PROFITABILITY OF PRUNING WHITE PINE

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RESUME

On pourra réaliser de bons profits si on émonde des gros pins blancs âgés de moins de 80 ans, considérant que les planches de qualité D sélect sans noeuds sur une face se vendent au prix fort. Ce que sera la bille de souche de 16 pieds peut être efficacement émondé au moyen d'une scie à perche. Le coût de l'émondage diminue à mesure que le peuplement vieillit, et la croissance par décennie est à peu près régulière entre 40 ans et l'âge de la rotation qui est de 120 ans. L'auteur recommande que 40 ans s'écoulent entre l'émondage et la récolte: on obtiendra ainsi une production économique maximum de bois sans noeud.

ABSTRACT

Good profits are possible from pruning select large eastern white pines up to 80 years old, considering the acceptability of clear one-face boards as D Select lumber commanding a premium price. Pruning 16-foot butt logs with a pole saw is advocated as an efficient method. Pruning costs decrease with increasing stand age, and growth per decade is fairly uniform between age 40 and a rotation of 120; balancing compounded costs and conservatively estimated clear wood yields, a period of 40 years between pruning and harvesting is advocated.

PRUNING ESSENTIAL FOR QUALITY PRODUCTION

Pruning of eastern white pine (*Pinus strobus* L.) can be a profitable proposition. It is, moreover, a necessity if white pine is to maintain its market position as the most favoured softwood lumber for many uses. The wood's reputation stems from its unequalled properties of uniform texture, density and straight grain, but this reputation was built on old-growth timber which contains a fair proportion of clear wood as a result of natural pruning. The end of the old pine in Ontario and Quebec is in sight—apparently less than two decades away at present depletion rates. So-called second growth trees, those younger than the general rotation age of 120 years (Horton and Bedell 1960), are forming an increasing portion of the pine cut; they may yield a higher average (mill run) dollar value than old growth trees but they yield only 2 to 10% lumber of D Selects grade or better, according to grading studies in Ontario² and in the North-eastern States (Fedkiw *et al.* 1960). Since sub-average grade pine material is plentiful throughout the pine region, it commands a poor price and its competitive position is not promising.

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² Data obtained by Forest Products Research Br., Dept. of Forestry, and by Ont. Dept. of Lands and Forests.

Thus the writing is on the wall. If eastern white pine is to compete with other wood and alternative building materials, it must be through the maintenance of a supply of high-quality timber. There are only two silvicultural measures by which clear lumber yield can be increased—by maintaining stand density sufficient to maximize the rate of natural pruning, or by pruning artificially. As to the former, higher density implies slower growth, and in any case dead branches are retained so long in eastern white pine (Paul 1938) that clear wood production is unacceptable within the normal economic rotation. Artificial pruning, then, seems essential to the economic future of white pine.

CAN LARGER TREES BE PRUNED PROFITABLY?

The object of this study is to examine the silvicultural efficiency and economic limits of pruning second-growth white pine. Of particular interest is the feasibility of pruning stands 60 to 90 years old, which appear to be predominant in the existing pine forests of Central Canada and which will soon support the bulk of the pine lumber industry. Work by Smith and his associates (1956b, 1961) has clearly indicated that handsome profits are realizable from pruning large Douglas-fir in this age range.

The pertinent literature on pruning is extensive. Henman's (1963) studies in England provide an apt comprehensive background reference. For white pine specifically, pruning reviews have been presented by Stiell (1959), Horton and Bedell (1960), and Funk (1961). Most of the work concerns young stands, usually plantations. For many years the consensus was that the smaller the diameter of the tree at time of pruning, the greater the return from clear wood production. This is certainly the case if tree growth alone is considered, but not necessarily so, as will be shown, if cost and utilization factors are taken into account. There is, of course, a minimum tree size suitable for pruning; reduction of the live crown by more than 50 percent is said to reduce height growth of young white pine by one-third (Hawley 1935). It has been repeatedly stated that the maximum girth for pruning should be 4 to 6 inches, or in some cases 8 inches dbh. (Cline and Fletcher 1928; Hawley and Clapp 1935, 1942; Curtis 1939; Bickerstaff 1942; Campbell 1956). However, one school of thought in New York State holds that it is profitable to prune select trees up to about 12 inches in diameter and two logs (35 feet) in height (Foster and Kirkland 1949, Fedkiw *et al.* 1960). This treatment applies to the choice 25 or 30 trees per acre, in conjunction with frequent thinnings to favour their growth, and these trees would be carried beyond the normal stand rotation to the point of optimum value increment.

Presumably if such pruning of larger pines is a worthy investment in neighbouring New York, it should apply in Canada, at least to the better crop trees on the better sites under intensive management. This is the main issue under examination. To test it, pruning method and time studies were carried out in a variety of white pine stands in central Ontario. From these trials, pruning costs were obtained, then profitability was calculated by relating these costs to known growth rates and diagrammatically determined clear-board recovery.

In selecting crop trees for pruning, the main criteria were a vigorous crown, straight bole, absence of obvious defects, and light to moderate branching.

POLE SAW PRUNING MOST EFFICIENT

The first step was to compare the efficiency of several pruning methods under uniform conditions, namely in an 80-year-old white and red pine stand, well stocked and fairly uniform in spacing, with 25 trees per acre marked for pruning. The methods were:

1. Hand saw and 10-foot aluminum tripod ladder, pruning to 17 ft.
2. 12-foot pole saw from the ground, pruning to 17 ft.
3. 10-foot pole saw, hand saw, Swedish tree ladder (two 10' sections attached).
4. Hand saw, climbing spurs, safety belt, pruning to 34 ft.

The use of climbing spurs with inexperienced men proved too fatiguing and slow, so this technique was abandoned early.

Efficiency comparisons of the other methods are provided in Table 1.

Pole sawing from the ground to a height of 17 feet proved markedly more efficient than other methods and was adopted for further tests. Mollenhauer (1938) discounted pole saws because of unwieldiness and flexibility, but these drawbacks are remedied in light, rigid, sectional or telescopic types now available. In actual sawing time the California hand saw was as fast as the pole saw, but the handling of the tripod ladder reduced production. The wide crop tree spacing involved in natural white pine stands would reduce the efficiency of any pruning method involving unwieldy equipment, including power pruners which compare favourably in cost with manual pruners in pine plantations according to Lemmien and Rudolph (1963).

The high-pruning technique involving the 20-foot Swedish tree ladder gave

TABLE 1
COMPARISON OF DIFFERENT PRUNING METHODS

Method	No. of Trees Pruned	Height Pruned (Ft.)	Average time per tree		No. of Trees Pruned Per Hour ³
			Pruning ¹ (Seconds)	Moving ² (Seconds)	
1. Handsawn from tripod ladder	18	17	173	21	20.8
2. Polesawn from ground	69	17	118	15	30.5
3. Handsawn and polesawn from Swedish ladder	63	34	571	44	6.8 (13.6 logs)

¹ Pruning time included equipment handling.

² Average moving distance in each method was about one chain (66 ft.).

³ No allowance made for resting.

better results than anticipated. With practice, considerable facility was achieved in handling the equipment. The average timing per tree of the various actions was as follows: ladder installation—112 sec., pruning first log—37, attaching safety belt and elevating pole saw—52, pruning second log—271, descending and dismantling—55, moving—44; total 571 seconds. However, it is evident that the cost of pruning the second 16-foot log is exorbitant compared with that of the first log, so the method is not advocated except for situations where high level pruning is especially desired, economy notwithstanding. The desirability of pruning many one-log trees rather than few two-log trees in a stand is emphasized by Heiberg's (1942) claim that two-thirds of the value of a white pine tree is found in the first 16-foot log. Calvert (1963) also has shown that the quality of the butt log in white pine of various ages is clearly superior to that of upper logs.

TABLE 2
COMPARATIVE PRUNING COSTS IN STANDS OF DIFFERENT AGE

Stand age	No. of trees pruned	Av. dbh (in.)	Av. No. of branches per log ¹				Av. pruning time per tree ² (seconds)	Av. cost per tree ³ (cents)	Mortality allowance ⁴ (per cent)	General cost per tree (cents)
			live small	live large	dead small	dead large				
35	60	4	7	7	42	8	260	10.1	35	14
55	160	8	2	2	32	4	203	7.9	30	10
80	70	14	0	0	14	5	160	6.2	25	8

(1) Small branches less than 1 inch diameter; large more than 1 inch.

(2) Pruning time includes 15 seconds moving from tree to tree and 20% allowance for rests, etc.

(3) Costs based on \$1.50 per hour, prevailing wage for trained forest workers.

(4) Mortality allowances were chosen arbitrarily.

TABLE 3
GROWTH RATE IN RELATION TO TREE SIZE

Tree class	No. of trees sampled	Dbh	Av. ht. (feet)	Av. crown ratio	Av. radial increment per decade (inches)
80-year-old pine stand					
					(1)
Intermediate	26	8.6-12.5	80	.341	0.45
Codominant	25	12.6-16.5	88	.421	0.75
Dominant	10	16.6*	94	.433	1.02
110 - 120-year-old pine stand					
					(2)
Intermediate	24	8.0-11.5	72	.360	0.28
Codominant	36	11.6-16.5	84	.370	0.49
Dominant	26	16.6-20.5	89	.430	0.71
Dominant*	2	24	93	.460	0.80

(1) radial increment at breast height;

(2) at top of 16-foot log.

PRUNING COSTS LITTLE IN OLDER STANDS

Pruning time studies carried out in three different stands provided an indication of the effect of stand age on pruning cost. The three stands were on comparable site conditions and represented different stages in normal development from mixed pine-aspen-white birch in the 35-year-old age class to almost pure white and red pine in the 80-year age class. In the younger stands a Meylan saw and 6-foot pole saw were used to prune the lower portion of the butt log and a 12-foot pole saw the remainder to 17 feet.

It was found in each stand tested that pruning cost did not increase significantly with increasing tree diameter within the range sampled. Some studies have indicated a considerable increase in pruning time with tree diameter (Shaw and Staebler 1950; Smith 1954; Campbell 1956) but others (Smith and Walters 1961; Smith *et al.* 1961) suggest that this range is relatively small. It depends on the rate of natural pruning which, though it varies widely from tree to tree, increases with tree size. Thus, though larger trees have somewhat larger branches, this is offset by faster natural pruning.

These cost figures resulted from carefully timed special pruning jobs. The moving allowance of 15 seconds was the average timing tested in the 80 and 55 year stands for an average distance of one chain between trees, considerably wider spacing of crop trees than would normally be expected. Ample allowances were made for resting and for subsequent loss of crop trees due to mortality or damage (Table 2).

The costs are lower than those generally appearing in the literature on pruning of red and white pine, for which figures of 20 or 25 cents per tree are common (Ralston and Lemmien 1956; Fedkiw *et al.* 1960; Berry 1964). However, they compare favourably with costs incurred locally in larger-scaled pruning operations. Piece rates recently paid in one area by the Ontario Department of Lands and Forests to workers pruning red and white pine plantations varied from 8 to 15 cents per tree. In another operational pruning of select white pine in a 75-year-old mixedwood stand at the Petawawa Forest Experiment Station the cost of pruning 16-foot butt logs of 20 trees per acre on 7 acres averaged 11.6 cents per tree with a 20% resting allowance.

The costs of marking prunable crop trees, of supervising pruning, and of other overhead items have not been included in these figures so that the cost of pruning *per se* would be clear. Much of the overhead cost would be incurred in an intensively managed stand whether pruned or not. However, to incorporate an ample blanket allowance for overhead, the actual pruning costs were increased by 50% and profitability was calculated accordingly, as presented in Table 4.

The salient feature is the reduction of pruning cost with increasing stand age, obviously attributable to natural pruning. The particularly low cost of pruning the butt log of the 80-year-old trees is a key point in the argument that follows.

BEST GROWTH ON LARGER TREES

To maximize profits, pruning should be confined to select, fast-growing trees in the stand. The rate of growth and the growth period between pruning and harvesting become the next major issues. It has been suggested that a diameter increment of at least 1.5 inches in 10 years is needed to make pruning pay

TABLE 4
CLEAR WOOD YIELDS AND PROFITS FROM PRUNING OF 16-FOOT BUTT LOGS,
CALCULATED FOR VARIOUS GROWTH PERIODS AND TREE SIZES

Stand Agent Pruning yrs.	Growth Period yrs.	Tree Size Class				Dominant +			
		Intermediate		Codominant		Dominant		Dominant +	
		Clear ¹ Yield bd. ft.	Return ² %	Clear Yield bd. ft.	Return %	Clear Yield bd. ft.	Return %	Clear Yield bd. ft.	Return %
40	120	40	2.8	102	4.1	202	5.7	304	5.5
40	100	24	2.9	61	4.6	114	6.6	214	6.6
60	120	27	3.7	77	5.6	150	6.7	228	7.5
40	80	11	2.5	27	4.8	56	8.2	107	8.4
60	100	21	5.0	35	6.3	72	8.3	139	10.1
80	120	27	6.2	43	7.5	85	7.8	155	11.0
40	60	0	0	0	0	24	12.2	37	11.5
60	80	0	0	0	0	27	11.6	43	14.2
80	100	0	0	0	0	32	10.7	43	15.5

¹ Clear Yield = clear board footage as calculated diagrammatically (see page 11 and Figure 1).
² % return calculated from the formula $\frac{C_o}{1.0p} = C_n$ where

C_n = clear yield x increased value of 5 cents per bd. ft.
 C_o = tested pruning cost per log as in Table 2 (which includes allowances for pruner's moving and resting and for mortality of pruned trees), increased by 50% to cover overhead.

(Davis 1958). A minimum period between pruning and harvesting of 30 years has been proposed (Hawley and Lutz 1943). This would provide a clear wood shell four inches thick around the knotty core.

To obtain data pertinent to Ontario conditions, growth rates were determined from two different pine stands:

Case 1. — The 80-year-old white-red pine stand at Petawawa in which pruning tests were carried out.

Case 2. — A 110-120-year-old pine stand which had developed from a pine-aspen-birch mixture (these data were taken from stem analysis records obtained 40 years previously at Pakesley, Ontario).

Within each case radial growth was fairly constant for each decade after 40 years of age, so an average radial increment figure is given, varying with size class (see Table 3). In the 80-year stand radial growth at breast height was used, whereas in the 110-year stand growth was measured at the top of the first 16-foot log. The latter is preferable considering that log scaling is done at top diameter and that taper is accounted for. Taper would tend to reduce after pruning because wood growth increases with height. Smith (1956a), for instance, in Douglas-fir, found that diameter growth at 16 feet was 116% of that at breast height. Because of these points, plus the fact that the rotation age is more suitable, the 110-year rather than the 80-year case will be used in following profitability calculations. Since the chosen stand was unmanaged and the pine had developed quite slowly as an understory, the growth rate may be considered conservative, doubtless much less than would be attained under intensive crop tree improvement.

It should be noted that radial growth rate increases with increasing tree diameter and crown ratio (live crown length over tree height), indicating that the selected crop trees should be the most vigorous individuals or those with crowns that can best benefit from thinnings. A crown ratio greater than .40 seems desirable.

CLEAR-ONE-FACE BOARDS ACCEPTABLE

The white pine lumber grade "D Selects" (Anon. 1960) permits *one side* of a board to be No. 2 grade or better, namely, providing for a fair number of red and black knots, particularly on the back width. This situation appreciably reduces the clear shell thickness requirement; the allowances required for bark thickness and stub healing, which others have set at 2 inches of diameter growth (Hawley and Lutz 1943) can thus be reduced to about 1 inch, since the bark is generally 0.5 inches (range 0.3-0.6) thick (see Fig. 1).

To determine the production of clear lumber involving boards clear on one as well as two faces, it was deemed necessary to set aside existing log rules and calculate board recovery from diagrams representing different log sizes (i.e. growth rates) and different growth periods between pruning and harvesting. Figure 1 provides an example, using the growth rates of the 110-120-year-old stand. To simplify the tabular presentation the rates were rounded off and calculated to compare growth after pruning at ages 40, 60, and 80 years and leaving the trees to 120 years. Production from the same trees if cut at 80 or 100 years was calculated similarly (not shown) and the results are given

Figure 1.
Diagrammatic Clear Board Recovery for Various
Top Log Sizes and Growth Periods Between
Pruning and Cutting at 120 Years

in Table 4. As to the diagrammatic method of determining board recovery, the following explanations are warranted. Actual bark thicknesses encountered are used. There is no allowance for branch stubs protruding beyond the bark line after pruning, but the clear-one-face approach takes this into account in the inside boards of each tangent. Board recovery on one tangent only is shown for each growth period; recovery on the opposite side of the log has been assumed identical, and required board width reductions have been applied to the other two tangents of the log in calculating total recovery. This presupposes perfectly round and cylindrical logs and optimum sawing recovery, situations which do not exactly apply but have been assumed for standardization. A standard sawn board thickness of 1 inch has been used, with a minimum slab thickness of 1 inch, and a band saw kerf allowance of 6/32 inch. The board yield estimate is considered quite conservative because of the somewhat slow growth rates used and also because of the top log scaling which ignores additional clear wood at the butt end resulting from taper. Taper sawing would be advocated to minimize slab loss.

The diagrammatically calculated clear wood yields following pruning and cutting at different age combinations are given in Table 4. Analyses were made for 16-foot logs and for the 10, 14, 18, and 24 inch diameter classes, which respectively represent the intermediate codominant dominant and largest trees.

NATURAL CLEAR WOOD YIELD SMALL

It remains to calculate the value increment resulting from pruning—the difference in value between the resultant clear lumber and the lower grade knotty lumber that would have grown without pruning. The main problem is in evaluating clear wood development through natural pruning. Indications from the literature are that natural clear wood production would be small. Paul (1938) found that dead branches on white pine persisted an average of 27 years and up to 73 years, producing lowest grade lumber with loose knots all this time.

Felkiw *et al.* (1960) cite a grade yield comparison between butt logs from a 70-year-old stand at Holderness, New Hampshire, pruned 30 years prior to harvest, and unpruned butt logs from other stands. The former yielded 29.7% C Selects and better and 69.0% No. 1 Common and better, compared with the latter's 1.3 and 13.9% respectively (N.E.L.M.A. grades).

Grade yield in Ontario³ as determined from sawmill recovery involving 484 logs in the 70-90 year age class located on the Petawawa sand plains were as follows: D Selects—0.1%, No. 1—28.6%, No. 2—28.1%, No. 3—30.2%, No. 4—8.2%, No. 5—4.8%. Thus in stands less than 90 years of age natural clear wood production is likely to be negligible. There are no pertinent data available for stands about 120 years old, which are practically non-existent in Ontario. In allowing for natural pruning at this rotation, therefore, the only recourse is to be amply conservative in the value differential between pruned and unpruned logs.

³ Data supplied by the Timber Branch, Ontario Department of Lands and Forests. C.L.A. grades.

PRUNING BRINGS HANDSOME RETURNS

Select grades have roughly twice the value of the No. 3 and 4 grades in Canada and the U.S.A. and as Holland (1960) has shown, the differential has prevailed for many years. White pine's suitability for many high-quality uses such as interior trim, millwork and pattern stock cannot be matched by other species, and it is reasonable to expect that select grades which alone meet the requirements for such uses will continue to command premium prices. The relatively high price assigned to knotty pine panelling is not relevant to this pruning argument, since most such lumber originates from upper logs, tight knots (from green branches) being prerequisite. Loss of markets to alternative woods and building materials will, in all probability, affect the lower grades much more than the selects.

In computing expected returns on pruning investments as applied to white pine in the northeastern States, Fedkiw *et al.* (1960) used an increased value of \$100 per Mfbm, based on a median price of \$210 per M for D Selects and Better, and \$110 per M for the weighted average price of the total pine production in 1959 (comparable to the price of No. 3 Common). In the same 1959 terms applied to the aforementioned Holderness, N. H. case, the difference in value between pruned and unpruned logs was \$63 per M.

Turning to current Canadian white pine wholesale prices, the grade differential is similar but somewhat wider than the above. Average current prices for 1 inch, 16-foot boards of widths varying 4 to 12 inches are: C Selects—\$263, D Selects—\$231, No. 1—\$193, No. 2—\$140, No. 3—\$101, No. 4—\$82, No. 5—\$65. If these prices are applied to the Petawawa grade yields for 80-year trees, the weighted average price is \$135—again about \$100 lower than the averaged prices of C and D Selects. Another point is that these prices relate to 4/4 inch thick boards; if 5/4 to 8/4 inch Select boards are recovered, the price increases 15%, and if 10/4 to 12/4 inch, 50%. Such increases do not apply to thicker boards of the lower grades.

The object of these comparisons is to choose an arbitrary, conservative, differential value between pruned and unpruned lumber grown over the periods indicated in Figure 1 and Table 4. Other investigators (Hawley & Clapp 1935; Smith 1954) have ascribed twice as much value to clear lumber as to highest grade knotty lumber. A value increase of \$100 per Mfbm would seem reasonable, but to assure an ample allowance for natural pruning, let us halve that figure. This increased value of 5 cents per bd. ft. is applied to the various clear wood yields for different growing periods as calculated diagrammatically (e.g., Figure 1), and against the tested pruning costs given in Table 2 (increased by 50% for overhead) to compute the return as an expression of compound interest on the pruning investment for 16-foot butt logs of various tree sizes (Table 4).

The returns on the pruning investment increase directly with tree size (i.e. growth rate), with increasing age at pruning, and with *decreasing* period between pruning and harvesting. Calculated returns are acceptable for most combinations of tree size and timing but are particularly inviting for the larger trees pruned 20 or 40 years before harvesting. A reconciliation is necessary between rate of return and volume of clear wood produced, since management

and logging efficiency would increase in proportion with wood yield per acre. The 20-year growth period gives appreciably higher returns but on an appreciably lower wood yield per treated tree. This is an argument for pruning the maximum number of trees possible per acre for the 20-year clear wood production period, but the number of fast growing trees per acre suitable for pruning is usually limited, limiting the per acre yield for the 20-year period. Therefore the 40-year period, which provides relatively high returns and clear wood yields is advocated.

Pruning of stands older than class 80 or younger than 35-40 is not recommended considering the lengthened rotation and probable growth reduction in older stands and the inefficiency of pruning (the higher costs compounded for a longer period, and the difficulty of choosing ultimate crop trees) in the younger stands.

PRUNE SELECT LARGE TREES UP TO 80 YEARS OLD

Thus the thesis of this study, that it is profitable to prune larger, maturing white pine, appears to be upheld, assuming a continued premium for clear wood used for finishing purposes. The data indicate a modest operational cost and a good future profit based on reasonably conservative estimates of growth and relative values of clear versus knotty lumber. These growth estimates originated from unmanaged pine-mixedwood stands. If pruning can pay under these circumstances, then intensive management, i.e., pruning of select, vigorous white pines in maturing stands on good sites, must surely be advocated. As many suitable crop trees as are available (with due regard to reasonable spacing) in such stands should be pruned to one 16-foot log. The future possibility of maximizing crop tree growth by artificial fertilizer applications as well as by intensive thinning schedules should not be overlooked.

To end, the main points of variance between this and other published pine pruning studies are recapitulated:

1. Pruning 16-foot butt logs with a variable-length pole saw proved much more efficient than hand saw and ladder methods applied to one or two logs per tree.
2. The tested costs of pruning disregarding overhead were 8 to 14 cents per tree, and these costs did not increase with tree diameter within even-aged stands. Costs decreased appreciably with increasing stand age.
3. The utilization of clear-one-face boards as D Select grade considerably reduces the clear wood increment required for profitable pruning. A clear wood shell as little as two inches thick grown over a 40-year period is feasible; however, twice this growth can be expected on large vigorous trees with a crown ratio greater than 40.
4. The limit of tree size and stand age previously suggested for profitable pruning can be extended. Rather than recognizing an upper prunable diameter limit, it is shown that the larger the tree at pruning, the greater the clear board yield, hence profit. This presupposes an even-aged stand and a fixed adequate clear wood increment period. Balancing compounded pruning costs and growth rates, a suggested maximum age suitable for pruning is 80 years, and a growth period following pruning, 40 years.

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