrish, Cnoc-na-Croige, Cat Hill and Badger Hill, must have been raised in a dense crop until at least the period of middle age, when the woods were probably thinned heavily in order to meet a demand for squared timber, which, forty or fifty years ago, realised from lOd. to Is. per cubic foot f.o.b on Foulis beach. It is said that in Mr Hugh Munro 's time all woods were grown as dense crops ; he would not permit the breaking of the canopy, and restricted thinning to the removal of dead, dying or damaged trees.

The worst of the older woods, such as Temple Park, were planted by Mr Hugh Munro after the previous crop had been cleared off"; but weevil, rabbits and squirrels ruined his young plantations, which, the vacancies thus caused not having been regularly filled up, resulted in thin crops of low-crowned, branchy trees, grown in a more or less complete state of isolation.

The rough trees now keeping back younger crops in Claisdruim

! Compiled from information supplied by the Estate Office, and also, in part, by Mr D. Robertson, formerly forester on this estate, but now at DunrobiTJ.

and in Contullicli Belt are self-sown seedlings which have always been isolated.

The average value of the timber (including wind-falls) cut annually from the estate during the eighteen years — from 1881 to 1898 — which have passed since the present owner came into possession, has been about £5550; the maximum, £9800, having been reached in 1894, after the disastrous gales of that and the preceding years. During the first thi-ee years of the above period, the timber was sold entirely *'in the round," either standing or felled and logged ; clean-felling being done by the purchasers, but thinnings being carried out by estate labour. During these three years many improvements to the agricultural land and buildings were efifected ; and in order to provide timber for farm steadings and other purposes, it became necessary to employ a steam saw-mill. The results attained by its use led the proprietor to begin selling manufactured timber, for which a considerable local demand

existed ; and the system thus begun was continued and,developed, until it almost entirely superseded the former practice of selling timber in the log.

During the years from 1893 to 1896, vast numbers of trees were blown down, and after the gales of 1893 the market for home-grown timber all over the country became glutted. More wood was offered for sale than the timber merchants wished to buy ; prices fell rapidly, and it was almost impossible to dispose of wind-falls in the form of logs. But, on this estate, experience previously gained in manufacture enabled the proprietor to meet the diificulty promptly and effectually. Four additional steam saw-mills were purchased, by which the wind-fall trees were rapidly cut up and sold, for use, principally, in local buildings, or on English railways or street pavements ; but a considerable quantity of the finer class of timber was shipped to Sunderland, where, owing to cheap sea-freights, it was delivered at but little more than one-half of the sum it would have cost to transport it 25 miles by rail to Inverness. The smaller stuff was disposed of as pit- wood or for fencing.

The creosoting plant, erected during the summer of 1893, has proved very useful ; with it, fencing-posts have been rendered as durable, or more so, as similar posts of larch, and they have been turned out at a cheaper rate. A large quantity of creosoted Scots fir boarding has also been prepared for use on the estate as well as for sale.

An 8-horse-power traction-engine was added to the plant in

1897, and has been the means of effecting important savings, both in the carriage of sawn timber and in the haulage of logs on the felling-areas. In 1898 a Universal Wood Worker and a band-saw ■were purchased.

There can be no doubt that during the period of depression above referred to, when timber in the log was almost unsaleable, the system of manufacturing it for the market proved highly successful. Mr Meiklejohn estimates that during 1897 and 1898 the profits on manufactured produce were, on an average, nearly 86 per cent, higher than they would have been had the timber been otherwise sold.

The following statement, furnished by the Estate Office, shows the average annual income and expenditure in connection with the woods of the estate during the past five years : —

Timber' Works. — Kealised by the sale of 93,537 cubic feet

(average annual gross revenue), . . . £8368

Deduct for Outlay on the above, and on 13,751 cubic feet used on the Estate, —
Felling and logging, ... £203
Manufacture, transport and share of manage-

ment charges, ... 4820
Creosoting, ...139
Cost of plant, ... 400

5562

Average annual nett profit on timber works,
Deduct Exijenditure on Maintenance of Woods, —
Loss of grazing rents.
Rates and taxes,
Draining,
Roads and fences,
Fire insurance, .
Nursery expenses, . . . £173

Less plants sold, . . .160

Restbcking ground, including forester's

salary, ...

Average annual nett revenue.

£2806

£110

8

33

59

14

13
545

782

£2024

From the above figures it may be gathered that the gross revenue on timber sold during the past five years has been at

the riite of nearly Is. 9-|-d. per cubic foot; and that if £300 be credited as the value of timber used on the estate, the nett revenue (obtained by deduction of the outlay on timber works) was at the rate of 7d. per cubic foot of the out-turn ; while, if the cost of maintaining the woods be also deducted, the nett cash profit on the business amounted to nearly b^d. per cubic foot of the out-turn. When considering the above rates, the fact should not be lost sight of that the volume of timber (which, with the exception of 4000 cubic feet, was all manufactured) is given in statute cubic feet, and that a considerable amount of wood in slabs, etc., remained unsold. Had the produce been sold in the log, these slabs would have increased the volume disposed of; but, on the other hand, the unit (quarter-girth) of measurement would have been larger, and the nett result of these modi-fications does not materially affect the rates above given as "nett revenue" and "nett cash profit on the business."

Before 1890, in which year the manufacture of timber was tirst undertaken on a considerable scale, the trees were sold either to local traders of Kiltearn, Assynt and Invergordon, or to others from Inverness, Larbert and Glasgow. Larch, oak and elm timber went to Sunderland for boat-building, while Scots fir and larch were taken to Wick for the manufacture of herring baiTels. Small-sized oaks were purchased by cartwrights, and wood of rough quality was sold for conversion into brush-backs. But since 1890 the bulk of the manufactured wood has gone either to Aberdeen, in the form of boards, for box-making ; to Sunder-land or Newcastle for rail way -sleepers, pit-sleepers or paving-blocks ; to the Highland Railway for sleepers, fencing or the construction of waggons ; or for other uses to various parts of Scotland or England. Sales have usually been effected on orders received, or as local cash tran8actions, auction sales not being much resorted to.

The prices per cubic foot now prevailing for standing timber are as follows : — Oak and ash, Is. to Is. 6d. ; sycamore, Is. to 5s.; horse-chestnut and elm. Is.; beech, 6d. to Is.; lime, 4d.; larch, Is. to Is. 2cl.; Scots fir, 3d. to 6d. ; spruce, 3d. These prices are obtainable for timber growing in fairly accessible places; for trees less favourably situated the rates are lower, and in some localities their value is at present extremely small.

Abundance of local labour is available for planting work at the rate of 17s. or 18s. a week; men employed in the manufacture of

timber receiving from 18s. to 20s. a week In order to avoid loss of time in going to and from work, the building and furnishing of suitable bothies near some of the more remote woods has been undertaken.

FUTURE MANAGEMENT.

In the future, as in the past, the main object of management will be the production of timber grown in High Forest; and the treatment of the growing woods in all stages will be regulated by a

desire to develop a final crop consisting of fine healthy trees in large numbers, so that the timber may be of first quality, and that the crop as a whole may realise the highest possible price per acre.

In all forest management, it is important to place upon the market annually, or at regular intervals, an approximately equal supply of timber. Were these woods in full bearing, a regularly graduated series of age-classes being on the ground, it would be easy to make provision for annual cuttings which would yield such an out-turn permanently from the present time. Such, however, is by no means the position, as may be seen by a glance at the abstract given on p. 27. There are 924 acres of "older" woods, ranging in age from 47 to 122 years, and 1819 acres of "younger" woods, the oldest of which is only 19 years of age; crops between 20 and 46 years old are absent, and 989 acres of ground are unstocked. As regards the younger woods, which consist mainly of Scots fir, the age at which they will be cut need not be prescribed now; but there is little doubt that a rotation of 80 years will ultimately be decided on, as this is financially the most favourable age, while on other grounds it is in every way suitable. Assuming that 80 years will be fixed as the age for felling, it follows that a period of 61 years must elapse before the first crop from the oldest of the younger woods will be available for the market. But in view of the present age and condition of the older woods, it is not possible to extend the cutting of them over so long a period as 61 years; they must be felled much earlier, and 25 years has been fixed upon as the limit of time within which they should disappear. Hence 25 years is the period for which the present Plan provides. The average annual out-turn during the past five years has been 107,000 cubic feet, but the an-angement of fellings now proposed will reduce it to about 52,000 cubic feet.

When the last of the older crops has been removed, the oldest of the younger woods will still be 36 years below felling age

(assumed to be 80 years), and during this interval no final fellings in High Forest of mature age can be made; but an increasing amount of timber, the result of thinning the younger woods, will annually become available ; the 265 acres of woods now excluded from the Plan will no doubt yield something; and, as time goes on, it must be considered whether some of the more backward portions of the younger woods (the oldest of which will, 25 years hence, be 44 years of age) should be cut for pit-wood or some other purpose, rather than be allowed to stand for another 36 years to attain the normal felling age. This question may be considered and decided in twenty yeai's' time ; but it is probable that the produce of early thinnings in the coniferous woods will, in any case, be sold as pit-wood or for the manufacture of wood-pulp, and the bark of young larch and spruce trees may prove saleable as tanning material when a regular supply of it can be offered.

Consideration has been given to the question whether it would be good policy to purchase standing crops of trees from neighbourincr proprietors in order to maintain the present out-turn of manufactured produce from the saw-mills, during at any rate a portion of the time that must elapse before the younger woods become available for the market ; but the conclusion arrived at is that the

proprietor would not be justified in incurring the risks that this course would involve.

Here, as everywhere else, it is difficult to reconcile sporting and grazing interests with those of forestry. Shooting rents over the whole area of the estate yield a nett income to the proprietor of about Is. per acre; grazing brings in from 6d. to 5s. per acre, according to quality. The growing of timber will be a much more profitable business than either of these; but although grazing can be stopped wherever it appears likely to injure young woods, the preservation of game cannot be considered from a purely financial standpoint, and a 7nod^lS vivendi for the game and the woods must be found. Speaking generally, the gamekeepers do not object to forest work of any kind from the close of the shooting season up to about the middle of April, and efforts should be made to get through as much as possible before that time.

In this connection, it may be useful to consider the position in

respect of each item of work during the next twenty-five years :

Felling in the coniferous woods, with the extraction of timber, is carried on all the year round, and it would be difficult to complete the work before 15th April; but the average annual felling-area

will be limited to about 37 acres, and this is so small a portion of ground that much inconvenience to the game interest is not involved. Thinnings, which will before long become necessary in some of the young woods, can be completed before 15th April. Burning the coarse heather and other herbage is usually done in February and March of the year before that in which the ground is planted. Burning the "brush," or branches and tops left on the ground after felling, can be carried out before 15th April by the system of "feeding the fire"; and this plan should be adhered to except in localities where, later in the season, fire can be allowed to run over the ground without prejudice to the game; but the gamekeeper's consent should be obtained in each such case of late burning. There remains the question of keeping parts of the young crops, up to six or seven years old, free from suppression by striking off the young shoots of brackens with a stick. This operation, which is carried out between June and August, is very strongly opposed by the gamekeepers, on account of the disturbance it causes to the birds during the breeding season and while the broods are still young. In future, when the felling of the younger woods has been commenced, and when the ground is systematically restocked immediately after the crop has been removed, there will be but few brackens to impede the growth of the young trees; but even during the period for which the present Plan provides, there will be very little trouble from them after the bracken-covered portions (say 330 acres) of the younger plantations have grown up sufficiently to suppress the objectionable growth, and after the bare ground, with its 400 acres of brackens, has been restocked, and the crop on it has attained the age of six or seven years. After that time, the ground to be restocked annually will average only 37 acres ; and assuming the bracken-covered area in the older woods to be 270 acres, it is estimated that not more than, on an average, 60 or 70 acres of brackens, now established beneath their open stock, need be under

treatment at one and the same time. The period during which the greatest difficulty will be encountered is, then, that during which the crops existing and to be raised on 330 acres of young plantations and on 400 acres of ground now unstocked will be growing out of danger from brackens, or, say, during the next fifteen years. These 730 acres will not all come under treatment at once. Brackens on the unstocked area need not be taken in hand until the ground they occupy is about to be planted up ; and, with a little help, the existing young plantations will gradually outgrow and suppress the

weeds. The experiment may at once be tried, in a locality suited to the Douglas fir, to plant up some patches of brackens with this tree, in order to ascertain whether, and within what time, it can overcome the objectionable growth, either without aid or otherwise; the Douglas fir grows rapidly, and stands a considerable amount of shade.

When once the woods are all fully stocked, there will be no room for grazing ; but in the meantime it is probably more in the interest of the game to keep the farm stock ofi" the ground than it would be to prohibit the keeping down of brackens, which in some places are dense and tall enough to render it extremely difficult to establish young trees among them. Unless the weeds in such places can be effectually dealt with, one-fourth part of the woods of the future may be little better than bracken-covered blanks ; and some sacrifice of the shooting interests for a few years seems called for in order to avoid the loss which this would entail. Planting work is completed before 15th April, and does not interfere with the game.

Existing conditions do not warrant the immediate abandonment of the present systena of selling manufactured produce; but the disposal of trees as they stand in the woods has many advantages which are likely to prevail in the future, Avhen the constant yield of the younger woods has had time to develop an improved local trade, capable of undertaking the work of bringing the timber to depot (with the aid, on suitable terms and conditions, of the estate appliances), and of converting it to suit the varying demands of the market. It may here be repeated that during the past five years, the average annual nett revenue on converted timber, without deduction of maintenance charges at Ifd., has been about 7d. per statute cubic foot (see p. 41).

ANNUAL FINAL FELLINGS IN THE OLDER WOODS.

It has already been stated that under the present scheme the felling of the older woods will be spread over a period of twenty-five years. Under this arrangement the average annual felling-area will be about 37 acres; and it will yield about 4220 trees (mostly conifers, but with a few hardwoods), measuring about 52,200 (quarter-girth) cubic feet. In this calculation no addition has been made for the growth of the woods during the progress of the fellings ; in some cases the crops will not improve by standing, and

the increase of the remainder may be held in reserve as a factor of safety.

A Table of Annual Fellings has been drawn up for the older woods, and will be found in Appendix C. In its preparation the following aims have been kept in view: — (1) To avoid the re-stocking at one time of large continuous areas, such being always unfavourable to young crops; a maximum limit of 15 acres has been fixed. (2) To allow an interval of time, not less than four years, to elapse between the restocking of adjacent areas; this being done in order to reduce the danger from insects, such as pine weevils, which habitually attack very young crops. (3) To give an approximately constant annual out-turn of produce, with a mixture of comparatively good and of inferior qualities ; and at the same time to avoid considerable variations in the extent of the areas to be annually i-estocked after felling. (4) To avoid the necessity for carrying on the felling work of any year at two or more points separated by very inconvenient distances.

It will be readily understood that when dealing with irregular crops such as these, it was not found possible to fulfil all of the above conditions ; and where interests were found to be conflicting, preference has been given to the principle of limited continuous areas, to a four years' interval between adjacent plantings, and to an approximately equal annual out-turn. The arrangement actually made was rendered possible only by establishing two cutting-series in Meann Chnoc and in ContuUich Wood (Scots fir portion), and four such series in Cnoc Duchaire. In the working of these cutting-series, great care must be taken to avoid risk of damage by storms. The lines of severance should be selected at once, and should, where possible, be laid where the cover, in the desired direc-tion, is already thin ; the crowns of a belt of trees at this place should then be lopped so as to reduce their liability to be blown down when deprived of the protection of the crop now standing to windward of them. These belts may be at once under-planted with Douglas fir or some other species which will grow rapidly and will soon afford some shelter against wind.

In cases where the entire wood is not felled in a single year, the felling-area should, when possible, consist of a narrow strip, cut on the side opposed to that from which the most dangerous wind blows, and running at right angles to its direction. It has been previously said that the outer trees on all sides should be left standing until the last portion of the crop is removed; and it is, of

course, of great importance to thus guard those sides from which danger is most to be feared.

When carrying out the fellings, it will be desirable, in view of the irregular constitution of the crops in many of the woods, to have regard, in such woods, rather to the nuinher of trees the cutting of which is prescribed in the Table, than to the extent of the area from which the removal of the crop is prescribed. Should, unfortunately, any considerable number of trees be blown down on ground not included in the felling-area of the year ; or should fellings, not pro-vided for by the Plan, have been made in consequence of the

occurrence of fire, or to take advantage of a seed-year or otherwise; a corresponding reduction in the number of cubic feet removed from the felling-area of the year should be made, in order to adjust the yield account.

Save in very exceptional places, the practice of leaving a few old trees or groups of trees standing for ornament should be discontinued. Such trees make no useful growth, and therefore occupy the ground unprolitably ; they are usually, sooner or later, blown down, and either lost or brought in at unnecessary cost ; while, when the new crop has once been established, they are likely to injure it by their shade while they stand, and to crush and break the young plants when they fall or are cut down. Such trees are now standing in BuUockeshan, Broom Hill and other woods, to the detriment of the young crops, and they should be carefully removed as soon as possible, the crowns being reduced before they are felled. Work of this kind is expensive and should be avoided. The tops and branches left after each annual felling should, be removed or burnt without delay ; they should on no account be allowed to remain long on the ground.

There will be no final fellings in the younger woods during the period provided for by the present Plan.

Much of the ground on which the woods stand is favourable to the use of wet or dry timber-slides, tramways and other labour-saving and expense-saving appliances, which, when the crops of the fully-stocked younger woods come under the axe, will almost certainly be employed for conveying timber from them to the estate depot or to the railway line. But although the present cost of bringing in timber from the more remote woods and from the higher elevations is excessive, extensive engineering works for moving timber from the older woods would not now be justified, on account of their scattered situation and liy:ht stock. It must

also be remembered that after the expiry of the period to which the present Plan relates, there will, throughout an interval of about thirty-six years, be no regular fellings on the estate. But no opportunity should be lost of cheapening the cost of moving timber ; and temporary slides, etc., should be constructed wherever they can be profitably employed.

RESTOCKINO.

The average felling-area during the next twenty-five years Avill be 37 acres, of which 35 acres will be in coniferous woods and the remainder in hardwoods. In order to enable the new crop to establish itself before an increased growth of briars, brackens and other coarse vegetation has had time to develop into a serious obstacle to its progress, as well as for other reasons, the grouad should be restocked as soon as possible after felling.

On this light and favourable soil, indications of successful natural regeneration of Scots fir and larch are very encouraging. Tiie larch seeds well almost every year, and plentiful crops of Scots fir seed are produced at intervals not usually exceeding five or six years. Advantage should be taken of each seed-year of Scots fir to obtain

as complete a crop of natural seedlings as possible on the felling-area of the year, by leaving a few — not more than twenty-five to the acre — evenly distributed, full-crowned trees standing as seed-bearers, to be subsequently removed within two or three years, preferably -when the ground is protected by snow. In some places it may be necessary to loosen the soil, or at least to clear away coarse herbage in horizontal strips with a wide-toothed iron rake. Such strips might be 1| foot wide and 3 feet apart, the mineral soil being exposed ; they would be interrupted where not required, or where obstacles, such as stumps or rocks, intervened. In broken ground patches might be substituted for strips. Coarse herbage and debris might also be got rid of by carefully conducted burning. Some portions of the four or five areas next in order for felling may perhaps, on the occurrence of a seed-year, be found thinly enough stocked to enable a partial young natural crop to be secured by similar treatment of the soil and its covering; and in other portions of these areas the removal of a comparatively small number of trees might suffice to afford the needful degree of light. Thus, by a judicious and very moderate anticipation (to be subsequently adjusted) of the yield during seed-years of Scots fir,

it may be possible to secure the regeneration of a considerable portion of the older woods by natural seedlings. This would be a very interesting experiment, which, if successful, would result in a saving of capital expenditure ; and it is by no means improbable that a dense crop of such seedlings might be less retarded by the attacks of ground game than a crop of young planted trees standing conspicuously at regular intervals. It will be necessary to rigidly exclude farm stock from all areas actually under natural regeneration ; but as an irregular growth of more or less isolated young trees, self-sown long in advance of the felling, is a doubtful advantage, it is not desirable to forego any considerable amount of grazing revenue in order to obtain it. Hence, as regards woods which are not to be felled within four or five years, the question of closing must, in each case, be decided on its merits. A heavy crop of Scots fir seed is expected in 1900.

Portions of felling-areas which, two years after the felling, are found to be insufficiently stocked by natural seedlings, should be at once filled up by direct sowing or by planting, as may be considered best in view of the varying condition of the soil and its covering. Wherever the old crop has been dense enough to keep down coarse herbage, the sowing of Scots fir seed in strips or patches may be resorted to ; or where the soil is at the same time sufficiently loose, two-year-old Scots fir and larch seedlings may be put in with a])eg ; but where the state of the soil and its covering is otherwise, older transplants must be used. Young plants are to be preferred to older ones whenever the conditions admit of their use.

When hardwood crops are felled, a few of the best trees only will be left here and there, and the restocking of the ground by natural seedlings is not likely to occur to any important extent ; but, after felling, a new crop sliould be raised without delay, and this may be done by a combination of direct sowing and planting, according to the nature and condition of the soil and its covering. In places suited to oak, acorns may be dibbled in at 1 foot intervals; or young oak or other species, such as ash or sycamore,

may be planted in pits 4 feet apart, existing brushwood, other than promising young seedlings, being cleared away where necessary.

Carefully conducted and recorded experiments should be undertaken in order to ascertain what system of planting is, in this locality, the best, from a consideration of the comparative success or failure of the young crop and its rate of early development, as well as of the initial outlay involved. The method hitherto followed

Pitting.

Notching.

£ s. d.

£ s. d.

2 3

15 I)

12 3

1 15

1 15

ill tlio plauLiiiy of conifers has, almost universally, been that of "notching," the cost of whicli, per acre stocked, has thus been conn>ared with that of pitting: —

Digging 3500 pits,
Putting in [)Iaiits, .
Purchase of 2 year-1 year Scots firs, at 10s. per lOOO, .

.£-1 11 G £.-1 7 .3

That is to say, the initial cost of pitting has been exactly double that of notching. But this fact alone does not suftice to decide the question, for all parts of the estate, in favour of notching ; for in places where either the soil is very shallow or the sod is very thick, there are obvious objections to that system. In such places,

at any rate, the filling up of death-vacancies must cause a serious addition to the initial cost j while, es])ecially if one or two dry seasons should occur before the young plants have fully established themselves, the rate of growth of the young crop will })robably be slower thau it would have been had the plants been pitted. Then again, by the use, where the soil-covering is low, of two-year seedling plants of Scots fir and larch, put in with a peg where the soil is light; as well as by the adoption of an improved pattern of planting spade, suited for small-sized plants; a reduction may be effected in the average cost of putting plants into the ground with their roots disposed naturally, as contrasted with the position they are forced into under the notching system. And further, if advantage be taken of all natural growth that can be raised, and if this be supplemented, in suitable places, by direct sowing, the savings thus etiected may enable a thoroughly successful system of planting to be adopted in less favourable localities, withotit increasing the j)resent average cost per acre taken over the whole area annually restockoil. In other words, if the work can be cliea})ened in some places, more may be spent in others without thereby increasing the total expenditure.

The advantages of securing the effective restocking of the ground at llu; first effort are obvious; and it is clearly permissible to make some initial pecuniary sacrifice in order to secure tliat most desirable end. On this estate a large amount of '' beating up " (filling

of death-vacancies) has now to be d(Hie, tlie young wcjod.s where the stock is most defective being the following, viz. : —

Area in which	Name ol Wood.	Yeara OM.	VacancicH have to he Filled up.
Acres.	Dail (Jhoal, .	17	

2

Acliarn,

IG

160

Caoc-an-Eiliknaidh,

15-

9

30

Broom Hill,

14

3

Toll licit, .

11

4

ContuUich P>elt,

11

5

Clai.sdruim, .

11

4

Ardooh,

10

75

i:adger Hill,

9-

-7

50

JJalreoch, ' .

9-

-6

300

liuUockeshan,

\

10

Jilarvorich, .

3

15

Cnoc-ria-Cr()ig(!,

:j

16

Evantoii,

.-{-

-1

30

ContuUich, .

1

58

Black Park,

1

112

Cnoc Fyrish,

1

64

Total,

928

Vacancies, to an iinportant extent, do not exist on this entire area, but the ground has all to be gone over. Many of these young woods have now passed the age at which deficiencies might be made good by putting in plants of the original .species. Jn some cases, as for instance in parts of Cnoc-an-Eiliknaidh, Toll Belt and Dail Gheal, the stock might now be made good with silver fir (if its healthy growth could be relied on) or with beech, both of which stand shade well; or with Uouglas fir, which, though it stands less shade, grows faster in youth ; and this would to some extent mend matters; but if not C(nnpleted, these crops will suffer through-out life from their too open condition in youth. In the more recently planted of the young Scots fir and larch crops, it will be possible to fill a portion of the vacancies with the original species ; but where deaths have been caused by brackens or othci- coarse growth, a shade-bearer should be substituted for Scots fir or larch. The cost of this work will be heavy; and this circumstance, so far as failures may be attributable to the system adopted in planting, must be set again.st the advantage of a small initial outlay.

In view of the ravages worked by cancer in the larch woods, the principal tree will, for the present, continue to be the Scots fir ; but in most parts of the woods larch may be evenly distributed among the Scots fir, to the number of about seventy trees per acre. Over limited areas, Scots fir, in even-aged mixture with either beech, silver fir, Weymouth (or White) pine, or with Douglas fir, may be grown ; but the mixture of Scots fir with spruce in an even-aged crop is not recommended. Spruce may be raised as a pure crop in low and moist localities with comparatively stifi" soil. The Douglas fir presents a very encouraging appearance at Novar ; and in order to determine its ultimate value here as a forest tree, the species should be grown to a moderate extent, both as a pure crop and mixed with others. It has been attacked by a fungus in some parts of Scotland ; when young, it suffers from spring and autumn frost ; and it is liable to lose its leading shoot when grown in exposed situations. It appears to stand a considerable amount of shade, and will probably succeed well as an under-crop below larch and Scots fir. In Black Park Corner, at the age of fourteen years, it forms a valuable associate at even ages for the larch, though in this mixture its own lower branches remain, for the most part, green. The Weymouth (or White) pine might be grown to a limited extent. The Austrian or the Corsican pine may replace Scots fir in exposed situations ; and these two trees, with Cembran pine and Mountain pine, will be valuable additions to permanent shelter-belts at the higher elevations. Experiments may be made with other species, as, for example, the redwood [Sequoia semjjer-

virens), the white cedar (Librocedrus decurrens), the hemlock (Albert) and the Menzies spruces, the Grandis silver fir, Lawson's and the Monterey (Macroca?'pa) cypresses, and the Canadian cedar (Thuja gigantea). Hardwoods, such as oak, sycamore, beech, ash and others, will as a rule be confined to the lower ground.

The advantages of mixed woods as compared with woods composed of a single species are universally admitted ; but the number of species planted together on one and the same piece of ground should not ordinarily exceed two, and should never be more than" three. Here, where the Scots fir is raised as a pure crop or mixed with larch, the stock will, as a rule, in course of time, be underplanted or under-sown with silver fir, beech, spruce or Douglas fir. These shade-bearing species will profit, in youth, by the shelter of the lighter-crowned Scots fir and larch, which will protect them from frost, while they in return will keep the stock dense after the stage at which pure crops of the last-named species naturally

become too tliiu ; and they will add considerably to the value of the final crop. They will also lessen the risk of failure which attaches to all stock composed of a single species.

The permanent nursery was formerly situated between Broom B ill and Temple Park, at an altitude of 500 feet, and at a distance of half a mile from the present site, which is 300 feet lower, and close to the gardens of Novar House. The change was effected in 1893, on account of the injury done to the young plants by blackgame, and the cost of carting manure up the hill.

The site of the present nursery is somewhat low, but the ground has recently been well drained, and but little damage is done by frost. Nearly all the plants required on the estate are raised here, very few being purchased, and surplus plants are sold to neighbouring proprietors. The experiment may be tried of raising the plants required for some of the more distant woods, at higher elevations, in temporary nurseries near to the ground on which the plants are to be put out. When pricking out seedlings into nursery lines, care should be taken to avoid turning the roots to one side by putting them into too shallow trenches. The stock in the nursery is much in excess of the probable requirements of the next few years. An area of 6 acres was set aside in 1897 for certain planting experiments. But a series of systematic experiments, of the nature indicated at pp. 34, 35, 49, should now be undertaken and completely recorded; plots of ground suitable for larch may be found in Meann Chnoc and Cnoc Duchaire, wliile in Dail Gheal other species will be grown.

The work of restocking to be undertaken during the period of

twenty-five years for which the present Plan provides will be as

follows : —

Acres.

1. Sites of the successive annual fellings in the older

woods to be restocked artificially, save where natural seedlings may have been raised in sufiicient numbers. Average area to be dealt with annually, 37 acres (Details in Table of Annual Fellings, Appendix C), ... 924

2. Filling blanks in existing plantations (see p. 51).

Total area about 928

3. Planting up ground now temporarily bare of trees

[Details in Appendix A^ (3)], less 40 acres in Cnoc Duchaire which are unsuited for forest, . . 949

Total, . . .2801

In addition to the above work, the under-stocking of the younger woods will be taken up as suggested hereafter. The restocking of the successive annual felling-areas must on no account be allowed to fall into arrear.

The filling up of vacancies in existing young plantations should be undertaken at once, as an urgent work of first importance, the most advanced crops being given the preference ; it can probably be completed within a period of four years, at the rate of about 230 acres a year. Every year that the imperfectly stocked portions of these plantations are allowed to grow on in their present condition, the task of filling them up becomes more difficult.

The planting up of the ground temporarily unatocked, though also a work of urgency, must give way to the above ; and except when, the whole of the existing plantations on low ground having been filled up, the high ground is not in a workable condition, no bare ground should be restocked until the filling up of vacancies in all existing plantations has been completed.

This having been accomplished, the 949 acres of unoccupied ground might be restocked in six years, that is at the rate of about 158 acres a year. Of the above area, about 440 acres are situated on high ground, and about 509 acres are on low ground. Weather permitting, about one-sixth part of each class of ground (73 acres of high and 85 acres of low) may be stocked each year. In carrying out this work within the time mentioned, it is unavoidable that large continuous stretches of land will, for some years, be stocked ^ith young trees. But the planting-area of each year should be distributed so as to reduce this evil to a

minimum ; strips of unstocked ground should be left as long as possible between the newly stocked areas; and these should, when the conditions of soil and slope are suitable, be protected from weevils by isolating trenches, as described at p. 154 of Schlich's " Manual of Forestry," vol. iv. The insects should also be trapped and caught in the manner suggested at pp. 204 and 205 of the same volume. If, in spite of these precautions, serious damage is done by weevils, the restocking of the bare ground must be extended over a longer period than six years, and a more complete isolation of the successive pi anting- areas must be maintained.

Vacancies occurring in new plantations must be steadily filled up as they occur, so that the young crop may, as soon as possible, outgrow the stage at which it is most liable to injury, and may develop to the best possible advantage.

Planting work should not be extended beyond the limits of the area included in the present scheme until the whole of the existing young plantations have been filled up, so far as their condition permits of this being done, and until all the ground now bare has been planted up ; that is to say, not until after the lapse of about ten years. "When this stage has been reached, planting and sowing will, for a period of about fifty years, be confined to the restocking of the annual felling-area (for fifteen years only), and to the gradual under-stocking of the younger woods,

THINNING.

It is impossible to lay down in advance the exact age at which the thinning of the young woods should begin, to prescribe the number of stems then to be taken or to be left, or to fix the length of the intervals that should elapse between subsequent thinnings ; and the more so as the stock will not everywhere be complete. These matters must be decided with reference to the changing condition of the growing stock ; but it is, nevertheless, possible to indicate the principles that should guide the manager in dealing with them. A plantation of Scots fir will start with about 3550 plants (3i X 3^ feet) to the acre ; and the forester's object will be to have standing, upon the best class of soil, at the age of eighty years, about 250 tall, sound, well-shaped trees, such as may realise the highest market price. In inferior localitie?, where the trees do not attain such large dimensions, the number per acre may exceed 250. To attain this end, it will, from time to time, become necessary to execute a "thinning," which Broilliard defines to be "a lessening of the crowded condition of the crowns of the best trees in a canopy, so as to favour their development." The leaving and favouring of the best trees in a crop, and the removal of those which are inferior to them, does not lead to the stems removed

during thinnings being always worthless. Undoubtedly the early thinnings of Scots fir will, for the present at any rate, be of small value; but the advantage of clearing out young trees of the class that will at first be cut, and of allowing the best representatives of the stock to stand, will be subsequently felt, not only when the final crop is realised, but intermediately, by a gradual improvement in the quality of the poles removed at each successive thinning, the last of which will yield material approaching in quality to that of the final crop. Say, for example, that after a thinning made on this principle when the crop of Scots fir was forty years

of age, 700 to 750 of the best of the stems remained standing; then, ten years later, some 200 to 250 of these might be taken out. Most of these would, it is true, be the worst stems then found in the crop ; but in consequence of the previous thinning, which left but few inferior trees, they would bring in a good revenue. And so for subsequent thinnings.

Up to the age of about forty years, as a rule, little need be done in a Scots fir plantation but to remove stems which, having been crowded out by their more vigorous neighbours, or from other causes, are either dead or dying. At about that age the thinnings will become somewhat heavier, in order to permit the trees, which have hitherto been encouraged to grow tall, straight, and cylindrical, to develop their girth ; and by timely repetition of such moderate thinnings the final stock will attain the desired condition. If, however, the crop of Scots fir is to be under-stocked, this should be done at that stage in its development (usually between the thirtieth and the fortieth years of age), when the shade given by the canopy of crowns begins naturally to lessen, and thus permits the reappearance of grass in place of the moss which formed the chief soil-covering during the previous period of denser shade. At this time a special thinning must be made, sufficient to enable a young under-crop of ehade-bearing species to be successfully introduced by planting, or by sowing in patches; and thereafter, during the progress of thinnings, the light-requirements of this crop must receive due consideration. The under-crop keeps the soil well shaded after the period at which the Scots fir begins to fail in this respect ; and it thus promotes the further development of the remaining trees of the principal species, while it also adds considerably to the value of the final crop. When the time for felling the Scots fir ai rives, the under-crop, which will then be from forty to fifty years old, may either be cut with it and sold as pit-wood, or be allowed to gj'ow on to larger size, as may then seem best.

The same principle should guide the thinning of young larch woods, the shade given by which usually begins to lessen about ten years earlier than that by Scots fir, and sooner or later becomes so much reduced that, through impoverishment of the soil, the trees composing the crop may begin to fall off" in their growth, and may fail to attain the required dimensions. For this reason it is, generally speaking, desirable, in the case of a pure larch crop, to introduce an under-crop of shade-bearers between the twentieth and the thirtieth year. But in view

of the prevalence of larch disease, and of the condition to which some of the young woods have been reduced by it, the question arises whether these woods should be under-stocked at an earlier age. No general rule can be laid down ; but it is certainly desirable, especially where the disease is most prevalent, to commence at once, in the older of the young larch woods, the cutting out of those stems which from the effects of disease or other causes are evidently incapable of competing any longer with their more successful neighbours. Such a thinning may do good. Where it results in a cover thin enough for the introduction of an under-crop, such a crop may be established by planting or by sowing; but under other conditions the process of under-stocking may be postponed until the usual time, as above indicated. At the time of under-stocking, all but the most healthy and vigorous of the young trees will be removed, and these latter will be allowed to grow on to full dimensions, standing over the under-crop, which will promote their development. It has been said at p. 34, that where the disease is less prevalent, infested young trees should be removed ; but this will not, as a rule, involve such a thinning as would lead to early under-planting.

Crops which are now to be raised of oak, ash, sycamore and other hardwoods, giving light or moderate shade, will usually, between about the twentieth and the fortieth year of their age, be under-sown with beech.

From what has been said above, it will be seen that the details of work in connection with the thinning and under-stocking of the younger woods during the next twenty-five years cannot now be laid down. On the expiry of that period, the oldest of the young Scots fir woods will be only forty-two years of age ; and should under-stocking before the fortieth year prove unnecessary, only three woods, covering 272 acres, will have to be so treated within the time named. But should it become desirable to under-stock at thirty years of age, the area to be so dealt with under the present Plan would be raised to 1341 acres. Each wood must be dealt with on its own merits, and no general rule can be laid down. But the whole of the existing young larch woods, covering 195 acres, will probably have to be under-stocked within the next twenty-five years, and similar treatment may perhaps be applied to a portion of the new hardwoods. It is not thought desirable to under-stock any of the existing older Scots fir or larch woods.

Throughout the young woods, the removal of dead and dying trees should be carried out at short intervals, commencing from the time that such trees begin to be produced in considerable numbers,

FINANCE.

When considering the financial results of the foregoing pro-

posals, it should be borne in mind that they are limited to the period of twenty-five years, within which the whole of the older woods will be cut down.

The average felling-area during that period will be 37 acres ; and it has been estimated that the average annual out-turn from this area will be 52,200 (quarter-girth) cubic feet. The felling-area will be promptly restocked (where natural seedlings do not exist in sufficient numbers); and, in addition, vacancies will be filled up on 928 acres of thinly-stocked plantations, during four years, at the average rate of about 230 acres a year. During a further period of six years, the restocking of 949 acres of bare ground will be effected, at the annual rate of about 158 acres. After the expiration of these ten years, and for the remaining fifteen years of the period for which the present Plan provides, the work of restocking will be limited to the annual felling-area of 37 acres. The thinning and under-planting of the young lai-ch woods will, however, become necessary before the close of the twenty-five years ; and a portion, at any rate, of the young Scots fir woods will, no doubt, come under similar treatment.

The estimates for carrying out the above work are as follows:—

(1) For the four years ending vnth 1903.
Annual nett profit on 52,200 cubic feet of timber at

7d. per cubic foot, ...£1522

Deduct, —

For draining, fencing, planting, forester's salary, share

of management, and all other maintenance charges, 934

Annual nett revenue, . . £588

(2) For the six years ending with 1909.

Annual nett profit on timber, as above, . . .£1522

Deduct, —

Maintenance charges, as above, . . . 682

Annual nett revenue, . . £840

(3) For the fifteen years ending with 1924.
Annual nett profit on timber, as above, . . £1522

Deduct, —

Maintenance charges, as above, . . . 330

Annual nett revenue, . . £1192

It is impossible to make any useful estimate of the amount of the annual nett revenue for the period of thirty-six years which must elapse between the year (1924) in which the last of the older woods will be felled, and that (1960) in which the oldest of the younger woods will attain the age of eighty years. If the thinnings from woods of the latter class yield sufficient to pay the expenses of management, that is, perhaps, as much as can be expected.

In regard to the younger woods and new plantations, which will come into full yield about the year 1960, it may be confidently anticipated that timber of the high quality they will yield must secure a good return, according to the scale of prices that may then prevail ; and that in consequence of the inevitable falling off of our importations from abroad, prices will without doubt be higher than they are now. But assuming that they are merely maintained at present rates, a rough estimate of the financial results of working the woods on the estate, from and after the year 1960, might be made somewhat as follows, on the assumption that the annual felling-area will be 50 acres : —

Final yield per acre, 5000 cubic feet at 7d.

= £145, which x 50 . . . = £7,250

Thinnings from the whole area, equivalent to

1900 cubic feet per acre on 50 acres, at 7d., = 2,750

Gross annual receipts, . . = £10,000

Deduct Expenses, —

Draining, planting, fencing

50 acres at £4, . . - £200

Tending and management of

whole area (4000 acres) at

3s. per acre, . . = 600 800

Annual nett revenue, . £9,200

This sum, which includes neither the considerable value of the under-stcck of shade bearing species, nor the higher price obtainable for larch, is equivalent to 46s. per acre per annum. But

allowing for crops at the higher elevations and unforeseen contingencies, it will be safe to estimate a nett surplus of £2 per acre per annum, which represents an income from the woods of £8000 a year. If these 4000 acres of land were not to be occupied by woods, they could not be expected to yield more than, on an average, 3s. 6d. per acre from grazing and shooting.

CONCLUSION.

Control Book.

A Control Book will be instituted for recording the revenue derived from sales, as well as the expenditure under all heads, so that the financial results of the business may be clearly seen, and may form a reliable guide to the framing of future Plans for the estate.

Ordnance Maps.

A set of the sheets of the 25-inch Ordnance Map, on which the boundaries of the woods included in the present Plan are all clearly and accurately shown, should be kept in a bound atlas as one of the records of the Plan.

Museum.

A small museum for specimens of the wood of various species grown on the estate ; of injurious insects and of the damage they cause; of the eflects of disease and of unfavourable influences; as well as of tools, implements, and other objects connected with forestry at Novar, has already been commenced. It should be further developed.

The thanks of the writer are due to Mr John J. R. Meiklejohn, factor, Mr J. D. B. Whyte, assistant factor, and Mr William Mackenzie, forester, all of whom gave cordial assistance in the work which has now been concluded.

The Plan has been sanctioned by the proprietor, and is now in operation.

APPENDICES.