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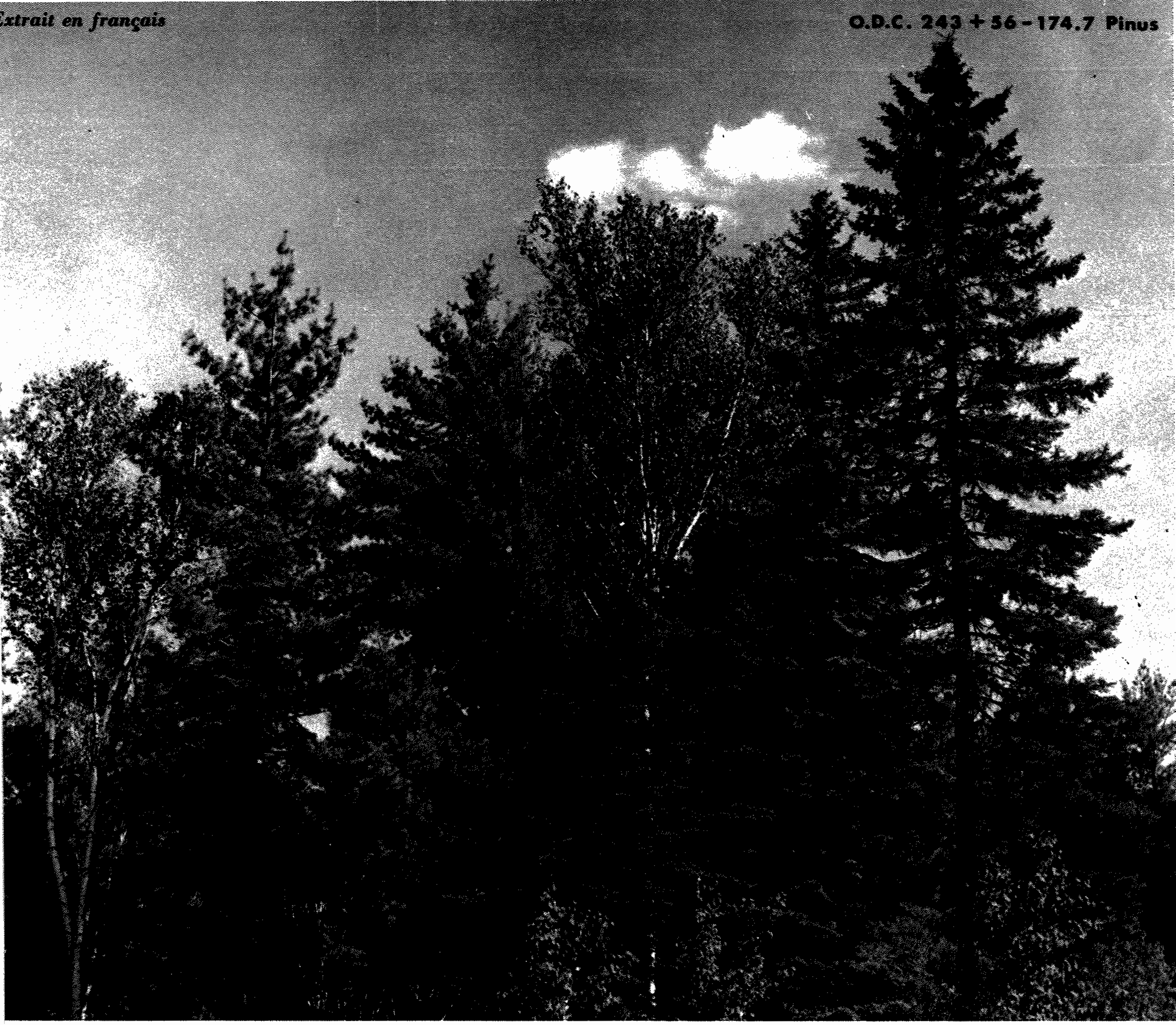

IMPROVEMENT CUT IN PINE MIXEDWOODS

by L.G.BRACE

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ABSTRACT

An improvement-cut experiment was established in 60-year-old pine mixedwoods at the Petawawa Forest Experiment Station in 1939. Treatment converted mixedwoods to predominantly softwood stands and more than doubled growth for two subsequent decades. Sawlog volumes increased most. Results of sawing in 1966 showed that pruning of selected white pine crop trees during the improvement cut brought about considerable lumber-value increases.

EXTRAIT

Une expérience de coupe d'amélioration a été entreprise en 1939 à la Station d'expériences forestières de Petawawa dans des boisés mixtes de 60 ans comportant des Pins destinés aux sciages. Le résultat a été des peuplements où les résineux prédominaient et où le taux moyen décennal de croissance, de 1939 à 1959, était deux fois plus élevé. Ce sont les volumes marchands qui ont augmenté le plus. En outre, à la suite d'élagages (faits en 1939) de Pins blancs (*Pinus strobus*) sélectionnés, la qualité des sciages obtenus en 1966 a considérablement augmenté.

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INTRODUCTION

Mixed stands containing white and red pine[2] characterize extensive areas of forest in the Great Lakes-St. Lawrence Forest Region (Rowe, 1959). In the Ottawa Valley, and particularly the Middle Ottawa Section L.4c, common associates are tolerant and intolerant hardwoods, jack pine, white spruce and balsam fir. The mixtures have evolved after heavy cutting of white and red pine, and fire, and constitute about 50 per cent of the forest area. The pine and spruce in these extensive and usually middle-aged stands are in high demand, but utilization of the hardwoods is relatively low. Problems are thus posed of applying effective silvicultural treatments to increase the softwood composition and yields of these stands. An improvement-cut experiment with such objectives was established at the Petawawa Forest Experiment Station in 1939. This paper describes the operation and presents 20-year results.

DESCRIPTION OF THE AREA

The study area is rolling to rough, with thin-soiled ridgetops, occasional rock outcrops and wet depressions. Soils are sandy and sandy-loam tills. The area, which totalled 132 acres, can be classified generally as the Sherborne land-type (Hills, 1959) and represents a prevalent commercial forest site in the region.

In 1939, the forest was largely an even-aged 60-year-old mixture of intolerant hardwoods and conifers, with white birch-aspen-pine and white birch-aspen-balsam fir-spruce-pine the principal subtypes. Other associates of the pine were red maple, hard maple and yellow birch on the moister sites, and red oak on the ridgetops. A large proportion of the hardwood component of the stands was decadent at the time of treatment.

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[1]Research Officer, Canada Department of Forestry and Rural Development, Petawawa Forest Experiment Station, Chalk River, Ontario.

[2]Botanical names are appended.

METHODS

Treatment

Treatment was aimed at converting mixedwood stands to stands with a high proportion of thrifty well-formed softwoods (Bickerstaff, 1942).[3] White pine, red pine and white spruce were favored by the treatment. High-quality aspen, hard maple and yellow birch were also retained. White birch and red maple were considered weed species.

Desirable residual trees were released by girdling and felling low-quality or overmature competitors. The area was divided into four blocks of roughly 30 acres each, and the degree of utilization varied from removal of all fuelwood[4] and sawlogs in the first block, fuelwood being manufactured at the stump, to removal of sawlogs only and girdling of all fuelwood trees in the last block. Cost and cut figures were kept for each block.

Selected white pine crop trees were pruned to 18 feet.

Sampling and Compilation

Untreated stands similar in composition and quality to treated stands were selected for purposes of comparison. Permanent sample transects one chain wide were established for the sampling of all site and species conditions in both treated and untreated stands. These transects were subdivided into tenth-acre subplots, which were measured in 1939, 1949 and 1959. Records of girdling and natural mortality were kept by subplot. This report is based on 114 subplots, 71 in treated stands.

In 1962 increment borings were taken at breast height from all sizes of white and red pine throughout the area to provide individual tree growth data.

The area was considered as one site complex, and average growth and yield figures were compiled. No distinction was made between girdled and cut stands in computing growth and yield.

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[3]Bickerstaff, A. 1942. Comparison of costs and silvicultural results of various improvement cutting methods. Establishment Report - Project P-44. Petawawa Forest Experiment Station, Chalk River, Ontario. Unpublished manuscript.

[4]Fuelwood trees were equivalent in size and quality to those used for pulpwood today.

RESULTS AND DISCUSSION

Precut and Postcut Comparisons

Precut volumes in treated and untreated stands averaged 2,372 and 2,388 cubic feet[5] per acre respectively for all species 4 inches d.b.h. and larger.

The average cut was 910 cubic feet per acre, made up of 723 cubic feet of cordwood and 187 cubic feet of sawlogs. The cut was mostly hardwood and averaged 35% of the initial basal area, although it varied from 30 to 60% depending on the amount and decadence of hardwoods and the amount of releasable softwood.

Table 1 shows the immediate postcut comparison for treated and untreated stands.

The treatment changed the average composition from 38 to 76% softwood.

Postcut Volume Growth and Yield per Acre

The average volume growth for all species in treated stands was more than double that of untreated stands in both decades following treatment (Table 2). By 1959, the net volume of treated stands was nearly equal to that of untreated stands, and net yield (i.e. including the cut) was 759 cubic feet per acre greater for treated stands.

Softwoods accounted for most of the volume increase in the two decades following treatment in both the treated and the untreated stands, and their relative growth is an index of treatment success. The softwood volume of treated stands increased by 1,264 cubic feet to 2,380 cubic feet per acre, and that of untreated stands increased by 524 cubic feet to 1,440 cubic feet per acre (Table 1). The sawlog component (10 in. d.b.h. and over) of treated stands increased by 4,658 merchantable board feet per acre to 5,840 f.b.m.[6] per acre, while that of untreated stands increased by 1,973 merchantable board feet per acre to 2,863 f.b.m. per acre. This represents a 240% superiority for both cubic foot and merchantable board foot increases in treated stands.

By 1959, treated stands contained 51% more volume for all softwoods[7] and 94% more volume for sawlog-sized softwoods than untreated stands (Table 1).

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[5]Cubic feet means <u>total</u> cubic feet, unless a merchantable product is specified.

[6]1 merchantable cubic foot = 5 board feet.

[7]Equivalent to a 7-cord-per-acre superiority for treated stands, derived by reducing total cubic feet by 20% to obtain merchantable cubic feet, then taking 1 cord = 85 merchantable cubic feet.

TABLE 1. POSTCUT COMPARISONS FOR TREATED AND UNTREATED STANDS

	All species -4" d.b.h. +				Softwoods -4" d.b.h. +				Softwoods -10" d.b.h. +			
	Treated		Untreated		Treated		Untreated		Treated		Untreated	
	1939	1959	1939	1959	1939	1959	1939	1959	1939	1959	1939	1959
Number of trees per acre	293	330	450	395	243	266	231	227	15	63	12	31
Mean d.b.h. (in.)	6.4	8.2	6.4	7.6	6.3	8.1	5.9	7.0	11.2	11.5	11.2	12.0
Volume per acre (total cu.ft.[1])	1,462	2,848	2,388	2,999	1,116	2,380	916	1,440	295	1,460	223	716
Volume per cent of total[2]	100	100	100	100	76	83	38	48	20	51	9	24

[1]Volume from local volume tables derived from: Anon. 1944. Interpolated volume tables (total volume) for use in compilation of sample plot data. Canada Department of Mines and Resources. Miscellaneous Series No. 3.

[2]Expressed on total volume of all species in corresponding year.

Volume differences existing between treated and untreated stands in 1939 were adjusted before volume superiority and percentages were computed for 1959. As sawlog stumpage is currently two to three times greater than pulpwood stumpage, the sawlog-volume increase is most significant.

The foregoing results are in general agreement with the reported behavior of other conifers freed from hardwood competition, as exemplified by white spruce released from aspen suppression in Alberta, Saskatchewan and Manitoba (Lees, 1966; Cayford, 1957; Steneker, 1963 and 1967). Hatcher (1967) reported similar results for red spruce and balsam fir released from suppression by hardwoods in mixedwood stands in Quebec.

Species Behavior

The proportion of growth attributable to different species and species groups is summarized in Table 3. The superior growth of pine is clearly shown. Tolerant hardwoods (a minor stand component) grew relatively well and intolerant hardwoods, particularly white birch and aspen, grew poorly. Intolerant hardwoods on these sites should be utilized by age 50 if heavy losses owing to decadence are to be avoided.

Superior second-decade growth, particularly for softwoods (shown in Tables 2 and 3), may be related to hardwood mortality. In untreated stands, increased hardwood mortality in the second decade would have resulted in some softwood release. In treated stands, mortality in the second decade complemented the release effect of cutting. Also, there may have been a lag in first-decade response during crown build-up on released intermediate and codominant trees.

The improvement cut resulted in salvage equivalent to 23 cubic feet per acre per year of potential hardwood mortality in the two decades following treatment.

Growth per Tree

Regression equations of 10-year and 20-year basal-area growth on the 1939 basal area of individual trees, together with curves derived from them, are shown for white and red pine in Table 4 and Figure 1. These values represent average results of treatment over the entire area.

The increment cores showed that trees in both treated and untreated stands had grown similarly in the decade before treatment.[8]

Treatment effects were considerable for both species in both decades. The response of white pine to treatment was greater than that of red pine.

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[8]Tested at the 5% level of significance by Sheffé "S" tests.

TABLE 2. TOTAL VOLUME GROWTH AND YIELD
(cubic feet per acre)

	Treated	Untreated
1939 postcut volume	1,462	2,388
1939-49 net growth	611	258
1949 volume	2,073	2,646
1949-59 net growth	775	353
1959 volume	2,848	2,999
1939 cut	910	0
1959 net yield	3,758	2,999
1939-59 mortality	205	669
1959 gross yield	3,963	3,668
Decadal softwood growth per cu. ft. of 1939 softwood 1939-49	.48	.14
1949-59	.66	.43

TABLE 3. COMPARATIVE VOLUME[1] AND VOLUME GROWTH, BY SPECIES, FOR TREES 4" D.B.H. +

Species	1939-49 growth				1949-59 growth				1939 volume			
	Treated		Untreated		Treated		Untreated		Treated		Untreated	
	Cu. Ft.	%	Cu. ft.	%	Cu. ft.	%	Cu. ft.	%	Cu. ft.	%	Cu. Ft.	%
White pine - red pine	479	78	126	49	685	88	347	78	1,016	69	768	32
Other softwoods	38	6	1	0	62	8	50	11	100	7	148	6
All softwoods	517	84	127	49	747	96	397	89	1,116	76	916	38
Aspen	61	10	44	17	15	2	-	0	191	13	741	31
White birch	17	3	17	7	-	0	-	0	87	6	442	19
Red oak	10	2	49	19	10	1	21	5	45	3	209	9
Other hardwoods[2]	6	1	21	8	7	1	29	6	23	2	80	3
All hardwoods	94	16	131	51	32	4	50	11	346	24	1,472	62
Total	611	100	258	100	779	100	497	100	1,462	100	2,388	100

[1]Total cubic feet 4" +.

[2]Mainly yellow birch and sugar maple.

TABLE 4. BASAL AREA GROWTH REGRESSIONS FOR INDIVIDUAL TREES

Treatment		White pine			n	R^2
Untreated 1929-1939 basal area growth	=	.2858 BA[1]	-	.0867 BA^2	79	.812
Treated " " " "	=	.3112 BA	-	.2749 BA^2	226	.567
Untreated 1939-1949 basal area growth	=	.2610 BA			79	.840
Treated " " " "	=	.5207 BA	-	.2837 BA^2	226	.843
Untreated 1949-1959 basal area growth	=	.4290 BA			79	.823
Treated " " " "	=	.7572 BA	-	.4991 BA^2	226	.846
Untreated 1939-1959 basal area growth	=	.6900 BA			79	.859
Treated " " " "	=	1.2779 BA	-	.7828 BA^2	226	.862
		Red pine				
Untreated 1929-1939 basal area growth	=	.2485 BA			43	.956
Treated " " " "	=	.2397 BA			152	.945
Untreated 1939-1949 basal area growth	=	.2595 BA			43	.934
Treated " " " "	=	.4701 BA	-	.3436 BA^2	152	.905
Untreated 1949-1959 basal area growth	=	.3566 BA			43	.874
Treated " " " "	=	.6559 BA	-	.6124 BA^2	152	.829
Untreated 1939-1959 basal area growth	=	.6162 BA			43	.916
Treated " " " "	=	1.1260 BA	-	.9559 BA^2	152	.881

[1]BA = basal area of tree in 1939.

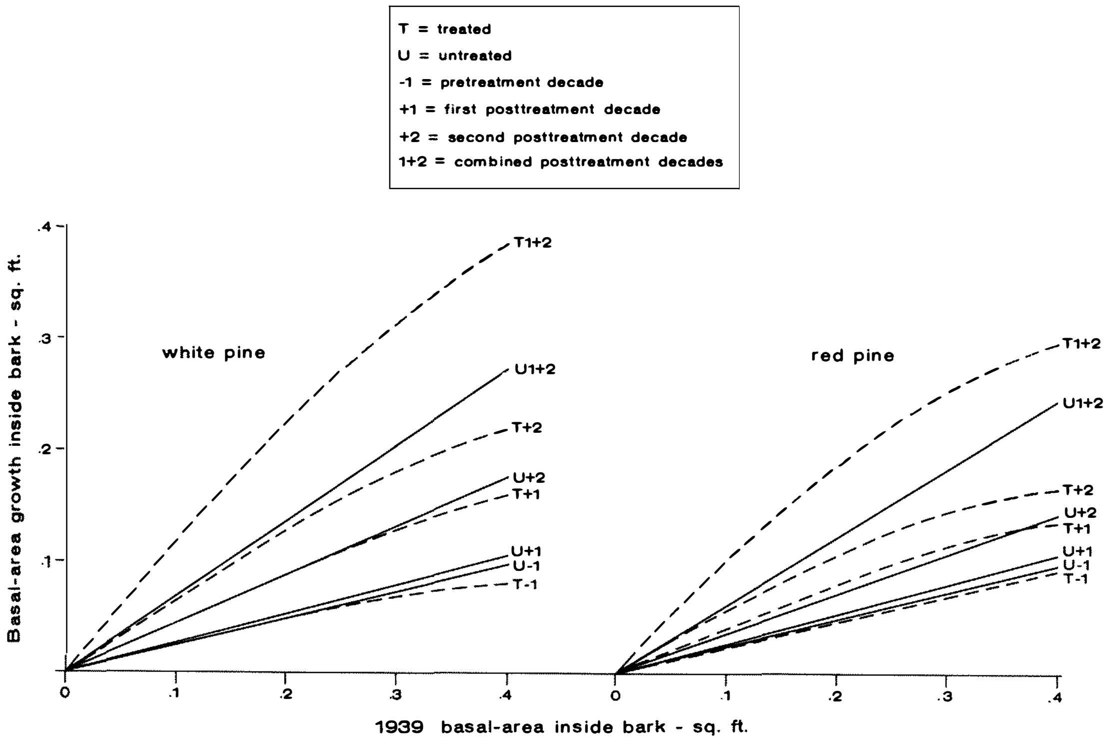

Figure 1. Basal-area growth of individual trees.

Greater second- than first-decade basal-area growth per tree shown in Figure 1 is consistent with that previously discussed for softwood volume growth per acre.

In general the results of borings further illustrate the effectiveness of treatment in shortening the waiting period before harvest.

The Effect of Pruning on Sawlog Value

The effect of pruning on the quality of white pine saw timber was demonstrated by sawing a sample of 58 pruned and 58 unpruned trees from the improvement-cut area. The trees averaged 8.3 inches d.b.h. at the time of treatment, and 13.8 inches d.b.h. when sawn 27 years later.

On the average, lumber from pruned trees was worth $9.50 per thousand board feet[9] more than that from unpruned trees. The compound interest yield on the pruning investment was 14.2%.

[9]1966 lumber prices, wholesale f.o.b. From a report on pruning and sawing eastern white pine, currently in preparation by W.W. Calvert of the Forest Products Research Laboratory, Ottawa, Ontario, and L.G. Brace, Petawawa Forest Experiment Station, Chalk River, Ontario.

Costs

Costs of treatment by four different methods were obtained for the four blocks. Net costs ranged from $26 per acre when all marked material was cut, manufactured into fuelwood and sawlogs at the stump, and removed to the roadside, down to $2 per acre when only merchantable sawlog material was removed and other material girdled. The latter method, combined with pruning and release of selected white pine crop trees seemed to offer the most economically promising method at that time. This presupposed a log market that paid a premium for high-quality pruned sawlogs.

Markets for products available from pine-mixedwood treatment, and the technology available for stand treatment in 1939, were considerably different from the markets and technology that apply today. Research should now be directed toward determining the cost of achieving similar stand improvement in terms of present economic conditions, with particular attention to alternative standards of utilization (e.g. sawlogs only, sawlogs and pulpwood) and modern treatment technology. Operations research techniques seem to have application here. The data thus gathered could be used immediately with expected growth and yield results to demonstrate the current cost-effectiveness of improvement cutting.

SUMMARY

In 1939 an improvement-cut experiment was established in pine mixedwoods on the Sherborne land-type at the Petawawa Forest Experiment Station. The treatment favored thrifty softwoods, particularly white pine. On the average, 35% of the initial stand basal area, totalling 910 cubic feet per acre, was removed; 723 cubic feet was fuelwood (approximately 8.5 cords) and 187 cubic feet was sawlogs (approximately 1,000 f.b.m.). The results were as follows:

1. Treatment converted stands from 38 to 76% softwood.
2. The average cubic foot volume increase in treated stands was more than double that of untreated stands in the 20 years following treatment.
3. Softwoods were the main growing component in both treated and untreated stands. They showed a 240% superiority in both cubic foot and merchantable board foot increases for treated compared with untreated stands in the two decades following treatment. The volume of white pine sawlogs, the most valuable product, was doubled in 20 years as a result of treatment.
4. The combined effect of cutting and growth increased the yield of treated stands by 25% more than the yield of untreated stands in the 20 years after treatment.
5. Data from increment borings showed that release was effective over the entire diameter range of white and red pine. The release effect was considerably more pronounced for white pine than for red pine.

6. Treatment resulted in salvage of potential mortality equivalent to 23 cubic feet per acre per year for the 20 years following treatment.
7. Intolerant hardwoods showed little promise as growing stock after age 50 on these sites, owing to decadence.
8. Pruning of white pine resulted in a gross value increase of $9.50 per thousand board feet of lumber by 27 years after treatment, a yield of 14.2% compound interest on the pruning investment.
9. Treatment costs ranged from $26 to $2 per acre, depending on the degree of hardwood utilization.
10. Definite gains in growth and yield were shown to result from the improvement cut, but the profitability of the operation under today's economic conditions could not be demonstrated. Specific cost-effectiveness studies should provide such information.

BOTANICAL NAMES

White pine	*Pinus strobus* L.
Red pine	*Pinus resinosa* Ait.
Jack pine	*Pinus banksiana* Lamb.
White spruce	*Picea glauca* (Moench) Voss
Red spruce	*Picea rubens* Sarg.
Balsam fir	*Abies balsamea* (L.) Mill.
Red maple	*Acer rubrum* L.
Hard maple	*Acer saccharum* Marsh.
Yellow birch	*Betula alleghaniensis* Britt.
White birch	*Betula papyrifera* Marsh.
Largetooth aspen	*Populus grandidentata* Michx.
Trembling aspen	*Populus tremuloides* Michx.
Red oak	*Quercus rubra* L.

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