THE COURSE OF GROWTH RESPONSE IN RELEASED WHITE SPRUCE-- 10-Year Results

by Robert M. Frank

USDA FOREST SERVICE RESEARCH PAPER NE-258
1973

NORTHEASTERN FOREST EXPERIMENT STATION, UPPER DARBY, PA.
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE
WARREN T. DOOLITTLE, DIRECTOR

THE AUTHOR

ROBERT M. FRANK, research forester, received a bachelor of science degree in forestry from the Pennsylvania State University in 1954 and a master of forestry degree in forest products from the same university in 1956. He joined the USDA Forest Service in 1957 and has served in economics research, forest survey, and mine-spoil revegetation projects of the Northeastern Forest Experiment Station. Since 1963 he has been on the staff of the station's spruce-fir silviculture project at Orono, Maine.

MANUSCRIPT RECEIVED FOR PUBLICATION 1 JUNE 1972.

THE COURSE OF GROWTH RESPONSE IN RELEASED WHITE SPRUCE--10-Year Results

Abstract

Weekly bole measurements at 4.5 feet in height were made on individual codominant white spruce trees released on one, two, three, and four sides, and on untreated controls.

Results showed that after 10 years annual circumference growth was still significantly related to the degree of release. The growth trend was established the first year but significant differences in annual growth were not evident until the third year. The growth rate reached a maximum during the ninth year. Trees with three and four sides released outgrew controls and trees with one and two sides released by a 2 to 1 ratio.

Seasonal growth usually started around May 10, peaked during the second week in June, and ceased around August 20. Trees released on three or four sides appeared to start growing earlier and cease growing several days later than the other trees. The length of the growing season ranged from 100 to 115 days.

AMOUNT OF RELEASE IS IMPORTANT

HOW MUCH additional growing space does a potential crop tree spruce need to benefit from thinning? On how many sides should such a tree be released? How soon and for how many years will the effects of release be evident? Questions like these must be answered before timber stands can be managed intensively with conscious silvicultural treatment. A knowledge of the spatial requirements of the individual tree is necessary before maximum merchantable growth can be obtained in overstocked spruce-fir stands.

Timber-marking rules for uneven-aged stands and marking rules for intermediate cultural treatments in even-aged stands are not complete unless they contain spacing recommendations. And the length of crop rotation cannot be reduced until crop trees are groomed to merchantable size in fewer years.

Therefore we undertook a study in Maine to determine the level of release needed to produce and maintain significant growth response in pole-size white spruce. I concluded that release on more than two sides is required. It was also determined that the number of days that a tree grows during the growing season is affected by release.

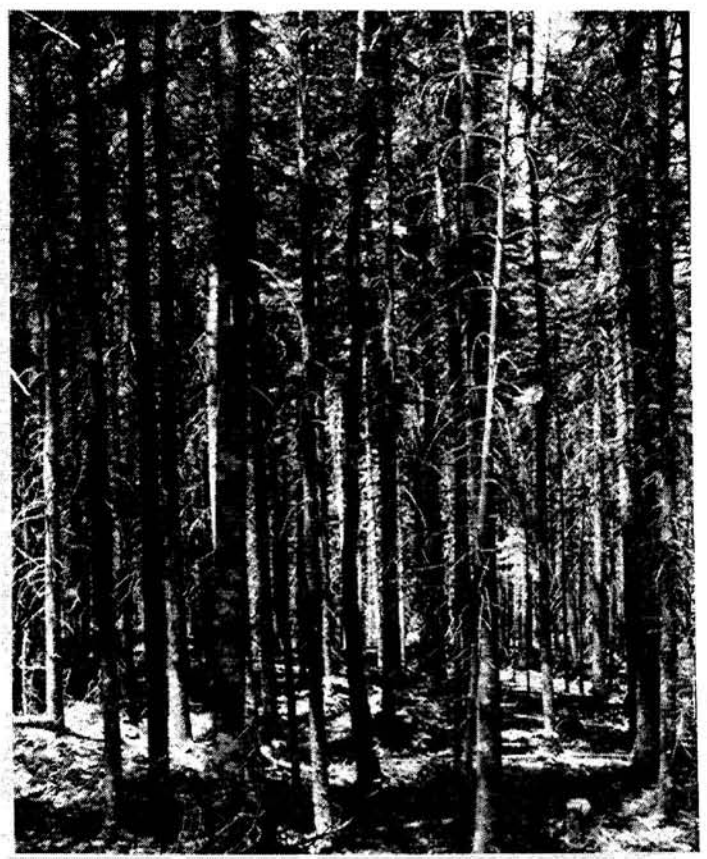
THE STUDY

The study was begun in 1961 in a white spruce-balsam fir stand on the Penobscot Experimental Forest located 8 miles northeast of Bangor, Maine (44° 52′ N.; 68° 39′ W.), at an elevation of approximately 100 feet. The topography is flat to very gently sloping. The

soils in the one-acre study area vary from silt loam to some glacial till. Drainage ranges from moderately good to poor. Precipitation during the growing season usually totals about 12 inches, and is evenly distributed. Mean temperature ranges from 54°F., in May to 68°F. in July.

The trees are pole-sized, even-aged, and became established around 1890. Dominant and codominant trees averaged about 50 feet tall with an average crown diameter of 10 feet. The stand contained about 190 square feet of basal area in trees in the intermediate and better crown positions. White spruce [*Picea glauca* (Moench) Voss] and balsam fir [*Abies balsamea* (L.) Mill.] were about equally represented (fig. 1), with a scattering of associated species that accounted for less than 10 percent of the basal area.

Figure 1.—The study area is an even-aged stand of pole-sized white spruce and balsam fir.



RELEASING METHOD

Twenty-five codominant white spruce trees between 5.0 and 6.7 inches in diameter at 4.5 feet were selected for study. Sample trees were selected at random and far enough apart so that crown release treatments did not interfere with each other. There were five trees in each of five groups:

Control	— no crown release.
Crown released on one side	— adjacent trees removed from east quadrant.
Crown released on two sides	— adjacent trees removed from east and south quadrants.
Crown released on three sides	— adjacent trees removed from east, south, and west quadrants.
Crown released on four sides	— all adjacent trees removed.

Each treatment consisted of removing adjacent trees to a distance approximating the average crown diameter of the sample tree. This distance, measured from crown to crown, usually ranged between 8 feet and 10 feet. In most quadrants only one or two trees were removed; in others, three or more trees were removed. Felled trees were bucked, limbed, topped, and left in place. There were no other activities on the site for the duration of the study.

MEASUREMENTS

Dendrometer bands[1] were installed at breast height (4.5 feet) on each sample tree (fig. 2). Each tree was assigned a number and tagged.

Dendrometer readings were recorded to the nearest 1/100th inch of circumference. Observations were taken weekly from before diameter growth started in the spring to late summer or early fall, when three successive weekly readings failed to show any increase

[1]Liming, F. G. 1957. HOMEMADE DENDROMETERS. J. Forest. 55:575-577.

Figure 2. — Dendrometer band in place on a tree with vernier scale being positioned for a reading.

in circumference. In most years, measurements were taken from the latter part of April to the early part of October.

DATA ANALYSIS

Circumference growth was charted for each group of trees for each year. Comparisons were made by analysis of variance to determine whether significant differences developed (table 1).

Table 1.—*Mean annual circumference increase by treatment, 1961 through 1970*

Year	Control	Released on			
		1 Side	2 Sides	3 Sides	4 Sides
			Inches		
1961	0.158[a]	0.178	0.136	0.238	0.212
1962	.194	.196	.168	.280	.298
1963	.220	.212	.206	.368	.438
1964	.190	.224	.214	.408	.524
1965	.202	.226	.228	.420	.450
1966	.170	.232	.208	.374	.426
1967	.234	.244	.232	.422	.482
1968	.246	.296	.324	.480	.560
1969	.326	.322	.372	.622	.580
1970	.274	.282	.338	.500	.440
Mean annual increase	0.221	0.241	0.243	0.411	0.441

[a]Means not underscored by the same line are significantly different at the 5 percent level.

RESULTS AND DISCUSSION

Stand Development

Stem analyses of the two sample trees that died after the ninth year of observation gave insight into stand structure, both past and present. Plotted data indicate that excessive numbers of trees were present from the establishment of the stand (fig. 3). Overstocking is suggested by d.b.h. and growth rings per inch and also by the slow growth of the sectioned trees:

	Tree #1	*Tree #2*
Age, yrs.	87	77
D.b.h., inches	7.5	6.4
Height, ft.	51.0	50.9
Growth rings per inch	23.2	24.1
Years to reach:		
4.5 ft.	20	12
10.0 ft.	30	21
20.0 ft.	43	36
30.0 ft.	60	47
40.0 ft.	71	58
50.0 ft.	85	75

Circumference Growth Response

Mean annual circumference growth for the five trees in each treatment group was plotted by date of reading for each growing season. A sigmoid curve, the characteristic curve of growth, resulted when the data for all 10 years and all sample trees were combined. It shows the percentage of annual growth that had occurred by various dates during the growing season (fig. 4).

Similar curves developed from data from individual treatments failed to show much difference. There was an indication however, that trees released on three or more sides achieved a specified percentage of growth one to three days earlier than the control trees.

A difference in growth response related to the degree of release was noticeable the first year after thinning, continued during the second year, and became statistically significant in the third year. The difference continued, except for a slight disruption midway through the study, probably caused by less than normal rainfall, peaked in the ninth year, and was still evident at the termination of observations after the tenth year (fig. 5).

The controls and the trees released on one or two sides grew only one-half as much as

Figure 3.—Height/age relationships of two white spruce trees.

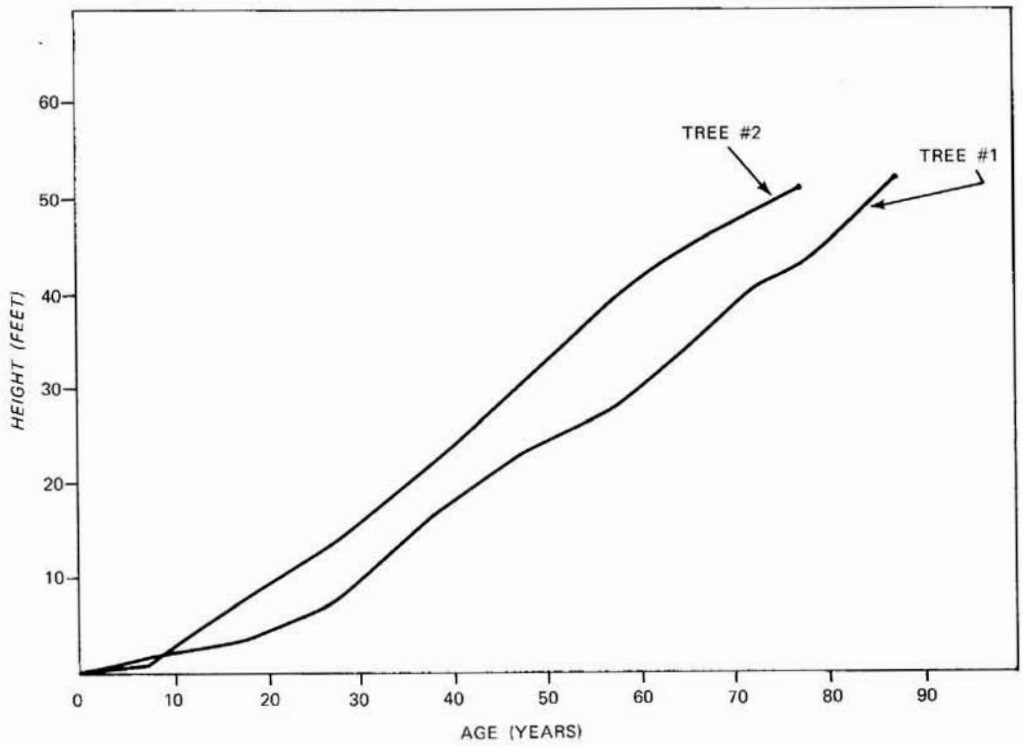


Figure 4.—Percentage of mean annual circumference growth that had occurred by various dates (All treatments and all years combined).

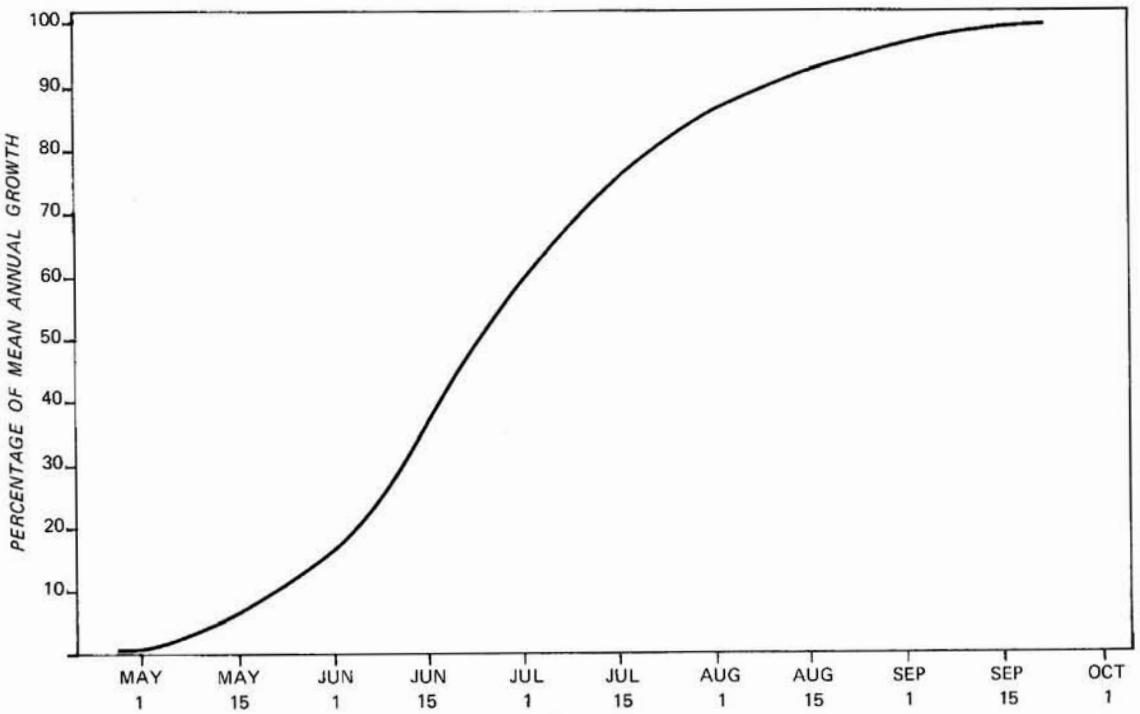
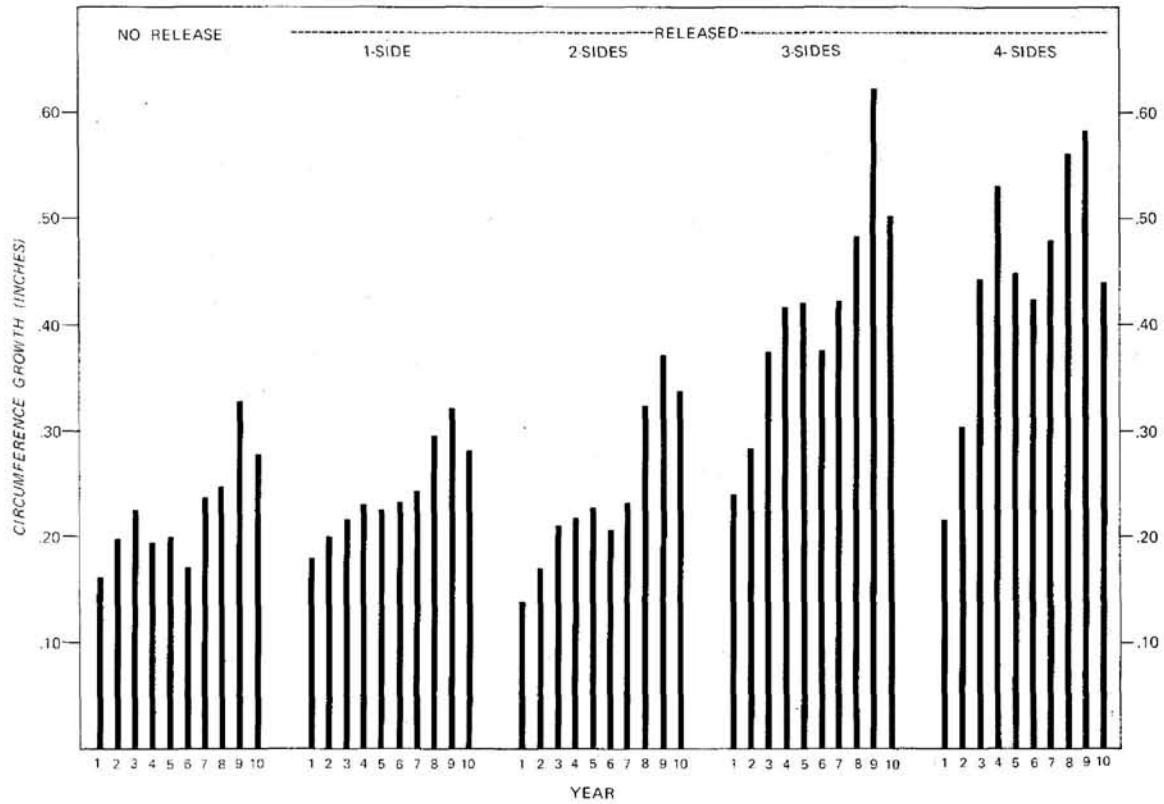


Figure 5.—Mean annual circumference growth by treatment.



the trees released on three or four sides (fig. 6). Cumulative growth curves were developed by summing the growth responses of all trees in each treatment group.

Up to the time of thinning, the mean number of annual growth rings per inch of diameter in sample trees ranged between 25 and 30. During the 10-year period after thinning, the mean numbers of rings per inch were:

	Mean number of rings per inch
Controls	28
Released one side	26
Released two sides	26
Released three sides	15
Released four sides	14

The Distribution of Growth

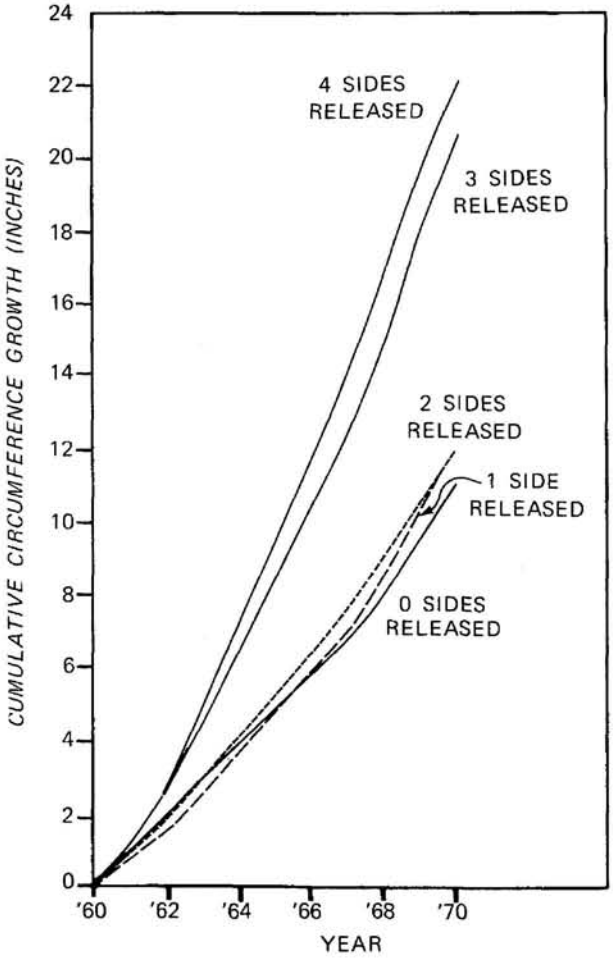
During the 10-year study period, the first evidence of circumference growth appeared between the first week in May and the first week in June. The most common date was around May 10.

Growth was usually most rapid during the second week in June, when it approached 2 percent a day. The seasonal rate of growth for various periods is shown by the slope of the curve in figure 4. As the growth rate accelerates in the spring, the slope becomes steeper; it remains relatively steep until mid-July; then rapidly flattens out in late August and September, when seasonal growth finally ceases.

Growth was one-half completed by the fourth week in June; almost two-thirds completed by the fourth of July; and 85 percent completed by August 1.

The controls and trees released on one or two sides commonly ceased growing around August 20, while the trees released on three or four sides appeared to grow for an additional one to two weeks. The relatively free-growing position of the more fully released trees may have given them greater access to light and less competition for available moisture, and thus extended their growing season.

Figure 6.—Mean cumulative circumference growth by treatment for all trees, 1961 to 1970.



But growth at the end of the growing season is very slow and contributes an insignificant amount to annual growth.

The length of the growing season, derived from average dates when growth began and ended, ranged from about 100 to 115 days. The frost-free season is 140 to 145 days.

CONCLUSIONS

Ten years of observations indicate that neglected white spruce, 70 to 75 years old, will respond to release. Clearing around individual crop trees must be done on at least three and preferably four sides for significant benefits. In spruce-fir stands on wet and steep sites, no more than 10 to 20 percent of the total volume should be removed in a single operation. On well drained sites, up to 50 percent can be removed. And older stands should not be logged as heavily as younger stands.[2] Excessive removals can result in wind damage.

How many crop trees per acre to release will depend on the management objectives of the landowner or manager.

For a thinning to be effective, the minimum distance between the crown of a selected crop tree and the crowns of competitors on each thinned side should be equal to the crown diameter of the tree being released. This was the spacing used in this study.

■

[2]Westveld, Marinus. 1953. ECOLOGY AND SILVICULTURE OF SPRUCE-FIR FORESTS OF EASTERN NORTH AMERICA. J. Forest. 51:422-430.

THE FOREST SERVICE of the U. S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.