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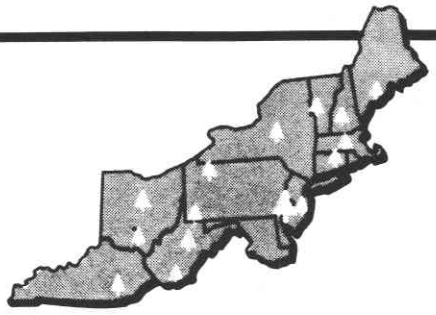

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GROWTH TRENDS IN PRUNED RED SPRUCE TREES

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Abstract. The diameter growth of red spruce with 1/6, 1/3, and 1/2 crown removed was compared with that of unpruned trees for 18 growing seasons. Although removal of 1/6 of the live crown did not adversely affect annual radial growth, compared with that of the controls, removal of 1/3 and 1/2 had a significant effect on the cumulative radial growth for 2 and 9 growing seasons, respectively.

Pruning of softwood trees is generally to improve wood quality by increasing the production of knot-free wood. In the case of a relatively slow-growing species like red spruce, pruning may be practical only on the fastest growing individuals on better sites where a usable shell of clear wood can be produced in a reasonable time. Any adverse effect that pruning might have on growth is, therefore, a major concern. This concern prompted researchers at the Northeastern Forest Experiment Station unit at Orono, Maine, to investigate the effect of pruning on the radial growth of red spruce.

METHODS

During the fall of 1958, 40 forest-grown red spruce trees (*Picea rubens* Sarg.) on the Penobscot Experimental Forest in Bradley, Maine, were chosen for study. Treatments consisted of no pruning and removal of 1/6, 1/3, and 1/2 of the live crown. Each treatment was randomly assigned to 10 of the 40 trees. Sample trees were vigorous codominants with at least 60 percent of their total height in live crown (crown length ratio = 0.60).

Initial measurements were diameter at breast height (dbh) and bark thickness to the

nearest 0.1 inch, total height to the nearest foot, height to live crown before and after pruning to the nearest foot, and diameter at 17 feet. These data were later converted to metric units (Table 1).

The trees were remeasured in 1976, 18 growing seasons after pruning. Annual radial growth was determined to the nearest .01 mm from increment cores taken at breast height. Thirty-two trees remained in 1976; 8 control trees; 7 with 1/6 crown removed; 9 with 1/3 crown removed; and 8 with 1/2 crown removed.

RESULTS AND DISCUSSION

The differences among the four pruning treatments were found not to be significant by analysis of variance on the total 18-year radial growth measured at breast height. This result was unexpected, as the data indicated initial differences in growth, and cumulative differences were expected to be reasonably long-lasting (Fig. 1). Therefore, cumulative radial growth data were analyzed on an annual basis through the 1976 growing season to determine in what year cumulative growth differences first occurred.

Differences in cumulative radial growth were significant through the first 9 years following treatment (Table 2). There were no significant differences among treatments in cumulative growth from the 1968 through 1976 growing seasons. This trend in cumulative growth among treatments led to the speculation that as the trees increased in height, the effect of crown removal on annual radial growth was reduced. This was probably due to crown development of the pruned trees, as indicated by the relative equality of the average crown length ratio of all but the most severely pruned trees in 1976 (Table 1). The crown length ratios for the control trees and those with 1/6 of their crowns pruned decreased somewhat, while those for the other treatments increased.

To explore this further, the mean annual growth differences among the pruning treat-

Table 1.—Average characteristics of sample trees in 1958 (after pruning) and in 1976

Characteristic	Treatment			
	Control	1/6 crown removed	1/3 crown removed	1/2 crown removed
Number of trees				
1958	10	10	10	10
1976	8	7	9	8
dbh (cm)				
1958	18.5	17.8	15.7	15.0
1976	23.9	21.3	20.6	18.3
Average annual growth in dbh outside bark	.3	.2	.3	.2
Height (m)				
1958	13.7	12.8	11.3	10.0
1976	18.0	16.8	15.2	13.7
Average annual growth in height	.24	.23	.22	.21
Crown length (m)				
1958	7.9	6.7	4.6	3.1
1976	8.8	8.2	7.3	5.8
Crown length ratio				
1958	.58	.52	.41	.30
1976	.49	.49	.48	.42

Figure 1.—Cumulative radial growth, by treatment.

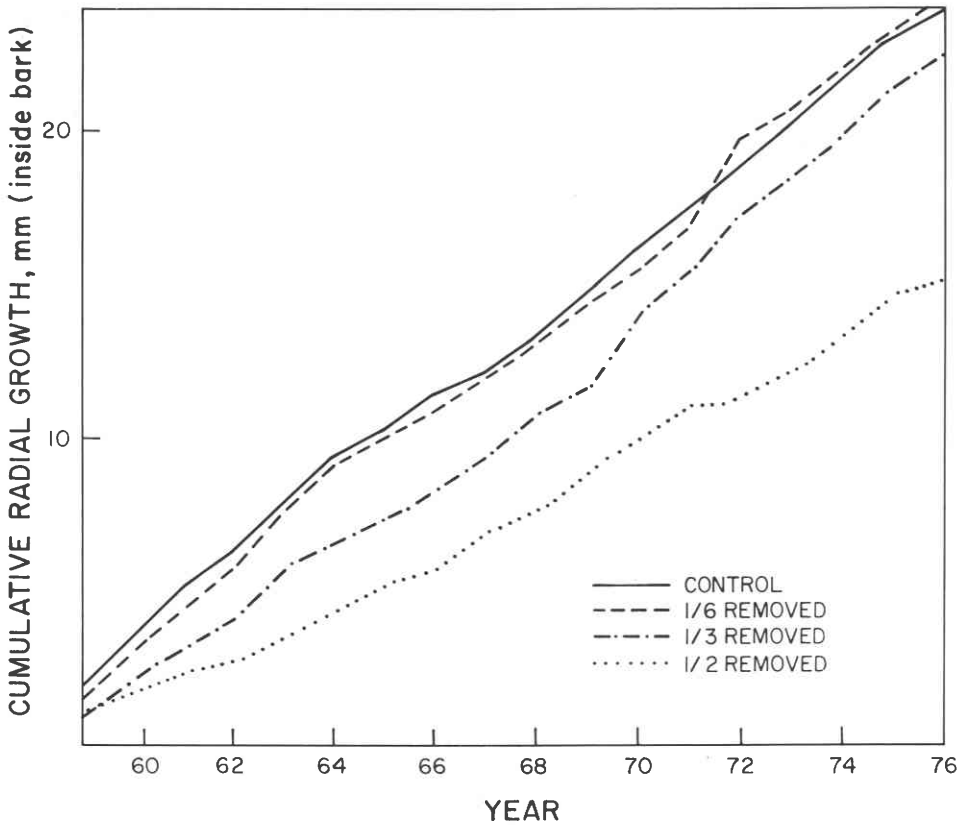
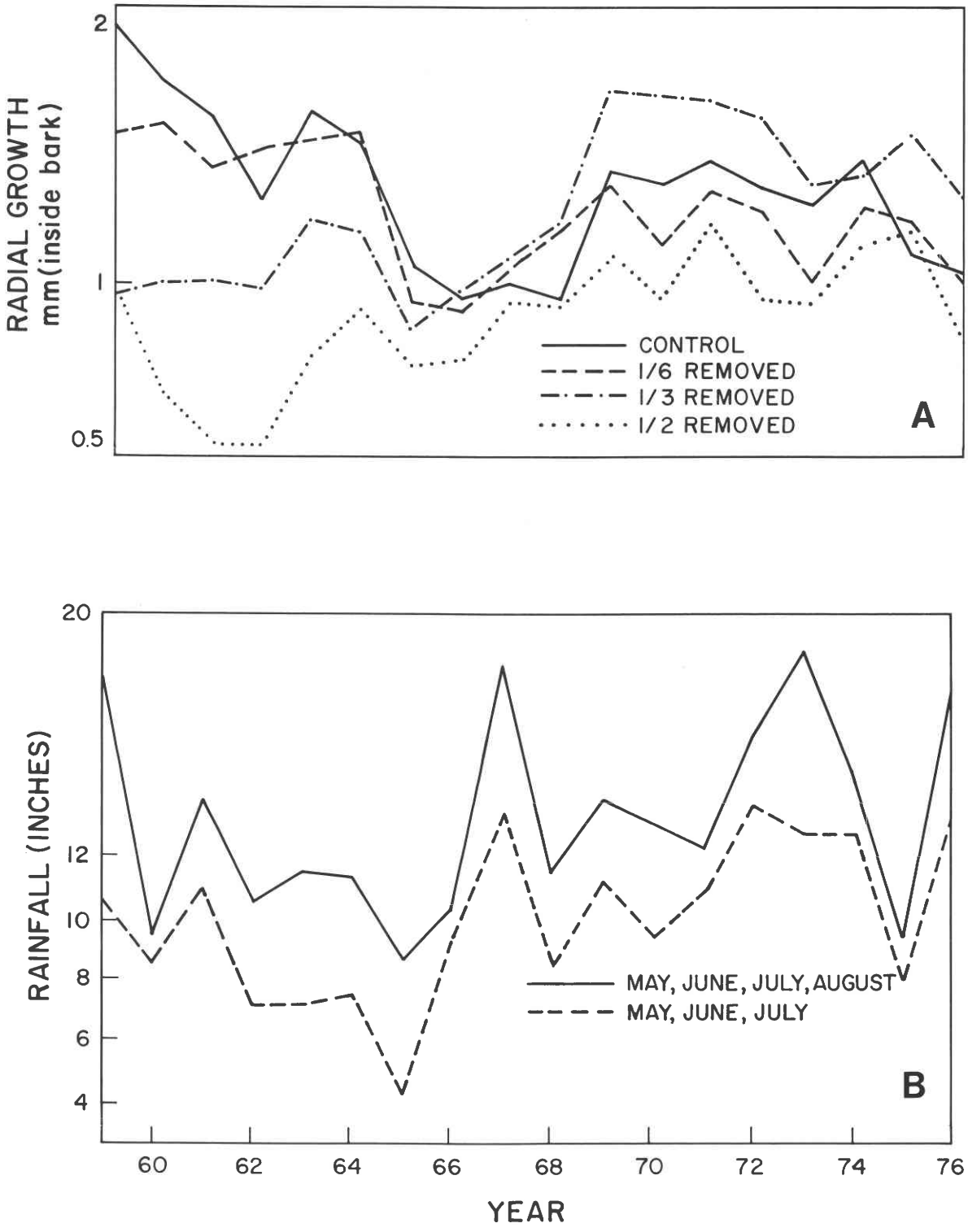


Table 2.—Cumulative growth by treatment and year (mm)

Year	Crown removed				Within-treatment MS	F
	None (control)	1/6	1/3	1/2		
1959	1.86	1.49	.96	1.01	1.52	4.76**
1960	3.49	3.01	2.01	1.65	6.29	6.64**
1961	5.07	4.39	3.15	2.21	13.99	7.10**
1962	6.35	5.84	4.13	2.79	23.03	5.97**
1963	7.92	7.59	5.76	3.65	32.87	4.73**
1964	9.38	9.05	6.50	4.45	46.93	4.50**
1965	10.43	9.99	7.35	5.18	52.43	4.13*
1966	11.39	10.90	8.32	5.92	55.76	3.71*
1967	12.39	11.95	9.41	6.87	57.12	3.07*
1968	13.34	13.12	10.62	7.77	59.59	2.64
1969	14.75	14.44	10.75	8.86	64.63	2.19
1970	16.26	15.57	13.87	9.95	69.94	1.88
1971	17.47	16.87	15.48	11.01	74.87	1.61
1972	18.79	19.68	17.03	11.28	111.06	2.21
1973	20.14	20.69	18.33	12.21	118.27	2.06
1974	21.59	21.93	19.78	13.34	125.20	1.88
1975	22.68	23.14	21.27	14.53	125.56	1.68
1976	23.72	24.11	22.53	15.35	133.08	1.60

**Significant at 0.01 level
*Significant at 0.05 level

Figure 2.—(A) Mean annual radial growth by treatment; (B) Total periodic rainfall, Old Town, Maine.



ments were analyzed and plotted in Fig. 2A. Differences among treatments were found for the years 1959 through 1963 (Table 3), and there is some evidence of an initial shock effect due to treatment, particularly with more severely pruned trees. No significant differences were found among treatments for the remaining years to 1976, and in no case did comparisons among treatments indicate a significant difference between the control trees and those with 1/6 of their crowns removed. In fact, from about 1966 on, those trees with 1/3 of their crowns removed grew the fastest. Also, significant differences between the controls and the trees with 1/3 of their crowns removed were present only the first two growing seasons after pruning, 1959 and 1960.

It appeared from the plots in Figure 2A that the radial growth of the control trees and those with the lighter pruning treatment (1/6 crown removed) was reduced, relative to the more severe treatments, during the growing seasons of the mid-1960's (ca. 1965-66), which may account for the lack of cumulative growth differences at the end of the study in 1976. During this period the radial growth of all but the most severe treatment (1/2 crown removal) was about at its lowest point. Rainfall data (Fig. 2B) indicate that a drying trend reached a low point in 1965.

Possibly the greater foliage area on the lightly pruned and control trees, resulting in greater transpirational capacity, may have produced moisture stress in these trees that adversely affected radial growth to a greater degree than in the more heavily pruned trees. Although soil moisture was not measured in this study, the interaction of rainfall, soil moisture, and foliage area in creating water deficiency in trees has been established (Kramer 1962).

CONCLUSIONS

These results indicate that the annual radial growth was adversely affected by removing more than 1/6 of the live crown, although the data indicate that the removal of up to 1/3 of

Table 3.—Mean annual growth of pruned trees by treatment (mm)

Year	Crown removed				Within-treatment MS	F
	None (control)	1/6	1/3	1/2		
1959	1.86	1.49	0.96	1.01	0.318	4.80**
1960	1.67	1.52	1.05	0.64	0.269	7.11**
1961	1.55	1.38	1.14	0.57	0.283	5.55**
1962	1.28	1.45	0.98	0.57	0.400	3.32*
1963	1.57	1.72	1.20	0.76	0.457	3.61*
1964	1.45	1.49	1.17	0.91	0.778	0.85
1965	1.06	0.94	0.85	0.73	0.157	1.06
1966	0.95	0.91	0.98	0.75	0.194	0.48
1967	1.00	1.05	1.08	0.94	0.284	0.14
1968	0.95	1.17	1.21	0.94	0.326	0.64
1969	1.37	1.32	1.64	1.09	0.658	0.68
1970	1.34	1.13	1.62	0.95	0.648	1.16
1971	1.41	1.29	1.61	1.20	0.737	0.38
1972	1.32	1.24	1.55	0.96	0.506	1.00
1973	1.34	1.01	1.30	0.93	0.388	0.90
1974	1.44	1.24	1.44	1.13	0.507	0.41
1975	1.09	1.21	1.49	1.19	0.431	0.61
1976	1.04	0.98	1.25	0.82	0.407	0.66

**Significant at 0.01 level
*Significant at 0.05 level

the live crown affected growth for only two growing seasons after pruning. Cumulative growth differences became nonsignificant the ninth growing season after pruning. At the end of the study period, crown length ratios had become practically equal for trees in all treatments.

The effect of pruning on growth is only one of many variables that enter into a decision to invest time and money in pruning red spruce trees. While in general our growth rates following pruning are somewhat lower than those reported by Davis (1958), in our opinion the differences in growth among the two lightest pruning treatments and the control are not sufficient to affect a decision to prune or not.

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