EFFECTS OF UNDERSTORY REMOVAL IN THINNED UPLAND OAK STANDS -- 22-YEAR RESULTS[1]

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Abstract.--Dense understory develops in thinned upland oak stands and potentially competes with overstory trees for moisture and nutrients. To test this hypothesis, we examined the 22-year results of six plots in a 52-year-old stand thinned to 60 percent of normal stocking in 1963. The understory trees on three of the plots were removed by cutting and spraying with an herbicide. After 22 growing seasons, understory trees were larger and taller on the untreated plots. Understory removal treatments altered the species composition of the understory but did not prevent its reestablishment. Growth of overstory trees was not increased by removing the understory. Understory removal is not recommended as a viable management alternative to increase the growth of overstory trees.

INTRODUCTION

When an even-aged upland oak stand is thinned to 60 percent or lower relative stand densities, a dense understory often develops in response to the increased sunlight. The understory originates from (1) advanced regeneration, (2) sprouting from stumps of recently-cut trees and advanced regeneration damaged in logging, and (3) seedlings that develop from dormant seeds in the litter and seeds that are newly deposited in the exposed mineral soil. As this understory develops, it may compete with the overstory for moisture and nutrients. We do not know the long-term effects of this understory on the growth of the residual trees, or if the effects are great enough to influence forest management.

The data analyzed in this report were from a study established in a 52-year-old, even-aged, upland oak stand in southeastern Ohio in 1963. Ten-year results were reported by Dale (1975). No significant effects due to understory removal were evident at that time. However, the effects of silvicultural treatments sometimes change over time. After 22 years, the thinned stands in this study have now closed, and the effects of understory removal on the growth of residual trees can be considered conclusive. The long-term results also provide valuable information on the growth and yield of thinned upland oak stands, as well as on the species composition, quantity, and size of the understory that develops.

THE STUDY

Six 0.25-acre plots were established in a 52-year-old, fully-stocked, even-aged, upland oak stand in southeastern Ohio in 1963. A randomized block design with two plots in each of three blocks was used. Site index was uniform across all plots, and averaged 73 feet according to Schnur's (1937) site index curves. Species composition was typical for an upland oak stand of this age and site--primarily scarlet oak, black oak, and chestnut oak, with some white oak, and a few hickory and yellow-poplar trees (Little 1979).

All six plots were thinned to the 60-percent stocking level according to the tree-area-ratio equation (Gingrich 1967). This stocking level was selected because it (1) opens the crown canopy enough to allow adequate light for understory development, and (2) was thought to be about the lowest level of stocking for full site utilization. The major consideration during thinning was to leave the specified stocking level

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distributed on the best trees as evenly spaced as possible throughout the plot. Within this framework, noncommercial species such as dogwood, sourwood, sassafrass, and blackgum, commercial species in the lower crown classes, and larger trees with stem deformities (forks, crook, and sweep) were removed first. Some of these less desirable trees had to be left to achieve uniform spacing.

After thinning, an understory removal treatment was applied to one plot in each of the three blocks. The understory was defined to be all trees less than 2.6 inches dbh in 1963. Treatment consisted of two phases: (1) all stems less than 2.6 inches were removed by cutting immediately after thinning, and (2) any resprouting that occurred was killed the following spring by mist blowing each plot with 2, 4, 5-T in a solution of 40 lbs (AI)/gal of No. 2 diesel fuel. Misting killed the sprouts without damage to the overstory trees. The understory was not removed on the corresponding untreated plots in each block. An isolation strip 30 feet wide surrounded each plot and received the same treatment as the plot.

All residual overstory trees greater than or equal to 2.6 inches dbh were numbered for remeasurement so that future mortality and ingrowth could be determined. Dbh was measured initially and at various yearly intervals on these trees through 1985. The total number of overstory trees and their respective basal areas per acre were nearly identical for the untreated and treated plots after thinning in 1963 (table 1). Species composition varied slightly with untreated plots having more white oaks and the treated plots having more chestnut oaks.

Understory trees were numbered and measured accordingly as they grew larger than the 2.6-inch diameter limit. In 1985, we also recorded the species and dbh of all trees taller than 4.5 feet (but less than 2.6 inches in diameter) to gain more insight on the development of the understory. Heights of these smaller trees and any trees that grew larger than 2.6 inches were measured with a telescoping pole.

Table 1.--Number and basal area (BA) of overstory trees following thinning for plots with untreated and treated understories.

Species	1963		1985	
	Number	BA	Number	BA
	No/ac	Ft^2/ac	No/ac	Ft^2/ac
		UNTREATED		
White oak	30.7	8.5	25.3	11.9
Black oak	48.0	19.3	37.3	30.1
Scarlet oak	85.3	37.3	68.0	62.0
Chestnut oak	5.3	2.5	-	-
Yellow-poplar	2.7	1.1	1.3	1.3
Hickory	2.7	0.4	2.7	0.8
Total	174.7	69.1	134.6	106.1
		TREATED		
White oak	12.0	2.6	9.3	3.2
Black oak	44.0	18.8	38.7	32.7
Scarlet oak	72.0	33.6	50.7	45.5
Chestnut oak	41.3	11.7	29.3	15.3
Yellow-poplar	8.0	2.0	8.0	3.5
Total	177.3	68.7	136.0	100.2

Overstory trees were graded in 1985 using the provisional grade specifications for hardwood growing-stock trees (Boyce and Carpenter 1968). This grading system applies to pole-size stands because all trees larger than 7.0 inches dbh with a potential 12-foot butt log are assigned a grade. Grades are based on the probability of the tree yielding a Grade 1, 2, or 3 butt log when it reaches 16 inches dbh. Below-grade trees were classified as Grade 4.

RESULTS

Understory Development

Considerable understory developed in both the untreated and treated plots (table 2). The difference in the total number of trees per acre, 1428 for the untreated plots and 1447 for the treated plots, was not significantly different ($p>0.05$). However, basal areas per acre were significantly different ($p>0.05$), averaging 11.70 and 7.31 square feet for the untreated and treated plots, respectively. Given that the number of understory trees per acre was the same, the difference in basal areas can be attributed to the presence of larger understory trees on the untreated plots. Average dbh was always greater on the untreated plots, regardless of species (table 2). A graph of the number of trees in each 0.5-inch dbh class clearly illustrates the presence of larger trees on the untreated plots (fig. 1). The two distributions were significantly different ($p>0.05$) based on a chi-square test for equality. We conclude that the effect of understory removal was to delay the development of understory growth; however, it did not prevent the reestablishment of the understory.

Understory removal treatments substantially altered understory species composition (table 2). There was a major increase in the amount of sassafras on the treated plots. Sassafras is a prolific seeder that established itself quickly on disturbed soil. Sassafras, and to a lesser degree, sourwood and yellow-poplar, seemed to replace blackgum and dogwood, both of which were present in greater numbers on the untreated plots. The difference in the number of commercial trees per acre was not significant ($p>0.05$), averaging 243 and 264 for the untreated and treated plots, respectively.

Heights of understory trees tabulated by 5-foot height classes clearly indicate the presence of taller trees on the untreated plots (table 3). Nineteen percent of the trees on the untreated plots were taller than 15 feet, compared to only 11 percent on the treated plots.

Overstory Development

The number of overstory trees per acre in 1985

Table 2.--Number, basal area (BA), and average DBH of understory trees in 1985, 22 years after thinning, for plots with untreated and treated understories.

Species	Untreated Number	Untreated BA	Untreated Dbh	Treated Number	Treated BA	Treated Dbh
Commercial	No./ac	Ft^2/ac	In.	No./ac.	Ft^2/ac	In.
Oaks	44	0.46	1.2	40	0.14	0.7
Yellow-poplar	13	.39	1.8	48	.12	0.5
Red maple	83	.86	1.1	93	.46	0.8
Hickory	87	.70	1.0	52	.10	0.5
Other commercial[1/]	16	.13	1.1	31	.24	1.0
Total commercial	243	2.54	1.2	264	1.06	0.7
Noncommercial						
Black gum	369	2.82	1.0	169	.61	0.7
Dogwood	667	4.17	0.9	496	1.53	0.6
Sourwood	48	1.42	2.1	124	2.45	1.7
Sassafras	89	0.63	1.0	352	1.59	0.8
Other noncommercial[2/]	12	.11	0.9	41	.06	0.4
Total noncommercial	1128	9.16	1.2	1183	6.24	0.9
Overall Total	1428	11.70	1.2	1447	7.31	0.8

[1/] White ash, American beech, basswood, sycamore, sugar maple.

[2/] Hazelnut, serviceberry, red bud, Ohio buckeye, American chestnut, cucumber tree.

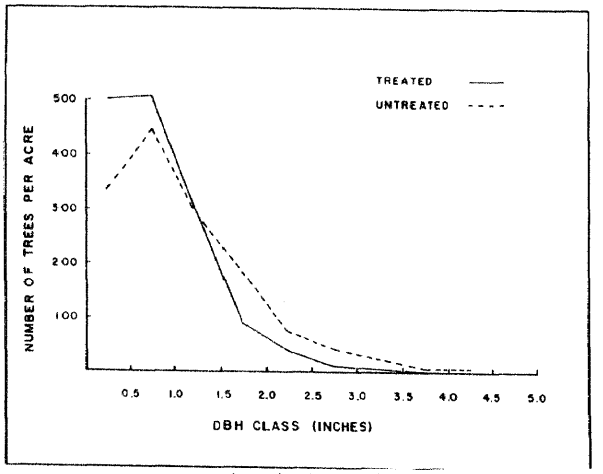

Figure 1--Diameter (dbh) distribution of understory trees in 1985, 22 years after thinning.

Table 3.-- Number of understory trees per acre in each 5-foot height class in 1985, 22 years after thinning, for plots with untreated and treated understories.

Height class	Untreated	Treated
0-5	169	201
6-10	551	697
11-15	433	393
16-20	213	128
21-25	33	20
26-30	23	7
31-35	5	1
36-40	1	0
Total	1428	1447

was nearly identical for untreated and treated plots, averaging 134.6 for the untreated plots and 136.0 for the treated plots (table 1). Although ending basal areas averaged 106.1 square feet for the untreated plots and 100.2 square feet for the treated plots, they were not significantly different (table 4). The reason for the difference in basal areas is the increased mortality of scarlet oak on the treated plots (fig. 2). Some of the larger scarlet oaks began dying at age 67. Since this increased mortality occurred nearly 15 years after thinning, we cannot attribute its cause to the understory removal treatment.

Table 4.--Basal areas, basal area growth, and mortality of overstory trees over 22 years for plots with untreated and treated understories.

Item (Ft^2/Ac)	Untreated	Treated	Difference	Significance*
Basal area 1963	69.1	68.7	0.4	N.S
Basal area 1985	106.1	100.2	5.9	N.S
Gross growth[1/]	52.1	50.2	2.3	N.S
Mortality	15.6	19.2	-3.6	N.S
Net growth	36.9	30.7	6.2	N.S

[1/] Growth rates computed for the 22-year study period are appropriately termed accretion--they include growth on trees that later died.

*Significance level -- 0.05.

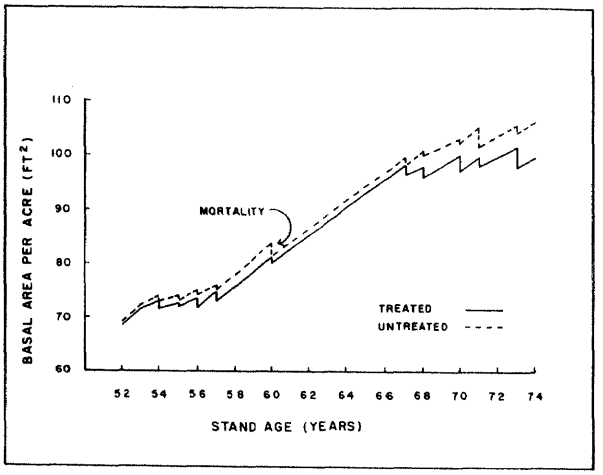

Figure 2--Relationship between overstory basal area and stand age for thinned plots with untreated and treated understories.

The slope of the lines between measurements in Figure 2 indicates gross stand growth (survivor growth). Gross basal area growth per acre was nearly the same in the untreated and treated plots for any measurement period, as indicated by the parallel lines. Gross growth for the entire 22-year period was not significantly different ($p>0.05$) for the treated and untreated plots (table 4). Mortality and net growth were not significantly different either ($p>0.05$). We conclude that understory removal had no effect on the stand growth of the overstory trees.

Diameter growth rates of the largest 40 trees per acre are plotted for five measurement periods in Figure 3. Comparisons of diameter growth rates should be made on an equal number of crop trees per acre (Adams and Chapman 1942; Smith 1962; Hilt 1979). The 40 largest trees per acre are commensurate with the European standard of 100 trees per hectare. Diameter growth rates were not significantly different ($p>0.05$) between the untreated and treated plots for any of the measurement periods. Since growth rates were slightly larger on the untreated plots, we conclude that the understory removal had no effect on the diameter growth of the larger trees.

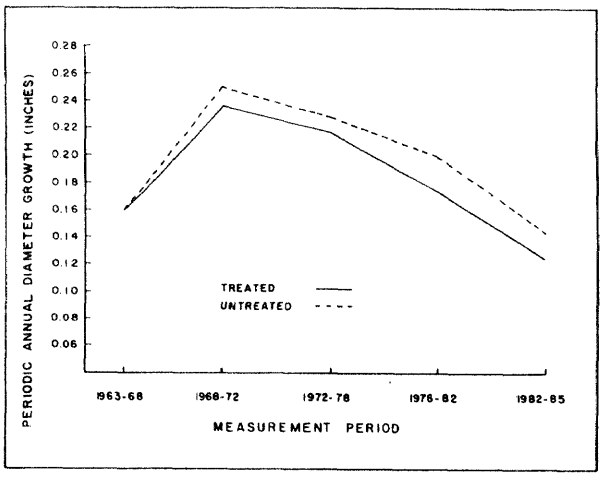

Figure 3--Periodic annual diameter growth rates of the largest 40 trees per acre for thinned plots with untreated and treated understories.

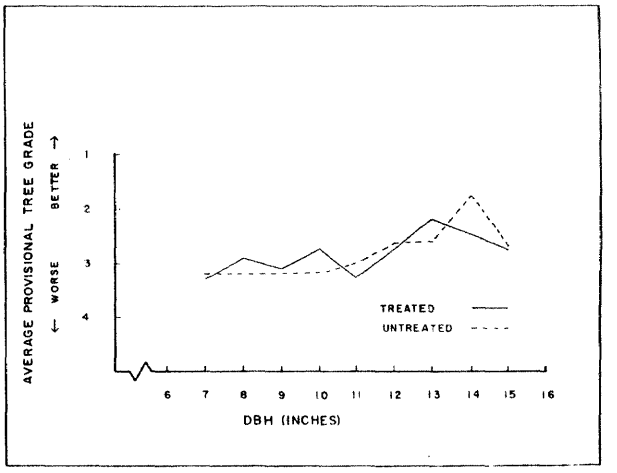

Figure 4--Average potential tree grades in 1985, 22 years after thinning, for trees in thinned plots with untreated and treated understories.

It has been suggested that an abundant understory shades the boles of the overstory trees and increases the quality of the overstory trees because of the early death of existing and epicormic branches (Dale and Sonderman 1984). Since the trees were not graded in 1963, we could not analyze grade changes. However, provisional tree grades in 1985 indicated no differences between the untreated and treated plots (fig. 4). The only trend was an increase in provisional grade with increasing dbh. This trend was similar for both the untreated and treated plots, and indicates that the highest quality trees at age 74 were also the largest trees.

CONCLUSIONS

A dense understory develops in upland oak stands that are thinned to 60 percent and lower relative stand densities. The untreated plots in this study still had nearly 1,400 understory stems per acre 22 years after thinning. This understory could presumably compete with the overstory trees for moisture and nutrients. A single understory removal immediately after thinning failed to prevent the reestablishment of the understory. Some resprouting can be expected, and, additional regeneration can be expected from the seed sources in the litter that respond to the disturbed soil and increased sunlight. Sassafras quickly established itself on the treated plots in this study. After 22 years, the understory trees on the treated plots were smaller in diameter and shorter than understory trees on untreated plots. However, understory density in the treated and untreated plots was the same with nearly 1,400 trees per acre.

The one-time understory removal treatment did not have any effect on the growth or quality of the overstory trees. Gross basal area growth per acre, net growth, and mortality were not significantly different between treated and untreated plots. Diameter growth rates of the largest 40 trees per acre were actually slightly larger on untreated plots. Potential tree grades assigned after 22 years indicated no difference in tree quality due to treatment.

It may be argued that understory removal in this study did not affect overstory growth because the understory reestablished itself and should have been removed again. While this argument has some merit, the high cost of herbicide treatments makes repeated applications unprofitable. In our opinion, if understory removal is to be practical, it should be applied only once after each thinning.

Forest land managers should be aware of the dense understory that develops after thinning. However, we cannot recommend understory removal in thinned stands as a viable management practice because understory removal did not increase the growth of overstory trees. Because of the negative attitudes toward the use of herbicides, herbicide use is appropriate only when a specific result is desired, or under intensive management where repeated applications are economically possible.

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CAUTION

This publication reports research involving herbicides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of herbicides must be registered by appropriate State and/or Federal agencies before they can be recommended.

Herbicides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife--if they are not handled or applied properly. Use all herbicides selectively and carefully. Follow recommended practices for the disposal of surplus herbicides and herbicide containers.