

Logging Damage Using an Individual-Tree Selection Practice in Appalachian Hardwood Stands

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ABSTRACT. Four West Virginia hardwood stands, managed using individual-tree selection for the past 30 years, were examined after the third and, in one instance, the fourth periodic harvest to determine the severity of logging damage. On existing skid roads, trees were removed with a rubber-tired skidder or a crawler tractor with a rubber-tired arch. Logging damage reduced residual stand basal area by 6%, a total of 6.1 ft² per acre. Damage was concentrated in the saplings—85% of the stems lost to logging damage were less than 5.0 in dbh. An adequate number of undamaged stems in all diameter classes remained after logging to achieve individual-tree selection stand structure goals.

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Forest managers are often concerned about applying individual-tree selection and other types of partial cuts to forest stands because of the apparent risk of damage to the residual trees. Obviously, some residual stems will be damaged when partial cuts are made, but does logging damage associated with partial cuts jeopardize a stand's potential to produce quality hardwood products? This paper reports on felling and skidding damage to residual trees in stands where individual-tree selection has been practiced for 30 years.

Individual-tree selection is an uneven-age harvest practice in which trees are periodically removed throughout a range of diameter classes. A successful cut establishes regeneration and stimulates residual trees to grow into larger diameter classes. This method maintains a fairly rigid stand structure with a specified number of trees in each diameter class. Several cutting cycles may be needed to attain the goals for number of trees in each class.

Normally, individual-tree selection harvests are made every 10 to 15 years depending on stand conditions and site quality. Trees marked for removal are in diameter classes with surplus trees, or are high-risk and low-quality trees. With deficit diameter classes, some trees from smaller surplus diameter classes are retained to compensate for the deficits. As the residual trees grow into larger diameter classes the deficit classes are filled in, resulting in a stand structure that is closer to the established goal. Some trees in surplus diameter classes are also retained so that the residual basal area will not be reduced below the desired level. The methods for establishing stand structure goals and applying individual-tree selection were described by Smith and Lamson (1982).

METHODS

Data were collected from four stands on the Fernow Experimental Forest in the Appalachian Mountains near Parsons, West Virginia. The stands are 11 to 34 acres in size and have been managed using individual-tree selection (Smith and Lamson 1982) for the past 25 to 30 years. Site indexes (SI 50, northern red oak) for the four areas varied from 59 to 70 ft. Slopes varied from 30 to 50%. Rainfall in the study area averages about 55 in per year. Soils are well-drained, 2 to 3 ft deep and derived from sandstones or shales.

The stands were high graded from 1905 to 1910 primarily for larger oaks, yellow-poplar, and conifers. Also, American chestnuts died during the period from 1930 to 1940. The resulting stands were essentially even-aged, second growth with scattered large residual stems left from the early

logging and saplings and pole-size trees resulting from the death of the chestnut. When management began in the early 1950s, species composition on site index 70 areas was a mixture of yellow-poplar, black cherry, white ash, sugar maple, northern red oak, American beech, and cucumber tree. On site index 60 areas, a mix of red, white, and chestnut oak predominated with some sassafras, blackgum, sourwood, beech, and red maple. After applying the individual-tree selection practice for 25 to 30 years, the understory saplings and poletimber are primarily sugar maple and beech on the higher sites and red maple and beech on the lower sites.

Uneven-age silviculture and management guidelines are being applied in an effort to convert even-aged stands to uneven-aged stands where tree diameter would eventually indicate age. Data were collected during the period from 1978 to 1983. Three areas were marked for a third periodic cut and one area was marked for a fourth periodic cut. For this selection practice, the largest tree to grow was 20 in dbh on oak SI 60 and 26 in dbh on oak SI 70. The residual-tree basal area goal was 35 or 50 ft² per acre for trees over 11.0 in dbh, depending on oak site index. A *q*-value of 1.3 was used on both site indexes to determine the desired number of residual trees in each diameter class. Marked trees for cutting were in diameter classes with surplus trees 11.0 in diameter and larger. We also marked smaller stems of sprout origin attached to marked sawlog-size trees and trees in deficit diameter classes that would die before the next cutting cycle. Some trees in surplus diameter classes were retained to compensate for deficit diameter classes and to maintain residual-tree basal area goals. The cut volumes did not exceed periodic growth, and residual basal area goals for trees over 11.0 in diameter have been achieved in three or four periodic cuts.

Logging was conducted during the dormant season. Trees were usually topped at merchantable height or 8.0 in dib and skidded full length (20 to 50 ft) using a rubber-tired skidder and/or a crawler tractor with a rubber-tired arch. In most cases, both the skidder and the tractor were used on the area. Skid roads and decks, planned by foresters, were constructed during the first cutting period in 1952. The same

Table 1. Per-acre logging damage by diameter class (in) during the third or fourth cut using individual-tree selection practices.

Item	Number				Basal area (sq. ft.)				Cubic foot			Board foot
	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	427	137	59	623	14.4	43.8	73.9	132.1	767	1840	2607	10344
Marked trees	0	6	19	25	0	2.3	24.4	26.7	39	601	640	3306
Residual stand ^a	427	131	40	598	14.4	41.5	49.5	105.4	728	1239	1967	7038
LOGGING DAMAGE—Residual Stand												
Destroyed	40	5	2	47	1.0	1.3	1.3	3.6	22	31	53	167
Bent or leaning	28	4	1	33	0.8	1.1	0.6	2.5	18	15	33	73
Net residual stand ^b	359	122	37	518	12.6	39.1	47.6	99.3	688	1193	1881	6799
Exposed sapwood	58	17	4	79	2.1	5.4	5.6	13.1	98	139	237	795
Broken crown branches	29	4	1	34	1.7	2.0	0.9	4.6	35	22	57	123

^a Residual stand = initial stand minus marked trees.

^b Net residual stand = residual stand minus destroyed trees minus bent or leaning trees.

skid roads and decks were used for all successive cuts.

Damage to the residual trees caused by felling and skidding was recorded for one cutting period only. A total of 18 plots, each one-half acre in size, were established within the four stands. On each plot, all trees at least 1.0 in dbh were permanently identified. Plots were inventoried before logging, and conditions such as exposed sapwood on the tree bole or root, broken crown branches or dead tops, and leaning trees were noted. Immediately after logging, all plots were again inventoried and each residual tree was carefully examined. Four types of logging damage were noted: destroyed, bent over or severely leaning, exposed sapwood wounds, and broken crown branches. In addition, the size of each exposed sapwood wound was measured individually.

RESULTS

The marked cut averaged 32% of the initial board-foot volume (International 1/4-in) and 20% of the initial basal area per acre (Table 1). Marked trees included an average of 19 sawtimber trees (11.0 in dbh and larger) and 6 poletimber trees (5.0 to 10.9 in) per acre. This amounted to an average yield of 3,300 bd ft per acre.

Destroyed

An average of 47 trees per acre was destroyed during logging. Eighty-five% of the destroyed trees were less than 5.0 in dbh, and 96% were less than 11.0 in dbh (Table 1). Two residual sawtimber-sized trees per acre were destroyed during logging. Destroyed trees amounted to 3.4% of the residual basal area and 2.4% of the residual board-foot volume per acre.

Bent Over or Leaning

After logging, an average of 33 trees per acre in the residual stand was bent over or leaning (Fig. 1). Similar to the destroyed category, 84% of the bent or leaning trees were less than 5.0 in dbh, and 97% were less than 11.0 in dbh (Table 1). An average of only 1 sawtimber-sized tree per acre was left leaning after logging. This type of damage affected 2.4% of the residual basal area and only 1% of the residual board-foot volume per acre.

Exposed Sapwood

A total of 79 trees per acre (of a possible 518) had exposed sapwood wounds due to logging (Fig. 2). Trees in the destroyed-leaning damage

classes were not included in the exposed sapwood category. Seventy-three % of the trees with exposed sapwood wounds were less than 5.0 in dbh, and 95% were less than 11.0 in dbh (Table 1). This type of damage affected 12% of the residual basal area per acre and 11% of the residual board-foot volume per acre.

The effect of exposed sapwood wounds on future stand structure and quality depends on the severity of the wounds. Research indicates that individual wounds greater than 100 in² are likely to result in decay (Nyland and Gabriel 1971). Less than 1% of the residual trees had any individual wounds that exceeded 100 in² in size. This amounted to an average of four



Fig. 1. Tree bent over or leaning caused by logging.



Fig. 2. A serious exposed sapwood wound resulting from logging. At least two wounds are present on this tree.

trees per acre—one sapling, two pole-size, and one sawtimber-size tree per acre. Exposed sapwood wounds averaged 17, 39, and 26 in² for the saplings, pole-size, and sawtimber-size trees, respectively. Many of the exposed sapwood wounds will callous, some will produce decay in the butt log, but few will result in tree death.

Net Residual Stand

Since we expect most of the trees categorized as bent over or leaning to die in the near future, we have subtracted both destroyed trees and bent or leaning trees from the residual stand to compute a "net" residual stand. This provides a realistic picture of the growing stock and stand structure after logging. For example, 87% of the trees in the residual stand survived the logging operation, leaving an average of 518 trees per acre in the net residual stand (Table 1). More specifically, 84% of the saplings (1.0 to 4.9 in dbh) and 93% of the poletimber- and sawtimber-sized trees (5.0 in dbh and larger) remained after logging. Because most of the destroyed and leaning trees were saplings, 94% of the residual basal area survived the logging operation. This resulted in a net residual stand comprising 359 saplings (1.0 to 4.9 in dbh), 122 pole-size trees (5.0 to 10.9 in dbh), and 37 sawtimber-size trees (11.0 in dbh and larger) per acre. These figures were well within

the residual stand structure goals we established before logging.

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Broken Crown Branches

A total of 34 trees per acre, not counting destroyed and bent or leaning trees, had broken crown branches due to logging (Fig. 3). Eighty-five % of the trees with broken crown branches were less than 5.0 in dbh and 97% were less than 11.0 in dbh. This type of damage affected 4% of the residual basal area and 2% of the residual board-foot volume per acre.

DISCUSSION

The results of this study indicate that the damage observed following an individual-tree selection cutting is about the same as other partial cuts in hardwood stands logged with conventional ground skidding equipment. Generally, this type of logging destroys less than 10% of the residual basal area and the damage is concentrated in sapling-size trees (Weitzman and Holcomb 1952, Herrick and Deitschman 1956, Nyland and Gabriel 1971, 1972). In our study, 6% of the residual basal area was destroyed or leaning after logging, and 85% of the destroyed or leaning trees were less than 5.0 in dbh.

Is the damage associated with individual-tree selection cuttings acceptable in terms of its effect on residual stand structure goals? The results of this study show that the net residual stand contained an adequate number of trees in all diameter classes to continue selection management. Our goals for these stands require from 45 to 50 trees per acre in the 5.0- to 10.9-in dbh class. The net residual stand contained 122 trees per acre in this size class and more than 100 of these incurred no damage of any kind. Most of these were valuable red maple or sugar maple. The goals also require about 30 to 35 sawtimber-size trees per acre. These stands averaged 37 sawtimber-size trees per acre after logging. Thirty-two trees per acre incurred no damage of any kind.

Good care of the saplings is important to the success of any uneven-age practice, and individual tree selection is no exception. Our stand structure goals require a minimum of 102 trees per acre in the 1.0- to 4.9-in dbh class. The results of this study indicated that the net residual stand contained more than 270 saplings with no damage of any kind. Of the additional 58 trees per acre with exposed sapwood wounds, only 1 tree per acre had a se-



Fig. 3. Sapling-size tree with a broken top caused by felling.

vere wound greater than 100 in² in size.

In hardwood stands managed using the individual-tree selection practice, residual stem quality improves through periodic cutting. After one or two periodic cuts, selecting trees to harvest based primarily on poor quality or low value can be difficult. After old residuals and poor-quality stems have been removed only desirable species remain, and the guidelines for number of trees in each diameter class can be applied more rigidly. Sometimes a previous logging injury is the only good reason to select one particular tree over another in the desired cutting diameter class. This is why minor wounds to larger residual stems are not cause for alarm. Wounded trees can be examined in the next cutting cycle and removed if the wounds have not healed properly. Minor wounds to saplings and pole-size trees can be tolerated because of the surplus of injury-free stems in these size classes. Although summary data indicate that some residual stems are damaged during selection cutting,

there is an adequate number of stems available to achieve the individual-tree selection practice goals. Conventional ground skidding equipment can be used to make periodic removals without causing excessive damage to residual trees. There is no need to improve logging practices used in this study to protect residual trees.

CONCLUSIONS

Damage to residual stems associated with individual-tree selection harvests made every 10 to 15 years does not jeopardize a stand's potential to produce quality hardwood products. Normal levels of logging damage that result from making partial cuts with conventional ground skidding equipment can be tolerated and it is still possible to achieve and maintain the stand structure goals of individual tree selection management. Specific conclusions of this study are:

- Logging damage reduced the residual stand basal area by 6%, a total of 6.1 ft² per acre.

- Damage was concentrated in the saplings—85% of the stems lost to logging damage were less than 5.0 in dbh.
- The net residual stand contained an adequate number of stems in all diameter classes to achieve stand structure goals and produce quality wood products in the future.
- When applying the individual tree selection practice using logging methods as outlined in this paper, no improvements in logging methods are needed if damage to residual trees is the main concern. □

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