VALUE GROWTH RATES FROM OVERWOOD TREES IN THE IRREGULAR SHELTERWOOD METHOD IN SOUTHERN INDIANA UPLAND HARDWOODS

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Abstract.--A two-cut irregular shelterwood method was used at the Southern Indiana Purdue Agricultural Center to allow subdominant trees to develop into high quality sawlog trees, and to provide minimal shade for the developing understory. Approximately 16 trees per acre averaging 11.1 inches dbh were left as overwood in 3 study areas harvested in either 1964 or 1966. The residual trees were numbered, and diameter, height, volume and grade were determined at the time of harvesting, and again 11 to 15 years later.

The overwood trees responded to the low residual stocking levels with excellent growth rates. In general, the butt log grade of the trees improved. Value growth rate of overwood trees in the 11 to 15 years following the initial cutting averaged 25.6 and 21.9 percent, compounded annually. Value growth was reduced somewhat by windthrow, especially in trees initially greater than 14.5 inches dbh. The high value growth rates of the overwood and the accompanying satisfactory regeneration layer response makes this system an attractive alternative for private nonindustrial woodlands.

Additional keywords: silviculture, shelterwood, economics, upland hardwoods, value growth.

INTRODUCTION

A study of timber harvesting alternatives was initiated in 1964 at the Southern Indiana Purdue Agricultural Center (SIPAC). The harvesting methods were selected for their applicability to the private nonindustrial forest. The central hardwood forest is composed primarily of these small ownerships, and efficient production of wood products is dependent upon the deployment of silvicultural systems which will be consistent with the management objectives of these landowners.

One of the regeneration harvesting alternatives included in this study is a combination of the irregular shelterwood and reserve seed tree methods. The irregular shelterwood method is a modification of the shelterwood system whereby the overwood trees are retained for a longer period of time than normal. Two age classes, namely the overwood trees and the developing regeneration, are maintained through at least 20 percent of the next rotation. In the reserve seed tree method, seed trees are reserved not only to provide seed for regener-

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ation but also to grow satisfactorily so that they can be harvested in the future. Thus, both seeding capacity and the ability to obtain further increments are tree retention criteria (Smith, 1962). The overwood trees in this study were selected for their predicted capacity to grow into high quality sawlogs and veneer logs and thereby generate an intermediate cash flow while regenerating the next even-aged stand (Weaver, 1966). These residual overwood trees were not selected for and were probably inadequate in terms of seed production for the reserve seed tree method. However, the relatively low density of overwood trees gives the appearance of a discontinuous upper story (the overwood) of a two-storied stand, corresponding more with the seed tree method. For the purposes of this paper we have chosen to call this an irregular shelterwood.

The aesthetic appeal of the retention of a cover of larger trees and the potential for an intermediate cash flow may make the irregular shelterwood desirable to the private nonindustrial forest landowner. Since most of the invested timber capital has been harvested, with only a few dollars of growing stock value remaining, the potentialities of leading woodland owners into an economic program of forestry appear great.

For the irregular shelterwood to be seriously considered, the growth of the overwood in value must be greater than the suppressed value growth of the developing regeneration, and greater than alternative capital investments. This paper presents an analysis of the value growth of the reserved overwood trees in an 11 to 15 year period following the initial preparatory cut of a 2-cut irregular shelterwood.

THE STUDY AREA

The upland central hardwood stands included in this study are typical of the unmanaged woodlands in the area. The old growth timber was harvested in 1914, with additional high-grading harvests occurring in 1932 and 1952. The study area had a history of livestock grazing prior to 1953. SIPAC is located within the unglaciated sandstone-shale soils area of south-central Indiana. The soil types are in the Wellston, Gilpin and Zanesville series, with a black oak site index of 70 to 80 feet.

In 1964, average stand volume was 2,190 board feet Doyle per acre, with over 80 percent of the total volume in oak species. Basal area in trees 10 inches in diameter at breast height (dbh) and larger averaged 42 square feet per acre.

METHODS

Two treatment areas were harvested using the irregular shelterwood method in 1964 and one treatment area received an irregular shelterwood harvest in 1966, for a total of 7.95 acres in the study. Prior to the harvest, approximately 16 trees to the acre were designated as "leave" trees and reserved from timber harvesting. The remaining merchantable trees were harvested and utilized as either sawtimber or pulpwood. All other trees 2 inches dbh and larger were deadened.

The residual trees were selected based on their potential to develop into high quality logs. Trees of desirable species and form, and free from defects

were chosen. The residual trees ranged from 5.7 to 16.5 inches in dbh and were primarily intermediate and codominant in crown position in the preharvest stand. The average dbh of these overwood trees was 11.1 inches and basal area averaged 11.2 square feet per acre. Average residual stocking immediately following harvest was 9 percent (Gingrich, 1967).

The study trees were permanently numbered, and species, dbh and merchantable height were measured. The species included in the overwood include white oak (*Quercus alba L.*), red oak (*Quercus rubra L.*), black oak (*Quercus velutina Lam.*), yellow poplar (*Liriodendron tulipifera L.*), white ash (*Fraxinus americana L.*), sugar maple (*Acer saccharum Marsh.*), black walnut (*Juglans nigra L.*) and sycamore (*Platanus occidentalis L.*). The log grade of each individual 12 foot log in a tree was recorded using the Purdue Log Grading System, which is based on diameter and percentage of clear length in the log (Herrick, 1955). On the 1964 harvest areas, overwood trees were measured at the time of harvest. On the 1966 harvest area, the overwood trees were not measured until two years after cutting in 1968. The dbh, merchantable height and the grade of each merchantable log was remeasured on all trees in 1979. In total 124 overwood trees were included in this study.

The rate of value increase for each individual tree over the 11 to 15 year period was determined using a value growth rate approach (Davis, 1966). The general equation used for determining value growth rate is shown below:

$$(1) \quad V_n = V_o \ (1 + i)^n,$$

where V_n = value at the end of the period

V_o = value at the beginning of the period

n = number of years in the period

i = interest rate

This equation is solved for "i" to give the value growth rate.

$$(2) \quad i = \left(\frac{V_n}{V_o}\right)^{1/n} - 1$$

Individual tree values for the beginning and end of the study period were estimated using price data assembled by Brundage and Straszheim (1964 and 1968) and Hoover (1979). The price information reported gives the average delivered log prices per thousand board feet by species and Purdue log grade. For the purposes of this study the value of standing timber was determined by subtracting the average logging and hauling costs for that year, also determined by the yearly survey, from the average delivered log prices. For pulpwood trees a stumpage value (V_o) of $1.00 per ton was assumed (Weaver, 1967). Minimum sawlog standards were 8 feet in length and 10 inches diameter inside bark at the small end. Equation 2 was then used to calculate the value growth rate of each individual tree over the 11 to 15 year period.

RESULTS AND DISCUSSION

In 1979, only 98 of the original 124 trees were left in the study. The other 26 trees were lost to windthrow. Diameter growth of the remaining over-

wood trees following harvesting had averaged 0.36 inches per year, with those trees having larger initial diameters making slightly better diameter growth than the trees with smaller diameters. These diameter growth responses are consistent with those found by other researchers (Hilt, 1979). There were an average of 12.3 trees per acre in 1979, with an average dbh of 15.6 inches and an average basal area of 16.3 square feet per acre. Average stocking had increased to 12 percent (Gingrich, 1967).

Value growth rate expressed as a percent is a function of the physical growth of the tree, market fluctuations, and a change in log grade. Table 1 shows the percentage of trees by butt log in the 4 Purdue log grades and pulpwood category by dbh class at the time of initial measurement and these same trees again in 11 to 15 years by butt log class. The percentage of trees lost to windthrow is also shown. In general, log grade improved over the 11 to 15 year period in all diameter classes. The amount of windthrow ranged from 11 to 18 percent of the original trees for the three diameter classes less than 14.5 inches. However, windthrow for those trees with initial diameters greater than 14.5 inches averaged 57.9 percent.

Table 1.--Percent of overwood trees by dbh and butt log class initially and 11 to 15 years following preparatory cuts in a 2-cut irregular shelterwood system

Butt Log Class	DBH Class							
	5.5-8.4		8.5-11.4		11.5-14.4		14.5+	
	1964,68	1979	1964,68	1979	1964,68	1979	1964,68	1979
Prime				4.3		24.3	5.3	21.1
#1		9.1		28.3	5.4	13.5	52.6	10.5
#2		59.1	2.2	37.0	54.1	32.4	36.8	10.5
#3		13.6	23.9	19.6	27.0	13.5	5.3	
Pulpwood	100		73.9		13.5			
Windthrow		18.2		10.9		16.2		57.9

Table 2 gives the value growth percents of the 98 residual overwood trees by dbh class and species group for the 11 to 15 year period since first measured. Value growth percents for the residual trees in the 1966 harvest area (1968 measurement) averaged 25.6 percent compounded annually over the 11 year period, while value growth percent for the residual overwood trees in the 1964 harvest area averaged 21.9 percent compounded annually over the 15 year period. These value growth percents are for nominal dollars, and include the effects of inflation.

If the 26 trees lost to windthrow are included in the calculations, the Vo variable (equations 1 and 2) is increased by the amount of the original value of these trees, and the Vn variable remains the same. This lowers the value growth percent for the 11 year period in the 1966 harvest area to 16.5 percent, and the 15 year value growth percent in the 1964 harvest areas to 20.9 percent. The largest decrease in value growth percent due to the addition of windthrow trees occurs in the greater than 14.5 dbh class. The value growth percent of all trees greater than 14.5 inches in the 1966 harvest area is decreased from 23.5 percent to 8.8 percent.

Table 2.--Percent value growth rates for overwood trees in 2-cut irregular shelterwoods by DBH class and species group following 11 and 15 years of growth. Dates indicate year of harvest. Numbers in parenthesis are the number trees in each category.

DBH Class	WHITE OAK		RED & BLACK OAK		OTHER*		TOTAL	
	1966 (11 Yr)	1964 (15 Yr)	1966 (11 Yr)	1964 (15 Yr)	1966 (11 Yr)	1964 (15 Yr)	1966 (11 Yr)	1964 (15 Yr)
5.5-8.4	--	17.0 (5)	--	19.0 (7)	44.5 (1)	19.2 (5)	44.5 (1)	18.4 (17)
8.5-11.4	24.4 (6)	21.5 (13)	--	24.9 (15)	32.5 (6)	15.4 (1)	30.0 (12)	23.1 (29)
11.5-14.4	26.9 (4)	19.6 (5)	28.3 (7)	22.5 (11)	18.6 (2)	25.6 (2)	24.5 (13)	22.2 (18)
14.5+	22.7 (1)	--	28.1 (3)	20.3 (3)	11.7 (1)	--	23.5 (5)	20.3 (3)
Total	25.4 (11)	20.3 (23)	28.2 (10)	22.4 (36)	23.1 (10)	24.1 (8)	25.6 (31)	21.9 (67)

*includes 6 yellow poplar, 6 white ash, 3 sugar maple, 2 black walnut, 1 sycamore

When the windthrow trees are added to the value growth percent calculations, the average value growth percent is decreased. However, the rate is still above 15 percent for trees initially less than 14.5 inches dbh. The "cost" of the 10 to 18 percent of the total trees lost to windthrow in these diameter classes does not "significantly" reduce the value growth rate. However, the large amount of windthrow that occurred in trees greater than 14.5 inches dbh caused large decreases in the value growth rate. In areas with a high windthrow hazard, the irregular shelterwood may not be a wise investment if larger-size, merchantable trees are retained for a subsequent harvest.

The diameter and volume growth of these overwood trees responded to the large amount of growing space created by the irregular shelterwood harvest. Board feet volume growth rates for the trees which were sawtimber size when the harvest occurred averaged 11.0 percent compounded annually over the 11 year period and 8.9 percent compounded annually over the 15 year period.

In addition to the excellent physical growth exhibited by the overwood trees, the log quality showed an improving trend during the course of the study. Since the irregular shelterwood system as implemented here relied on codominant and intermediate crown class trees to form the overwood, some quality degrade due to epicormic branching might be expected (Wahlenberg, 1950; Brinkman, 1955). However, less than 7 percent of the total butt logs in the study decreased in log grade, while 63 percent increased at least one grade. More epicormic branching was observed in the second 12 foot log. However, 94 percent of the second logs showed no decrease in log grade over the 11 to 15 year period.

It is expected that the value growth rate of the overwood will decrease over time. The overwood should be harvested when the capital contained in the trees could be invested in an alternative investment at a higher interest rate. Also, the overwood should be harvested when its value growth falls below the potential value growth of the developing regeneration layer. At this time, however, a study of the species composition and height growth of the regeneration, shows that there are no significant differences between the irregular shelterwood areas and adjacent patch clearcut areas.

SUMMARY

This case study shows the results when trees from 6 to 17 inches dbh, which would have been harvested as lower value products in a clearcut or group selection opening, were retained as the residual overwood in an irregular shelterwood. These trees responded to the low stocking levels with excellent growth rates. Log grade of these residual trees improved following the preparatory cut of the irregular shelterwood. Value growth rate of overwood trees which survived in an 11 to 15 year period after initial cutting averaged 25.6 and 21.9 percent respectively, compounded annually. Value growth was reduced somewhat by windthrow, especially in trees greater than 14.5 inches dbh. These preliminary findings indicate that the overwood in an irregular shelterwood in the central hardwoods is capable of growing at high value growth rates. These results correlate well with a study by Smith, et. al. (1979) concerning the raising of cutting diameters to increase financial returns from eastern hardwoods. Also, the species composition and height growth of the regeneration was not significantly different from other types of regeneration cuttings in

adjacent stands. The intermediate cash flow obtained from the eventual harvest of the overwood trees may make this system attractive to the private nonindustrial woodland owner.

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