Pruning Conifers in Ireland

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Summary

The case for pruning of conifers in Ireland is discussed and the financial implications considered. Pruning Tables produced for the major conifer species in Irish forests are described.

Introduction

The pruning of forest trees is an established practice in many countries to improve the quality of timber. In Ireland, pruning was carried out extensively in the 1950s and 60s, but has almost ceased in recent times, due mainly to its high cost with no guarantee that any cash benefit will accrue.

Recently, the view has been expressed by members of the timber trade, the Institute of Industrial Research and Standards (now Eolas) and members of the Forest Service (FS) that the quality of timber from Irish forests could be greatly enhanced by the re-introduction of pruning.

This paper summarises the findings of a Forest Service working party on pruning whose report was produced internally in 1985.

Historical Perspective

Pruning lapsed as a silvicultural practice in State forests in the early 1970s as a result of an increased awareness of the need for cost control. Prior to this all stems in a stand were low pruned or brashed (branches removed from the bottom 2m of stem), which resulted in a high cost being charged against the rotation at an early age, thus requiring a significant increase in price to justify the cost of the operation.

The timing of pruning was frequently late, resulting in the removal of dead branches, which often resulted in a cosmetic operation rather than an improvement in timber quality. Even where pruning was carried out early, the lack of a thorough recording system meant that the amount of clear timber to be expected in any stand was not known. In these circumstances, often no substantial differential in price between pruned and unpruned stands was obtained.

Reasons for Pruning

The presence of knots in sawn wood is a recognised strength-reducing factor in timber used for structural (load bearing) purposes. Currently, about 76% of sawlog dimension timber produced in Ireland has a structural end-use. In grading rules for joinery timber, knots are regarded as undesirable for a variety of reasons. However, in some instances, such as panelling, the presence of some knots may be beneficial.

In conifers, the central core of a log is composed of juvenile wood which has many undesirable properties. There is evidence that the removal of live branches (green pruning) reduces the size of this core. A pruned log may be regarded as two cylinders; the inner knotty core and an outer shell of clearwood. The smaller the inner cylinder and the larger the outer one the more clearwood available. Using the normal technique of sawing parallel to the axis of the tree, most of the conversion loss occurs in the removal of slabs from the outer shell of clearwood. Thus the wood produced by the tree in the years after pruning will be removed as conversion waste, unless the outer cylinder is reasonably thick. These points are illustrated in Fig. 1.

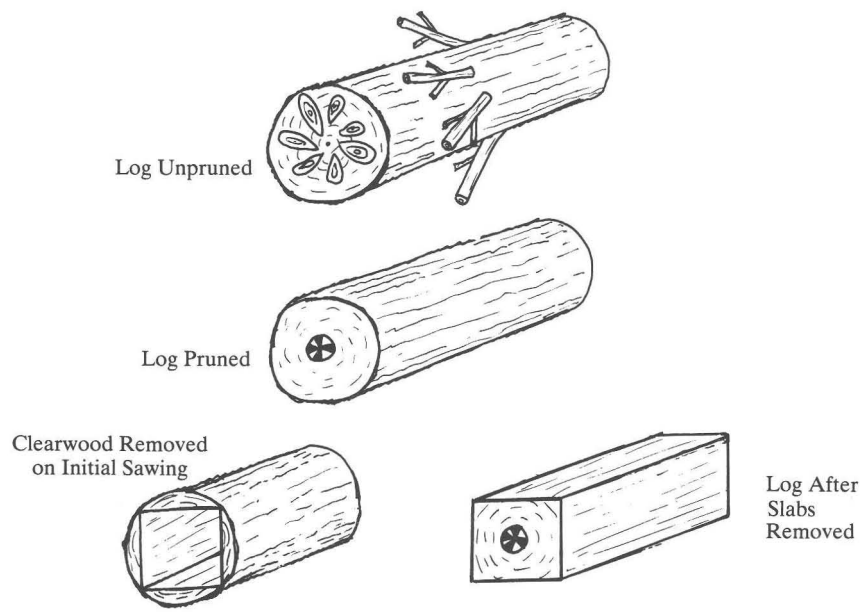

Figure 1: Effects of pruning on knottiness in round and sawn timber.

The greater the ratio of diameter at felling to the knotty core the more clearwood available on sawing. As larger diameter logs produce less percentage conversion waste, for any given clearwood to knotty core ratio,

the bigger the diameter at sawing the greater the amount of clear wood. It can be seen, therefore, that in modern plantation forests where diameter at clearfelling tends to be smaller than in old growth stands, it is essential to prune early and keep the core narrow if worthwhile quantities of clearwood are to be produced.

Pruning for Structural Timber

Increasingly, timber used for structural purposes must be graded. There are numerous grading systems and most developed countries have their own, geared to meet the needs of their particular circumstances. In Ireland the system applied to home grown softwoods when grading is required is Irish Standard Recommendation, SR11 (Anon. 1988). The use of timber graded to this recommendation is overseen by the Timber Grading Bureau of Ireland. Grading is divided between visual and machine stress grading. Two of the major features of Irish conifers which can be influenced by silviculture and in turn influence grade are: knottiness, measured in terms of knot area ratio (KAR) and rate of growth (ROG) i.e. ring width. In machine grading the separate influences of these factors are not easy to isolate. This is because a force is applied to a plank, the response is measured and a grade is assigned. The response is determined by all the properties of the plank which affect its strength. In visual grading, however, all the strength-affecting elements are assessed separately according to a set of rules andd thus the effect of knots on grade can be directly determined.

Using visual grading, the importance of pruning is clearly illustrated by a series of grading studies undertaken by the Forest Service as shown in Table 1.

Table 1: Visual Stress Grading Results. (Graded on KAR only)

Material	Treatment	% planks per grade		
		SS	GS	Reject
Sitka spruce (Fitzsimons 1980)	Pruned	28	57	15
	Unpruned	3	47	50
Lodgepole pine (Coastal) (Phillips 1978)	Pruned	90	0	10
	Unpruned	86	5	9

SS=special structural. GS=general structural (Anon. 1973).

Pruning for Joinery Timber

Joinery grades are all visual and excessive knottiness is the most common reason for rejection. This is of particular importance in Ireland in relation to lodgepole pine. There are 60,000 ha of coastal provenances from Washington and Oregon (LPC) planted in this country, most of them at initial densities of 2,500 stems/ha. As is shown in Table 1 knots are potentially a serious problem. The difficulties posed by poor stem form have been considered elsewhere (Fitzsimons 1982); they are the subject of current research and will not be discussed here. Tests carried out in the 1960s on home-grown LPC have shown it to be an excellent joinery timber, similar in many respects to Scots pine (Dunleavy et. al. 1969).

Given the wide spacing of most plantings since the early 1960s, pruning appears to offer the chance of converting much of this material from palletwood to joinery timber.

When is Pruning Justified?

After allowing for the occlusion of the branch stubs the layers of timber added annually to the pruned portion of the tree will be clearwood. In a straight log, once formation of the clearwood starts, some improvement in sawn wood quality can be expected. As can be seen from Fig. 1, however, if the only clear timber left after slabbing is in the corner of the squared-off log, the improvement would be very slight indeed, and not likely to fetch a premium to repay pruning costs.

In commercial forestry practice, the amount of clearwood required is that which will obtain an increase in price sufficient to repay the compounded costs of the pruning. A variety of factors will affect the calculation of what size the shell of clearwood must be to enable such a premium to be paid. These factors are summarised under the two interrelated headings of utilisation and financial considerations.

(i) *Utilisation*

Before embarking on a pruning programme the objectives, in terms of the kind of produce, must be clearly defined. Six species are considered in this context. They are:

Sitka spruce
Norway spruce
Coastal lodgepole pine
Douglas fir
Scots pine
Japanese/hybrid larch

Sitka spruce

Because of the fast growth rate of this species there were fears that Sitka spruce, in certain circumstances, would not produce structural timber.

However, the results of recent studies in Ireland indicate that growth rate may not be as serious a degrading factor as was previously thought (Picardo 1986). Some of these studies have indicated that knottiness does have a significant effect on reducing strength, even under the silvicultural regimes employed i the past. The effect of knots in causing degrade is greatly increased when spacings wider than 2m were examined.

Sitka spruce can be used for structural purposes. It dries quickly but, because of rapid growth rate, very mild schedules have to be used when kiln drying to avoid distortion. While spruce is not as strong as pines, larches or Douglas fir, it has greater strength/weight ratio, this making it ideal for structural timber providing its KAR is acceptable.

Norway spruce

Norway spruce is a general purpose timber and in the past its small knots have not been considered a severe drawback to quality. Under modern silvicultural practices it is doubtful if this would apply to Irish grown Norway spruce. It has similar properties to Sitka spruce, is slightly less strong, but it may be used in low grade joinery. No grading studies have been carried out in this country in order to establish the effect of knottiness on timber quality. However, it is likely that results similar to those found for Sitka spruce would apply.

Lodgepole pine

As a structural timber, on achieving the grade, lodgepole pine is considerably stronger than spruce. It is particularly suitable for joinery purposes, and with appropriate silvicultural practice, is considered superior to Scots pine (Evertsen 1987). It finishes better, has much less obvious heartwood, and has a lesser difference between the properties of early and late wood, than Scots pine.

Grading studies have indicated serious degrade due to knots. This is the species where pruning is most essential, if the timber is to have any chance of becoming a high-value product. Due to its short rotation, compounded pruning costs are moderate. The potential benefit is the movement of the end-product from palletwood to first class joinery timber.

Scots pine

Pruning will benefit this species for reasons similar to those given for lodgepole pine (coastal). Its established place as a high-class joinery timber makes this pine suitable for pruning, specifically to produce clear timber. However, slow growth of Scots pine relative to many other species, will increase the real cost of pruning.

In many countries it is the first choice for transmission poles. Pruning for this purpose may not always be necessary, though in Ireland Scots

pine is not rarely used for transmission poles due to previous breakages at knot clusters.

Douglas fir

Douglas fir is an excellent structural timber, and can also be used for joinery, providing knots are eliminated. Consignments of home grown Douglas fir tested by Eolas have been severely degraded for structural uses due to knots, such material was also unsuitable for joinery. Larch and Douglas fir have the greatest strengths of the species considered here.

In summary, the production of structural timber of the highest grade will be the aim with Sitka spruce, while with pines it will be the production of joinery timber. The other species will be pruned with a view to supplying either market. For both types of product the pruning strategy will be the same – the removal of branches as early as possible without reducing increment and the production of the maximum amount of clearwood.

There are products where a different pruning schedule might be emphasised, for example, certain types of joinery (as previously mentioned) or transmission poles. It can be safely assumed that sufficient timber with live knots will always be available for the former so pruning for such a limited outlet will not be considered here. In the case of transmission poles, in some countries a late pruning is carried out to provide a knot-free skin. In Ireland such measures are not required for the transmission pole market, however if an export trade developed they might be considered. For the purposes of this discussion it can be assumed that nearly all pruning will have as its aim the production of maximum amounts of knot-free timber for joinery and structural end-uses. Thus the pruning strategy in both cases will be similar, except that for joinery, shorter log lengths are acceptable.

(ii) *Financial Considerations*

Based on growth and yield research for the six species, estimates can be made of tree diameters at clearfelling for numerous combinations of growth rates and silvicultural practices. Similarly, pruning research indicates the smallest diameters at which branches can be removed without significantly affecting the growth of the pruned trees (Gallagher 1875). Combining the two, the time taken to produce varying amounts of clearwood can be calculated. Before deciding to prune, however, it is necessary to decide whether any given proportion of knot-free wood will pay for the pruning required for its production.

At present, most timber in this country is sold standing or in lots segregated only by size. There is no reason, however, why pruned stands could not be segregated into pruned logs and unpruned logs. Whether segregated or not, the price obtained for the stand must cover the cost of pruning, compounded at a selected interest rate, at time of felling.

While the cost of pruning can be directly measured there is surprisingly little definite information on the exact relationship between improvement in quality (and therefore value) and the amount of clearwood. Both the relationship and the amount of information vary with species. To further complicate matters the techniques and efficiency of different sawmills will have a bearing on the relationship and the results will be different depending on whether joinery or structural timber is being produced.

To illustrate this, a cubic metre of LPC upgraded by pruning from palletwood to joinery timber would increase it's value by a greater factor than the same volume of Sitka spruce in which the outturn of top grade boards rises from 60% to 80%. There is, however, no information to quantify this.

The approach taken in this investigation has been to (a) examine the literature available to decide on the amount of clearwood required to attract a premium and (b) based on discussions with wood processors and experts from Eolas estimate the premium likely to be achieved by the various species considered, given that amount of clearwood.

How much Clearwood is Required?

There is no definitive answer to this question. From the literature available, it appears that 10cm of clearwood is the minimum necessary to attract a premium (Henman 1963, Fenton 1976, Walderidsson 1981). Any less than this is unlikely to produce a significant improvement in the sawn timber, though as mentioned previously, the value of any given amount of clearwood will vary with species, end-use and sawing technique. Size of tree will also have a bearing; the larger the tree the greater the volume of clearwood produced.

Some foresters are convinced that the removal of branches a few years before felling, attracts higher prices due to the improved appearance of the trees; however, this cannot be verified.

Given the differences of opinion in the literature and also among sawmillers and lack of conclusive information, it was decided that pruning should be carried out in a manner which would produce trees at clearfelling with a diameter at breast height (DBH) of 2.5 times the diameter at time of pruning. All sources consulted indicated that this would produce sufficient clearwood to attract a premium for the six species as they are commonly managed in Ireland. In terms of pruning height, it was considered that a clear butt section of 5m should be produced for all species except LPC, where a 3m section was considered useful and attainable. Two factors restricted the recommended pruning to the butt section; the greatly increased costs involved and reduced clearwood produced with higher pruning. To achieve a 5m pruned section, pruning to 6m is recommended and to achieve a 3m section, pruning to 4m. This is to allow for loss of length during harvesting.

Accepting the 2.5:1 ratio as the target for clearwood production a series of tables were constructed to indicate how this might be achieved.

The financial aspects were then examined. Rather than attempt to predict the premiums attainable for all the species concerned the approach taken was to indicate the percentage increase in price required (based on current prices for unpruned material) to repay the compounded costs of pruning at time of felling.

The Pruning Tables

The tables were constructed in order to estimate the ages at which the pruning operations would have to be carried out in order to obtain the 2.5:1 clearwood to knotty core ratio. They are also used in the economic analysis. For each yield class and species, a range of five ages of first-stage pruning is given and the ratio of the DBH of the 500 largest trees per hectare at pruning to the mean DBH at clearfelling is given. This ratio is used as an estimate of the clearwood to knotty core relationship of the final crop trees. All tables assume 2,500 stems/hectare initial stocking, and that no thinning will be carried out prior to pruning for any of the five first-stage ages given. They are based on Forestry Commission, UK yield models (Edwards & Christie 1981) with the exception of the LPC table which is based on Irish data (Anon. 1976). The age of second stage is calculated mainly from Forestry Commission information. It is the estimated age at which the full 6m can be pruned without removing more than 40% of the live crown and assumes normal thinning practice, except that some allowance is made, based on observations in early thinned stands, of the likely effect of early thinning on crown development.

The tables produced are based on a maximum of two 'lifts', or pruning operations. Further lifts were not considered as being logistically or financially practical. The aim is to reach the target height as early as possible without removing more than 40% of the live crown in any operation. A series of pruning experiments conducted by the Forest Service Research Branch indicates that this is the maximum that can be pruned without seriously reducing tree growth in some species (Gallagher 1975).

The timing of the second lift allows for the fact that the initial pruning artifically reduces the live crown. A further 40% of the crown obviously cannot be removed a year after the first lift.

Tables 2 and 3 are examples produced for Scots pine, similar tables are available for the other 5 species. They cover only the range of yield classes for which a ratio of at least 2:1, final diameter to knotty core (DBH:KC) ratio can be achieved by the age of maximum mean annual increment (MMAI).

In the tables 'Normal' first thinning age refers to Forestry Commission recommended age.

The 'Reqd. Rotation' indicates the age to which the crop would need to be grown to give the 2.5:1 ratio, using conventional silvicultural practices.

Table 2: Example of Pruning Table including crop statistics.

SCOTS PINE

First Lift Before or at Thinning (3m)				Second Lift Post Thinning	Clearfell				Ratio	Reqd. Rotation (Yrs)	'Normal' 1st Thinning Age
YC	Age	Mean DBH	Top DBH	Max. Age	Age	Mean DBH	No. Stems	Total Vol(m^3)			
14	17	12	16	25	66	49	230	475	3.1	53	21
	18	13	17						2.9		
	19	13	17						2.9		
	20	14	18						2.7		
	21	14	18						2.7		
12	20	12	16	29	69	46	260	429	2.9	59	23
	21	12	16						2.9		
	22	13	17						2.7		
	23	13	17						2.7		
	24	14	18						2.6		
10	23	12	16	33	73	41	310	388	2.6	70	25
	24	12	16						2.6		
	25	13	17						2.4		
	26	13	17						2.4		
	27	14	18						2.3		
8	28	12	16	39	77	35	380	336	2.2	90	29
	29	12	16						2.2		
	30	13	17						2.1		
	31	13	17						2.1		
	32	13	17						2.1		

Table 3: Example of Pruning Table for field use (with footnotes)

Applied to Unthinned Stands or Stands at Time of First Thinning

Species	YC	Earliest Age of Pruning	Max. Height of Pruning at this Age	Latest Age of Pruning	Second Lift Age
Scots pine	14	17	3m	23	25
	12	20	3m	25	29
	10	23	3m	24	33
Norway spruce	22	17	4m	21	21
	20	18	4m	23	23
	18	19	4m	24	24
	16	20	4m	25	26
	14	22	4m	26	28
	12	24	4m	27	31

1. 400 stems per hectare should be pruned.
2. No yield classes lower than given in these tables should be considered.
3. There is flexibility as indicated in time of first lift. However, second lift to 6m should never deviate by more than one year either side of the age indicated in the tables.
4. If even one growing season elapses between thinning and pruning these tables will be invalid and DBH assessments to establish ratios must be taken.
5. If stand is understocked, or if initial spacing is outside the range 1.9m-2.1m (2,800-2,400 stems/ha) these tables will be invalid and DBH assessments to establish ratios must again be taken.

Financial Return

Tables 4 and 5 show, by species and yield class, the premiums required to repay, at an interest rate of 4%, the compounded costs of pruning as recommended in the Pruning Tables. The base price on which the premium is calculated is the average price for sales from State forests over a ten year period; the costs are based on Forest Service costings data. Figures are given only where a 2.5:1 ratio of felling DBH:knotty core can be achieved by MMAI using 'normal' silvicultural management.

Pruning in Practice

In situations of normal Irish stand management, that is, 2,500 stems/ha initial stocking and thinning to marginal intensity thereafter, the Pruning Tables will indicate pruning times and heights. Some other factors to consider are:

(i) Selection of Stands

The stands to be pruned will be primarily those on good sites. They must

be capable of producing trees of sufficient diameter and thus clearwood in a short enough time to repay pruning costs. The sites must be stable to allow the pruned trees to reach the target dimensions. This is a very important consideration and will exclude many Sitka spruce and LPC stands which might otherwise be suitable. Stands where access problems are likely to preclude the necessary thinning operations should not be pruned and isolated stands in areas where the bulk of the forest is not going to be pruned should be carefully considered before a decision is made.

Table 4: Premium Required/m^3 at MMAI after Pruning as Recommended in Pruning Tables

Expressed as a Percent of Base Timber Price*

No. Stems Pruned 600

	YIELD CLASS								
Species	24	22	20	18	16	14	12	10	8
Scots pine						16	18	20	
Norway spruce		10	11	12	14	15	17		
Larch						12			
Sitka spruce	7	8	8	9	10				
Douglas fir	8	9	10	11	12				
Lodgepole pine (coastal)				6	7	7			

Assumptions:

All species 4m first lift at earliest age in tables.
Second lift 2m at recommended age.
*Ten year average for State Forest sales, unpruned.

Table 5: Premium Required/m^3 at MMAI after Pruning as Recommended in Pruning Tables

Expressed as a Percent of Base Timber Price*

No. Stems Pruned 400

Species	YIELD CLASS								
	24	22	20	18	16	14	12	10	8
Scots pine						11	12	14	
Norway spruce		7	7	8	9	10	11		
Larch						8			
Sitka spruce	5	5	6	6	7				
Douglas fir	6	6	6	7	8				
Lodgepole pine (coastal)				4	5	5			

Assumptions:
All species 4m first lift at earliest age in tables.
Second lift 2m at recommended age.
*Ten year average for State Forest sales, unpruned.

Where many stands are suitable but resources for pruning are scarce, priority should be given to species in the following order:

1. LPC and Scots pine.
2. Larch and Douglas fir.
3. Norway spruce.
4. Sitka spruce.

This ranking is based on the estimated improvement in value attainable. It is rather tentative and may be subject to change in the light of further information. For example, widely spaced Sitka spruce (2.2m or greater) should

be given priority over larch and Douglas fir as there are indications that, if unpruned, it may produce low yields of high grade structural timber.

(ii) *Selection of Trees*

(a) Number of Trees

This should not exceed the number expected to reach the diameter required, except to provide a small reserve against accidental loss. As thinning cycles and intensities will always vary in practice it is not possible to recommend precise numbers applicable to all species and conditions. For this reason a figure of 400 stems/ha is regarded as a reasonable overall figure for all species and yield classes to allow for attrition of pruned stems, where the rotation is age of MMAI. The single exception is LPC where 600 stems/ha should be pruned. This is because the number of trees at clearfelling is greater than with other species due to the shorter rotations applied for LPC in Ireland.

(b) Type of Tree

These must be the largest and most vigorous of the dominants in the stand, unless they are unsuitable. Reasons for rejection include crokedness, forking, leaning, heavy swelling at whorls and branch bases, severe spiral grain, damage or signs of disease (Henman 1963). Coarse branching is not a good reason for rejecting a tree. Any dominants not pruned must be removed in early thinnings least they interfere with the growth of the pruned trees. It is vital to remember that there is no point in pruning a tree which will subsequently be suppressed.

(iii) *Season of the Year*

There is no clear evidence of disease or insect damage in this country from pruning in any season.

(iv) *Thinning of Pruned Stands*

Thinning should be to marginal intensity, favouring the pruned stems and removing in particular competing unpruned dominants or 'wolves'.

(v) *Pruning not in accordance with the Pruning Tables*

Many stnds will not conform to the management systems implied in the Pruning Tables. In most situations where future management can be controlled, yield models are available to estimate tree size in the future. Thus the age at which the 2.5:1 ratio will be achieved can be predicted with reasonable assurance, even if diameter at pruning exceeds the Pruning Table values. However, it should be remembered that if greater diameter is required this may involve greater terminal heights and the question of stand stability must not be overlooked. The ratio itself is only a guide. However, if pruning is done outside the strictures of the Tables the figures for premiums required to recoup the investment presented in Tables 4 and 5 may not apply.

(vi) *Records*

Pruning operations should be recorded in such a way as to allow the purchaser to have an accurate assessment of the amount of clear timber in the stand at felling.

The earlier the pruning the more clearwood will be available and the greater the value of the record. Pruning in state forests in Ireland lapsed in large measure due to the fact that timber buyers could not accurately gauge the amount of clearwood in pruned stands which had frequently received late or cosmetic pruning. Thus premiums for pruned lots were small, in turn leading the grower to conclude that pruning did not pay.

The working party considered that accurate recording of pruning details is vital to maximise the return from pruning.

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