research notes

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Development of the Lodgepole-pine Types in the North-Central Interior Following Selective Cutting for Railroad Ties

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DEVELOPMENT OF THE LODGEPOLE PINE TYPES IN THE NORTH-CENTRAL INTERIOR FOLLOWING SELECTIVE CUTTING FOR RAILROAD TIES

During 1913 and 1914, the building of the Grand Trunk Pacific Railway (now a part of the Canadian National Railway system) through the Prince George Region created a demand for ties. Extensive, even-aged stands of Lodgepole Pine, of site index 60 to 80(1), and aged 90 to 120 years, provided the bulk of this product and the establishment of the railway in turn opened the stands to exploitation for domestic use. By 1926, some concern was expressed for the development of the residual stands resulting from the economic selection cuts for hewn ties. The popular theory was that the residual pine stand, released by the cuttings, would show accelerated growth and, 15 to 30 years after cutting, it would be possible to return for a further cut of tie material.

The basic data under review consist of measurements of 6 four-tenth-acre, permanent plots established in 1926 on cut-over areas - 2 on an area logged in 1913, 2 on an area logged in 1922, and 2 on an area logged in 1926. Periodic re-measurements were made in 1938 and 1948. Radial increment data based on borings in 1926 were recorded for various periods up to 20 years prior to logging.

Growth of Residual Stands

The Lodgepole Pine stands studied were pure types before cutting, i.e., 70 to 90 per cent pine by volume. The remaining 10 to 30 per cent was White Spruce and Balsam, usually occurring as an understory with few trees reaching up into the general crown-canopy. The cut for ties normally removed only dominant and codominant pine and reduced the pine volumes by 50 to 80 per cent. The resultant residual stands are, therefore, mixed pine-spruce-balsam types and, because of the relative intolerance of pine, will probably develop into a spruce-balsam type in the course of time.

Table 1 (see page 2) presents the general statistics for the stands, except reproduction, at time of plot-establishment and for the re-measurements 12 and 22 years later. In the initial release following logging no apparent differences in growth were noted for Spruce and Balsam so these two species are grouped together. The mortality between dates of cutting and plot establishment are unknown on 4 of the plots, hence the initial residual stands are unknown and the estimated cuts on these plots, based on stump counts, are subject to error. On Plots 121 and 122 the estimate is believed to be within 1 per cent and on Plots 125 and 126 within 5 per cent.

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(1) Average height of dominants and codominants at 80 years.

BLE 1 - DEVELOPMENT OF NUMBER OF TREES AND AVERAGE DIAMETERS OF CUT-OVER PLOTS

(Per acre)

Plot No.	123	124	121	122	125	126
At time of cutting - Age	120	120	116	116	87	87
Site Index	75	75	75	70	75	70
Volume Lodgepole Pine cut - per cent	54.6	53.7	77	72	55	70
1926 Examination -						
No. of years after cutting	0	0	4	4	13	13
No. of Lodgepole Pine	127	230	70	85	112	75
Av. D.B.H.	9.0	8.6	9.2	8.7	8.8	9.0
No. of Spruce and Balsam	205	242	172	132	285	232
Av. D.B.H.	7.4	5.3	6.3	6.5	6.7	7.1
Mortality, 1926-1938						
No. of Lodgepole Pine	27	50	40	20	2	20
Av. D.B.H.	8.0	7.6	9.1	8.2	5.0	8.8
No. of Spruce and Balsam	20	42	12	10	35	25
Av. D.B.H.	7.7	4.7	7.7	9.8	5.8	8.1
1938 Examination						
No. of Lodgepole Pine	100	180	30	65	110	55
Av. D.B.H.	9.8	9.4	10.1	9.4	9.4	9.7
No. of Spruce and Balsam	185	200	160	122	250	207
Av. D.B.H.	8.1	6.4	7.7	7.5	7.8	8.2
Mortality, 1938-1948						
No. of Lodgepole Pine	15	15	8	10	10	7
Av. D.B.H.	7.9	7.9	9.0	9.3	6.7	7.8
No. of Spruce and Balsam	5	20	2	2	8	7
Av. D.B.H.	8.0	3.2	11.0	8.0	7.0	2.7
1948 Examination						
No. of Lodgepole Pine	85	165	22	55	100	48
Av. D.B.H.	10.4	10.1	11.0	9.8	10.0	10.3
No. of Spruce and Balsam	180	180	158	120	242	200
Av. D.B.H.	8.9	7.5	8.8	8.5	8.6	9.3

Av. D.B.H. weighted by basal area.

All trees 0.6" plus in 1926 - Ingrowth shown separately in Table 3.

Table 2 shows the periodic volume develor ' the type. Critical study of the numbers of trees, average dia site, and years after cutting, shown in Table 1, are recommended be oss-comparing plots.

TABLE 2 - VOLUME GROWTH AFTER SELECTION CUTTI

(Total cubic feet, entire stand 1" d.b.h. and over, ;

Plot No.		123	123A*	123B*	124	124A*	1	122	125	126
						Lodgepol				
Age of stand at time of cutting		120			120		16	116	87	87
No. yrs. after cutting to 1926		0			0		4	4	13	13
Net volume cubic feet - 1926		2,400	1,792	2,005	3,917	3,128	25	1,375	1,870	1,142
Mortality - 1926-1938		397			617		30	275	10	280
Periodic Annual Increment	Net	-2.3	30.7	30.7	8.2	59.5	.4	-3.7	23.7	2.5
	Mortality	33.1			51.4		.0	22.9	.8	23.3
	Gross	30.8			59.6		.6	19.2	24.5	25.8
Net volume cubic feet 1938		2,372	2,162	2,372	4,015	3,843	00	1,330	2,155	1,172
Mortality - 1938-1948		210			172		47	197	97	95
Periodic Annual Increment 1938-1948	Net	-6.5	14.5		25.0	42.1	.3	-10.5	9.7	3.5
	Mortality	21.0			17.2		.7	19.7	9.7	9.5
	Gross	14.5			42.2		.4	9.2	19.4	13.0
Net volume 1948		2,305	2,305		4,265	4,265	07	1,225	2,252	1,207
Years after cutting to 1948		22			22		26	26	35	35
						Spruce a				
Net volume cubic feet 1926		1,950			1,015		020	795	2,140	1,812
Mortality 1926-1938		215			122		110	162	197	275
Periodic Annual Increment 1926-1938	Net	28.9			28.3		6.4	17.5	45.4	62.7
	Mortality	18.9			10.2		9.2	13.5	16.4	22.9
	Gross	47.8			38.5		5.6	31.0	61.8	85.6
Net volume cubic feet 1938		2,297			1,355		577	1,005	2,685	2,565
Mortality 1938-1948		40			20		55	22	60	5
Periodic Annual Increment	Net	54.5			41.5		1.3	39.7	70.5	82.0
	Mortality	4.0			2.0		5.5	2.2	6.0	.5
	Gross	58.5			43.5		6.8	41.9	76.5	82.5
Net volume cubic feet 1948		2,842			1,770		190	1,402	3,390	3,385

* Note: A--Growth of trees surviving all examinations.
B--Growth of trees surviving first two examinations.

Lodgepole Pine

In columns headed 123A and 124A, is show ievelopment of those stems surviving 3 examinations and, in columns 123 124B, those surviving the first 2 examinations. The periodic annual inc s of pine have decreased from 30.7 to 14.5 cubic feet per acre per n Plot 123A and from 59.5 to 42.1 cubic feet per acre per year on Plot ver two successive periods on the same trees. This is definite evid the decelerating growth rate of Lodgepole Pine with increasing tim cutting. It is unnecessary, however, to segregate surviving trees e changing growth rates under certain conditions. Gross increments e the actual volume of new wood added to a stand during the period un sideration. On permanent experimental plots the volume of a dead tr sually assumed to be the volume it had the last time it was measured a Hence periodic volumes of mortality do not include any measurable between the beginning of the period and the date of death, and the gross increments, therefore, measure the volume of wood added to surviving trees. (On 56 permanent plots in faster-growing species - Douglas Fir and Western Hemlock - where growth on mortality was recorded, the maximum periodic gross increment on the trees dying on any plot was only 3 per cent of that on surviving trees over comparable periods.)

In this study the gross increments were 30.8 decreasing to 14.5 cubic feet per acre per year for Plot 123 and 59.6 decreasing to 42.2 cubic feet per acre per year for Plot 124 during the successive periods. These figures are identical (the maximum difference due to growth on mortality being included is 0.33 per cent) with the values for surviving trees and the change in gross periodic annual increments is direct evidence of decelerating volume growth.

With the exception of Plot 121, all plots show material decreases in gross periodic annual increments or decelerations in volume growth of residual Lodgepole Pine with time after cutting. Plot 121 suffered heavy blowdown losses in the first period and the residual pine volume on this plot is of no economic importance.

It should be noted that these decelerations are not necessarily abnormal. Well-stocked pine stands of these ages and sites are beyond their technical rotation. Analysis of the diameter growths of 79 trees showed average increases of 0.84 inches for the 20-year period before cutting and 0.70 inches for the 20-year period following cutting. Over the range of diameters in the stands, 6 inches to 14 inches d.b.h., the growths were less than average on the smaller diameters and more than average on the larger diameters both before and after cutting.

There is a slight indication that mortality is heaviest immediately following logging - 23 to 65 cubic feet per acre per year in the first 12-year period decreasing to 1- to 23-cubic feet in the subsequent 10-year period. Study of the stem distributions of the individual plots shows that all the mortality occurred in trees of less-than-average stand diameter, or trees which would normally die first whether the stand was cut or not. The sudden exposure of the weaker trees in the stand by removal of the majority of the dominants and codominants may have encouraged heavier initial losses.

The indications are that residual Lodgepole Pine of site index 70-75 and ages over 90 years continue to develop as in uncut stands and definitely show no beneficial effects from release.

Spruce and Balsam

The benefits of the release cutting are apparent in the other conifers. Analysis of the diameter-growth of 48 Spruce and Balsam showed average growths of 0.85 inches (the same as pine) for the 20 years prior to cutting and average growths of 1.68 inches (2.4 times that of the pine) for the 20 years subsequent to cutting. Over the range of diameters in the stands, 2 inches to 14 inches d.b.h., the growths before cutting were less than average on the smaller and more than average on the larger diameters.

After cutting, the growths were more or less constant over the entire diameter-range. The greatest increases were on the intermediate and suppressed trees and the least on the dominant and codominant trees.

In all cases, except Plot 126, there is an increase in periodic gross increment, with increasing time after logging, showing accelerated volume growth on surviving trees. Plot 126 is now fully stocked and producing at its maximum capacity and the slight decrease indicates that, under the favourable conditions of adequate residual growing stock found on these plots, adjustment to normal conditions may not require more than 35 years.

Reproduction

Table 3 shows the development of the reproduction on the plots, all under 0.6 inches at time of plot establishment. The advance and new reproduction cannot be separated on these plots.

TABLE 3 - 22 YEAR DEVELOPMENT OF ADVANCE AND NEW REPRODUCTION ON CUT-OVER PLOTS

(All per acre totals.)

Plot No.		123	124	121	122	125	126
No. of years since cutting		0	0	4	4	13	13
No. of trees under 0.6" D.B.H.:	Spruce	130	60	10	10	10	60
	Balsam	430	370	50	490	520	280
	Total	560	430	60	500	530	340
	% Spruce	23.2	13.9	16.7	2.0	18.9	17.6
After 22 years growth on all plots							
No. of trees under 0.6" D.B.H.:	Spruce	40	40	90	100	30	110
	Balsam	540	280	210	1490	1310	360
No. of trees over 0.6" D.B.H.: (all between 0.6" and 4.0")	Spruce	40	50	20	70	0	0
	Balsam	410	500	360	810	70	170
	Total	1030	870	680	2370	1410	640
	% Spruce	7.7	10.3	16.2	7.2	2.1	17.2

Note: At the last examination there were 8 P_1 per acre on Plot 121, 5 per acre on Plot 122 and none on the remaining plots.

The residual stand had ample numbers of good quality, seed-bearing Spruce and Balsam. Table 3 shows a persistent seeding-in of these species, particularly Balsam, on all plots. While there is no measure of satisfactory stocking for this type all plots appear to be well-stocked. In spite of the low percentage of Spruce the increase in absolute numbers of this, presently, more desirable species is encouraging.

Indications from other studies are that Spruce survival rates are higher than Balsam and that these few Spruce will account for a greater volume of some subsequent crop than their present small numbers would indicate.

On tie-cutting operations, where humus and soil are little disturbed, there is no healthy advance or new reproduction of Lodgepole Pine. Had the original stands been pure pine it is doubtful if natural regeneration would be satisfactory without clear cutting, burning, or other seed bed preparation.

Merchantable Yields - Lodgepole Pine Only

The rigid specifications for hewn ties restrict the sizes of suitable tie-trees to narrow limits. Nine inches D.O.B. at the small end of the log is required for a tie. Diameters over 14 inches require too much hewing for economic production. An elliptically shaped 9-inch-D.B.H. tree will produce 1 tie, an average 10-inch tree - 2, 11-inch - 4, 12-inch - 5, 13- and 14-inch - 6. (2)

Utilization of all suitable trees is apparently required to provide an economic cut. Little variation is found between operations in percentage of number of trees, number of ties, basal area, or volumes removed by diameter-classes. On the operations studied the cuts were distributed by diameter groups as follows: no trees cut over 14 inches D.B.H., 93 per cent of the trees 11 inches to 14 inches, 45 per cent of the 10-inch trees, and 20 per cent of the 9-inch trees. A further 11 per cent of the trees under 9 inches were destroyed in logging.

Table 4 presents the statistics for the first harvest of trees and ties, and forecasts the possible second yields at various periods after logging for the plots studied.

TABLE 4 - Merchantable Yields of Lodgepole Pine - Trees and Ties

(Per acre)

	Plot No.		123	124	121	122	125	126
	Original Stand	- No. of Trees	220	370	Unknown		Unknown	
	First Cut	- No. of Trees	92	140	150	135	58	115
		No. of Ties	395	570	605	478	250	458
	No. years after First Cut		0	0	4	4	13	13
1926	Total Stand	- No. of Trees	128	230	70	85	112	78
Exam.	Possible Second Cut	- No. of Trees	32	42	10	17	30	22
		No. of Ties	82	120	20	28	80	65
	No. of years after First Cut		22	22	26	26	35	35
1948	Total Stand	- No. of Trees	85	165	22	55	100	48
Exam.	Possible Second Cut	- No. of Trees	50	72	8	25	50	28
		No. of Ties	195	258	22	72	188	110
	Assuming trees 10" - 14" D.B.H. left							
1948	after original cut as still unsuitable for ties							
Exam.	The Second Cut	- No. of Ties	42	98	0	0	Unknown	

(2) F. W. Elley, 1926, MS. Report to B. C. Forest Service.

The development of Plot 123, established immediately following logging, is typical of all plots. Of 220 trees in the original stand, 92 suitable for hewn ties were cut to produce 395 ties. Of the residual 128 trees, 32 were of tie-size and they, theoretically, contained 82 ties. These trees were not utilized because of defects, crook and catfaces being the most common, or because of selectivity on the part of the logger who did not wish to risk cutting a marginal value product.

During the 22 years following logging, mortality, confined to trees under 10 inches D.B.H., had depleted the residual pine from 128 to 85 trees per acre. Of these, 50 trees were then tie-size and theoretically would produce 195 ties - 42 from ingrowth trees and 153 from original tie-sized trees. Average diameter growths on all trees of 0.70 inches in 20 years have thus doubled the number of ties in the trees originally tie-sized but have produced only 42 new ties from trees originally under tie-size. A second harvest, subject to the same selectivity as the first, would yield less than 40 ties per acre after 22 years' growth. A maximum second cut, something less than 195 ties, would include trees originally rejected for tie material and would, therefore, include a large proportion of low-quality ties.

Studying all plots, the residual pine could be left somewhat longer than 35 years for maximum yield. However, the first harvest removed from 250 to 605 ties per acre. If the lower number is assumed to be a marginal economic yield, then the trees on only one plot (124) would provide a second cut. If the trees originally left in the 10-inch to 14-inch D.B.H. classes are still unsuitable for ties, then a second harvest from any plot is highly improbable.

We may conclude that a second harvest of ties within 35 years of cutting, if any, would be due to a chance leave of sufficient tie-sized trees. Any such cut would probably be handicapped by a large proportion of low quality (No. 3) ties.

Summary

In the Lodgepole Pine stands studied, site index 70 to 75 and aged 90 to 120 years, the selection cuttings removed from 50 to 80 per cent of the total pine volumes, yielding from 250 to 600 hewn ties per acre.

The residual pine apparently continued to develop as in uncut stands of similar sites and ages. Average diameter growths of 0.84 inches for 20 years prior to logging decreased to 0.70 inches for 20 years following logging. In successive periods following cutting, the volume growths of pine decreased. Dependent on the selectivity of the first harvest and the resultant chance-leaving of tie-sized trees, a marginal second cut of lower quality ties may be possible within 35 years. There was no healthy reproduction of Lodgepole Pine following cutting.

The Spruce and Balsam understory showed increases in diameter from retarded average growths of 0.85 inches in the 20 years prior to logging to more or less normal growths of 1.68 inches in the 20 years following logging.

Volume growths of these species showed rapid increases following logging.

This study indicates that where mature Lodgepole Pine occurs in admixture with an understory of Spruce and Balsam the pine should be cut to the minimum diameter economically possible so as to remove the mature overstory and create conditions more favourable for the growth of the potentially vigorous understory.

Tie-hacking methods are not destructive and utilize only a finished product of Nature. The residual stands are capable of rapidly absorbing the nutrients and light made available by the cuttings. Given favourable numbers of advance growing stock and a persistent seeding in of Spruce and Balsam it is expected that about 35 years will elapse before an area will again become fully-stocked and attain its maximum capacity of volume production.

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