Some considerations in connection with the Thinning of Conifers in Ireland.

By P. F. O'KELLY

IN modern scientific forestry thinning is of paramount importance but unfortunately our experience of it is limited to 15 or 20 years in scattered small blocks up and down the country. Furthermore our climate is exceptionally favourable to species from the North American continent and Japan and, wisely or otherwise, we have used a lot of these exotics—*Picea sitchensis, Pinus Contorta, Pseudotsuga taxifolia* and *Larix leptolepis* being the species mostly used—so that thinning techniques in Britain, which would approximate more closely to conditions here than would those on the European continent, may not always suit especially in the South of Ireland. One has only to glance at crops of *Picea sitchensis* and *Pinus contorta* in the South to realise that the rotation for either species on the evidence to date will, in certain places, be considerably shorter than was anticipated.

Analysis of the Problem.

Forest capital consists of the land plus the trees growing on the land plus improvement, engineering and protective works but mainly it consists of the land plus the trees. The trees are the means by which the interest is got from the capital (land and trees) and in a forest the interest is the annual increment in wood which the land and the trees produce. Thus if the productive capacity of the land is impaired or if the crop is handled in such a way that the trees which are an integral part of the capital cannot assimilate the full timber producing capacity of the land then the capital is *ipso facto* reduced and with it a consequent reduction of the rate per cent. (the annual increment) it yields.

Good thinning increases the value of the crop and improves its quality; it gives an intermediate yield which offsets to some extent the cost of thinning; it insures that the interest on the capital—the annual increment—is added to the capital in the most advantageous manner possible—in other words the productive capacity of the land is apportioned to exactly the right number of good stems.

Thinning is the most important aspect of management because good practice in establishment and maintenance can be negatived for quite a number of years by injudicious thinning; a vigorous stand that is successively thinned too lightly or a near stagnant one that is thinned too heavily may be damaged for many years to come resulting in an unnecessary lengthening of the rotation which represents a considerable increase in the charges on the stand. As an example let us assume that an area of land is acquired for afforestation at a cost of £500 (including the price paid for the land and the fees for transfer of title) and that establishment costs another £500—a total outlay of £1,000. If this sum is borrowed at 5% compound interest and if the crop can be harvested in 45 years then the charges on the stand (excluding the summarised future value of maintenance costs) will be £8,985. If, for one reason or another, the crop is not harvested until it reaches its 50th year then the charges will be £11,467. In other words a lengthening of the rotation for a period of 5 years puts an extra £2,482 on to the charges on the crop.

This idea of shortening the rotation is fraught with danger if it is carried too far; it represents the viewpoint of the economist who will try to have short rotations and thus realise a quick return on the capital invested. Forestry is, however, a long term policy so the forester must never lose sight of the fact that the land is in fact the most important part of the capital of forestry. He must endeavour to improve it from one rotation to another until its optimum in productiveness is reached. If he should do anything that would impair the productive capacity of the land he is faced with the prospect of diminishing returns. For this reason a shortening of the rotation should be in conformity with good silvicultural practice and then and only then would it be permissible.

We must also bear in mind that our resources are not unlimited and that imports of timber represent a big drain on these resources so that if we decide that logs of a given size—say an average log measuring 30 feet by 12½ inches Q.G. mid. from each stem in the final crop—will meet the nation's requirements for lumber the sooner we can produce them the better. If, by systematic thinning as against hit or miss methods, we can harvest a crop as little as 3 or 4 years earlier we will be able to show a big reduction in carrying costs and a lessening of imports.

Thinning.

Before a decision regarding the degree of severity of any particular thinning is reached the following factors always should be taken into account as then there is less liklihood that any bad mistakes will be made.

1. Windfirmness of the species.
2. Powers of recovery of crown.
3. Suitability of one species as compared with another or others in mixed woods, either from the silvicultural or economic viewpoint or from both.

1. Windfirmness of a species will have a direct bearing on the severity of a thinning and in the case of shallow rooting species on wet or soft sites it will dictate early and rather heavy thinnings on the assumption that attack is the best method of defence as against a supine policy of a little and often which must be adopted if the stand is

allowed to go to the point where a heavy thinning might result in extensive windthrow.

2. Power of recovery of crown where it is poor in light demanding species may dictate heavier early thinnings than volume and stocking would indicate. It will also affect policy with regard to the various stands in a particular thinning cycle—those stands with species in which the power of recovery of crown is poor receiving attention first. If crowns have dwindled considerably a policy of *festina lente* will have to be adopted.

3. Preference for one species over another or others in reasonably well stocked mixed stands will have to be decided on and *ceteris paribus* the species to which preference is given will be kept.

So much for these safeguards. The salient point is that a crop requires to be thinned and we want to treat it in the best manner possible. We want to apportion the productive capacity of the soil (the mean annual increment) to the exact number of good stems that can *readily* assimilate that capacity and at the same time keep up or improve the productiveness of the soil itself. For those whose experience of thinning is limited and oftentimes too for those with fairly extensive experience there is some doubt about the severity of a thinning. Is it too heavy or too light? If the various stands in the thinning cycle are nearly all in the one age group and if the quality class does not vary considerably it is not too bad but where the stands vary both in age and quality class it is more difficult to manage them because thinning technique must vary to suit each stand.

First Thinnings.

In Ireland most of the regeneration is artificial and planting is done in straight lines at a particular spacing usually from 4′ × 4′ to 6′ × 6′ spacing. Crops are mostly coniferous either pure or mixed so that it would not be absolutely beyond the bounds of possibility that one could find an even-aged, pure coniferous stand fully stocked and uniform in regard to height, girth and crown spread.

In other sciences it is not unusual to make use of suppositions and to arrive at a result by the process known as *reductio ad absurdum* so it might be worth a trial in this case.

Let us assume then that such a stand could be found and that in addition to the above it was a vigorous stand planted in straight lines at a 5′ × 5′ spacing. Now if a 5′ × 5′ spacing was sufficient for the crop up to the pruning stage an extra 2 ft. spacing could not be deemed excessive to carry the crop through the period from pruning to just before second thinning. Assume that the spacing is increased by 2 ft. either way to 7′ × 7′. Such a spacing would represent a reduction of the original stocking of 1742 to 889 stems per acre standing after T1. In other words roughly half the crop would be removed.

Now if such a hypothetical stand did exist how could it be thinned? We could represent a portion of the stand diagramatically thus:

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.   .   .   .   .   .   .   .   .
.   .   .   .   .   .   .   .   .
.   .   .   .   .   .   .   .   .
.   .   .   .   .   .   .   .   .
.   .   .   .   .   .   .   .   .
.   .   .   .   .   .   .   .   .
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and we could proceed to thin it as follows (x's represent the stems removed in thinning). Remember that every stem in the stand is supposed to be uniform and straight.

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x   .   x   .   x   .   x   .   x
.   x   .   x   .   x   .   x   .
x   .   x   .   x   .   x   .   x
.   x   .   x   .   x   .   x   .
x   .   x   .   x   .   x   .   x
.   x   .   x   .   x   .   x   .
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Note that exactly half the crop is removed and that the spacing is 10 ft. × 5 ft. with the stems staggered in the lines. Also that the stocking after thinning is roughly the same as that given by a 7 ft. × 7 ft. spacing and that it is in fact a line thinning and that the lines taken out run diagonally.

Now let us get back to reality to see how the results arrived at in the hypothetical case compare with it. From experience we know that the average stocking of normal coniferous stands at the pruning stage will be roughly $\frac{7}{8}$ of the original stocking at initiation; deaths and "misses" will account for $\frac{1}{8}$ of the original number of trees planted. Normally weeding will reduce the stocking of the stand by a further $\frac{1}{8}$ so that we arrive at first thinning with something less than $\frac{1}{4}$ of the original stocking being removed. Now a first thinning at the rate of 1 in 4 is about normal so that the stocking after T1 is generally something greater than half the original number. But mark that I am speaking of vigorous crops in which the spacing is not greater than 6 ft. × 6ft. or less than $4\frac{1}{2}$ ft. × $4\frac{1}{2}$ ft. Therefore the hypothetical case does in fact approximate pretty closely to the result we get in reality.

Now it is not unusual to find young even-aged, fairly uniform, vigorous crops that are reasonably well stocked. Such crops, provided the original spacing was not greater than 6 ft. × 6 ft., can be thinned successfully and easily by a variation of the method used in the hypothetical case above.

Take three lines at a time and proceed as follows. Mark the centre stem of the first three stems and the outside stems of the next three stems as shown in the following illustration.

.	x	.
x	.	x
.	x	.
x	.	x
.	x	.
x	.	x
.	x	.

Continue to do so until you find that a good centre stem is being marked leaving two inferior outside stems or, *vice versa,* two good outside stems are being marked leaving an inferior centre stem. Then mark the inferior stems and let the good stems stand. The following diagram will illustrate what should be done in such cases. (G represents good stems P represents inferior stems and stems with * thus are marked for removal).

G*	G	P*
G	P*	G
P*	P	P*
G	G*	G
G	G*	G
P*	P	P*
G	G*	G
G	P*	G
P*	G	P*

In the fifth set of threes the two outside stems should be marked for removal according to the rule but the centre stem is taken instead and you continue after that according to the rule until the next variation is met with.

From observations I have found that a vigorous dominant stem or a group of 2 or 3 dominant stems will usually have an equal number or more inferior stems in their immediate vicinity so that a thinning carried out by this method will rarely result in bad spacing. After a little practice it will be found that weeding and first thinning can be done together which is an important thing if staff is inexperienced and the area to be gone over is large. By this method most of the rubbishy stems except those required for ground cover in fairly large openings are removed.

Second and Subsequent Thinnings.

In T1 we got rid of all inferior, deformed stems together with some of the better stems leaving us, insofar as it was possible to do so, with a crop of good stems spaced in such a way that the annual increment was apportioned to them as evenly as possible. How are we to set about marking the second or any subsequent thinning?

Is there any rough and ready method of making a quick and at the same time a reasonably safe assessment of the condition of a given crop —whether it needs to be thinned and if it does what should the stocking be after it is thinned? There is but the method cannot be used in crops whose total average height does not exceer 40 ft. In such crops the following relationships will generally hold good. It will be found to be somewhat inaccurate in respect of certain species like *Pinus contorta* and *Larix leptolepis* but it has this advantage that it errs on the safe side so that it will never lead to too drastic a thinning in any species.

$$\frac{\text{Total Height}}{4} = \text{Crown length}$$

$$\frac{\text{Total Ht. called inches}}{8} = \text{Q.G. B.H.}$$

$$\text{Q.G. B.H. called feet} \times 1\tfrac{1}{2} = \text{Spacing.}$$

Thus if a stand of sitka spruce, to take an example at random, had an average total height of 56 feet a rough and ready evaluation of its present condition can be made quickly by comparing it with the results given by the foregoing formulae. If its average Q.G.B.H. is 7 inches or thereabouts (allow $\frac{1}{2}$ to $\frac{3}{4}''$ either way) and the stocking per acre is 395 stems (allow 50 stems either way) (7 ft. $\times$ $1\frac{1}{2}$ = $10\frac{1}{2}$ ft. spacing) then the crop is fairly normal and does not urgently need to be thinned. If the stocking was much less than 395 it would indicate that the stand had been thinned rather heavily. If the stocking exceeded 395 stems per acre by 100 or more stems it would mean that a thinning was due.

To reiterate, the above formulae are just a rough and ready though safe guide for crops whose average total height is not less than 40 feet.

Now whether we continue to thin by hit or miss methods or to conform in a general way with the foregoing rough guide we are still in doubt. In the case of *Pinus contorta* or *Larix leptolepis* we may be thinning too lightly and thereby lengthening the rotation unnecessarily or in the case of *Pinus silvestris* we may be thinning too heavily thereby reducing the quality of the timber and possibly the fertility of the soil.

In my spare time I have been toying with the idea of formulating some method by which we would be able to say that a particular thinning is exactly right—that this is the type of thinning that will give us a final crop in the shortest time without impairing fertility—in other words the perfect thinning.

We all know that nature has an unhappy knack of upsetting most of our forecasts and calculations but generally we can forecast with the prospect of a reasonable amount of accuracy for the period between one thinning and another provided that the cycle is not unduly long.

In each and every stand there is at least one concrete result—a result which the soil plus the trees growing on it have combined to produce—the actual volume of the stand. The stand may be quality class I by comparison with yield tables or it may be stagnant due to inhibitory growth factors, the crowns of the trees may be much too small or the stocking too great in other words be the stand a good one or a bad one the total volume is the measure of the actual performance of this combination of land and trees to date. And total volume, to risk giving a definition, is the sum total of annual increments from initiation to date.

If volume is the sum of the increments how is increment put on? Increment is put on in two ways. Height increment by the elongation of the growing tip of the tree and girth increment at the cambium layer by a succession of concentric, expanding rings just under the bark. Thus we have two concrete results of the performance of each individual tree in the stand—Average annual height increment $\frac{\text{(Total Height)}}{\text{Age}}$ and Average annual girth increment $\frac{\text{(Total basal diameter)}}{\text{Age}}$

As well as this we have a ready made record of year by year girth increments in the form of annual rings. So that we have three concrete results on which to base our calculations namely the mean annual increment, height increment and girth increment. Furthermore we can assume that fertility will not decrease in the immediate future and that a good thinning, assuming the stand to be in a reasonably normal condition, will result in an *increase* in girth increment of the individual stems and possibly in height increment also. So that if we assume that height increment will not increase we must, perforce, agree that the girth increment per stem will because a greater circumference automatically gives a bigger girth increment even if there is no increase in the width of the annual rings. So that if the soil has been capable of producing a given number of rings to the inch on an average since initiation it should continue to do so after a good thinning.

Therefore we should now be in a position to find out the number of trees that can readily assimilate the productive capacity of the soil if the spacing of the stems is reasonably well attended to during thinning.

The following formula subject to the condition specified below should give the ideal stocking per acre after thinning and thereby indicate the severity of the thinning.

The average of the mean annual increments ÷

$$\frac{\left\{\begin{array}{c}\text{Forecast total volume}\\\text{(true measure)}\end{array}\right\} - \left\{\begin{array}{c}\text{Present total volume}\\\text{(true measure)}\end{array}\right\}}{\text{Estimated number of years in the cycle}}$$

The number of years in the cycle will be governed by the vigour of the stand and will vary from $2\frac{1}{2}$ to 5 years. The forecast volume will be governed by the height increment and the girth increment over a period equal to the length of time for which the forecast is made. Thus if we say that we decide to forecast volume 4 years hence we base this forecast on the figures given by the actual performance of the average stem over the past four years.

Theoretically the formula is correct but the accuracy of the results it will give will depend on the accuracy of the figures used. For this reason the *average of the mean annual increments* for the various species and the various quality classes will have to be ascertained and compiled into table form. For recognition and classification purposes in the field these tables should also give height increment, diameter increment, age and volume. The relative form factor should also be given in the tables. Since all volume must be calculated to give true cubic contents a table of basal areas in square feet to 3 or 4 places of decimals should be appended. Under no circumstances should volume be estimated either by the "square of quarter girth" measurement or by the "die square" measurement. The form factor used to estimate present total volume should be used also for estimating the forecast total volume as no appreciable variation in the value of the form factor could be envisaged for the short period between one thinning and another except perhaps in young crops.

As an example let us assume that we are about to thin a stand of sitka spruce classified as quality class II from the tables; that the average of the mean annual increments is given as 260 cubic feet per acre, the height increment of the average stem has been $2\frac{1}{4}$ feet per annum, and diameter increment 8 rings per inch or $\frac{1}{4}''$ per annum; the relative form factor is given as 0.42 and the cycle is to be 4 years. (The length of the cycle will be ascertained by an examination of the annual rings; a reduction in the width of the rings below the average since the last thinning indicating the length of the most suitable cycle). If present height is 34 feet and present basal diameter is 5″ then the forecast height will be 43 feet and forecast diameter will be 6″.

$$\begin{aligned}
\text{Present total volume} &= \text{Height} \times \text{basal area} \times \text{form factor.} \\
&= 34 \times 0.13632 \times 0.42 \\
&= 1.9463 \text{ cubic feet} \\
\text{Forecast total volume} &= 43 \times 0.1963 \times 0.42 \\
&= 3.5451 \text{ cubic feet} \\
\therefore \text{Difference} &= 1.5988
\end{aligned}$$

$$\text{Divide by length of cycle (4 years)} = 0.3997$$

$$\therefore \text{Stocking after thinning} = \frac{260}{0.3997} = 650$$

Unfortunately I have had no opportunity of finding out how accurate the above formula is in practice but the results it gives for a given height and basal diameter appear to be somewhat similar to the stocking given in Revised Yield Tables for Conifers in Great Britain.

Considerations affecting costs.

Thinning—and by this I mean the severing, brashing and extraction of the stems to suitable loading sites—is, along with road making, the most expensive operation in forestry. But there is this difference that whereas the cost of the road is a charge on the forest as a whole and it is normally spread over 4 rotations the cost of thinning is charged against the individual stand to the end of the rotation. Any means of reducing the cost of thinning, therefore, should not be neglected.

Accessibility is a factor that affects both the sale and the price received for thinnings. A prospective customer will buy more readily and pay more for material that is both accessible and easily loaded. In first thinnings the value of the material removed is rather low; in fact it had little or no sale value until the wood pulp mills began to operate. But the cost of the first thinning, because it must be carried right through to the end of the rotation, will increase the carrying charges on the crop considerably. Therefore any outlay within reason that would effect a sale of this type of material is justified.

If the thinning of norway spruce stands is done from mid November to mid December an extra return can usually be got from the sale of Christmas trees from selected tops. At any other time of the year this material is either unsaleable or its value as brushwood is very low.

If extraction is done to ride lines the cost of extraction is considerably increased. Extraction lanes can be cut out in young crops by removing one line of trees every 44 yards and if the thinnings are piled in convenient lots along these lanes the shorter draw will effect a considerable saving.

Each lot of poles should rest on two or three short lengths of timber. This makes for ease in handling the poles as well as preventing decay from being in direct contact with the soil. Lots should be "faced" in the direction in which the poles will be taken out—that is butt ends should face the direction in which they will be removed.

It is not necessary to snag very light inferior poles unless there is a ready sale for them as bean stakes etc. Neither is it wise to snag any pole past a certain point except perhaps in the case of scaffolding poles. Tops should be cut off when the diameter is $2\frac{1}{2}''$ or $3''$ as it is both a waste of time and money to continue snagging beyond this point.

The men employed to carry out the thinning should work in squads of two or four, preferably four, and they should fell and snag only as many stems as they can drag out before they finish work for that day. If the men employed at severing the stems know that they will not have to snag them and carry them out they usually fell them this way and that so that butts face the wrong way and oftentimes they throw the poles across one another so that snagging is difficult and extraction more troublesome with a consequent rise in costs.

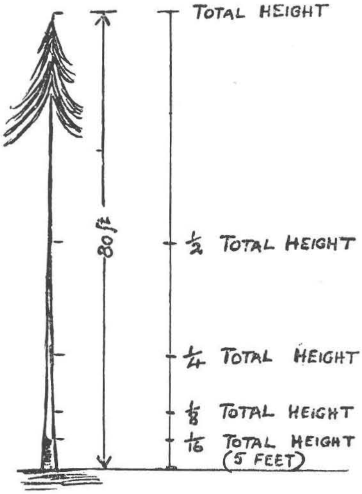
Small suppressed living stems need not be cut out inasmuch as they are "out of the running" as far as the canopy is concerned and they also afford a certain amount of soil protection. Besides the cost of cutting and extracting them would not be recouped by the amount their sale would realise.

The removal of very large stems—almost wolf stems—in an otherwise uniform crop is not recommended if they carry a straight bole for 20-25 feet or more. The adjoining suppressed stems may not recover after the removal of the large stem and even if they did their total value as lumber would be much less than that of the large stem for many years to come.

If the rate of thinning were much too heavy—besides being potentially harmful to fertility—it may represent an added expense which will have to be borne by the crop at compound interest to maturity.

Estimation.

In estimating the height of a tree without the aid of an hypsometer I have found the following method to be reliable. Stand back from the tree at a distance from which you can view the whole length of the stem without raising or lowering your head. Then visually divide the tree in half and having made a mental note of the half way mark on



the stem divide the lower half in two and continue to do so until you reach a height that can be measured (normally heights will not exceed 120 feet so that more than 4 divisions of the stem will not be needed to get a height that can be measured). This height multiplied by the inverse of the fraction that represents it will give total height.

Five feet is a height that can be measured so you multiply $5 \times 16/1$ to get the total height.

Stocking per acre can be estimated from sample plots—the triangular 1/10 acre plot is easy to count—but any other one of the well known methods may be used.

Spacing.

A fairly uniform spacing of the stems that will remain after the thinning is important insofar as it gives each stem a chance to benefit from the increased growing space resulting from a decrease in the stocking. Of course it would be foolish to sacrifice quality for exact spacing so that at all times one is obliged to leave small groups in places but nevertheless even spacing should be aimed at where possible.

Marking the Thinning.

Tne marks on the stems to be removed should be easily seen from a distance of 20-25 feet and the marks should be made on the sides of the trees in the direction in which the thinning is being marked. Thus if you mark from East to West all the marks should be on the Western side of the stems. This is so because in thinning a decision in respect of the trees to be marked in a particular group will be influenced to a degree by the trees already marked in the adjoining groups and those that will be marked further on if one is to avoid either irregular spacing or a too severe opening of the canopy.

In marking a first or second thinning it is advisable to have a helper to mark the trees. He should be both lively and intelligent and have a good memory for marking the trees pointed out to him because besides being a waste of time it is very distracting to have to turn back and point out the trees a second time.

It requires a good deal of concentration to mark a good thinning and for this reason one should never carry on a conversation while marking. Neither should one try to count the trees being marked.

It is inadvisable too to continue to mark thinnings after one gets tired and there is nothing that tires the man marking the thinning more quickly than to stand at the base of a clump of trees looking up into their crowns in an endeavour to reach a decision. Instead make a provisional selection from a distance of 10-12 yards then walk up to the clump or group and having ascertained that the boles of the trees that will remain are straight see if the crowns of the group justify your provisional selection. Then if all is well mark the doomed stems quickly. If unable to reach a decision pass on and in all probability inspiration will come on the return journey.

When marking on a steep slope start at the lower side,follow the contour of the ground while marking and of course, mark the trees on the upper side. This allows felling to be started on top of the hill and to proceed downward on a broad front the trees being thrown up hill to reduce damage and facilitate extraction.

Can the practice of marking the trees to form the final crop be recommended? Yes, but with this reservation; it should not be attempted until after the third thinning and it should include as many more trees as will form the final crop so as to obviate the danger of mechanical or other damage to the selected stems. It has this to recommend it that one need not be too well versed in thinning to remove the more obvious of the stems as time goes on.

If extraction lanes are being marked the stems to be removed should be marked on both sides and the lines flanking the lane should not be marked until the thinning is done because there is a danger that one may mark them too heavily.

Costs.

The cost of thinning will vary with the volume per acre being removed, the size of the trees and the degree of difficulty of working on the terrain but a good average figure is 25 man-days per acre. Assuming for estimation purposes that the number of working days in any year is 250 then one man will deal with 10 acres of thinning annually.

The operation of thinning is sub-divided further into the following

(1) Severing, de-branching and cross cutting.

(2) Extraction and piling in lots.

For light thinnings in which the poles do not exceed 2 cubic feet and where they are dragged to extraction lanes at 44 yards apart the cost will generally work out as follows

$\frac{5}{8}$ of total cost of thinning = cost of severing and de-branching.

$\frac{3}{8}$ of total cost of thinning = cost of extraction and piling.

Conclusion.

Thinning is a laborious job of work when you consider that you must walk anything from $1\frac{1}{2}$—2 miles to mark an average acre of thinning. The ground generally is uneven and as often as not there is a dense growth of briars etc. on the floor of the stand. Unfortunately you cannot keep your eyes on the ground and on the canopy at the same time because they are "poles" apart with the result that you will stumble often enough and possibly get an occasional fall which is not always followed by an ejaculation such as "Goodness me." And it may yet come to pass that foresters will make a contribution to the list of occupational diseases; like "housemaid's knee" they may add yet another known as "forester's neck". But joking apart if we have to thin, and thin we must for success, then if it is worth doing at all it is worth doing well.