O.D.C. 854.2:174.7

CANADA
DEPARTMENT OF FORESTRY
AND RURAL DEVELOPMENT

YIELD OF CLEAR CUTTINGS FROM LOWER GRADES OF EASTERN WHITE PINE

by
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Extrait en français

FORESTRY BRANCH

DEPARTMENTAL PUBLICATION No. 1227
1968

Published under the authority of the
Minister of Forestry and Rural Development
Ottawa, 1968

ROGER DUHAMEL, F.R.S.C.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1968

Catalogue No. Fo 47-1227

PRINTED IN CANADA

ABSTRACT

This study of Nos. 3, 4 and 5 White Pine lumber was primarily concerned with its conversion into clear components of specific sizes for toys, novelties, millwork and other uses. A total of 1,350 1-inch (nominal) boards scaling 9,900 board feet were selected by grade, length and width. Lengths of the cuttings varied from 12 to 48 inches with 3-inch increments and widths from 1 to 6 inches with half-inch increments. These sizes conformed to industrial requirements.

This study was designed to illustrate: yield and frequency distribution of cutting sizes by grade; correlation of the length and width of the board with the length and width of the potential cuttings; effects of selected defects on cutting yields; and, effect of knot frequency on average cutting length.

Cutting yields from Nos. 3, 4 and 5 White Pine (CLA Rules) were 76.0, 71.0 and 61.3 per cent respectively.

Approximately half the cuttings were less than 2-1/2 feet in length and not exceeding 1-1/2 inches in width. Length and width of lumber had little effect on yield when crosscutting operation was performed first. If the lumber within a grade is sorted to exclude all boards in which the grade-determining factors are defects other than knots, then the potential yield ranges from 78 to 75 per cent. On the other hand, for the excluded boards containing defects such as rot and shake, the potential yield is 68 to 56 per cent.

EXTRAIT

Résultats d'études sur la manière de couper les planches de Pin blanc (*Pinus strobus*) de qualités n° 3, 4 et 5 pour en tirer le maximum en bois d'échantillon destiné à la fabrication de jouets, objets de fantaisie, objets en bois tourné, etc.. Le matériel original consistait en 1,350 planches d'un pouce d'épaisseur mais de longueurs et largeurs diverses, totalisant 9,900 p.m.p.. Les longueurs variaient de 12 à 48 pouces (de 3 en 3 pou.) et les largeurs de 1 à 6 pouces (de ½ en ½ pou.), tel que l'exigent les industriels.

Les études portaient sur: 1) le rendement et la distribution de fréquences des dimensions du bois d'échantillon, selon la qualité; 2) la corrélation entre la largeur et la longueur des planches, d'une part, et la longueur et la largeur des pièces de bois d'échantillon fabricables; 3) l'effet de défauts nettement définis sur le rendement en bois d'échantillon; et 4) l'influence de la fréquence des noeuds sur la longueur moyenne des pièces de bois d'échantillon.

Le rendement en bois d'échantillon (sujet 1 ci-dessus) a été de 76.0, 71.0 et 61.3 p. 100 respectivement pour les qualités n° 3, 4 et 5 (règles normales de l'Association canadienne de l'industrie du bois (C.L.A.)).

Environ la moitié des pièces obtenues avaient une longueur moindre que 2½ pieds et une largeur ne dépassant pas 1½ pouce (sujet 2 ci-dessus).

Lorsque le débitage commençait par le tronçonnage, la largeur et la longueur n'avaient pas d'influence sur le rendement en bois d'échantillon. Si, parmi les planches de telle qualité, l'on met à part celles qui ne présentent que des noeuds à l'exclusion d'autres défauts, le dit rendement s'élèvera à 78 à 75 pour cent. D'un autre côté, l'autre groupe, i.e. les planches surtout affectées de pourritures et de gerçures, fournira un rendement aussi bas que 68 à 56 p. 100 (sujet 3).

La fréquence des noeuds réduisait légèrement la longueur moyenne du bois d'échantillon (sujet 4 ci-dessus).

YIELD OF CLEAR CUTTINGS FROM LOWER GRADES OF EASTERN WHITE PINE

by

F.J. Petro[1] and F.M. Lamb[2]

INTRODUCTION

White pine has long been an important softwood species for a wide variety of uses in eastern Canada. However, some difficulty has been encountered in marketing the lower grades due to competition from other species and substitute materials. To reduce the accumulation of these grades a number of special uses have been developed over the years. For instance, selected lumber containing incipient and soft rot is being marketed as "Anteek Pine" and used as panelling. Two and three-inch lumber of Nos. 4 and 5 White Pine [1] is used in plank wall construction in various Quebec municipalities. Perhaps the most noteworthy development using these grades in both Canada and the United States has been the production of finger jointed and edge-glued panels from clear or sound cuttings that have been obtained from full-size lumber by ripping or crosscutting, or both. In these operations, board defects such as rot, shake, wane and knot-holes are eliminated during remanufacture. A further development, which is the subject of this report, is the production of components for toys, novelties, millwork and such uses which require essentially defect-free cuttings of specific sizes. They are not intended for use in conventional finger jointing and edge-gluing operations.

Englerth and Wollen [2] determined the yield of clear cuttings that may be obtained from No. 4 Common (Standard) white pine graded according to the Northeastern Lumber Manufacturers Association Grading Rules [3]. However, that study differed in a number of ways from the present one in relation to factors such as cutting sizes and method of cutting up the lumber.

The objectives of the present study, carried out in cooperation with a large lumber company, were to determine:

(1) Yield and frequency distribution of cutting sizes available from Nos. 3, 4 and 5 White Pine lumber.

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(2) If a correlation exists between length and width of lumber and length and width of potential cuttings.

(3) Effect of selected defects on yield of cuttings.

(4) Effect of number of knots on the average length of cutting.

PROCEDURE

Selection of Lumber

A total of 1,350 1-inch (nominal) boards, scaling 9,900 board feet, were selected from the sawmill boardway by a licensed grader in three 450-board subsample lots. Each subsample represented an equal number of boards of Nos. 3, 4 and 5 White Pine, length classes from 6 to 16 feet with 2-foot increments, and width classes from 4 to 12 inches with 2-inch increments. There were 5 boards for each of the 90 combinations of grade (three), width (five) and length (six) within each subsample.

As natural stands of white pine can vary considerably in quality due to such factors as site, age class and stand density, lumber for this study was selected in three lots at 3-week intervals. This was done in an effort to obtain a wide cross-section of boards containing those natural defects common to all the three grades of lumber studied. The sawmill produced an estimated 100 M board feet of lumber each 9-hour day, and selection of the entire sample at one time probably would have resulted in lumber representing one age class or site condition. Selection of skip-planed lumber was made at random on the boardway after kiln-drying to about 15 per cent moisture content (M.C.) and prior to final dressing and grading. Skip-planing generally removed about 75 per cent or more of the rough surface from both faces of the boards. Each board was representative of a grade, and borderline pieces were excluded from the sample.

Marking and Measurement of Cuttings

Cuttings were outlined on the poor face of each board using a thick lead pencil to represent 1/8-inch crosscut and rip kerf lines. The poor face of the board was taken as that face which permitted the least total area of clear cuttings. None of the boards was actually "cut up" (Figures 1, 2, 3).

The minimum and maximum sizes of cuttings used were: length, 12 to 48 inches with 3-inch increments, and width 1 to 6 inches with half-inch increments. These sizes conformed to the cutting bill requirements of several industrial users of white pine dimension stock. The range of cutting sizes used did not conform to the size requirements of any specific end product. In all cases, the largest size of cutting possible was outlined.

In this study no limit was placed on the number of cuttings outlined or on the number of hypothetical ripping or crosscutting operations.

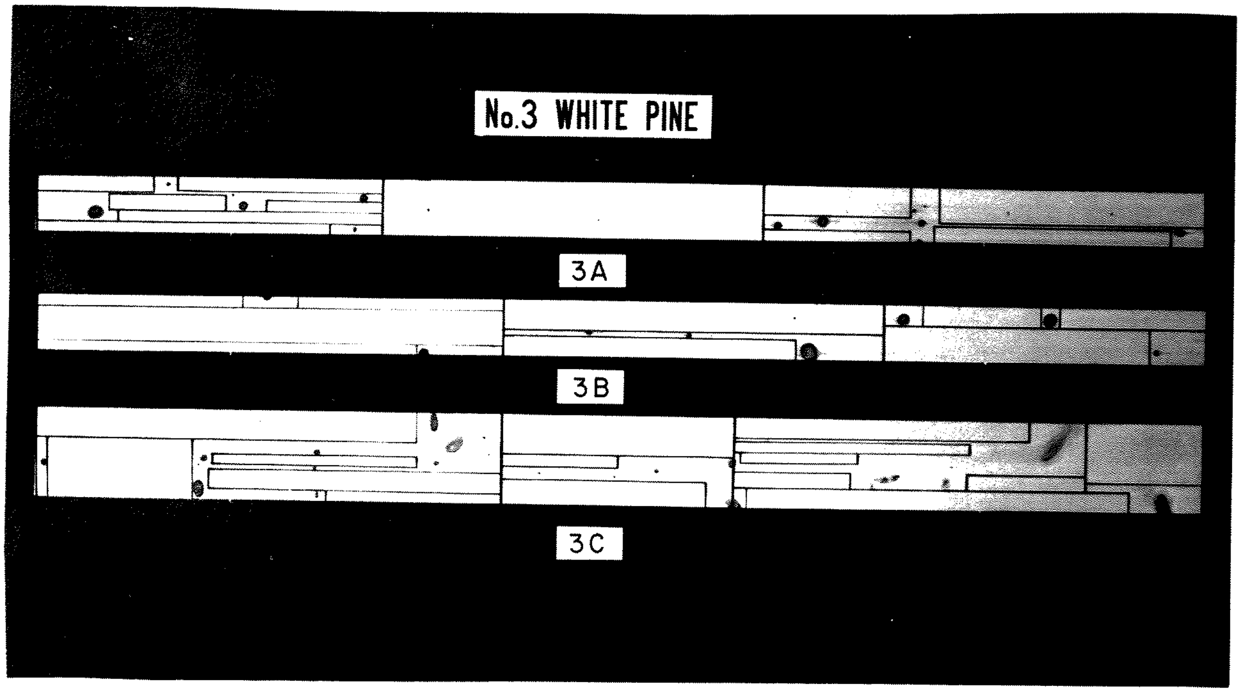

Figure 1. Cutting layout on selected No. 3 White Pine boards. Yields for these boards were: 3A - 84.9%; 3B - 77.6%; 3C - 68.4%.

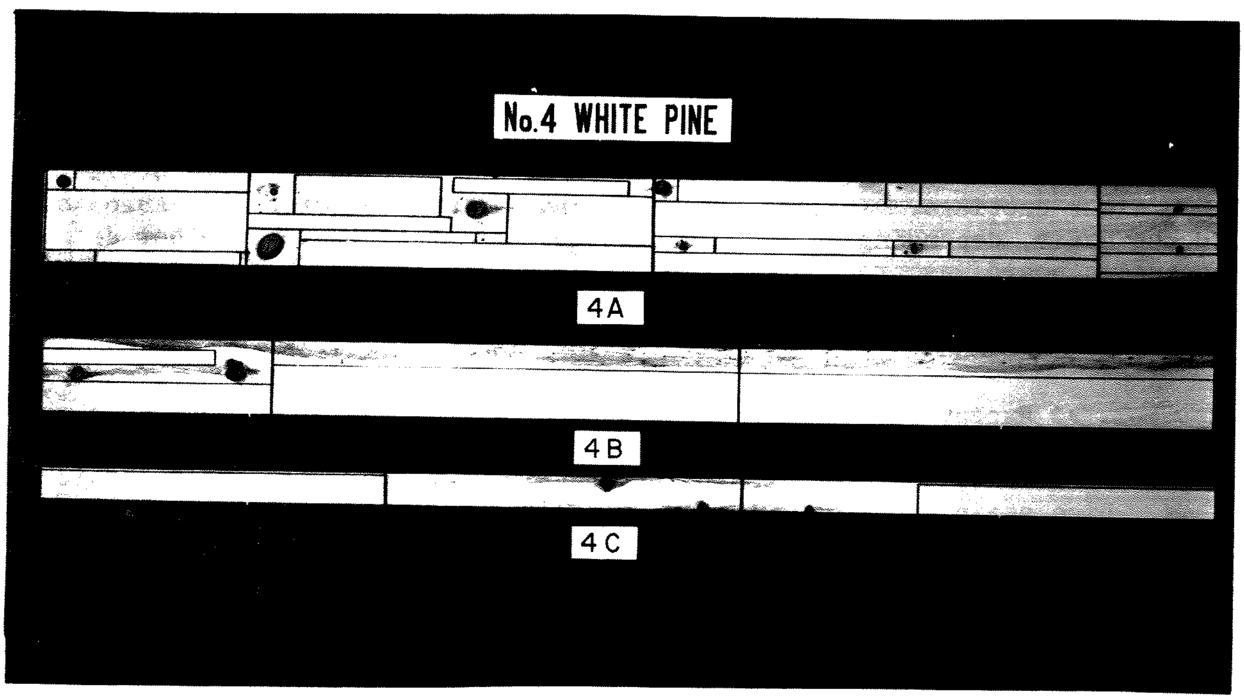

Figure 2. Cutting layout on selected No. 4 White Pine boards. Yields for these boards were: 4A - 84.9%; 4B - 63.2%; 4C - 48.6%.

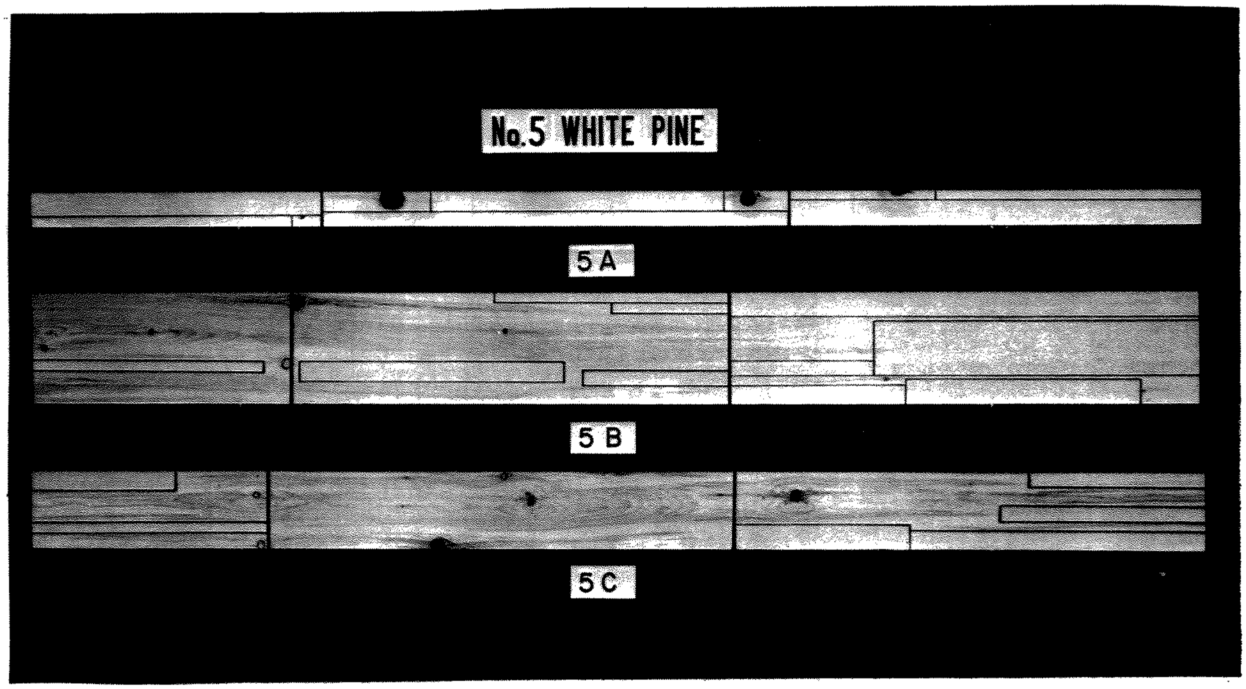

Figure 3. Cutting layout on selected No. 5 White Pine boards. Yields for these boards were: 5A - 78.1%; 5B - 40.3%; 5C - 22.5%.

The crosscutting operation was performed first at major knot whorls or other defective areas such as pitch pockets to produce short boards of 48 inches or less. For example, if a board contained a series of knot defects 16 inches apart (not extending completely across the board), it was assumed that it would be crosscut in actual practice into a series of 48-inch sections, forwarded to the rip saws for ripping into 48-inch clear cuttings, and then returned for crosscutting the remaining portion into 12- or 15-inch clear cuttings. Initial cross-cutting lines were often less than 48 inches apart, depending on the location and extent of knots or other defects, because a board was crosscut wherever a defect extended completely across it.

Defect Evaluation

Except for small surface checks, both faces of all cuttings were free from all visible defects. Surface checks were considered as non-degrading if they could be removed by dressing the board to 3/4-inch thickness. Blue stain and brown stain were excluded from the cuttings except when of such light colour as not to materially impair the appearance of the cuttings if given a natural finish. Brown stain was not prevalent because the lumber had been treated with sodium fluoride. All visible compression wood and torn grain were excluded. A minimum clearance of about 1/4 inch was maintained between cuttings and knots to reduce the amount of cross-grain in the cuttings and to eliminate possible knotty material below the clear surface.

In the three grades of lumber studied, several selected defects were evaluated to determine their individual and combined effect on the yield of clear cuttings.

This evaluation was also carried out to provide information on the character of lumber representing the three subsamples and to explain any unusually high or low yields of individual boards. The defects selected included rot (incipient and advanced decay), shake, compression wood, blue and brown stains, cross-grain, pitch, worm-holes, and wane. In addition, there was a category called "combination defects" which considered two or more of the defects just mentioned. These selected defects were evaluated only when they affected 5 per cent or more of the board.

When two or more of the defects listed in the preceding paragraph were present, either separately or together (as was frequently the case with blue stain and worm-holes), each was recorded separately. In addition, their combined percentage effect was recorded under "combination defects".

An ocular estimate was made of the amount of a given defect or defects in a board by 5 per cent increments. For example, if it was estimated that rot scattered throughout a 10-foot board could be contained in 6 inches of its length (full board width), this would represent 5 per cent of the board area; 12 inches would represent 10 per cent, and so on.

The effect of knot frequency on average length of cuttings for each grade was determined for those boards in which knots were the grade-determining defect. The number of knots occurring on the poor face and on the edges of the board were recorded. This count did not consider form, quality, growth or firmness of the knots. Knot holes, spike knots, sound knots, decayed knots, corner and edge knots, were treated equally. In addition, defects such as dog holes, picaroon holes, and bark pockets were considered equivalent to knots. Since several small knots in a cluster or a string of knots across the board might be less important than a single large knot, a set of rules was required in recording knot frequency. Based on a preliminary study, the following rules were formulated and used throughout the main study.

(1) Two knots up to 1½ inches in diameter and less than 3 inches apart, count as one knot.

(2) Two knots less than 2 inches apart, and with the largest knot not exceeding 2 inches in diameter, count as one knot.

(3) Knots over 2 inches in diameter, count as single knots.

(4) Three or more knots up to ½ inch in diameter each and less than 1 inch apart (from each other), count as one knot.

In determining the size of a knot or hole, the average of two diameter measurements taken at right angles to each other was used. To determine the size of a spike knot, the average of the length and width at the widest point was used. The distance between two or more knots was taken as the shortest distance between the edge of one knot and the edges of the others.

RESULTS AND DISCUSSION

Table 1 shows the per cent yield of clear cuttings by board length, width, and grade. Each entry is an average based on 30 boards because the six board lengths used were grouped into three classes. The per cent yield of clear cuttings for each grade and the associated confidence limits at the 99 per cent confidence level were:

No. 3 White Pine 76.0 ± 1.38 per cent

No. 4 White Pine 71.0 ± 1.48 per cent

No. 5 White Pine 61.3 ± 1.91 per cent

In order to determine the significance of the data in Table 1 a limited statistical analysis was performed using a three-factor factorial analysis of variance of a random block design. Tukey's HSD was employed as a mean-separation test. This analysis showed: (a) a highly significant difference in per cent yield with regard to grade and replications; and, (b) no significant difference in per cent yield with regards to board length and board width.

The descending order of per cent yield from Nos. 3 to 5 White Pine is quite natural due to the type and nature of defects admitted in each grade by the grading rules. However, factors such as the quality of cuttings (i.e., clear two face), limited range of allowable sizes, and lack of restriction on number of cuttings, all affect the per cent yield from each grade. Also, a series of lumber subsamples can show differences in per cent yield not only between grades but within grades as well. Yield differences within a grade can result when variations occur in defect type and quantity. For example, the average per cent yield of cuttings for the three subsamples selected in this study was as follows:

Per Cent Yield of Clear Two Face Cuttings

Subsample	No. 3 W.P.	No. 4 W.P.	No. 5 W.P.
1	74.3	67.7	55.5
2	73.0	70.5	61.8
3	80.6	74.7	66.6

An analysis of the board description data clearly showed that a greater number of boards in subsample 1 contained considerably more of such defects as hard and soft rot and shake, particularly in Nos. 4 and 5 White Pine, and these defects significantly reduced the potential recovery of clear cuttings. For example, in subsample 1 the No. 5 White Pine had 54 boards which contained an average area of 32.4 per cent of rot whereas in subsample 3 the same grade had 34 boards with an average area of 21.3 per cent of this defect. With regard to shake, subsample 1 had 17 boards with an average area of 32.1 per cent of this defect and subsample 3 had 9 boards with an average of 14.4 per cent in defective area.

TABLE 1. PER CENT YIELD OF CLEAR CUTTINGS BY BOARD LENGTH, WIDTH AND GRADE

Board length (feet)	No. 3 White Pine						No. 4 White Pine						No. 5 White Pine					
	Board width (inches)						Board width (inches)						Board width (inches)					
	4	6	8	10	12	Avg.	4	6	8	10	12	Avg.	4	6	8	10	12	Avg.
6 - 8	74.7	70.8	76.8	76.5	74.5	74.7	74.5	69.0	72.9	70.1	69.4	71.2	63.3	64.8	60.7	57.3	56.4	60.5
10 - 12	78.3	72.2	76.4	78.7	77.4	76.6	68.8	69.5	71.2	73.5	65.8	69.8	64.1	59.8	59.4	58.9	58.2	60.1
14 - 16	74.5	73.0	75.6	80.3	79.9	76.7	72.2	68.8	71.2	73.9	73.2	71.9	64.4	68.2	59.2	66.8	58.1	63.3
Average	75.8	72.0	76.3	78.5	77.3		71.8	69.1	71.8	72.5	69.5		63.9	64.3	59.8	61.0	57.6	
Average (Grade)						76.0						71.0						61.3

Generally, the main degrading feature in the subsample 3 lumber was knots, which varied only by size and type in all grades. The relative effect of knots and such defects as rot and shake in white pine lumber on yield of cuttings is clearly shown here, especially by the 11.1 per cent difference between the two subsamples of No. 5 White Pine.

The lack of a significant effect in this study of board length and width on cutting yield is largely due to the narrow minimum cutting width and short cutting length permitted (one inch and one foot respectively). Englerth and Wollen found board width to be highly significant in determining yields when random cutting widths of 2-2/3 to 4 inches were used in conjunction with a ripping first procedure based on the width of the board [2]. The wider boards afforded greater scope for ripping potentially usable cuttings of a minimum 1-foot length than the narrow boards. This procedure resulted in an increase in yield of cuttings with an increase in board width.

The minimum 1-foot cutting length is thought to be the main reason why per cent yield was unaffected by board length. Since branch whorls are frequently farther than 1 foot apart in merchantable white pine stems, major knot clusters in the study boards were frequently more than 1 foot apart. The crosscutting operation at 48-inch intervals (or less) was not an important factor because crosscutting was done at major defect whorls.

The frequency distributions of lengths and widths of cuttings for each grade are shown in Tables 2 and 3. These data show that the distribution patterns are largely independent of grade. The main difference is in the total number of cuttings obtained from each grade, which is a reflection of the difference in yield. For all three grades approximately 50 per cent of the cuttings were 21 inches or shorter in length and 45 to 50 per cent were from 1 to 1½ inches in width.

The effect of selected defects on the yield of clear cuttings is presented in Table 4. In general, these data show the extent to which various defects are admitted by the grading rules in each grade. The prevalence of rot and the severity of shake, for example, and their effect on yield, are shown quite clearly in Table 4. The effect of compression wood and stain on yield of cuttings showed little variation between the grades. In the case of stain the grading rules permit a certain amount and degree of discoloration in the grades studied which excludes it entirely from cuttings. As the amount of compression wood present in the boards studied was generally the same, the yields for each grade are also similar. Other defects such as pitch and wane, although not as important as rot and shake, do cause a decrease in yield by approximately 10 per cent between the Nos. 3 and 5 White Pine grades.

An important difference exists between average per cent yield for boards containing selected defects and per cent yield for boards without these defects, especially in No. 5 White Pine. The grade in boards not containing selected defects is mainly determined by knots of all forms and qualities (and by defects considered as equivalent to knots). The data show that these defects resulted in only a small difference in yield of cuttings among the three grades, that is the difference between Nos. 3 and 5

TABLE 2. FREQUENCY DISTRIBUTION FOR LENGTH OF CUTTINGS

Length of cuttings (inches)	No. 3 White Pine		No. 4 White Pine		No. 5 White Pine	
	Per cent of total cuttings	Cumulative per cent	Per cent of total cuttings	Cumulative per cent	Per cent of total cuttings	Cumulative per cent
12	18.7	18.7	18.9	18.9	19.7	19.7
15	12.0	30.7	12.0	30.9	12.7	32.4
18	9.8	40.5	10.4	41.3	11.4	43.8
21	9.0	49.5	9.3	50.6	9.0	52.8
24	11.1	60.6	10.7	61.3	10.8	63.6
27	5.3	65.9	5.4	66.7	5.9	69.5
30	4.9	70.8	5.0	71.7	4.4	73.9
33	4.2	75.0	4.2	75.9	3.8	77.7
36	3.9	78.9	4.2	80.1	4.0	81.7
39	2.6	81.5	2.8	82.9	2.6	84.3
42	2.6	84.1	2.8	85.7	2.6	86.9
45	2.6	86.7	2.4	88.1	2.4	89.3
48	13.3	100.0	11.9	100.0	10.7	100.0
Total number of cuttings	6271		6011		5550	

TABLE 3. FREQUENCY DISTRIBUTION FOR WIDTH OF CUTTINGS

Width of cuttings (inches)	No. 3 White Pine		No. 4 White Pine		No. 5 White Pine	
	Per cent of total cuttings	Cumulative per cent	Per cent of total cuttings	Cumulative per cent	Per cent of total cuttings	Cumulative per cent
1	26.9	26.9	27.0	27.0	31.4	31.4
$1\frac{1}{2}$	19.7	46.6	20.8	47.8	19.9	51.3
2	17.2	63.8	17.8	65.6	15.9	67.2
$2\frac{1}{2}$	9.8	73.6	9.7	75.3	9.8	77.0
3	8.5	82.1	8.1	83.4	7.6	84.6
$3\frac{1}{2}$	3.9	86.0	3.9	87.3	3.7	88.3
4	5.9	91.9	5.4	92.7	5.3	93.6
$4\frac{1}{2}$	2.1	94.0	1.7	94.4	1.8	95.4
5	2.1	96.1	2.4	96.8	2.0	97.4
$5\frac{1}{2}$	1.0	97.1	0.9	97.7	0.6	98.0
6	2.9	100.0	2.3	100.0	2.0	100.0
Total number of cuttings	6271		6011		5550	

TABLE 4. YIELDS OF CLEAR CUTTINGS IN BOARDS CONTAINING SELECTED DEFECTS

Defect	No. 3 White Pine		No. 4 White Pine		No. 5 White Pine	
	No. of boards affected	Average yield (%)	No. of boards affected	Average yield (%)	No. of boards affected	Average yield (%)
Rot	19	76.0	65	69.6	149	53.4
Pitch	13	75.8	20	70.0	53	64.5
Shake	34	70.8	50	64.8	42	54.4
Wane	9	78.4	19	69.7	24	67.9
Compression wood	11	53.7	12	51.9	7	53.1
Cross grain	6	73.8	8	72.5	5	63.8
Stain	23	59.8	16	55.7	8	61.3
Worm holes	-	-	2	84.3	5	65.8
*Combination defects	6	60.5	21	55.6	44	50.9
All defects	121	68.7	213	65.3	337	56.5
Boards not affected	329	78.7	237	76.3	113	75.6

*A combination of two or more of the above listed defects.

White Pine is only 3.1 per cent compared with 12.2 per cent between the same grades in boards containing the selected defects. The 3.1 per cent figure could possibly be explained by the proportional increase in size and number of knots between the two grades. A further explanation might be that the No. 5 White Pine boards contained a greater number of selected defects but that they affected less than 5 per cent of the board areas and were therefore disregarded in the evaluation of the effect of selected defects on yield.

The effect of knot frequency on the average length of cuttings for each of the three grades is presented in Table 5. Knot class refers to the number of knots recorded in accordance with the procedure outlined previously. These data show that the average length of cutting decreases as the knot frequency increases. This differential exists even though the boards were initially crosscut in lengths of 48 inches or less prior to the marking of cuttings. If the boards had been crosscut first to lengths longer than 48 inches, it would seem reasonable to expect that the increase in average length of cutting with a decrease in knot frequency would have been greater.

CONCLUSIONS

(1) The potential yield of industrial wood components from grades Nos. 3, 4, and 5 White Pine ranges from 76 to 61 per cent of the gross lumber volume. Approximately half the cuttings would be less than 2-1/2 feet in length or not more than 1-1/2 inches in width.

(2) If the lumber within a grade is sorted to exclude all boards in which the grade-determining factors are defects other than knots, then the potential yield ranges from 78 to 75 per cent. On the other hand, for the excluded boards containing defects such as rot and shake, the potential yield is 68 to 56 per cent.

(3) As expected, within a grade, average length of cutting decreases as knot frequency increases.

(4) Board width and length have little effect on yield when boards are crosscut initially to lengths of 48 inches or less.

ACKNOWLEDGMENT

The writers are grateful for the cooperation and assistance of the Consolidated Paper Corporation Limited in this study.

TABLE 5. THE EFFECT OF KNOT FREQUENCY ON THE AVERAGE LENGTH OF CUTTINGS

(for those boards where knots were the grade determining defect)

Knot class (numbers)	No. 3 White Pine			No. 4 White Pine			No. 5 White Pine		
	Average cutting length	Total no. of cuttings	Total No. of boards	Average cutting length	Total no. of cuttings	Total no. of boards	Average cutting length	Total no. of cuttings	Total no. of boards
1 - 5	29.2"	455	63	28.0"	264	41	28.5"	168	28
6 - 10	26.8"	1075	96	26.6"	843	79	26.5"	457	43
11 - 15	25.2"	1246	78	25.8"	817	55	24.9"	398	24
16 - 20	26.0"	847	45	25.2"	581	31	23.5"	255	14
Over 20	23.6"	1135	47	23.1"	764	31	25.4"	109	4

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1227-5-68-3.8M