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Coniferous swamps occupy roughly 6 million acres or about 11 percent of the commercial forest-land area in the Lake States region (1). The economic importance of this type is determined not only by the market value of the species involved, but also by its multipurpose function in providing wildlife habitat and food. Recent studies (3, 4, and 5) of coniferous swamps indicate that species composition in cutover areas is changing rapidly from the original stand makeup. Low-value hardwoods and balsam fir are increasing, and the higher-valued spruce and cedar are decreasing. Information on methods of cutting to increase the proportion of spruce and cedar in future stands is meager at the present time. Knowledge of growth following partial cutting also is limited. The latter aspect of conifer swamp management is dealt with in this report on the basis of results from a 10-year-old growth study of swamp conifers following partial cutting. Supplemental observations on reproduction are included.

1/ Research Forester, Lake States Forest Experiment Station. The Station is maintained at St. Paul 1, Minn., by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of Minnesota. Acknowledgment is given to J. H. Stoeckeler and G. R. Condit who planned and established the present study, and to Ivan Hassler of the Wisconsin Conservation Department who supervised the cutting in 1947 and 1956.

Stand Description

This study originated in 1947 as a cooperative partial cutting experiment by the Wisconsin Conservation Department and the Lake States Forest Experiment Station. The study area, located in northeastern Wisconsin, was purchased previous to 1947 by the State as a deer management area. The stand was essentially even-aged northern white-cedar (Thuja occidentalis L.), with some balsam fir (Abies balsamea (L.) Mill.) and black spruce (Picea mariana (Mill.) B. S. P.) in mixture.

In 1947 the trees averaged 5 inches in diameter and 30 feet in height. Although most of the stand was 65 years old, there was an overstory of 100-year-old cedar on one-half of the area.

The two age classes of white-cedar had a site index of 37 feet at 100 years. According to Gevorkiantz and Duerr (2), this is an average site for the species.

Stocking before treatment on individual plots varied from 660 to 1,700 stems per acre of trees 2.6 inches and larger at d.b.h. Basal area ranged from 112 to 227 square feet per acre; 72 percent of it was northern white-cedar, 14 percent black spruce, 13 percent balsam fir, and 1 percent miscellaneous species.

The swamp is well drained, particularly toward the edges. The entire area seeps with springs, but the water is clear and fresh. The soil is a muck type with an organic layer reaching to a depth of 2 to 4 feet.

Browsing by white-tailed deer has been negligible, as the swamp is not used for winter yarding. The swamp does, however, support a high population of snowshoe hare which feed heavily on the cedar reproduction during the winter months.

Treatment

The study area was made up of 20 compartments, each measuring 2 x $2\frac{1}{2}$ chains ($\frac{1}{2}$ acre). Growth and cut data were taken on 1/10-acre circular plots located at the center of each rectangular compartment.

The principles used in cutting were: (1) to obtain uniform spacing, (2) to favor dominant and codominant trees, (3) to favor cedar, spruce, and balsam in that order, and (4) to leave the best formed, most vigorous trees (fig. 1 on next page). Instead of thinning a homogeneous stand to various stocking levels, the present study involved several degrees of cutting on a number of stands, each with a different original stocking. The intensity of cutting varied with each plot; 4 plots were left uncut and the remaining 16 plots were each cut to a different basal area level. Therefore, instead of replications, there are as many treatments as plots. Table 1 on page 5 shows the data for each plot before and after cutting and in 1956, in terms of square feet of basal area, number of trees per acre, and average stand diameters.

The area was logged in February 1947 under the supervision of the Wisconsin Conservation Department. Skidding was done by horse and dray. Logging damage to the residual stand was minor. The slash was lopped, but no special effort was made for even distribution. As a result, large slash piles accumulated on the heavily cut areas. The few scattered nonmerchantable hardwoods were girdled or cut down.

During the fall of 1956, the study was remeasured to determine the effect of the partial cutting. Growth was computed for the 10-year period in basal area and converted to cords. The three major species in the stand (white-cedar, black spruce, and balsam fir) were considered individually in the growth analysis. The other species, which made up only 1 percent of the stand, were grouped together.

Development of the Stand

The immediate effect of cutting on species composition and stand structure was relatively minor. The proportion of white-cedar increased by approximately 4 percent in basal area. Black spruce and balsam fir each decreased about 2 percent. The maximum change in average stand diameter before and after cutting was 0.1 inch (table 1). Overall quality of the residual stand, especially white-cedar, was improved, as the trees removed were mainly those with abnormal sweep or thin, small, poorly formed crowns.

Ten years later the proportion of cedar had again increased slightly, while white spruce and balsam fir decreased; however, these changes were not large enough to be of any real importance.

Figure 1.--Picture taken in 1947 following cutting. Stand volume on this area was 105 square feet of basal area per acre.

This cutting had little effect on the susceptibility of the residual trees to wind damage. Although the area was hit by at least one severe windstorm during the 10-year period, very little volume was lost by uprooting.

Total basal area growth for the 20 plots during the 10-year period is shown in figure 2 on page 6. In general, growth was related closely to residual growing stock. Plots with the highest basal area stocking, approximately 180 or more square feet per acre, produced the most growth, roughly 55 square feet for the 10-year period, or 5.5 square feet annually. However, all densities sampled showed relatively good growth. The lowest density plots with a residual volume of about 90 square feet per acre grew almost 3.5 square feet annually; this growth in general was added to fewer and better formed trees than those in the higher density plots.

When basal area growth was converted to cordwood growth, using a factor of 4.8 square feet of basal area per cord, plots with the highest stocking (approximately 180 or more square feet per acre) produced 11 cords for the 10-year period or 1.1 cords annually. The lowest density plots, with a residual stocking of 90 square feet per acre, grew almost 0.7 of a cord annually.

Mortality was fairly uniform over the various stocking levels, averaging about 6 square feet of basal area per acre for the 10-year period. Ingrowth (basal area of trees reaching 2.6 inches d.b.h. or more during the 10-year period) amounted to less than 4 square feet and was not related to any particular stocking level.

Table 1.-- Stand data for 20 compartments before and after 1947 cutting and in 1956[1/] (arranged in order of basal area after cutting in 1947)

Basal area per acre			Trees per acre			Average stand d.b.h.		
1947			1947			1947		
Before cutting	After cutting	1956	Before cutting	After cutting	1956	Before cutting	After cutting	1956
Square feet	Square feet	Square feet	Number	Number	Number	Inches	Inches	Inches
114	88	138	1,270	1,010	1,000	4.0	4.0	5.0
140	92	130	1,120	700	690	4.8	4.9	5.9
112	93	126	910	750	710	4.7	4.8	5.7
123	95	134	660	500	490	5.8	5.9	7.1
128	96	126	1,300	1,050	960	4.2	4.1	4.9
114	105	146	930	830	810	4.7	4.8	5.8
146	114	154	1,000	760	750	5.2	5.2	6.2
136	116	159	1,650	1,430	1,420	3.9	3.9	4.5
154	126	175	1,110	910	900	5.0	5.0	6.0
159	131	181	880	690	680	5.8	5.9	7.0
171	137	177	1,580	1,310	1,180	4.4	4.4	5.2
145	139	212	920	850	850	5.4	5.5	6.8
151	143	185	1,120	1,010	970	5.0	5.1	5.9
165	147	202	1,560	1,370	1,330	4.4	4.4	5.3
167	148	194	1,110	980	970	5.3	5.3	6.1
148	148	169	1,360	1,360	1,250	4.5	4.5	5.0
156	156	187	1,700	1,700	1,600	4.1	4.1	4.8
196	177	233	1,510	1,360	1,350	4.9	4.9	5.6
192	192	246	1,510	1,510	1,480	4.8	4.8	5.5
227	227	283	1,290	1,290	1,100	5.7	5.7	6.9

1/For all trees 2.6 inches d.b.h. and larger, based on the 1/10-acre growth plots.

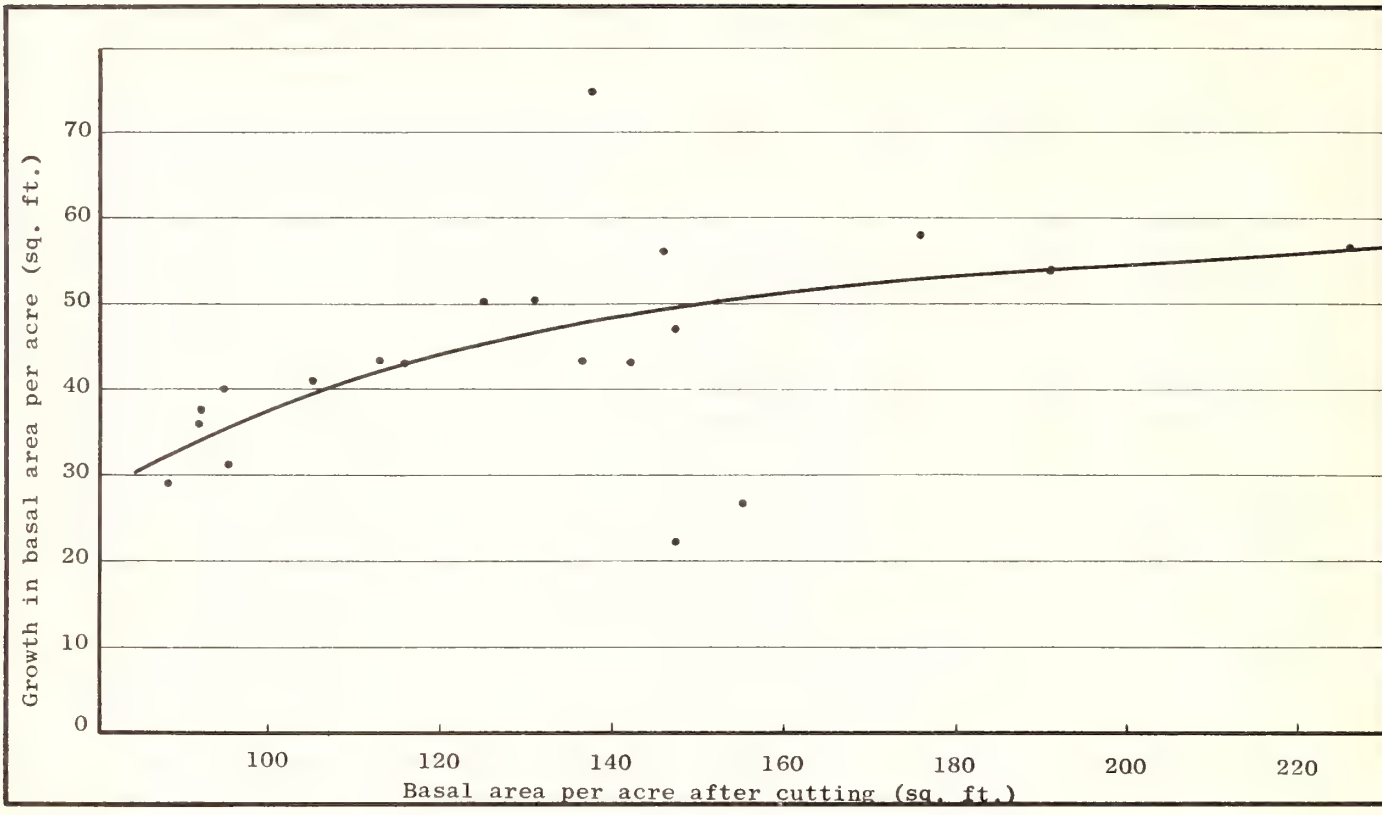

Figure 2.--Ten-year growth (1947-56) per acre in basal area for 20 compartments plotted over basal area per acre after cutting in 1947.

A study of diameter growth was made for the three principal species -- white cedar, black spruce, and balsam fir. For analysis, the 20 1/10-acre plots were divided into 2 basal area groups with an average basal area per acre of 106 and 161 square feet for all species. The results of this analysis are shown in figures 3 and 4. As would be expected, the greatest diameter growth was on the lighter stocked plots and larger diameter classes. However, all stand densities showed good diameter growth, ranging from 0.5 to 1.2 inches for the 10-year period.

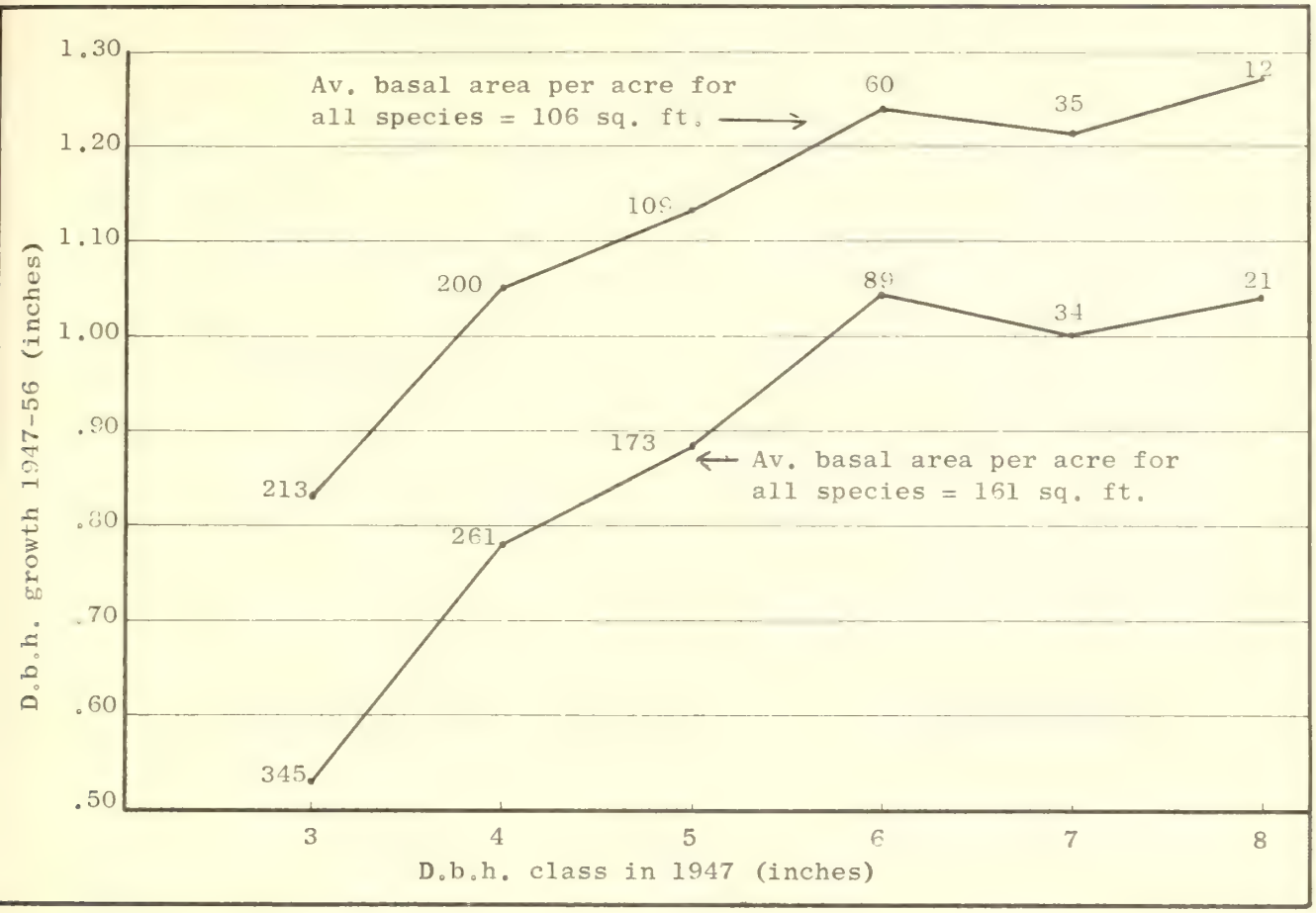

Figure 3.--Ten-year diameter growth of white-cedar as related to basal area stocking and d.b.h. class. The figures at plotted points are the numbers of trees on which observations were made.

Reproduction

A reproduction survey of the study area was made in 1957 to determine the effect of the 1947 cutting on reproduction establishment. The analysis of the survey data showed that except for very dense plots (those with over 210 square feet of basal area per acre in 1957) considerable reproduction of balsam fir, white-cedar, and black spruce was present at all plot densities. This reproduction, however, was mainly in the 0- to 2-foot class, usually 1- or 2-year-old seedlings. Except for a few patches of balsam fir, practically

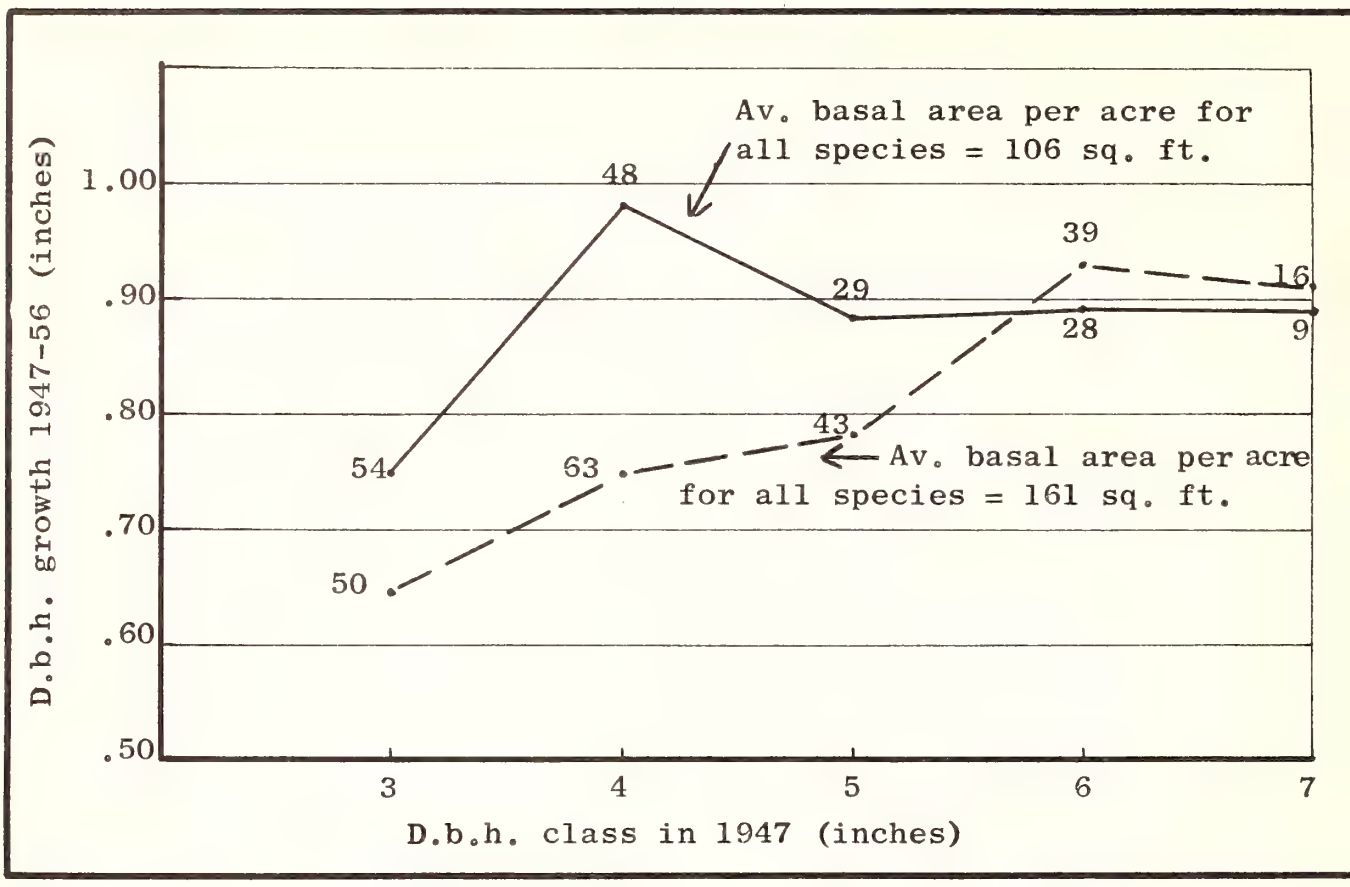

Figure 4.--Ten-year diameter growth of balsam fir and black spruce as related to basal area stocking and d.b.h. class. The figures at plotted points show the numbers of trees on which observations were made.

no reproduction was in the 3- to 7-foot class. This would indicate that the 1947 cutting was not heavy enough to insure the establishment of reproduction in advance of a second cutting.

Investigation of the importance of white-tailed deer and snowshoe hare in prohibiting the establishment of larger reproduction on the study area showed that deer were not a limiting factor. However, the hare population had, in frequent locations, severely browsed the young white-cedar (fig. 5).

Figure 5.--The upper half of this picture shows a fenced exclosure (fence is barely visible in photograph). The area in the lower half (not fenced) shows severe browsing of reproduction by snowshoe hare.

Summary

A growth study of the first 10-year period following partial cutting of a swamp conifer stand brought out the following information:

Total production in both cords and basal area was greatest for those plots with the heaviest residual stand density (approximately 180 or more square feet of basal area). Growth, however, was relatively good for all stand densities sampled. Although the lower density plots showed less total growth, this was placed on fewer and better formed trees, which in part offset their lower production.

Diameter growth for the three principal species ranged from 0.5 to 1.2 inches for the 10-year period, with the larger trees on the less dense plots showing the most growth.

Wind losses due to partial cutting were negligible, although at least one severe windstorm hit the study area during the 10-year period.

The partial cutting in 1947 was evidently not heavy enough to establish reproduction over 3 feet tall in advance of a second cutting. Although considerable reproduction was present in 1957 on all stocking levels below 210 square feet per acre, this reproduction was in the 0- to 2-foot class. Browsing by snowshoe hare was a further factor in limiting white-cedar reproduction.

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