United States
Department of
Agriculture

Forest Service

**Northeastern Forest
Experiment Station**

Research
Paper NE-540

1984

Costs of Reducing Sapling Basal Area in Thinned Cherry-Maple Stands in West Virginia

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Manuscript received for publication 16 November 1983

Abstract

Unmanaged 60-year-old cherry-maple stands in West Virginia were thinned to three levels of stocking according to the Allegheny hardwoods stocking guide. After the merchantable timber was removed, the basal area in saplings was reduced to less than 10 ft^2 per acre (2.3 m^2/ha), as the guide recommends for stands with dense understories. A detailed time study revealed that cutting saplings with chain saws costs about $17.00 per acre ($42/ha). This amount may be recoverable in increased yield, tax deductions, and fuelwood sales.

Cover Photo

Saplings were felled by experienced loggers.

Introduction

The stocking guide for Allegheny hardwoods recommends thinning even-aged stands to 60 percent of full stocking, the minimum stocking theoretically needed to utilize the site fully (Roach 1977). Other stocking guides developed for eastern forest types have similar residual stocking recommendations, but none of the guides, including the guide for Allegheny hardwoods, support their recommendations with actual response data (Leak 1981). As part of a large thinning study designed to test and refine the Allegheny hardwoods stocking guide for use in West Virginia, the implications of reducing sapling basal area as recommended by the guide were examined.

In addition to providing general guidelines on residual stand density, the Allegheny guide makes specific recommendations for distributing the cut among species groups and size classes, including saplings, defined as stems 1.0 to 5.5 inches (2.5-14.0 cm) dbh. Of particular concern from an economic standpoint is the recommendation to greatly reduce sapling basal area in stands with relatively dense understories. The economic impact of sapling removal depends on the cost of the treatment and the response of the residual trees in the stand. Net revenues from commercial thinnings can be quickly eroded by operations in the nonmerchantable portion of the stand. Without sufficient increases in the growth of residual trees, sapling removal will not only reduce net revenues of commercial thinning, but will also reduce net present value of timber production on the area.

Some recent studies have shown that reducing understory basal area in thinned hardwood stands increases the growth of residual trees in the overstory. Dale (1975) found that thinned upland oak stands with all woody stems less than 1.6 inches (4.1 cm) dbh eradicated grew faster than stands similarly thinned but with the understory left in place over a 10-year period. Karnig and Stout (1969) found that understory removal after a heavy thinning resulted in a slight increase in basal area growth of red oak over three growing seasons. Although these studies showed that understory removal in conjunction with thinning increases the growth of residual trees, cost and return data were not available to evaluate its economic feasibility.

This report provides cost indicators and discusses the economic and silvicultural implications of sapling removal as a separate stand treatment following commercial logging. Data were collected in cherry-maple (*Prunus serotina* Ehrh.—*Acer rubrum* L.) stands in West Virginia, but the information can be helpful wherever stocking guides are used to control intermediate cuttings in hardwood stands.

The Study Area

The study was conducted in the Middle Mountain area of the Monongahela National Forest. Treated stands were previously unmanaged even-aged black cherry-maple stands about 60 years old. The study area is representative of about 125,000 acres (50,600 ha) of commercial forests in north central West Virginia and resembles the Allegheny hardwood forests of northwestern Pennsylvania: rainfall averages about 55 to 60 inches (1.4-1.5 m) per year; site index for black cherry is 75 feet (23 m). The terrain in the immediate study area is gentle rolling hills with slopes generally less than 10 percent.

The overstory was primarily black cherry and red maple with some white ash (*Fraxinus americana* L.). The understory was made up of American beech (*Fagus grandifolia* Ehrh.), red maple, and sugar maple (*Acer saccharum* Marsh.). Based on a complete inventory of all trees 1.0 inch (2.5 cm) dbh and larger on eighteen ½-acre (0.2 ha) plots, the average basal area was 164 ft^2 per acre (38 m^2/ha) with 69 percent of the basal area in the cherry, ash, yellow-poplar (*Liriodendron tulipifera* L.) (CAPs) species group. Basal area in saplings averaged 25 ft^2 per acre (5.7 m^2/ha). The study area also averaged 826 trees per acre with an average diameter of 6.0 inches (15.2 cm). According to the stocking chart (Roach 1977), the area was about 110 percent stocked before thinning.

In merchantable trees 7.0 inches (17.8 cm) dbh and larger, the study area averaged 216 trees per acre (534/ha) with an average diameter of 10.4 inches (26.4 cm) dbh.

Plot Treatments

Eighteen 2-acre (0.8 hectare) experimental units were randomly divided among three thinning densities, 75, 60, and 45 percent of full stocking. Each 2-acre unit was marked as recommended in the Allegheny hardwoods stocking guide (Roach 1977). For example, two-thirds of the basal area cut was below the average diameter in each species group (CAPs and others). Saplings as well as poles and sawtimber were marked. Although marking in the poles and sawtimber varied with the target density, the marked cut for saplings was essentially the same for all thinning densities, averaging 16 ft^2 of basal area per acre (3.7 m^2/ha) in the 18 plots.

Calculations were based on a complete inventory of all trees 1.0 inch dbh (2.5 cm) and larger on a ½-acre (0.2 hectare) measurement plot located within each 2-acre unit. Trees not marked for cutting in the ½-acre measurement plot were tagged for long-term study.

Six 2-acre units, two from each thinning density, were logged in the fall of 1981. All marked trees 7.0 inches dbh (17.8 cm) and larger were cut and skidded. No trees smaller than 7.0 inches dbh were cut in these six units.

Twelve 2-acre units, four from each thinning density, were logged in the spring of 1982. After all marked trees 7.0 inches dbh and larger had been removed, marked trees smaller than 7.0 inches dbh were cut. These included marked saplings and marked nonmerchantable poles 5.6 to 6.9 inches (14.2–17.5 cm) dbh. This part of the thinning was carried out as a separate operation.

Data Collection

Cost data collected from these 12 thinning units included fuel usage, machine-hours, and man-hours. On five plots, man-hours were measured by the detailed time study method. The activities of workers were divided into work cycles and the cycles were subdivided into cycle elements. An observer recorded each element as it occurred without missing any time between successive elements.

Work cycle elements were classified as either productive elements or delay elements. Productive elements included WALK, SWAMP, and FELL. Delay elements included REFUEL, REPAIR SAW, WAIT, REST, and PERSONAL. The characteristic beginning and ending points of each element were defined to allow for consistency in the timing procedure.

Gross job time and the number of stems cut were recorded for each of the twelve 2-acre units. On the five time-study units, gross time was determined as the sum of all cycle times and the number of stems cut equaled the number of cycles. On the other seven treatment units, the number of cut trees was estimated from inventories of the ½-acre measurement plot within each unit.

Results

Cost Per Tree

A total of 632 trees were felled during the detailed time study. Productive time plus delay time totaled about 430 minutes of work. The bulk of productive time was spent walking from tree to tree, while swamping time was nearly negligible (Table 1). Delays amounted to 38 percent of the total job time, and half of the delay time was spent refueling, repairing, and servicing the chain saws. Another 35 percent of the delay time was spent resting.

The average time required to cut saplings under the conditions studied was 0.68 minutes per tree, counting delays. Gabriel and Nissen (1974) obtained similar results in New York. However, cutting saplings and small poles in the 45 percent treatment required about 0.76 minutes per tree, because the abundance of slash and tops made walking from tree to tree more difficult (Table 2). The actual dollar cost per tree depends on the size of the trees included in the cut, the intensity of the cut, and the hourly cost of labor and equipment.

Table 1.—Time in minutes for productive activities: cutting nonmerchantable stems after logging

Dbh class (inches)	No. stems	Percent	Elements			Total	Percent	Mean time per stem
			Walk	Swamp	Fell			
4	273	43	58.9	0.8	38.5	98.2	37	0.36
5	205	32	49.4	1.3	38.7	89.4	33	0.44
6	117	19	27.7	1.8	29.3	58.8	22	0.50
7	37	6	8.6	1.0	11.6	21.2	8	0.57
Total	632	100	144.6	4.9	118.1	267.6	100	0.42
Percent			54	2	44	100		

Table 2.—Time required to cut nonmerchantable stems after logging in the three thinning treatments

Treatment: percent stocking	Stocking before sapling cut	Cut required to reach desired stocking		Cutting time per tree	Total time per acre
	%	*Stems/acre*[a]	*BA/acre*(ft²)[b]	*min*	*hr*[a]
75	91	150	20	0.65	1.63
60	76	150	20	0.66	1.65
45	58	130	17	0.76	1.65

[a]For stems per hectare multiply stems per acre by 2.47.
[b]For m² per hectare multiply ft² per acre by 0.23.

Cost Per Hour

The machine costs presented here are based on a new McCulloch Pro Mac 800[1] with a 24-inch bar. The fixed cost, including depreciation and interest, insurance, and taxes was \$0.43 per hour (Miyata 1980). The operating cost was \$1.51 per hour. The total labor cost, including a wage of \$5.50 per hour and 28 percent mandatory fringe benefits, was \$7.04 per hour. The hourly machine cost will differ for different chain saws and the labor cost could differ with location. Total cost under the conditions studied was \$8.98 per scheduled hour of work.

Cost Per Acre

The cost per acre to cut saplings and nonmerchantable stems was nearly equal in the three treatments. In the 75 and 60 percent treatments, the cut required to reach the target level of stocking was 20 ft^2 of basal area per acre (4.6 m^2/ha), roughly 150 trees (Table 2). This required about 1.64 hours at a cost of \$14.58 per acre. In the heavily thinned plots, the cut required to reach 45 percent residual stocking was less, only 17 ft^2 per acre (3.9 m^2/ha). Because the cutting time per tree was higher in the 45 percent treatment, its cost was about the same as the other treatments, \$14.82 per acre. A contractor or consulting forester hired to cut nonmerchantable stems would require a margin of profit to complete the operation. A 15 percent margin for profit and risk brings the total treatment cost to about \$17.00 per acre (\$42.00 per hectare).

[1]The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable.

Silvicultural Implications

Ignoring the saplings and other nonmerchantable stems when thinning hardwood stands can lead to a silvicultural dilemma. If the stands are marked according to the stocking guide, with nonmerchantable stems included in the mark but not actually cut, the residual stands would have a higher percentage stocking than desired. In plots targeted for a 60 percent thinning, residual stocking was 76 percent before the saplings and nonmerchantable stems were cut (Table 2). At this level of stocking mortality begins to increase, reducing net growth and the rate of product development (Roach 1977). Growth is distributed among many trees, some of it wasted on trees that will die before the next cut.

On the other hand, if desired stocking is achieved by heavier cutting in the merchantable size classes, the dominant and codominant crop trees will be overcut. Mortality would not be a problem until the stand reached about 80 percent stocking, but growth would be concentrated on smaller stems (Roach 1977). As a result, board foot volume production would be reduced and the big dollar yield at rotation age would be delayed.

In stands with sparse understories, less than 20 ft^2 per acre (4.6 m^2/ha) in saplings, the effect of saplings in the marked cut is slight. However, in stands with dense understories, saplings and nonmerchantable poles should be included in the cut to achieve a balanced and effective thinning.

Economic Implications

The purpose of thinning these 60-year-old stands was to concentrate growth on the best trees in the stand, increase yield by salvaging trees that would die, and reduce the time required for the stand to reach physical maturity. Thinning merchantable stems reduces overstory competition and leads to faster growth of residual crop trees. If reducing sapling basal area further stimulates the growth of residual crop trees, then cutting saplings could produce a net economic gain.

For sapling cutting to be profitable, stands so treated must provide increased dollar yields in later thinnings and final harvest that exceed the cost of sapling removal. Increases in dollar yields, if any, will most likely be from improved tree quality or increased board foot yields, or both. An example shows that the additional yield required (over stands that were only thinned) is not unreasonable (Table 3).

The example presented deals with after-tax cash flows. Because the cost of noncommercial thinning in established stands may be deducted as an operating expense, the actual cost of sapling removal is determined by the landowner's marginal tax rate (U.S. Forest Service 1982; Weston and Brigham 1981). The example assumes a marginal tax rate of 25 percent, resulting in an after-tax cost of \$12.75 per acre (\$31.49/ha) for cutting saplings. Other assumptions include an average annual inflation rate of 5 percent and no real change in stumpage prices over the investment period. Three investment periods were considered.

If 9 percent is the alternative market rate of return, the sapling cut must result in added revenue of $47.08 per acre ($116.29/ha) from a final harvest 20 years after thinning. This means that annual growth must increase by about 17 bf (International ¼-inch rule) per acre (0.24 m^3/ha), roughly 6 percent of current annual growth, to equal the alternative investment.

The actual growth capabilities of stands treated this way are not known, but growth responses and quality changes will be monitored over the next 20 years. We know that saplings are important in determining stand stocking and that treatment costs do not require unreasonable growth increases to justify sapling removal in stands with dense understories. Periodic remeasurement of the residual trees will disclose how much of the treatment costs will be offset by increased board foot yields as the stand nears final harvest.

The cost of cutting nonmerchantable stems can be reduced by selling some of the material as fuelwood. The average volume available for sale as fuelwood from the 12 treated plots was about 8 cords per acre (6.2 m^3/ha). If fuelwood brought $2 per cord on the stump, such a sale could offset the cost of the treatment. Actual fuelwood revenues, however, would depend on accessibility of the product and local fuelwood markets.

Table 3.—Additional dollar and board foot yields needed to earn selected rates of return from cutting saplings in stands thinned to 60 percent residual stocking

Required return[a]	10 years		20 years		30 years	
	Value yield	Volume yield[b]	Value yield	Volume yield	Value yield	Volume yield
Percent	*$/acre*[c]	*bf/acre*[c]	*$/acre*	*bf/acre*	*$/acre*	*bf/acre*
5.25	18.76	213	27.60	193	40.61	174
7.50	22.04	251	38.09	266	65.84	282
9.00	24.50	279	47.08	329	90.48	388

[a]Converted to after-tax rates before computing required yields.
[b]Stumpage revenues were treated as capital gains to determine after-tax volume yields needed to earn selected rates of return.
[c]For $ per hectare multiply $ per acre by 2.47.
For m^3 per hectare multiply bf per acre by 0.014.

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ODC 242:323.2:535

Keywords: cost data, sapling removal, thinning, stocking, northern hardwoods

☆ U.S. GOVERNMENT PRINTING OFFICE: 1984—705-029/505

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