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Twenty-three years of management in the Rockland red pine plantation

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Sommaire en français

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Abstract

Effects of thinning and pruning on survival, growth and quality timber production were studied in a red pine plantation near Ottawa, Ontario. In the thinned stand diameter growth of the residual trees was increased as well as basal area growth per acre, while height growth was not affected. Gross volume production was nearly equal for both stands while net production was higher in the thinned stand due to salvage of natural mortality. Appraisal of all trees in regard to size, stem straightness and freedom from defects indicated that thinning and pruning had already increased average quality in the managed stand at age 50 and an even faster increase is expected in the production of quality material with increasing stand age. Calculation of gross returns under three intensities of utilization indicated higher returns for the control stand under pulpwood and sawlog-pulpwood management while the thinned stand showed higher returns under intensive pole-sawlog-pulpwood management.

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F. W. von Althen[1] and W. M. Stiell[2]

During the last 30 years, red pine (*Pinus resinosa* Ait.) has been extensively planted on sub-marginal agricultural land in Ontario. Many of these plantations are now approaching the age where management decisions must be made on the choice of final product and the selection of silvicultural treatment which will achieve the aim of management in the shortest possible time. Whether the plantations will be managed for sawlogs on a long rotation, or for piling, pole, or pulpwood production on shorter rotations, will depend mainly on the attitude of the forest owner and on local market conditions. But the basis for all management decisions should be knowledge of the probable stand development under different silvicultural treatments.

It is generally acknowledged that the total production of a fully stocked forest stand cannot be significantly increased by any cutting practice. However, the production of particular products can be greatly influenced by appropriate treatments at the right time.

The Rockland red pine plantation is one of the oldest in Ontario, and has been managed for the last 23 years. Its present condition reflects the influence of pruning and repeated thinnings, and the plantation can therefore serve as a demonstration for the development of similar stands under similar treatments.

History

In 1914, a 15-acre plantation of red pine was established near Rockland, Ontario, 25 miles east of Ottawa. Three-year-old seedlings from the provincial nursery at St. Williams, Ontario, were planted at a spacing of 6 by 6 feet on old pasture land. In 1938 the owner agreed to manage the plantation as a demonstration area in co-operation with the Federal Forestry Branch. Two one-half-acre permanent sample plots were established in the same year to study the effect of thinning and pruning on the survival, growth, form development and quality timber production of the stand. One plot was thinned and pruned, while the other, receiving no treatments, served as a control. The treated plot was thinned again in 1951 and 1961 and both plots were remeasured in 1943, 1951, 1956 and 1961.

The stand

When the plantation was first examined in the fall of 1938, at an age of 27 years from seed, the average diameter at breast height was 6.1 inches and the maximum height was 42 feet.

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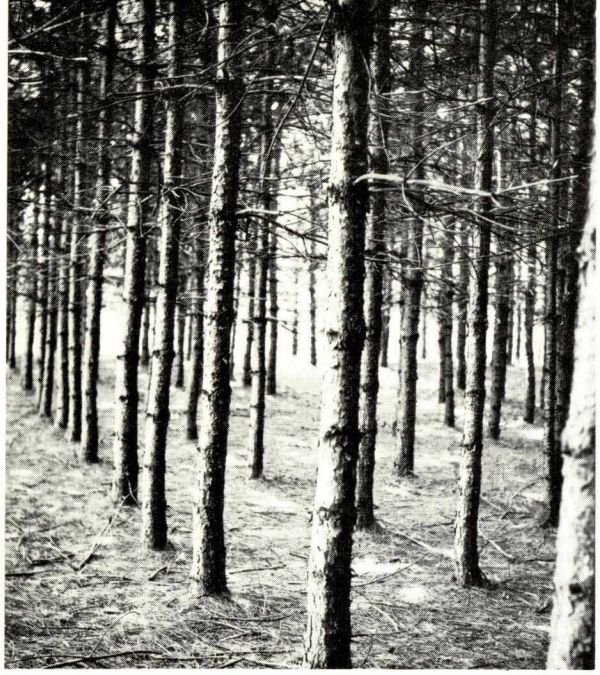


FIGURE 1. Red pine plantation before thinning, 1938.

A total mortality of 15 to 20 per cent had occurred, often in groups of three to six trees and may have been the result of poor planting. Despite these openings the crowns had closed, resulting in a very dense canopy of nearly even height with individual trees just beginning to express dominance. The average number of trees per acre was 1,000.

The density of the canopy almost completely obstructed all direct light to the forest floor. The ground was covered with 1 to 1.5 inches of dry needles and other organic matter but there was practically no vegetation or regeneration present (Figure 1). In 1956, five years after the second thinning, a dense stand of 2- to 5-foot high sugar maple, (*Acer saccharum* Marsh.) with a few basswood, (*Tilia americana* L.) and ash seedlings, (*Fraxinus americana* L.) had become established under the pine. In the summer of 1961 this understorey was so dense that the crowns of the pine trees could not be seen through the canopy of the hardwood saplings. Since the plantation borders an old sugar maple stand, the origin of the seed is explained, but there seemed to be no difference in the number or height growth of hardwood seedlings between the thinned stand and the control. A few one-year-old red pine seedlings were found in 1961, but it is most unlikely that they will survive.

The soil is a dry to fresh water-washed till on the western portion of the area, changing to dry interbanded sand and silt loam to the east. The stand is located on a broad ridge with swamps in the depressions on either side. The moisture-holding capacity is fairly high for a sandy soil with an average of 48 %. The determination of pH from dry samples gave a range of 4.9 to 6.3. The site index, based on the height of dominant trees, is 72 at 50 years.

Measurement and compilation

In 1938 the two permanent sample plots were carefully surveyed and corner and side pickets established. All trees within the plots were numbered consecutively with aluminum tags, and their positions plotted on a large-scale map, identifying each tree in relation to its neighbours. The breast height diameters of all numbered trees were measured with a diameter tape to the nearest one-hundredth of an inch and a stand table was constructed, using one-inch diameter classes. The heights of 10 to 15 trees in each diameter class were measured with an Abney level to the nearest one foot and height/diameter curves drawn.

From these curves, total cubic foot volume was computed for each diameter class, and the merchantable cubic foot volume was calculated for all trees of 6 inches or more in diameter, using the volume tables for red pine trees under 120 years, form class 70 (Anon. 1948). The merchantable board foot volume was compiled for all trees of 8 inches or more in diameter, using the International Log Rule (1/4), (Anon. 1948).

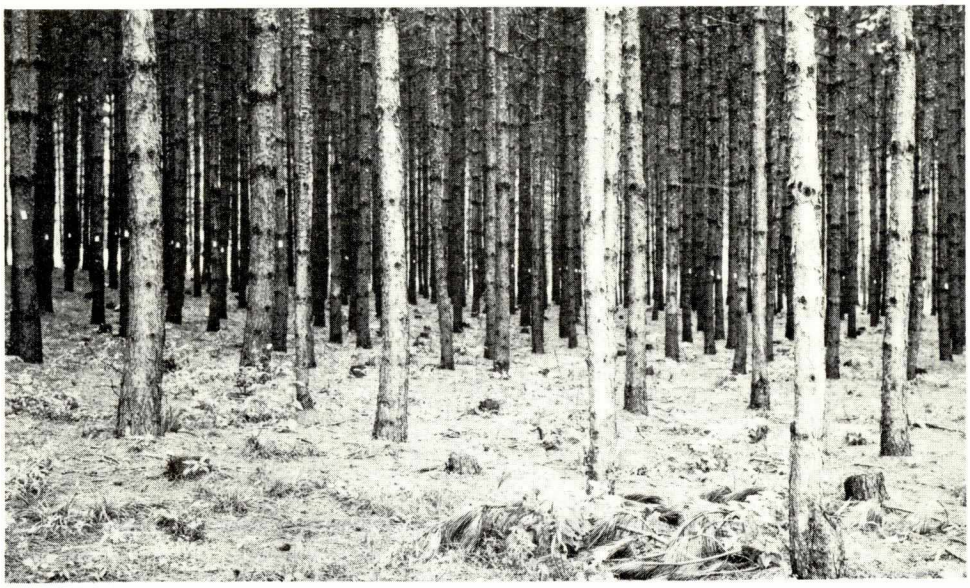


FIGURE 2. Five years after thinning and pruning, 1943.

Silvicultural treatments

Thinning

The plantation was first thinned in the autumn of 1938, after cross-sections of the stems showed that diameter growth had slowed down. The intensity of this first thinning was light owing to the fear of windthrow after a heavy cut and to the limited utilization of the small material which could only be sold for fuelwood.

Tree marking was aimed at the removal of poorly formed or badly suppressed trees, to favour the most promising individuals and to leave a uniform stand with a well broken canopy. The owner carried out the thinning with a crew of men, who cut all marked trees, lopped the branches, piled the wood, and burned the slash. No damage was done to the residual stand.

In the autumn of 1951 the stand was remeasured and although little reduction in growth rate was found, the density of crown closure and shortness of the live crowns suggested the desirability of a second thinning. The stand was therefore marked and thinned to release final crop trees selected at that time.

After remeasurement of the plots in the autumn of 1961, the plantation was marked for its third thinning. Since the previous release, 10 years before, the canopy had closed again and a further release of the crop trees seemed desirable. At the same time, suppressed trees which were not expected to survive the next decade were marked for removal.

Pruning

In 1938, at a stand age of 27 years, the branches of most trees were dead to a height of approximately fifteen feet but no self-pruning was yet evident. For the past few years the owner had removed the dead branches to a height of seven or eight feet by chopping them with an axe. This method nearly always left a protruding and sometimes broken stub of one-quarter inch to four inches in length and was considered to be more detrimental then useful. All trees on the thinned plot were therefore

TABLE 1. NUMBER OF TREES PER ACRE.

Year of measurement	Thinned					Control		
	Total number trees	Mortality	Removed in thinning	Residual	Annual mortality	Total number of trees	Mortality	Annual mortality
1938	912		322	590		976		
		8			1.6		92	18.4
1943	582		—	582		884		
		16			2.0		82	10.2
1951	566		162	404		802		
		0			0		72	14.4
1956	404		—	404		730		
		4			0.8		52	10.4
1961	400		128	272		678		

pruned with a pruning saw, to a height of 20 feet. In addition to the pruning of all dead branches, two or three whorls of living branches were removed leaving a live crown of approximately 50 per cent of the height of the trees (Figure 2). Trees in the control plot and the 35-foot border were not pruned. In the remaining stand 200 selected trees per acre were pruned to a height of 20 feet.

Results and discussion

Number of trees

The total number of trees per acre for the thinned plot and the control is shown in Table 1. In the thinned plot, 612 trees per acre were removed in three thinning operations. An additional 28 trees were lost due to natural mortality, reducing the total number per acre from 912 at age 27, to 272 at age 50, and increasing the average spacing from 6.9 feet to 12.6 feet.

In the control plot, natural mortality has claimed 298 trees, reducing the total number per acre from 976 to 678 and increasing the average spacing from 6.7 feet to 8.0 feet.

Diameter and height growth

The diameter growth of individual trees within a forest stand can be greatly accelerated by appropriate thinning operations, but a comparison of average stand diameters does not necessarily reflect true diameter growth, but may only represent a shift in diameter distribution resulting from the removal of trees of a certain diameter class. To show true diameter growth, the data of Table 2 are based on 1938 diameters of those trees still living in 1961. These values indicate that trees of all diameter classes in the thinned plot had a better diameter growth than those in the unthinned plot, and that trees of larger diameter in 1938 grew faster than the smaller trees. However, the per cent increment of trees of all diameter classes is surprisingly uniform within the thinned stand and the control (Table 2).

Comparative diameter and height growth of two stands may also be expressed by the growth of the 100 largest trees per acre. The average diameter and average height for the 100 largest trees were therefore computed for the Rockland plantation and are shown in Table 3. The diameter increment of these trees for the period from 1938 to 1961 was 2.7 and 1.8 inches respectively for the thinned plot and the control, indicating a much better diameter growth in the thinned stand. Height growth has been almost identical in both plots, but since Table 3 shows

TABLE 2. AVERAGE DIAMETER INCREMENT, BY 1938 DIAMETER CLASSES, OF TREES ALIVE IN 1961.

Year of measurement	1938 Diameter classes									
	5 inches		6 inches		7 inches		8 inches		9 inches	
	Thinned	Control	Thinned	Control	Thinned	Control	Thinned	Control	Thinned	Control
1938	5.23	5.20	6.14	6.57	6.98	6.93	7.88	7.88	8.92	8.72
1943	5.71	5.48	6.65	6.88	7.49	7.21	8.41	8.22	9.72	9.09
1951	6.22	5.82	7.34	7.27	8.22	7.62	9.17	8.65	10.86	9.65
1956	6.45	6.00	7.74	7.53	8.68	7.92	9.70	8.98	11.51	9.98
1961	6.71	6.14	8.19	7.80	9.22	8.28	10.35	9.40	12.42	10.44
23 year Increment inches	1.48	0.94	2.05	1.23	2.24	1.35	2.47	1.52	3.50	1.72
23 year Increment per cent	28.3	18.1	33.4	18.7	32.1	19.5	31.3	19.3	39.2	19.7

TABLE 3. DIAMETER AND HEIGHT OF THE 100 LARGEST TREES PER ACRE.

Year of measurement	Average diameter		Average height	
	Thinned	Control	Thinned	Control
1938	7.8	8.0	42	41
1943	8.3	8.3	50	50
1951	9.1	8.8	60	59
1956	9.6	9.1	68	66
1961	10.5	9.8	72	72

the height of the tree of average basal area, heights vary between the two plots, due to differences in average diameter.

Basal area

Basal area data for the thinned stand and the control are shown in Table 4. The first thinning in 1938 reduced the basal area of the managed stand from 193.2 to 139.9 square feet per acre, a reduction of 27.6 per cent. The second and third thinnings in 1951 and 1961 reduced the basal area by 21.8 and 26.6 per cent respectively. Intensity of thinning may best be indicated by expressing the basal area of the residual stand as a percentage of the fully stocked control. On this basis the residual basal area in 1938, 1951 and 1961 was 69.5, 68.0 and 58.8 per cent respectively. The thinnings have kept the treated plot at a relatively low residual basal area level and can be regarded as moderately heavy.

For the last 23 years, from 1938 to 1961, the gross periodic increment, which includes mortality and thinnings, has been 84.5 square feet per acre for the thinned stand and 67.6 square feet for the control. The treated stand has therefore produced 16.9 square feet, or 20 per cent more basal area than the control.

TABLE 4. BASAL AREA IN SQUARE FEET PER ACRE.

Year of measurement	Thinned								Control				
	Total basal area	Mortality	Thinned	Residual	Residual as % of fully stocked control	Gross periodic increment	Net periodic increment	Periodic annual increment	Total basal area	Mortality	Gross periodic increment	Net Periodic Increment	Periodic annual increment
1938	193.2		53.3	139.9	69.5				201.3				
		1.3				18.8	17.5	3.5		13.1	19.8	6.7	1.3
1943	157.4		—	157.4	75.7				208.0				
		3.1				29.8	26.7	3.3		12.9	16.6	3.7	1.5
1951	184.1		40.1	144.0	68.0				211.7				
		0				17.0	17.0	3.4		11.1	15.5	4.4	0.9
1956	161.0		—	161.0	74.5				216.1				
		1.0				18.9	17.9	3.6		8.8	15.7	6.9	1.4
1961	178.9		47.6	131.3	58.8				223.0				
Total		5.4	141.0			84.5	79.1			45.9	67.6	21.7	
Average		0.23						3.4		2.0			0.9

TABLE 5. TOTAL VOLUME IN CUBIC FEET PER ACRE.

Year of measurement	Thinned									Control					
	Total volume	Mortality	Thinned	Residual	Residual as % of fully stocked control	Gross periodic increment	Net periodic increment	Periodic annual increment	Mean annual increment	Total volume	Mortality	Gross periodic increment	Net periodic increment	Periodic annual increment	Mean annual increment
1938	3,681		1,000	2,681	70.2				136.3	3,820					141.5
		25				752	727	145.5			241	896	655	131.0	
1943	3,408		—	3,408	76.2				137.8	4,475					139.8
		68				1,385	1,317	164.6			288	1,179	891	111.4	
1951	4,725		1,001	3,724	69.4				143.1	5,366					134.2
		0				885	885	177.0			266	849	583	116.6	
1956	4,609		—	4,609	77.5				146.9	5,949					132.2
		24				891	867	173.4			243	1,047	804	160.8	
1961	5,476		1,453	4,023	59.6				149.5	6,753					135.1
Total		117	3,454			3,913	3,796				1,038	3,971	2,933		
Average		5						165.0	149.5		45			127.5	135.1

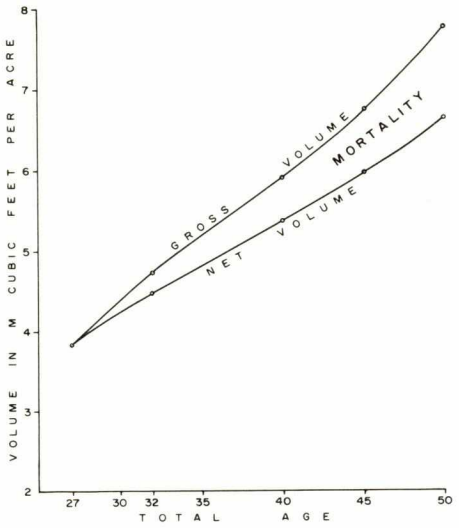
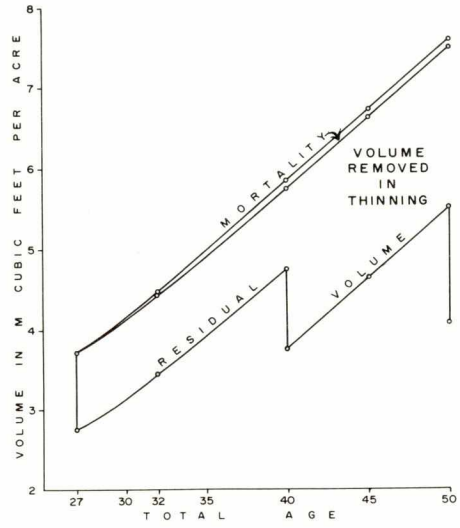


FIGURE 3. Total volume production of the control stand.

FIGURE 4. Total volume production of the thinned stand.



The net periodic increment, which includes the basal area removed in thinnings, but excludes the loss due to mortality was 79.1 square feet per acre for the thinned plot and 21.7 square feet for the control. This indicates that the thinned stand has produced 2.5 times more basal area than the control.

Thinning the plantation repeatedly in 10 to 13 year intervals has resulted in a nearly uniform periodic annual increment of 3.3 to 3.6 square feet per acre. The control on the other hand, shows periodic annual increment varying from 0.5 to 1.4 square feet per acre depending on mortality during periods between remeasurements.

Cubic foot volume

Total volume in cubic feet and periodic increment as well as periodic and mean annual increment of both plots is shown in Table 5. The first thinning operation removed a total of 1,000 cubic feet, or 27.2 per cent, from the managed stand, leaving a residual growing stock of 2,681 cubic feet or 70.2 per cent of the fully stocked control. The second thinning in 1951 removed 1,001 cubic feet, or 21.2 per cent, leaving a residual of 69.4 per cent of the control, while the third thinning reduced the volume by 1,453 cubic feet, or 26.5 per cent to 59.6 per cent of the unthinned stand. During the same period, natural mortality has claimed 117 cubic feet in the managed stand and 1,038 cubic feet in the control.

Since the production of maximum cubic foot volume is seldom an objective in thinning operations, increases in unit value as a result of an increase in tree diameters may justify a possible loss in total volume production due to a reduction in growing stock. But properly applied thinnings can keep this loss to a minimum while at the same time producing material of larger size and higher unit value. In the Rockland plantation the total wood production for the life of the stand, with the exception

of mortality prior to 1938, but including current volume, thinnings and mortality for the thinned stand and current volume and mortality for the control, has been 7,594 and 7,791 cubic feet respectively (Figures 3 and 4). The expected loss in total cubic foot volume, resulting from a reduction in growing stock by thinning, has therefore nearly been balanced by a 20 per cent increase in the basal area growth of the managed stand. This shows that repeated thinnings removing 21 to 27 per cent of the stand are not excessive.

The net periodic increment which includes thinnings, but excludes mortality, was 3,796 cubic feet per acre for the thinned stand and 2,933 cubic feet for the control. This represents a difference of 863 cubic feet or 29 per cent and indicates the advantage of salvaging volume which would otherwise be lost in natural mortality. Similarly, the periodic annual increment was consistently greater in the managed stand. The mean annual increment of the thinned stand has increased from 136 cubic feet per acre in 1938 to 149 cubic feet in 1961. During the same period the mean annual increment of the control has decreased from 141 to 135 cubic feet.

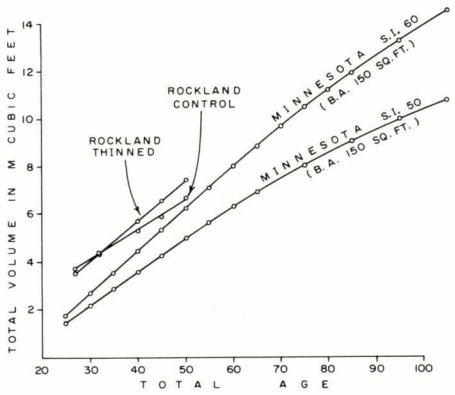


FIGURE 5. Comparison of net yield per acre of Rockland plantation with highest yield data from Minnesota.

Figure 5 shows a comparison of net yield per acre of the Rockland plots with yield data from Minnesota (Buckman 1962). At age 50 yield of the thinned Rockland plot would compare favourably with a Minnesota S. I. 70, while that of the control plot only equals S. I. 60 due to high natural mortality.

TABLE 6. MERCHANTABLE VOLUME IN CUBIC FEET PER ACRE FOR TREES 6 INCHES IN D.B.H. AND OVER.

Year of measurement	Thinned					Control		
	Total merchantable volume	Thinning	Residual	Net periodic increment	Periodic annual increment	Total merchantable volume	Net periodic increment	Periodic annual increment
1938	2,349	488	1,861			2,364		
				686	137.2		668	133.6
1943	2,547	—	2,547			3,032		
				1,278	159.8		1,027	128.4
1951	3,825	719	3,106			4,059		
				819	163.8		643	128.6
1956	3,925	—	3,925			4,702		
				779	155.8		768*	153.6
1961	4,704	1,206	3,498			5,470		
Total		2,413		3,562			3,106	
Average					154.9			135.0

* including ingrowth of 14 trees

FIGURE 6. Managed stand before thinning in 1961.

Merchantable volume in cubic feet

Table 6 shows the merchantable cubic foot volume per acre of trees 6 inches d.b.h. and over for the thinned stand and the control. A total of 2,413 merchantable cubic feet per acre were removed from the managed stand in the three thinning operations. The total net periodic increment, including material salvaged in thinnings, was 3,562 cubic feet per acre for the thinned stand and 3,106 cubic feet for the control. Thus the managed stand produced 456 cubic feet or 14.7 per cent more merchantable wood per acre than the control. The increase in periodic annual increment of the control during the last 5-year period is the result of an ingrowth of 14 trees into the 6-inch diameter class. There was no ingrowth in the thinned part of the stand.

Merchantable volume in board feet

Merchantable board foot volume per acre, computed for trees of 8-inch d.b.h. and over, is shown in Table 7 for both plots. In the three thinning operations, a total of 6,787 board feet per acre was removed from the managed stand, most of it in the last operation. The total net increment from 1938-1961 for the managed stand was 23,333 board feet per acre while that for the control was 18,154 board feet.

The managed stand, therefore, produced 5,119 board feet more than the control, but the latter has shown a very large increase during the last 5-year period, when 36 trees grew into the 8-inch diameter class as compared with only 12 trees in the thinned stand.

Pruning

An inspection in 1961, 23 years after pruning, revealed that most branch scars had healed, and that some clear wood had formed over the smaller scars but that no clear lumber could yet be sawn from the trees. However, better quality lumber could be sawn from the pruned trees due to their small tight knots (Figure 6).

At age 50 the trees in the managed plot have generally clean boles to an average height of 30 feet with dead limbs for the next 20 feet and a live crown starting at a height of approximately 50 feet above ground. In the control plot branch stubs of 2 to 8

TABLE 7. MERCHANTABLE VOLUME IN BOARD FEET PER ACRE FOR TREES 8 INCHES IN D.B.H. AND OVER.

Year of measurement	Thinned					Control		
	Total merchantable volume	Thinning	Residual	Net periodic increment	Periodic annual increment	Total merchantable volume	Net periodic increment	Periodic annual increment
1938	1,488	90	1,398			2,096		
				3,954	790.8		2,270	454
1943	5,352	—	5,352			4,366		
				8,054	1,006.8		4,652	582
1951	13,406	1,422	11,984			9,018		
				5,979	1,195.8		4,772	954
1956	17,963	—	17,963			13,790		
				5,346*	1,069.0		6,460**	1,292
1961	23,309	5,275	18,034			20,250		
Total		6,787		23,333			18,154	
Average					1,014.5			789.3

* including ingrowth of 12 trees
** including ingrowth of 36 trees

inches in length are frequent along the bole to a height of approximately 30 feet with dead limbs for the next 20 feet and a live crown starting at 50 feet above ground (Figure 7). There is little difference in the length of crowns in both plots, but the average width is much greater in the thinned stand (Figures 8 and 9).

Quality products

The purpose of most thinning and pruning operations is to increase diameter growth and quality of the residual trees. To evaluate the influence of pruning and repeated thinnings on tree size and quality development in the Rockland plantation, all trees in both plots were appraised in 1961 on the

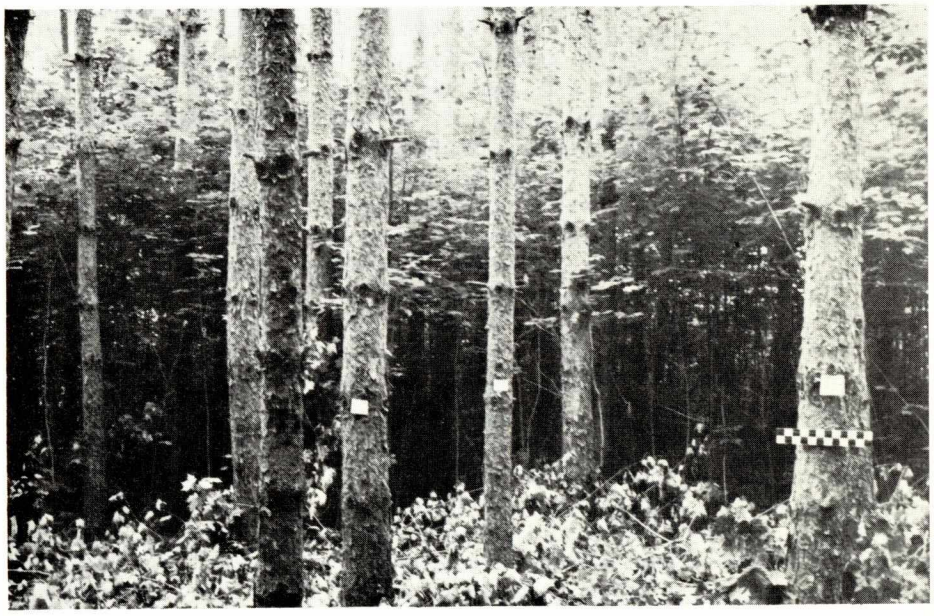


FIGURE 7. Control plot, 1961. Note hardwood understorey and branch stubs on trees.

FIGURE 8. Canopy density of the managed stand before thinning, 1961.

TABLE 8. POLES PER ACRE IN 1961, BEFORE THINNING.

Length in feet	Type of plot	Pole Class									
		2	3	4	5	6	7	8	9	10	Total
16	Managed				18		2				20
	Control				14		14				28
18	Managed		2	6		4					12
	Control		2			10		2			14
20	Managed			2	6	12		2			22
	Control	2		2	4	14		14			36
25	Managed				4	16		6			26
	Control		2		2	18		20	28	4	74
30	Managed					10	16		42		68
	Control			2		10	24		118		154
35	Managed						58	62			120
	Control						12	36			48
40	Managed					2					2
	Control						2				2
45	Managed						8				8
	Control										
50	Managed					4	4				8
	Control										
Total	Managed		2	8	28	48	88	70	42		286
	Control	2	4	4	20	52	52	72	146	4	356

FIGURE 9. Canopy density of the unthinned stand, 1961.

basis of size, stem straightness and freedom from defects for their possible utilization under different intensities of management. Under the most intensive management the order of preference was poles, sawlogs and pulpwood. All trees qualifying for poles were graded for size and length and were recorded in the appropriate pole classes (C.S.A. 1960). Trees with a d.b.h. of 8 inches and larger were recorded as sawlogs and merchantable volume was computed in board feet according to the International Log Rule (¼). Small trees and the tops of poles were classed as fuelwood or pulpwood on the basis of 85 cubic feet per cord.

Table 8 shows the number of poles per acre before thinning in 1961 by classes and length for the managed stand and the control. There are 70 more pole-sized trees growing in the untreated stand but average size and length of all poles in the control is smaller, so that the total cubic foot volume in pole material is slightly lower than that of the managed stand.

Since the trees were not appraised for quality in 1938 and 1951, the calculation of merchantable cubic foot volume in 1951 is based on the assumption that a tree acceptable as a pole in 1961 would also have been acceptable ten years previously if of sufficient dimension. Height and diameter data of the 1951 remeasurement were then used to group the trees into their respective pole classes. Determination of sawlog and pulpwood volume removed in thinnings in 1938 and 1951 is based on the percentage of these products in the 1961 thinning and adjusted by height and diameter data of 1938 and 1951.

Tables 9-11 show the total merchantable volume per acre by three intensities of utilization of all trees 6 inches d.b.h. and larger, inclusive of thinnings for the years 1938, 1951 and 1961. Dollar values, as listed in Table 12, were applied to the volume of poles, sawlogs and pulpwood to show the gross returns which might have been expected under any one of the three intensities of utilization. The market values of Table 12 are not

TABLE 9. GROSS RETURNS WHICH EXCLUDE COSTS AND INTEREST PER ACRE IN CURRENT DOLLARS FOR TOTAL CUT IN PULPWOOD BY AGE OF STAND AND TYPE OF CUT.

Stand age	Type of cut	Thinned stand		Control	
		Fuel & pulpwood		Fuel & pulpwood	
		Cords	$	Cords	$
27	1938 thinning	5.7	14.00		
	If clearcut before 1938 thinning	27.6	69.00	27.8	69.00
40	1951 thinning	8.5	102.00		
	If clearcut before 1951 thinning	45.0	540.00	47.8	574.00
50	1961 thinning	14.2	256.00		
	If clearcut before 1961 thinning	55.3	995.00	64.4	1,159.00
	If clearcut in 1961 plus returns from 1938 and 1951 thinnings		1,111.00		1,159.00

the actual prices paid to the owner, but represent average prices which might have been expected at time of sale. Only gross returns are shown in this study to give an indication of the profitability of silvicultural treatments carried out by the owner, without regard to cost or interest charges. A complete analysis of the economic implications of red pine plantation management, based on the yield data of the Rockland plantation is currently being carried out by the Economics Division of the Department of Forestry.

Table 9 indicates that for pulpwood management on a 50 year rotation, the highest returns would have been realized in the untreated stand due to its high cubic foot volume.

Table 10 shows the gross returns which might have been expected had the Rockland plantation been managed for the production of sawlogs and pulpwood. At a stand age of 50 years the returns from the managed stand are still lower than those of the control, because thinning and pruning have not yet sufficiently increased the unit value of sawlogs to offset the reduction in growing stock. However, the silvicultural treatments, especially pruning, are expected to greatly increase the value of the managed stand during the next decade due to the comparatively much faster increase in value for quality products than for quantity of wood produced.

Table 11 shows the expected gross returns under the most intensive utilization. At age 50 the returns from the managed stand are 9 per cent higher than those of the control, reflecting the effect of thinning on the production of large poles with higher unit value. The difference in value between the two stands is expected to widen progressively with time when the full effect of the silvicultural treatments is reflected in the production of large quantities of high quality products.

TABLE 10. GROSS RETURNS, WHICH EXCLUDE COSTS AND INTEREST, PER ACRE IN CURRENT DOLLARS FOR STANDS MANAGED FOR SAWLOG AND PULP PRODUCTION BY AGE OF STAND AND TYPE OF CUT.

Stand age	Type of cut	Thinned stand					Control				
		Sawlogs		Fuel & pulpwood		Total	Sawlogs		Fuel & pulpwood		Total
		f.b.m.	$	cords	$	$	f.b.m.	$	cords	$	$
27	1938 thinning	90	1.00	5.5	14.00	15.00					
	If clearcut before 1938 thinning	1,488	16.00	23.2	58.00	74.00	2,096	23.00	21.2	53.00	76.00
40	1951 thinning	1,422	36.00	4.9	59.00	95.00					
	If clearcut before 1951 thinning	13,406	402.00	12.1	145.00	547.00	9,018	270.00	25.2	302.00	572.00
50	1961 thinning	5,275	185.00	1.9	34.00	219.00					
	If clearcut before 1961 thinning	23,309	932.00	3.0	54.00	986.00	20,250	810.00	18.3	329.00	1,139.00
	If clearcut in 1961 plus returns from 1938 and 1951 thinnings		969.00		127.00	1,096.00					1,139.00

TABLE 11. GROSS RETURNS, WHICH EXCLUDE COSTS AND INTEREST, PER ACRE IN CURRENT DOLLARS FOR POLES, SAWLOGS AND PULPWOOD BY AGE OF STAND AND TYPE OF CUT.

Stand age	Type of cut	Thinned stand							Control						
		Poles		Sawlogs		Fuel & pulpwood		Total	Poles		Sawlogs		Fuel & pulpwood		Total
		cu. ft.	$	f.b.m.	$	cords	$	$	cu. ft.	$	f.b.m.	$	cords	$	$
27	1938 thinning	—	—	90	1.00	5.5	14.00	15.00							
	If clearcut before 1938 thinning	—	—	1,488	16.00	23.2	58.00	74.00	—	—	2,096	23.00	21.2	53.00	76.00
40	1951 thinning	352	130.00	715	18.00	2.6	21.00	179.00							
	If clearcut before 1951 thinning	1,308	510.00	5,960	179.00	15.6	187.00	876.00	992	367.00	7,310	219.00	18.9	227.00	813.00
50	1961 thinning	594	309.00	1,190	42.00	4.4	79.00	430.00							
	If clearcut before 1961 thinning	2,959	1,598.00	4,415	177.00	10.1	182.00	1,957.00	2,669	1,388.00	7,165	287.00	16.1	290.00	1,965.00
	If clearcut in 1961 plus returns from 1938 to 1951 thinnings		1,728.00		196.00		227.00	2,151.00							1,965.00

TABLE 12. MARKET VALUE OF WOOD PRODUCTS USED IN THE COMPILATION OF TABLE 9-11.

Product	Type of cut	Age 27 delivered (dollars)	Age 40 delivered (dollars)	Age 50 delivered (dollars)
Fuelwood (cord)	Thinning	2.50	12.00	—
Fuelwood (cord)	Clearcut	2.50	12.00	—
Pulpwood (cord)	Thinning	—	—	18.00
Pulpwood (cord)	Clearcut	—	—	18.00
Sawlogs (m.f.b.m.)	Thinning	11.00	25.00	35.00
Sawlogs (m.f.b.m.)	Clearcut	11.00	30.00	40.00
Poles (cu. ft.)	Thinning	—	.37	.52
Poles (cu. ft.)	Clearcut (thinned stands)	—	.39	.54
Poles (cu. ft.)	Clearcut (control)	—	.37	.52

Summary

In 1938 two one-half acre permanent sample plots were established in a 27-year-old red pine plantation near Rockland, Ontario. One of the plots was thinned in 1938, 1951 and 1961 and all trees were pruned to a height of 20 feet in 1938. The other plot received no treatments.

The effects of 23 years of management were evaluated in 1961 in regard to survival, growth, form development and quality timber production. The most important findings and conclusions of this study may be summarized as follows :

1. Diameter growth was higher in every diameter class of the managed stand and diameter growth of the 100 largest trees per acre for the 23-year period from 1938 to 1961 was 2.7 inches for the thinned stand and 1.8 inches for the control.
2. Height growth showed no response to thinning or pruning.
3. Thinnings salvaged nearly all of the natural mortality with a total of only 28 trees and 117 cubic feet of timber lost in the managed stand as against 298 trees and 1,038 cubic feet lost in the control.
4. For the period from 1938 to 1961 the gross periodic basal area increment, which includes mortality and thinnings, was 20 per cent higher in the managed stand.
5. The mean annual increment was 149.5 cubic feet per acre in the thinned stand and 135.1 cubic feet per acre in the control, indicating a 10 per cent higher growth in the managed stand.
6. The periodic annual increment in merchantable cubic foot volume was 13 per cent and in merchantable board foot volume 22 per cent higher in the managed stand, reflecting the concentration of diameter growth on fewer, but larger trees.
7. When all trees in both plots were appraised in regard to their possible utilization on the basis of size, stem straightness and freedom from defects and dollar values were assigned to these products, it was found that in a pulpwood operation the highest gross returns would be realized in the untreated stand.

   If the plantation was managed for the production of sawlogs and pulpwood, the untreated stand would still furnish higher gross returns at age 50, but this trend is expected to be reversed during the next decade when the effects of thinning and pruning will be reflected in higher unit values.

Under the most intensive management, namely the production of poles, sawlogs and pulpwood, slightly higher gross returns would be realized from the treated stand inclusive of thinnings than from the control. This advantage is expected to become more apparent with time due to the comparatively faster increase in value for quality products than quantity of wood produced.

Sommaire

En 1938, on a délimité deux places-échantillons permanentes d'une demi-acre chacune dans une plantation de pins rouges de 27 ans située à Rockland (Ontario). On a procédé à des éclaircies dans une des places en 1938, en 1951 et en 1961; en 1938, tous les arbres en ont été élagués jusqu'à 20 pieds de hauteur. Les arbres de l'autre place ont été laissés tels quels.

En 1961, on a étudié l'effet de ces 23 années d'aménagement, du point de vue de la survivance, de la croissance, de la forme et de la qualité des arbres comme bois d'oeuvre. Les principales constatations et conclusions de cette étude peuvent se résumer comme suit :

1. L'accroissement du diamètre s'est trouvé plus élevé dans chaque classe de diamètre du peuplement aménagé; chez les 100 plus gros arbres, par acre de surface, pour la période des 23 années, soit de 1938 à 1961, l'accroissement du diamètre s'établissait à 2.7 pouces pour le peuplement aménagé, et à 1.8 pouce pour le peuplement témoin.
2. Ni n'éclaircissement ni l'élaguage n'ont semblé influer sur la croissance en hauteur.
3. Les éclaircissements ont permis de récupérer presque tous les arbres qui seraient morts d'une cause naturelle, puisque seulement 28 arbres, soit 117 pieds cubes de bois sur pied, ont été perdus dans le peuplement aménagé, alors que les chiffres correspondants s'établissaient respectivement à 298 arbres et 1,038 pieds cubes de bois dans le peuplement témoin.
4. L'accroissement saisonnier de la surface terrière, de 1938 à 1961, compte tenu de la mortalité et des éclaircies, était de 20 p. 100 plus élevé dans le peuplement aménagé.
5. L'accroissement annuel moyen était de 149.5 pieds cubes à l'acre dans le peuplement éclairci, alors qu'il n'était que de 135.1 pieds cubes dans le peuplement témoin, soit un accroissement supérieur de 10 p. 100 dans le peuplement aménagé.
6. Les gains saisonniers en volume de bois marchand et en p.m.p. étaient respectivement de 13 p. 100 et de 22 p. 100 plus élevés dans le peuplement aménagé, ce qui indique que l'accroissement en diamètre se manifeste chez un nombre d'arbres moindre, mais chez les plus gros arbres.
7. Le classement des arbres des deux places-échantillons en fonction de leur valeur utilitaire calculée selon la grosseur, la rectilignité du tronc, l'absence relative de défauts et, par conséquent, leur valeur marchande, a révélé que le peuplement témoin serait d'un plus grand rapport brut en bois à pâte.

Même si le peuplement aménagé était exploité en vue de la production de billes de sciage et de bois à pâte, le rendement du peuplement non aménagé serait encore le plus avantageux, à 50 ans; toutefois, on prévoit que cet avantage disparaîtra d'ici une dizaine d'années, alors que l'éclaircissement et l'élaguage produiront de plus grandes valeurs unitaires.

Pourvu que le travail d'aménagement soit poussé à fond, en vue de produire des poteaux, des billes de sciage et du bois à pâte, le rendement du peuplement aménagé serait légèrement supérieur à celui du peuplement témoin, compte tenu de l'éclaircissement. On prévoit que cet avantage grandira avec le temps, vu que l'accroissement de la qualité et de la valeur des produits est comparativement plus rapide que l'augmentation de la production de bois.

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