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Growth and regeneration response to various stand treatments in a mature lodgepole pine stand

by N. R. Walker and H. J. Johnson

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GROWTH AND REGENERATION RESPONSE TO VARIOUS STAND TREATMENTS IN A MATURE LODGEPOLE PINE STAND

BY

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NORTHERN FOREST RESEARCH CENTRE
CANADIAN FORESTRY SERVICE
ENVIRONMENT CANADA
5320 - 122 STREET
EDMONTON, ALBERTA, CANADA
T6H 3S5

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ABSTRACT

*In 1951 several different improvement, harvest, and conversion cuts were employed to determine suitable techniques for thinning, harvesting, and regenerating a dense even-aged 84-year-old lodgepole pine (***Pinus contorta** *Dougl. var.* **latifolia** *Engelm.) stand. Ten-year results showed only small increments in gross volume for a number of cutting methods and losses for others, a large amount of mortality from sunscald and windfall, and moderate regeneration success on less than half of the cutovers. Except for clear-cutting, treatments tested in this study cannot be recommended for the management of mature lodgepole pine forests.*

RÉSUMÉ

*En 1951, les auteurs dirigèrent plusieurs coupes différentes d'amélioration, de récolte et de conversion afin de trouver des techniques appropriées pour éclaircir, récolter et régénérer un peuplement dense et équienne, âgé de 84 ans, de Pin tordu latifolié (***Pinus contorta** *Dougl. var.* **latifolia** *Engelm.). Après dix ans, les résultats obtenus démontrent de faibles accroissements, seulement, de volume brut après avoir employé un certain nombre de méthodes de coupe, et des pertes par suite d'autres méthodes de coupe. On expériencia beaucoup de mortalité par les brûlures du soleil et par le vent et la régénération resta modérée dans moins de la moitié des coupes. Sauf en ce qui concerne la coupe à blanc, les traitements essayés ne peuvent être recommandés pour l'aménagement des forêts arrivées à maturité de Pin tordu latifolié.*

INTRODUCTION

Dense, even-aged stands of lodgepole pine originating from fire occur commonly on the east slopes and lower foothills of the Rocky Mountains in Alberta. These high density conditions often restrict growth and final merchantability to lower-value, small-diameter products. In one such mature 84-year-old stand, radial growth measurements showed a decrease in diameter growth over the last 14 years on all trees including the dominants (Crossley 1953). In 1951 a series of studies was begun to determine suitable silvicultural practices for thinning, harvesting, and regenerating lodgepole pine (Crossley 1955). It was hoped that these treatments would ultimately result in significant increases in gross volume, a larger harvest of saw timber and pole-size trees, and adequate restocking of the area. This report contains results 10 years after treatment to 1962.

STAND AND SITE DESCRIPTION

The study was conducted near Strachan, Alberta in the B.19a Lower Foothills Section of the Boreal Forest Region (Rowe 1972). The area supported an 84-year-old lodgepole pine stand originating from a fire in 1867. A second, less intense fire in 1896 entered the stand in the northeast corner of the area and burned over an 8-ha patch which resulted in two distinct age-classes of pine and an understory of white spruce. At the inception of the study the main stand contained an average of 1648 pine stems/ha with a basal area of 31 m^2/ha. Average height of dominants was 20.4 m and average stand diameter 15.5 cm. Total and merchantable volume was 270 and 215 m^3/ha, respectively.

The area is located on a very gentle undulating plain. The surface fabric is alluvial over uniformly stratified outwash. Soil permeability is moderately rapid to very rapid and moisture regime is somewhat dry to dry.

METHODS

Twelve cutting compartments were established during the summer of 1951 (Figure 1). Nine of these (blocks 1-9) were 4.04 ha in size and three (blocks 10-12) were 2.4 ha. Stand treatments are shown in Table 1. Block 5 served as a control for blocks 1-9 and block 10 served as a control for blocks 11 and 12.

Five 0.08-ha permanent sample plots were located in blocks 1-4, 5, and 8 to provide a 10% sample. Two 0.08-ha permanent sample plots were located in blocks 10-12 to give a 6% sample. A hexagonal 0.5-ha plot, comprising a 25% sample, was established in block 9 because the 0.08-ha plots were not suitable for this type of treatment. All trees on each plot were tallied by species in 2.5-cm diameter classes. One residual lodgepole pine in each diameter class, randomly selected on each of the 0.08-ha plots, was measured for height and diameter, and local volume tables were constructed using Blyth's standard volume tables (1955). Local volume tables were constructed for white spruce using data collected on blocks 10-12 (Blyth 1952).

Cutting was completed during the summer and winter of 1951-52. Horse logging was adopted to minimize damage to the residual stand and slash was lopped and scattered to encourage seed dispersal. Stand

Table 1. Stand Treatments

Treatment	Block	Description
IMPROVEMENT CUTS		
Heavy low thinning	1	All malformed trees were removed. No trees <10.2 cm dbh cut.
Heavy crown thinning	2	All malformed and trees larger than 22.9 cm dbh were removed.
Sanitation cut	3	All malformed trees were removed.
HARVEST CUTS		
Diameter limit cut	4	All trees 16.5 cm dbh and larger were removed.
Control	5	No cutting
Seed tree	6	One hundred dominant, evenly distributed lodgepole pine were selected to remain as seed trees.
Clear-cut	7	A margin of original timber totalling 0.40 ha in area was left on the north and east sides as a seed source.
Shelterwood cut	8	A residual stand of 173 full-crowned dominants was left per ha.
Group selection	9	Circular clear-cuts following a grid pattern removed 25% by volume, numbers, and area.
Control	10	No cutting.
CONVERSION CUTS		
	11	All merchantable pine was removed.
	12	Half the pine overstory was removed. The largest and fullest crowned trees were cut.

statistics before and after cutting are given in Table 2*.

After logging, advance growth was tallied in each sample plot in blocks 1, 2, 3, and 4 to provide a 20% sample of the plot. A 2.4% sample was taken in block 6 and a 1.5% sample on block 7. A 10% sample was made on block 8 and 17% of each opening was tallied on block 9. On blocks 11 and 12 a 2.7% sample was made before and after logging to provide data on loss attributable to the logging operation. Advance growth was recorded in four height classes: 8-15 cm, 15-45 cm, 45-91 cm and >91 cm height to <1.27 cm dbh.

The regeneration survey on the 1962 remeasurement consisted of a 10% sample from each treatment block. Three height classes were used: 0-15 cm, 15-91 cm and >91 cm height to <1.27 cm diameter. No differentiation was made between advance growth and regeneration at this time.

RESULTS

GROWTH

Stand statistics for 1962 are given in Table 3. The average annual volume increase for pine was less than 2% for all treatments (Table 4). In the diameter limit cut (block 4) and in the conversion cuts (blocks 11 and 12) the volumes decreased. The relatively small increases or losses in volume are largely attributable to mortality from sunscald after cutting and to windfall which occurred in 1954. Windfall to 1956 accounted for 21% of final mortality in terms of numbers of trees and 22% in terms of volume (Table 5).

*Tables 2-6 in English units are in Appendix II.

Table 2. Stand statistics before and after treatment (per-ha values).

Treatment	Block	No. of trees						Basal area (m^2)						Average d.b.h. (cm)						Total volume (m^3)					
		Before			After			Before			After			Before			After			Before			After		
		lP	wS	tA*	lP	wS	tA	lP	wS	tA	lP	wS	tA	lP	wS	tA	lP	wS	tA	lP	wS	tA	lP	wS	tA
Heavy low thinning	1	1641	96	2	764	52	0	32	0.09	0.07	20	0.46	0	15.7	4.6	20.3	18.0	4.1	0	282	0.49	0.63	174	0.14	0
Heavy crown thinning	2	1725	42	5	801	40	2	30	0.09	0.16	16	0.09	0.16	15.0	5.1	20.8	16.2	5.6	27.9	259	0.28	1.40	141	0.35	1.33
Sanitation	3	1922	44	0	981	34	0	30	0.02	0	18	0.02	0	14.0	3.0	0	15.2	3.3	0	240	0.07	0	147	0.07	0
Diameter limit	4	1722	27	0	1287	27	0	30	0.01	0	17	0.02	0	15.0	2.8	0	13.0	2.8	0	243	0.03	0	128	0.04	0
Control	5	1586	62	2	1586	62	2	30	0.16	0.07	30	0.16	0.07	15.4	5.6	17.8	15.4	5.6	17.8	260	0.70	0.42	260	0.70	0.42
Seed tree	6	1492	91	2	25	0	0	32	0.25	-	1	0	0	16.5	6.6	2.5	22.9	0	0	268	0.98	-	9	0	0
Clearcut	7	1100	126	17	0	0	0	25	0.69	[illegible]	0	0	0	17.0	7.9	5.3	0	0	0	211	2.80	0.14	0	0	0
Shelterwood	8	1389	242	37	200	185	17	27	0.69	[illegible]14	6	0.69	0.09	15.7	6.1	6.6	19.8	6.6	7.9	228	2.66	0.56	54	2.24	0.35
Group selection	9	1297	272	37	665	163	20	26	0.92	0.69	15	0.69	0.23	16.0	6.1	16.2	17.3	7.1	12.4	229	2.87	5.67	132	2.59	1.68
Control	10	539	242	680	539	242	680	16	3.67	2.75	16	3.67	2.75	19.3	13.7	7.6	19.3	13.7	7.6	125	20.22	20.85	125	20.22	20.85
Conversion	11	1100	464	124	148	420	124	17	4.13	1.15	1	3.90	1.38	14.2	10.7	11.4	7.4	10.9	11.4	136	20.85	9.24	3	18.96	9.24
Conversion	12	914	277	390	623	222	346	22	298	3.44	11	2.75	3.21	17.8	11.4	10.7	15.2	12.7	11.2	194	14.90	24.00	92	15.53	22.74

* Species names for abbreviations are given in Appendix II.

There was no significant increase in terms of volume or numbers for the production of saw timber (trees 22.9 cm dbh or greater) on any of the treated blocks (1-3, 8, and 9) over that of the control (block 5) when compared by "t" tests at the .05 probability level.

The average annual volume increase for white spruce on the two conversion cuts of blocks 11 and 12 was 1.5 and 1.6 m^3/ha. As growth on the control (block 10) was also 1.5 m^3/ha, the white spruce had apparently not yet benefited from the removal of the pine by 1962.

REGENERATION

Logging damage on the two conversion cuts in blocks 11 and 12 caused 36 and 28% mortality respectively of the advance growth present in 1951 (Table 6). Percentage stocking of regeneration and advance growth in 1962 was only moderately successful (Candy 1951) on the seed tree, clear-cut, control (block 10), and on the two conversion cuts.

FOREST MANAGEMENT IMPLICATIONS

None of the treatments applied resulted in any substantial increase in gross volume of the pine. Growth after treatment was not sufficient to warrant two logging operations and this stand should have been clear-cut at rotation age (Figure 2). Bella and DeFranceschi (1974) have recommended precommercial thinning of dense jack pine stands at ages of less than 10 years.

Windfall damage to 1954 has tended to invalidate all meaningful growth gains. In multiple land use situations group-selection and shelter-wood cutting and their modifications may be considered as viable forest

Table 3. Stand statistics in 1962 (per-ha values)

Treatment	Block	Number of trees			Basal area (m^2)			Average d.b.h. (cm)			Total volume (m^3)		
		lP	wS	tA	lP	wS	tA	lP	wS	tA	lP	wS	tA
Heavy low thinning	1	692	143	-	21	0.46	-	19.6	5.8	-	199	1.40	-
Heavy crown thinning	2	660	77	7	17	0.18	0.01	18.3	5.3	3.6	156	0.91	0.03
Sanitation	3	828	54	-	20	0.14	-	17.5	5.8	-	173	0.42	-
Diameter limit	4	803	82	-	14	0.21	-	14.7	5.6	-	110	0.56	-
Control	5	1260	163	2	30	0.69	0.04	17.3	6.8	15.2	276	2.87	0.28
Seed tree	6												
Clearcut	7												
Shelterwood	8	163	225	30	6	1.61	0.21	22.4	9.6	9.4	59	7.63	0.77
Group selection	9	566	200	52	16	1.61	0.34	19.0	10.2	9.1	146	8.96	2.38
Control	10	440	252	716	15	5.51	3.67	21.1	16.8	7.9	138	37.15	26.66
Conversion	11	54	457	153	0.23	5.97	1.61	7.1	13.0	11.7	1	34.36	11.20
Conversion	12	502	247	371	10	4.82	4.13	16.5	15.7	11.9	86	31.28	27.50

Table 4. Total yearly volume change for lodgepole pine and white spruce from treatment to 1962 (m^3/ha values).

Treatment	Block	Lodgepole pine		White spruce	
		Volume increase	Percent	Volume increase	Percent
Heavy low thinning	1	2.52	1.5	0.12	90.0
Heavy crown thinning	2	1.55	1.1	0.06	16.0
Sanitation	3	2.57	1.7	0.04	50.0
Diameter limit	4	-1.79	-1.4	0.05	140.0
Control	5	1.55	0.4	0.20	28.0
Seed tree	6	-	-	-	-
Clearcut	7	-	-	-	-
Shelterwood	8	0.43	0.8	0.54	24.1
Group selection	9	1.45	1.1	0.64	24.6
Control	10	1.14	0.9	1.54	7.6
Conversion	11	-0.17	-6.1	1.54	8.1
Conversion	12	-0.57	-0.6	1.57	10.1

Table 5. Lodgepole pine mortality (per-ha values).

Treatment	Block	Mortality 1952-56		Windfall 1952-56		Mortality 1956-62		Total mortality 1952-62		Total mortality per year (m^3)
		No. of trees	Total vol (m^3)	No. of trees	Total vol (m^3)	No. of trees	Total vol (m^3)	No. of trees	Total vol (m^3)	
Heavy low thinning	1	40	4.41	12	1.33	27	3.22	67	7.63	0.77
Heavy crown thinning	2	91	11.34	44	7.21	59	6.58	151	17.91	1.82
Sanitation	3	79	5.95	44	4.27	64	4.55	143	10.50	1.05
Diameter limit	4	284	25.89	138	14.69	173	16.30	457	42.19	4.20
Control	5	203	19.52	22	2.52	104	10.64	306	30.16	2.73
Seed tree	6									
Clearcut	7									
Shelterwood	8	42	5.11	15	2.94	10	2.80	52	7.91	0.77
Group selection	9	62	7.42	12	0.77	42	4.13	104	11.54	1.12
Control	10	32	8.05	7	0.14	15	5.60	47	13.64	1.26
Conversion	11	79	1.82	30	0.70	25	0.49	104	2.31	0.21
Conversion	12	69	6.23	-	-	20	4.34	89	10.56	1.05

management practices provided that windfall risk, insect and disease damage, and stand conditions are properly assessed before cutting (Alexander 1974). In single-storied stands with a low windfall risk Alexander recommends removal of only 30% of the basal area for a first cut, 20% in moderate risk situations, and clear-cutting in high risk situations. Cutting on blocks 1 to 4, 8, and 9, however, ranged from 39 to 77% of the basal area, at least twice the cut recommended by Alexander, assuming moderate windfall risks. In addition, sunscald was a major cause of mortality and this should be considered when a lodgepole pine stand is exposed through partial cutting.

Regeneration was only moderately successful on less than half of the cutting blocks. In view of the advance growth mortality caused by the logging operation on the two conversion cuts up to 30% loss of regeneration could be expected in a second cut.

Mortality on the seed tree block to 1962 was 25% of the residual trees, of which 52% was caused by windfall. Endean and Johnstone (1974) report the use of lodgepole pine seed trees as a method of regeneration in combination with prescribed fire as being unsuccessful due to windfall both before and after burning. Excellent regeneration of lodgepole pine was obtained in an experiment conducted adjacent to and in conjunction with the present study (Johnson 1968). Prescarification and strip clear-cutting with lopping and scattering or piling and burning of slash was employed.

Smithers (1961) describes thinning as a method of "stand improvement combined with the salvage of mortality," and partial cutting

Table 6. Advance growth following treatment and regeneration in 1962 (per-ha values)

Treatment	Block	Advance growth 1952			Regeneration and advance growth 1962			Stocking percent 1962			
		1P	wS, bS	tA	1P	wS, bS	tA	1P	wS, bS	tA	all species
Heavy low thinning	1	0	37	37	388	57	0	15	2	0	16
Heavy crown thinning	2	0	25	25	455	104	143	16	4	6	24
Sanitation	3	0	86	0	529	166	54	17	8	2	24
Diameter limit	4	0	62	0	798	62	0	30	3	0	32
Control	5	Not measured			101	91	37	3	3	1	7
Seed tree	6	0	133	492	966	67	217	38	3	8	44
Clearcut	7	86	86	205	1122	106	516	42	4	15	55
Shelterwood	8	0	198	0	554	136	395	21	6	14	35
Group selection	9	47	143	143	257	237	240	10	10	9	25
Control	10	Not measured			284	376	1020	11	14	40	51
Conversion Before cutting	11	148	247	1908							
After cutting		59	198	1226	771	208	1226	17	7	29	46
Conversion Before cutting	12	69	109	3173							
After cutting		10	148	2263	188	89	1878	6	3	43	46

as a "harvesting method aimed at increased production and regeneration of the stand." Techniques used in the present study were unsuccessful in attaining these objectives. While some mortality may have been salvaged through logging, the cutting operation was in itself responsible for additional mortality through windfall and sunscald of the residual stand. Volume production showed only modest gains on some cutting compartments and losses on others, while regeneration was only marginally successful on less than 50% of the cutover.

Blyth (1957) carried out a detailed study of partial cutting in even-aged 50 to 110-year-old lodgepole pine stands. Measurements were taken 12-30 years after cutting low density stands averaging 815 stems/ha. Blyth concluded that there was no perceptible increase in the diameter growth rate of the residual stand, pine regeneration was very poor, and repeated partial cuts would convert these stands to a hardwood forest.

Partial cutting which removed substantial volumes cannot be recommended for mature lodgepole pine on either production or aesthetic grounds. Regeneration without adequate ground preparation will result in failures or produce only minimal stocking.

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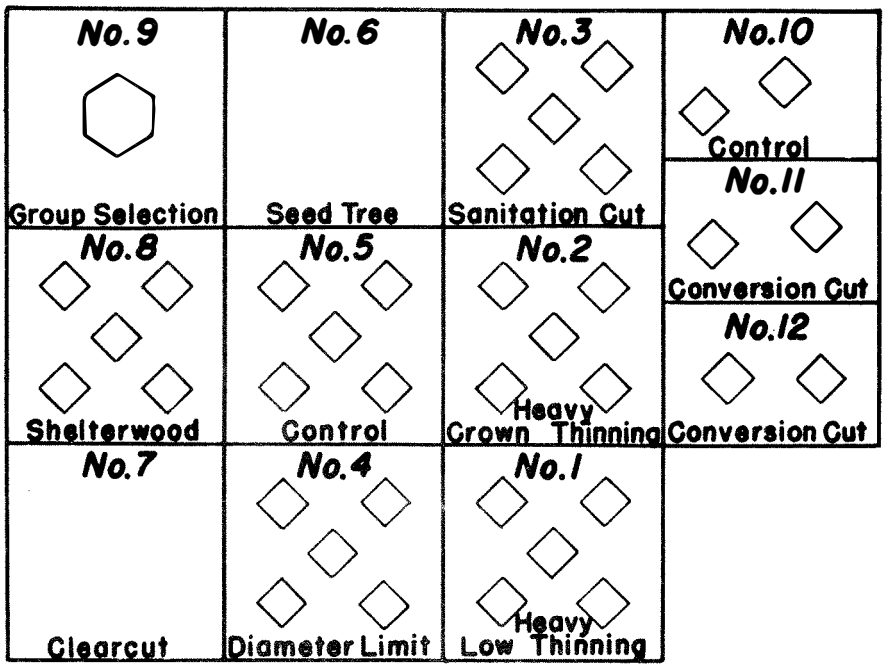

Figure 1. Location of treatments and permanent sample plots on experimental area.

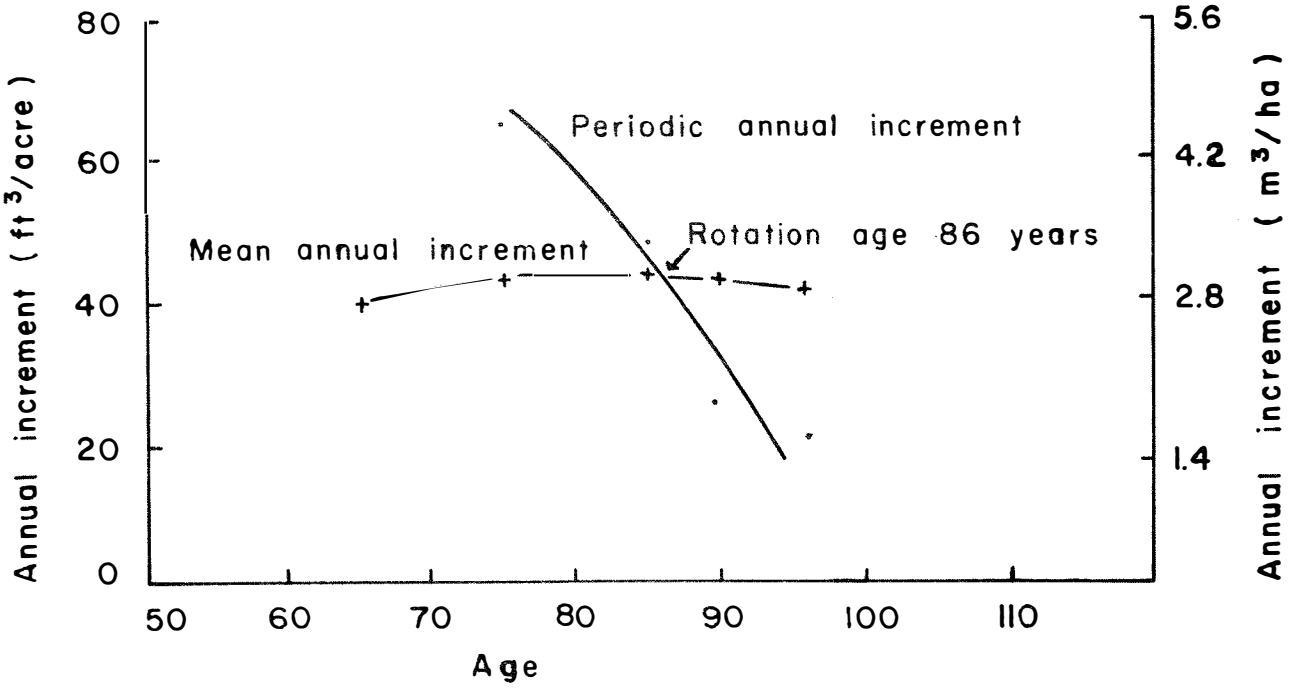

Figure 2. Rotation curve for pine, control block 5.

APPENDIX I

SPECIES NAMES AND ABBREVIATIONS.

lP - lodgepole pine, Pinus contorta Dougl. var. latifolia Engelm.

wS - white spruce, Picea glauca (Moench) Voss.)

tA - trembling aspen, Populus tremuloides Michx.

bF - balsam fir, Abies balsamea (L.) Mill.

bS - black spruce, Picea mariana (Mill.) BSP.

jP - jack pine, Pinus banksiana Lamb.

APPENDIX II

TABLES 2-6 IN ENGLISH MEASURE

Table 2. Stand statistics before and after treatment (per-acre values)

Treatment	Block	No. of trees						Basal area (ft^2)						Average d.b.h. (in.)						Total volume (m^3)					
		Before			After			Before			After			Before			After			Before			After		
		lP	wS	tA*	lP	wS	tA	lP	wS	tA	lP	wS	tA	lP	wS	tA	lP	wS	tA	lP	wS	tA	lP	wS	tA
Heavy low thinning	1	664	39	1	309	21	0	141	0.4	0.3	85	2	0	6.2	1.8	8.0	7.1	1.6	0	4041	7	9	2488	2	0
Heavy crown thinning	2	698	17	2	324	16	1	133	0.4	0.7	72	0.4	0.7	5.9	2.0	8.2	6.4	2.2	11.0	3697	4	20	2011	5	19
Sanitation	3	778	18	0	397	14	0	130	0.1	0	79	0.1	0	5.5	1.2	0	6.0	1.3	0	3435	1	0	2104	1	0
Diameter limit	4	697	11	0	521	11	0	131	0.08	0	74	0.08	0	5.9	1.1	0	5.1	1.1	0	3473	0.4	0	1836	0.5	0
Control	5	642	25	1	642	25	1	133	0.7	0.3	133	0.7	0.3	6.1	2.2	7.0	6.1	2.2	7.0	3709	10	6	3709	10	6
Seed tree	6	604	37	1	10	0	0	138	1.1	0	4	0	0	6.5	2.6	1.0	9.0	0	0	3827	14	0.05	134	0	0
Clearcut	7	445	51	7	0	0	0	108	3	0.2	0	0	0	6.7	3.1	2.1	0	0	0	3019	40	2	0	0	0
Shelterwood	8	562	98	15	81	75	7	118	3	0.6	27	3	0.4	6.2	2.4	2.6	7.8	2.6	3.1	3264	38	8	776	32	5
Group selection	9	525	110	15	269	66	8	115	4	3	67	3	1	6.3	2.4	6.4	6.8	2.8	4.9	3273	41	81	1885	37	24
Control	10	218	98	275	218	98	275	68	16	12	68	16	12	7.6	5.4	3.0	7.6	5.4	3.0	1787	289	298	1787	289	298
Conversion	11	445	188	50	60	170	50	75	18	5	3	17	6	5.6	4.2	4.5	2.9	4.3	4.5	1947	298	132	41	271	132
Conversion	12	370	112	158	252	90	140	98	13	15	50	12	14	7.0	4.5	4.2	6.0	5.0	4.4	2773	213	343	1318	222	325

* Species names for abbreviations are given in Appendix I

Table 3. Stand Statistics in 1962 (per-acre values)

Treatment	Block	Number of trees			Basal area (ft^3)			Average dbh (in.)			Total volume (ft^3)		
		lP	wS	tA	lP	wS	tA	lP	wS	tA	lP	wS	tA
Heavy low thinning	1	280	58	-	92	2	-	7.7	2.3	-	2849	20	-
Heavy crown thinning	2	267	31	3	76	0.8	0.03	7.2	2.1	1.4	2234	13	0.4
Sanitation	3	335	22	-	87	0.6	-	6.9	2.3	-	2471	6	-
Diameter limit	4	325	33	-	59	0.9	-	5.8	2.2	-	1580	8	-
Control	5	510	66	1	129	3	0.2	6.8	2.7	6	3953	41	4
Seed tree	6												
Clearcut	7												
Shelterwood	8	66	91	12	28	7	0.9	8.8	3.8	3.7	838	109	11
Group selection	9	229	81	21	70	7	1.5	7.5	4.0	3.6	2092	128	34
Control	10	178	102	290	66	24	16	8.3	6.6	3.1	1966	531	381
Conversion	11	22	185	62	1	26	7	2.8	5.1	4.6	16	491	160
Conversion	12	203	100	150	46	21	18	6.5	6.2	4.7	1236	447	393

Table 4. Total yearly volume change for lo gepole pine and white spruce from treatment to 1962 (ft^3/acre values)

Treatment	Block	Lodgepole pine		White spruce	
		Volume increase	%	Volume increase	%
Heavy low thinning	1	36.1	1.5	1.8	90.0
Heavy crown thinning	2	22.2	1.1	0.8	16.0
Sanitation	3	36.7	1.7	0.5	50.0
Diameter limit	4	-25.6	-1.4	0.7	140.0
Control	5	22.2	0.6	2.8	28.0
Seed tree	6	-	-	-	-
Clearcut	7	-	-	-	-
Shelterwood	8	6.2	0.8	7.7	24.1
Group selection	9	20.7	1.1	9.1	24.6
Control	10	16.3	0.9	22.0	7.6
Conversion	11	- 2.5	-6.1	22.0	8.1
Conversion	12	- 8.2	-0.6	22.5	10.1

Table 5. Lodgepole pine mortality) per-acre values

Treatment	Block	Mortality 1952-56 No. of trees	Mortality 1952-56 Total vol. (ft^3)	Windfall 1952-56 No. of trees	Windfall 1952-56 Total vol. (ft^3)	Mortality 1956-62 No. of trees	Mortality 1956-62 Total vol. (ft^3)	Total mortality 1952-62 No. of trees	Total mortality 1952-62 Total vol. (ft^3)	Total mortality per year (ft^3)
Heavy low thinning	1	16	63	5	19	11	46	27	109	11
Heavy crown thinning	2	37	162	18	103	24	94	61	256	26
Sanitation	3	32	85	18	61	26	65	58	150	15
Diameter limit	4	115	370	56	210	70	233	185	603	60
Control	5	82	279	9	36	42	152	124	431	39
Seed tree	6									
Clearcut	7									
Shelterwood	8	17	73	6	42	4	40	21	113	11
Group selection	9	25	106	5	11	17	59	42	165	16
Control	10	13	115	3	2	6	80	19	195	18
Conversion	11	32	26	12	10	10	7	42	33	3
Conversion	12	28	89	0	0	8	62	36	151	15

Table 6. Advance growth following treatment and regeneration in 1962 (per-acre values)

Treatment	Block	Advance growth 1962			Regeneration and advance growth 1962			Stocking %, 1962			
		1P	wS,bS	tA	1P	wS,bS	tA	1P	wS,bS	tA	all species
Heavy low thinning	1	0	15	15	157	23	0	15	2	0	16
Heavy crown thinning	2	0	10	10	184	42	58	16	4	6	24
Sanitation	3	0	35	0	214	67	22	17	8	2	24
Diameter limit	4	0	25	0	323	25	0	30*	3	0	32
Control	5	Not measured			41	37	15	3	3	1	7
Seed tree	6	0	54	199	391	27	88	38*	3	8	44
Clearcut	7	35	35	83	454	43	209	42*	4	15	55
Shelterwood	8	0	80	0	224	55	160	21*	6	14	35
Group selection	9	19	58	58	104	96	97	10	10	9	25
Control	10	Not measured			115	152	413	11	14	40	51
Conversion Before Cutting	11	60	100	772							
After Cutting		24	80	496	312	84	496	17*	7	29	46
Conversion Before Cutting	12	28	44	1284							
After Cutting		4	60	916	76	36	760	6*	3	43	46

* Stocking checked in 1975 - no significant difference from 1962.