LOGGING DAMAGE ASSOCIATED WITH THINNING CENTRAL APPALACHIAN HARDWOOD STANDS WITH A WHEELED SKIDDER

Gary W. Miller
Neil I. Lamson
Samuel M. Brock

ABSTRACT

In north central West Virginia, unmanaged 53-year-old, mixed oak-cove hardwood stands were thinned to 75, 60, and 45 percent residual stocking. Cut trees were skidded tree-length with a rubber-tired skidder. Logging destroyed or severely bent 26, 29, and 34 percent of the unmarked stems in the 75, 60, and 45 percent stocking plots, respectively. Because 94 percent of the destroyed and bent trees were less than 5.0 inches dbh, the effect on basal area and residual stocking was slight. Damage reduced the stocking by 6, 4, and 5 percent in the 75, 60, and 45 percent stocking plots, respectively. All plots combined, 14 percent of the residual stems sustained broken tops, which affected only 3 percent of the residual basal area. Less than 10 percent of the residual stems received wounds that resulted in exposed sapwood. Study results indicate that marking guidelines in the merchantable portion of the stand do not need to be adjusted to account for logging damage.

INTRODUCTION

Intensive forest management in hardwood stands involves a series of partial cuts in both even-aged and uneven-aged systems. These partial cuts damage some residual trees during the logging operation. Damage may include destruction of a potential crop tree, or it may be limited to broken branches or a skinned stem. An important question in thinning even-aged stands is: Should the marked cut be adjusted to account for logging damage to residual stems? We studied the effect of logging damage on residual stand density in mixed oak-cove hardwood stands thinned to three levels of residual stocking with a rubber-tired skidder.

Intermediate cuttings in hardwood stands can be controlled by quantitative stocking guides developed for major eastern forest types. The current recommendation for thinning oak stands is a residual stand density of about 60 percent of full stocking (Gingrich 1967). However, some studies indicate that additional stand growth may be achieved at densities lower than the recommended level (Leak 1981; Dale 1972). As part of a study to test the applicability of the upland oaks stocking guide (Gingrich 1967) in West Virginia, plots were thinned to 75, 60, and 45 percent residual stocking. In addition to growth and yield information, the plots provided data on logging damage associated with each level of thinning.

THE STUDY AREA

The study area was located on the West Virginia University Forest in north central West Virginia. Thinning treatments were applied in the mixed oak-cove hardwood type on generally northeast facing slopes. The stand was

53 years old with a site index of 70 for oak at the time the treatments were applied. The terrain was gentle rolling hills with slopes generally less than 10 percent.

For trees at least 1.0 inch dbh, the stands averaged 431 trees per acre with a basal area of 145 ft^2 per acre, a cubic-foot volume of 3,125 ft^3 for trees at least 5.0 inches dbh, and a board-foot volume (International) of 13,951 fbm per acre for trees at least 11.0 inches dbh. The stands were 129 percent stocked prior to treatment (Gingrich 1967).

DATA

Fifteen 3-acre plots, 5 at each thinning level, were included in this portion of the study. Within each 3-acre plot, a 1/2-acre observation plot was installed. After the 3-acre plots were marked for thinning, all residual trees at least 1.0 inch dbh on the observation plots were permanently identified. Each tree was carefully examined for wounds resulting from natural causes before logging. Species, diameter, crown class, and condition remarks also were recorded before logging.

The plots were logged by a commercial crew using chain saws and a rubber-tired skidder. Crew size varied from 2 to 3 men, depending on the circumstances. Merchantable logs were skidded tree-length to the decking area. Trees 3.6 inches dbh and larger were marked, but those less than 7.0 inches dbh were cut and left in the woods. Up to 4 chokers were used per hitch and the skidder was permitted to run throughout the plot. Trees from one 3-acre plot were not skidded through other plots. Felling and skidding started at the back of each plot and proceeded toward the main skid road or deck. Trees were directionally felled whenever possible, though the terrain and stand density made this difficult in some locations. The logging operations were done in the spring when the bark was slipping and logging damage to residual trees could be expected to be greatest. After logging, each residual tree on the measurement plots was carefully examined for four logging injuries: 1) completely destroyed; 2) bent or severely leaning; 3) exposed sapwood; 4) broken tops. The length and width of each sapwood-exposed wound were measured.

Data from the 1/2-acre measurement plots provided information relating to logging damage in only a portion of the residual stand. Because the logging contractor was not permitted to locate skid roads near the growth plots, the data do not represent the type of damage sustained along skid roads. In Appalachia, skid roads, haul roads, and landings occupy about 10 percent of the area logged with wheeled skidders (Kochenderfer 1977). Probably another 5 percent of the total area logged sustains damage that is not represented by the 1/2-acre plot data. As a result, the logging damage reported here represents the area between roads and landings, roughly 85 percent of the total area logged.

RESULTS

Two types of damage, destroyed trees and bent or severely leaning trees, reduced the number of residual trees and lowered the residual stand stocking below the desired level. In the following discussions, these types of damage are expressed as a percentage of the unmarked portion of the stand. Conversely, damage involving exposed sapwood and broken tops affected only the quality of the residual trees and did not affect stand stocking. These types of damage are expressed as a percentage of the net residual stand--the unmarked stand minus destroyed and bent or severely leaning stems.

Destroyed

For the 75, 60, and 45 percent residual stocking plots, 14, 20, and 27 percent, respectively, of the unmarked trees were destroyed by logging. Because most of the destroyed trees (94 percent) were less than 5.0 inches dbh, residual basal area was not seriously reduced. Only 4, 2, and 5 percent of the unmarked basal area was destroyed by logging in the 75, 60, and 45 percent stocking plots, respectively (Tables 1, 2, 3). One sawtimber-size tree per acre was destroyed in each of the 75 and 45 percent stocking plots. No sawtimber-size trees were destroyed in the 60 percent stocking plots.

Bent or Severely Leaning

For the 75, 60, and 45 percent stocking levels, a total of 41, 22, and 15 stems per acre, respectively, were bent or left leaning after logging. Ninety-two percent of these trees were less than 5.0 inches dbh. This form of damage amounted to 9 percent of the unmarked stems and about 2 percent of the unmarked basal area (Tables 1, 2, 3). Although this type of injury did not kill the trees, damage of this type associated with snow and ice often results in dead trees in the near future.

Effect on Residual Stocking

The plots were marked according to the stocking guide for upland oaks (Gingrich 1967) without making allowances for logging damage to the residual stand. In computing residual stocking, trees that were bent and trees that were destroyed were not considered part of the residual stand. As a result of logging damage, actual residual stand stocking was 69, 56, and 40 percent in the 75, 60, and 45 percent residual stocking plots, respectively (Tables 1, 2, 3).

Some of the trees that survived the logging operation suffered skinned stems or broken tops. These injuries did not affect residual stand stocking.

Exposed Sapwood

In the 75 percent residual stocking plots, 5 percent of the residual stems and 3 percent of the residual basal area had exposed sapwood damage (Table 1). In the 60 percent residual stocking plots, 9 percent of the residual stems and 11 percent of the residual basal area had exposed sapwood (Table 2). Sapwood damage was most severe in the 45 percent residual stocking plots. Eighteen percent of the residual stems and 16 percent of the residual basal area had exposed sapwood in the heavy thinning treatment (Table 3). Thus, exposed sapwood was directly related to intensity of thinning--as the number of stems and basal area removed increased, a greater percentage of the residual stand suffered exposed sapwood wounds.

An important factor in sapwood damage is the size of the tree suffering the wound. In this study, the percentage of residual trees with exposed sapwood increased with heavier thinning. However, the distribution of sapwood damage among size classes remained about the same in each treatment. For all treatments combined, about 53 percent of the wounded trees were less than 5.0 inches dbh

Table 1. Summary of logging damage in plots thinned to 75 percent residual stocking

Item	Number of stems				Basal area, ft²/acre				Cubic-foot volume			Board foot volume (Int)	Percent stocking
	1.0-4.9	5.0-10.9	11.0+	Total	1.0-4.9	5.0-10.9	11.0+	Total	5.0-10.9	11.0+	Total	11.0+	
					INITIAL STAND								
Initial	267	149	68	484	9.2	53.4	74.1	136.7	1,013	1,891	2,904	10,972	123
Marked cut	25	84	19	128	2.5	28.9	23.1	54.5	545	598	1,143	3,763	
Unmarked stand	242	65	49	356	6.7	24.5	51.0	82.2	468	1,293	1,761	7,209	75
					LOGGING DAMAGE								
Bent or leaning	39	2	0	41	1.1	0.6	0	1.7	8	0	8	0	
Destroyed	46	3	1	50	1.3	0.7	0.9	2.9	14	22	36	83	
Percent	35	8	2	26	36.0	5.0	2.0	6.0	5	2	2	1	
Net residual[2]	157	60	48	265	4.3	23.2	50.1	77.6	446	1,271	1,717	7,126	69
Exposed sapwood	7	5	1	13	0.3	1.6	0.7	2.6	30	18	48	74	
Percent[3]	4	8	2	5	7.0	7.0	1.0	3.0	7	1	3	1	
Broken top	28	1	0	29	0.7	0.4	0	1.1	2	0	2	0	
Percent[3]	18	2	0	11	16.0	2.0	0	1.0	0	0	0	0	

[1]Percent of unmarked stand. [2]Net residual=unmarked stand-bent or leaning-destroyed. [3]Percent of net residual stand.

Table 2. Summary of logging damage in plots thinned to 60 percent residual stocking.

Item	Number of stems				Basal area, ft²/acre				Cubic-foot volume			Board foot volume (Int)	Percent stocking
	1.0-4.9	5.0-10.9	11.0+	Total	1.0-4.9	5.0-10.9	11.0+	Total	5.0-10.9	11.0+	Total	11.0+	
					INITIAL STAND								
Initial	188	154	81	423	6.9	51.8	93.9	152.6	925	2,378	3,303	15,625	138
Marked cut	24	107	40	171	2.3	33.4	49.3	85.0	582	1,262	1,864	8,391	
Unmarked stand	164	47	41	252	4.6	18.4	44.6	67.6	343	1,116	1,439	7,234	60
					LOGGING DAMAGE								
Bent or leaning	20	2	0	22	0.5	0.9	0	1.4	15	0	75	0	
Destroyed	48	2	0	50	1.1	0.4	0	1.5	6	0	6	0	
Percent[1]	41	9	0	29	35.0	7.0	0	4.0	6	0	6	0	
Net residual[2]	96	43	41	180	3.0	17.1	44.6	64.7	322	1,116	1,358	7,234	56
Exposed sapwood	7	6	4	17	0.2	2.4	4.2	6.8	46	113	149	512	
Percent[3]	7	14	10	9	7.0	14.0	9.0	11.0	14	10	11	7	
Broken top	19	1	1	21	0.5	0.2	1.2	1.9	4	29	33	244	
Percent[3]	20	2	2	12	17.0	1.0	3.0	3.0	1	3	2	3	

[1]Percent of unmarked stand. [2]Net residual = unmarked stand-bent or leaning-destroyed. [3]Percent of net residual stand.

Table 3. Summary of logging damage in plots thinned to 45 percent residual stocking.

Item	Number of stems				Basal area, ft²/acre				Cubic-foot volume			Board foot volume (Int)	Percent stocking
	1.0-4.9	5.0-10.9	11.0+	Total	1.0-4.9	5.0-10.9	11.0+	Total	5.0-10.9	11.0+	Total	11.0+	
					INITIAL STAND								
Initial	179	130	78	387	7.0	43.7	93.9	144.6	782	2,387	3,169	15,255	126
Market cut	32	93	48	173	3.3	28.9	62.8	95.0	507	1,617	2,124	10,792	
Unmarked stand	147	37	30	214	3.7	14.8	31.1	49.6	275	770	1,045	4,463	45
					LOGGING DAMAGE								
Bent or leaning	13	2	0	15	0.3	0.8	0.2	1.3	14	6	20	26	
Destroyed	54	2	1	57	1.3	0.6	0.7	2.6	10	18	28	91	
Percent[1]	46	11	3	34	43.0	9.0	3.0	8.0	9	3	5	3	
Net residual[2]	80	33	29	142	2.1	13.4	30.2	45.7	251	746	997	4,346	40
Exposed sapwood	15	4	6	25	0.4	1.7	5.4	7.5	31	129	160	589	
Percent[3]	19	12	21	18	19.0	13.0	18.0	16.0	12	17	16	14	
Broken top	27	3	0	30	0.9	0.9	0	1.8	17	0	17	0	
Percent[3]	34	9	0	21	43.0	7.0	0	4.0	7	0	2	0	

[1]Percent of unmarked stand. [2]Net residual=unmarked stand-bent or leaning-destroyed. [3]Percent of net residual stand.

and 80 percent were less than 11.0 inches dbh.

Broken Tops

A few residual trees suffered broken tops during logging (Tables 1, 2, 3). The most damage occurred in the heavily thinned plots (45 percent residual stocking), where 21 percent of the residual trees suffered broken tops. In the 60 and 75 percent residual plots, 12 and 11 percent of residual trees, respectively, suffered broken tops. Nearly all trees (93 percent) with this type of injury were less than 5.0 inches dbh. As a result, a very small portion of the residual basal area was affected by top damage.

Injuries to Potential Crop Trees

Trees in a dominant or codominant position after thinning are the most likely crop trees of future harvests. The stand was marked to favor these trees so that growth would be concentrated on the best trees in the stand--a major objective of thinning. We examined dominants and codominants to determine the extent of logging damage to the crop trees of the future.

At the 60 percent residual stocking level, the current recommended thinning treatment, 68 dominant and codominant stems per acre were left in the stand. One tree per acre was severely bent and had to be eliminated from the net residual stand. Of the remaining 67 dominant and codominant trees per acre, 7 trees (10 percent) suffered exposed sapwood wounds. Only three of the wounded crop trees (4 percent) suffered severe wounds greater than 100 in^2 of exposed sapwood.

At the 45 percent residual stocking level, 57 dominant and codominant stems per acre were left in the stand. One tree per acre was destroyed, and two trees per acre were severely bent and eliminated from the net residual stand. Of the remaining 54 dominant and codominant trees per acre, 15 trees (28 percent) suffered exposed sapwood wounds. Only one of the wounded crop trees (2 percent) suffered severe wounds greater than 100 in^2 of exposed sapwood.

DISCUSSION

The results of this study are similar to other studies of logging damage in upland hardwood stands. In partial cuts, when using a rubber-tired skidder or crawler tractor with a rubber-tired arch and skidding tree-length, logging damage eliminated less than 10 percent of the residual basal area in the stand. Moreover, this damage was concentrated in the lower diameter classes (Weitzman and Holcomb 1952; Herrick and Deitschman 1956; Nyland and Gabriel 1972). In our study, damage and destruction of residual stems reduced stocking by 6, 4, and 5 percent in the 75, 60, and 45 percent stocking treatments, respectively. Because of the losses occurred in trees less than 5.0 inches dbh, competition for light among dominant, codominant, and intermediate trees was not influenced by logging damage.

Size of exposed sapwood wounds is an important factor in assessing logging damage. Hesterberg (1957) studied wounds on sugar maple and concluded that the amount of cull loss from a logging injury depends on the width of the wound and the length of time following the injury. His study showed that about 10 percent of the gross volume in wounded trees was degraded both 10 and 20 years after the injury occurred.

Apparently, narrow wounds are covered with callous tissue within the first 10 years, and no further degrading occurs in the next 10 years. Volume losses, however, were higher on trees with 20-year-old wounds. For example, 4-inch-wide scars caused about 3 board feet of cull after 10 years and 11 board feet of cull after 20 years (Hesterberg 1957). Wounds 8 inches wide can lead to cull deductions of 20 and 35 board feet 10 and 20 years, respectively, after the injury occurs. As cull deductions increase with time, further degrading will occur, and value losses will increase rapidly.

In this study, wounds on dominant and codominant stems averaged 5.5 inches wide. However, only 10 percent of the dominant and codominant stems suffered any wound at all. The other 90 percent were not damaged. In other words, it seems that most of the sapwood wounds on potential crop trees are small enough to heal with little danger of sapwood decay. Also, many of the trees with large sapwood exposed wounds can be removed in future thinnings before serious cull losses occur.

CONCLUSIONS

- Logging damage associated with the rubber-tired skidder was concentrated in trees less than 5.0 inches dbh.

- At the 60 percent stocking level, the current recommended thinning treatment, logging damage reduced residual stocking by only 4 percent.

  - Damage to residual dominant and codominant crop trees was not severe. Only one tree per acre (1.5 percent) was destroyed.

  - Ten percent of the residual dominant and codominant crop trees suffered sapwood-exposed wounds. Only 4 percent suffered wounds larger than 100 in^2.

RECOMMENDATIONS

- Marking guidelines in trees over 5.0 inches dbh do not need to be adjusted to account for logging damage.

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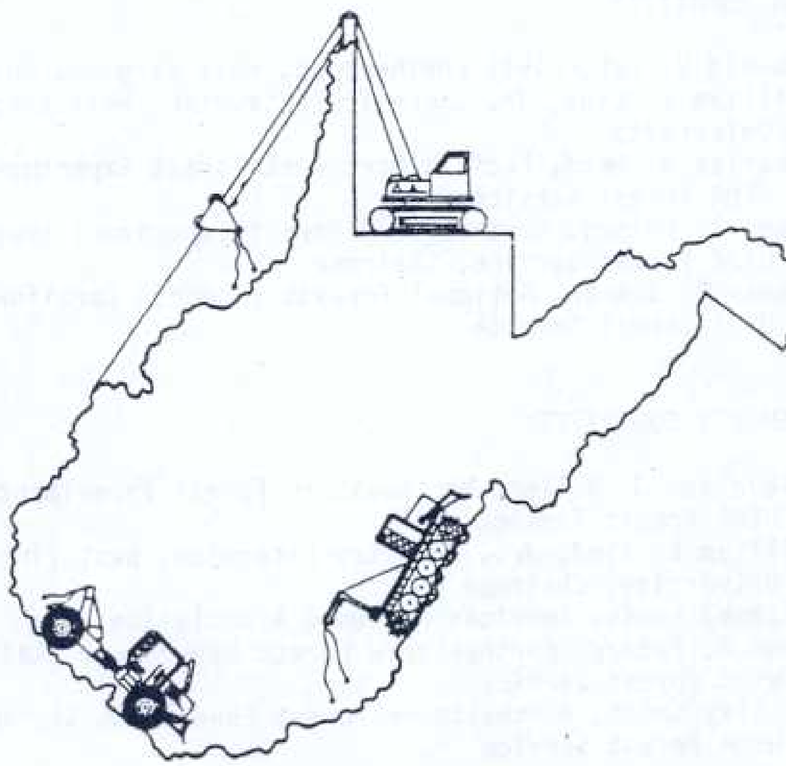
MOUNTAIN LOGGING SYMPOSIUM PROCEEDINGS



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