

RESIDUAL STAND DAMAGE SURVEY FOR THREE SMALL TRACTORS USED IN HARVESTING NORTHERN HARDWOODS

by

Neil K. Huyler, George D. Aiken,

and Chris B. LeDoux

ABSTRACT: There have always been concerns about the impact of timber harvesting with conventional ground-based harvesting equipment on many parts of the forest ecosystem. One of these parts, which is easily measured, is the residual stand. The interest in small tractors (less than 60 horsepower) has increased in recent years because private landowners are concerned that large harvesting equipment may damage their woodlot. Several of these small tractors in the 12- to 60-horsepower range have entered the marketplace. We report on residual stand damage following thinning operations in northern hardwood stands using three small tractors. They include a Holder A-60, Pasquali 993, and Forest Ant. Plots for each tractor were taken after the cut to determine damage to residual trees. Six classes of damage were recorded: bark abrasion, barked skinned, root damage, tree broken off, tree bent over, and felling damage. The following points can be made regarding stand damage caused by the tractors: (1) The Pasquali caused less damage than the other machines; (2) the Forest Ant required greater maneuvering to position it closer to the felled trees; therefore, directional felling was required which resulted in greater felling damage; (3) stand damage from the Holder was mostly due to the larger size and length of the load per trip.

KEYWORDS--harvesting, logging damage, small tractors, residual stand damage

INTRODUCTION

The timber resources in New England have increased steadily over the past 20

years. According to the 1989 RPA Assessment, "An Analysis of the Timber Situation in the United States: 1989-2040," the ratio of growth to removals in northern hardwoods is estimated to be about 2 to 1. Forest-land area also has increased: several New England states that were 25- to 50-percent forested 50 to 75 years ago are now 70- to 80-percent forested.

As the global economy expands and the demand for wood fiber increases for both wood products and as a source of renewable energy, more young-growth hardwood forest must be put into production. However, there are three basic constraints or challenges to putting these forested sites into production while maintaining a sustained yield: (1) The large proportion of forest land held by private owners (more than 70 percent of the available forest land); (2) the trend in decreased size of parcels suitable for timber harvesting in the Northeast; and (3) the integration of ecosystem management principles and environmental concerns into harvesting models. The last two factors are the principle reasons for the interest among landowners and foresters in evaluating and developing alternative small-scale harvesting systems.

One of the principle reasons that private forest-land owners are concerned about harvesting is that large equipment may damage their woodlot. Another important factor is that harvesting small, low-quality trees to attain a sustainable yield with large equipment often is uneconomical.

This paper reports residual stand damage and logging-residue analysis for three ground-based, small-scale harvesting machines that were used to conduct low thinnings on the Harvard Black Rock

Forest in Cornwall, New York.

Several studies have evaluated residual stand damage in northeastern hardwood forests by various ground-based harvesting systems and silvicultural treatments. Lamson et al. (1985) concluded that for a 10- to 15-year cycle, damage to residual stems associated with individual-tree selection harvest and ground-based skidding systems did not jeopardize a stand's potential to produce quality hardwood products. Lamson and Smith (1988) compared 5-year diameter growth of 102 wounded and 102 unwounded codominant crop trees that previously had been thinned in an even-aged Appalachian hardwood stand. They found that trees with wounds of at least 100 inches in size averaged 1.34 inches of diameter growth, while the unwounded trees averaged 1.40 inches. Paired t-tests showed no significant difference. Nyland (1986) found that logging wounds did not influence diameter growth but that trees with large wounds were likely to develop rot. The study also found that the loss of lumber/tree value was not substantial. In a study on yellow birch with wounds up to 10 years old, Ohman (1970) found that stems lost only about 0.7 percent in lumber value. For wounds on sugar maple that were 10 and 20 years old, Hesterberg (1957) found a 3.4-percent loss in lumber value. Gathering data on practices used for partial cutting in New York State, Nyland and Gabriel (1971) found that logging damaged about 30 percent of the residual trees; about 20 percent suffered major injuries. However, major injuries from felling were twice those from skidding. In another study, comparing injuries to hardwood stands resulting from skidding tree-length logs with crawler tractors and rubber-tired forwarders, Nyland and Gabriel (1972)

found little difference in the total proportion of skidding injury to residual stand damage resulting from these two harvesting machines. Although several studies have evaluated damage to residual stands by various harvesting machines and methods for various silvicultural systems, little information is available on small tractors or harvesting machines such as those used in this study.

TYPES OF TRACTORS STUDIED

The Pasquali Model 993 tractor, manufactured in Italy, is a small, four-wheel-drive tractor with an articulated frame and 3-point hitch with live power takeoff (pto). It is designed for use on small farms, landscape projects, nurseries, and light construction work in municipalities. The tractor has a 30-horsepower (hp) engine large enough to power a Farmi JL-25 logging winch. The winch has a 5,500-pound line-pulling capacity, spooled with 100 feet of 3/8-inch cable. The Pasquali 993 is 4-1/2 feet wide and 8 feet long, and is equipped with a 4-foot bucket. Safety options include loaded front and rear tires, roll bar, skid pan, and wheel chains. The average load for the Pasquali on the test site was about 1/4 cord or about 1,200 pounds per turn. The average productive time per turn at a 781-foot skid distance was 22-1/2 minutes. The owning and operating cost (machine rate) in 1988 was \$5.77 per hour.

The next tractor, a Holder A60 F, manufactured in Germany, is a small four-wheel-drive tractor with an articulated frame and 3-point hitch with pto. It is designed for use on farms and in light forestry operations. The tractor has a 48-hp engine, large enough to power an Igländ 3000 double-drum winch. The

winch has a 6,600-pound line-pulling capacity, spooled with 120 feet of 3/8-inch cable. The Holder A60 F was equipped with wheel weights, and front wheels were loaded for more traction. Safety options include forestry cab, roll bar, and skid pan. The average load for the Holder on the test site was slightly more than 1 cord per turn. The average hitch size was six stems or 2,962 pounds per turn. The average productive time per turn at a 1,126-foot skid distance was 27 minutes, and the machine rate in 1988 was \$14.42 per hour.

In Sweden, where it is manufactured, the Forest Ant would be translated as "Busy as a Bee." This tractor is designed to thin young stands and in large operations is used to forward stems to the main skid roads. It is a small four-wheel-drive, walk-behind tractor equipped with a crane type loader and a bunk jaw or clam bunk for skidding. The loader has a 10-foot, 8-inch reach and can lift 330 to 880 pounds depending on the reach. The bunk can hold a maximum load of 2,000 pounds. The average load for the Forest Ant on the test site was slightly less than 1 cord per turn. The average hitch size was about seven stems or 1,999 pounds. The average productive time per turn at a 253-foot skid distance was 22-1/2 minutes per turn. The machine rate in 1989 was \$4.27 per hour.

SITE DESCRIPTION AND RESIDUAL STAND INVENTORY

The sites selected for study were located in the Harvard Black Rock Forest, Cornwall, New York. Three timber tracts of relatively uniform size and condition in two slope classes of 0 to 15 percent and 15 to 30 percent were identified and inventoried. Slopes in excess of 35

Table 1. Pre-test inventory summary (per acre).

Item	Test Site I	Test Site II	Test Site III
Number of stems	287.0	323.0	244.0
Basal area (ft ²)	116.2	114.0	96.0
Volume (ft ³)	2692.0	2416.0	1948.0
Volume (cords)	33.6	30.2	24.0
Average d.b.h. (inches)	8.6	8.0	8.4
Total area (acres)	5.3	5.7	2.0

percent were excluded because of safety factors. The stands were mixed hardwoods, primarily oak. Table 1 is the pre-test inventory of each test site.

Test Site I had an average downhill slope of -7 percent. Tree form generally was good, boles generally were straight, and the merchantable height was 2.0 to 2.5 logs on dominant trees. The understory, composed of dogwood (*Cornus florida*), beech (*Fagus grandifolia* Ehrh.), and red maple (*Acer rubrum*), generally was sparse. The terrain was rough with rocks and boulders throughout, and the soil was moderately well drained to somewhat poorly drained. The stand was considered to be a large pole stand in need of a thinning to eliminate suppressed, poorly formed diseased and overmature trees. The site consisted of 5.31 acres with 287 stems per acre before cut. Average d.b.h. was 8.6 inches with a before-cut basal area of 116.2 square feet. The merchantable volume per acre was 2,692 cubic feet or about 33.6 cords. Table 2 describes the pre-test inventory and cut residuals.

The major species on this site were red and chestnut oaks, (*Quercus rubra* L. and *Q. castanea* L.). These species accounted for 62 percent of the species mix. Before the trees were marked, the landing and skid trails were located. The fellers were directed to fell the trees in a herringbone pattern, at a 30- to 60-degree angle to the skid trails to facilitate bunching and minimize felling and tractor damage to the residual stand and to trees along the trails. The objective for this site was a thinning from below to improve overall stand growth.

Test Site II had an average downhill slope of -18 percent (range: 15 to 28 percent). Tree form was good, though many of the trees had considerable butt rot. The terrain was rough and rocky, and the soils were moderately well drained. This stand also was considered a large pole stand in need of thinning to eliminate suppressed, poorly formed and overmature trees. This site consisted of 5.7 acres with 323 stems

Table 2. Test Site I pre-harvest and post-harvest summary (per acre).

Item	Before cut	Cut	Percent	Residual
Number of stems	287.0	160.0	55.8	127.0
Basal area (ft ²)	116.2	55.6	47.8	60.6
Volume (ft ³)	2692.0	1122.0	41.7	1570.0
Volume (cords)	33.6	14.0	41.7	19.6
Average d.b.h. (inches)	8.6	8.0	--	9.4

Table 3. Test Site II pre-harvest and post-harvest summary (per acre).

Item	Before cut	Cut	Percent	Residual
Number of stems	323.0	157.0	48.6	166.0
Basal area (ft ²)	114.0	48.0	42.1	66.0
Volume (ft ³)	2416.0	900.0	37.2	1516.0
Volume (cords)	30.2	11.2	37.1	19.0
Average d.b.h. (inches)	8.0	7.5	--	8.5

per acre. Average stand diameter was 8.0 inches with a pre-harvest basal area of 114 square feet. The merchantable volume on a per acre basis was 2,416 cubic feet or about 30.2 cords. Table 3 describes the pre- and post-test harvest inventories.

The major species on this site were red and chestnut oaks, which comprised nearly 70 percent of the species mix. The understory was sparse, consisting mostly

of red and sugar maple (*A. saccharum*). An existing road was used as part of the skid-trail system, and the landing was located at the edge of the road and the upper end of the test site. Logs were skidded uphill to the landing. Trees on this site also were felled in a herringbone pattern adjacent to the skid trails to minimize residual stand damage.

Test Site III had an average downhill slope of -6 percent. Tree form ranged