USDA United States Department of Agriculture

Forest Service

Northeastern Research Station

Research Paper NE-711

Performance of a Cut-to-Length Harvester in a Single-Tree and Group-Selection Cut

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Abstract

Presents production and cost data for a mechanized cut-to-length harvester used in a single-tree and group-selection cut on the Groton State Forest in central Vermont. Tree volume or size is an important factor in machine productivity and, therefore, cost of production. For trees whose average volume (size) was 7 to 18 ft^3, production ranged from 464 to 734 ft^3 per productive machine hour. The cycle time for processing trees into bunches to forward to a landing ranged from about 1 minute to 1.72 minutes per tree (average: 1.29 minutes). There was little above-ground residual stand damage. The results should assist forest planners, loggers, and land managers in their decisionmaking.

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Published by:
USDA FOREST SERVICE
5 RADNOR CORP CTR SUITE 200
RADNOR PA 19087-4585

November 1999

For additional copies:
USDA Forest Service
Publications Distribution
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Delaware, OH 43015
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Introduction

Mechanized cut-to-length (CTL) harvesting is becoming a popular alternative to traditional harvesting with a chain saw and rubber-tired skidder (Araki 1994; Brinker 1990; Kellogg 1995). Studies have shown that there is a high degree of residual stand damage and soil disturbance with conventional systems. There is considerably less residual damage with a CTL system because trees and/or logs are not pulled through the stand and trees can be felled directionally (Leech 1989; Tufts 1991). And because delimbing takes place in front of the machine and limbs and slash are used as a mat for the harvester and forwarder to travel on, soil disturbance and compaction are minimized (Pawlett 1985, Seixas 1995). Worker safety has been greatly improved with mechanized CTL harvesting, which is particularly effective in areas where there is a shortage of woods workers. Disadvantages of the CTL system are the high investment cost of the harvester and head, maintenance and repair costs related to the complex computerized electrical system, inability to handle hardwood stems larger than 22 inches in stump diameter , and the potential fire hazard from additional fuel loading.

In this paper we report production and cost for a CTL harvesting system operating in a mixed stand on moderately rough and wet terrain on the Groton State Forest in central Vermont. Our primary objective was to evaluate the performance of a large machine in a single-tree and group-selection cut, and to assess the degree of residual stand damage.

Study Area

The study was a cooperative effort among the Northeastern Research Station, the Giles Champagne Logging Company, Colebrook, New Hampshire and the Vermont Department of Forest, Parks, and Recreation. The 42-acre study site is predominately a mixed hardwood stand interspersed with commercially unoperable softwoods, primarily balsam fir. Most of the hardwoods consisted of poor-quality, small-diameter chipwood or pulpwood material (yellow birch and red maple). Several yellow birch sawlogs were scattered throughout the stand. The harvest objective was to encourage multiple-age classes to enhance the wildlife habitat for moose, snowshoe hare, and white-tailed deer.

The preharvest basal area averaged 100 ft^2/acre with a mean stand diameter of 8 inches. Sawlog quality was fair to poor. Most of the hardwood competition was removed in the cut. A single-tree and group-selection (red spruce and balsam fir) cut was the primary silviculture treatment. Small overstory removals were conducted in areas with dense balsam fir regeneration.

Soils were extremely wet in some areas and poorly drained in most of the remaining areas. Because of these extreme conditions and little or no slope, it was thought that winter logging with a CTL system would best achieve our objectives.

Equipment

The CTL harvester (also called a feller processor) is a Timbco Model T425[1] tracked excavator-type machine integrated with an Ultimate 5600 single-grip processor head. This harvester is designed to cut and delimb the tree and buck the stem to length in the stand. The harvester has cab leveling capability and can operate on moderate slopes, in wet areas, and in tight selective cuts (Fig. 1). The single-grip head has a maximum cutting diameter of 22 inches and a limbing diameter of 2 inches to 10 inches. The volume removed from the site was estimated from a 100- percent timber cruise. Each tree was marked with tree paint, measured, and tallied; 911 trees were marked as sawlog trees and 2,081 stems were marked as pulpwood trees (Tables 1-2).

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

Figure 1.—CTL harvester operating in mixed hardwood and softwood stand.

The Study

The study was divided into two phases. Phase 1 included cutting and processing individual trees and forwarding the cut-to-length material to the landing. The system on the site also included a Franklin forwarder and slasher at the landing. The operator of the forwarder had just begun job training, so no time data were recorded for the forwarder/slasher. In phase 2 we estimated residual stand damage caused by the harvester. Ten prism plots (10 BAF) were established prior to harvest and then reentered postharvest to measure and record any stem and/or root damage. These data will be analyzed and reported in detail in a future report.

The sequence of events for the CTL harvester was as follows. The operator scanned the area for marked trees[2] and positioned the processing head on the tree to be cut. The accumulator arms gripped the tree while cutting it with the circular chain saw-type cutting head. The tree was then turned horizontal to the ground and spiked feed rolls pulled it through delimbing knives to remove limbs. The operator then cut the stem to length, usually 8 feet for pulpwood and 12 to 16 feet plus 4 inches for trim allowance for sawlogs. The cut stems were placed into bunches or piles of pulpwood and/or sawlogs. The bunches later were picked up by the forwarder and taken to the landing. The operator had little opportunity for merchandizing. Spruce-fir that was 8 inches and larger were marked for sawlogs; hardwoods that were 12 inches and larger generally were marked as sawlogs.

Time and motion data were recorded over a 5-day period to determine the delay-free total cycle time for a range of tree volumes. Total cycle time includes cutting the stem, delimbing, cutting the stem to length, piling, and travel time to the next stem. We recorded the total number of trees per bunch, the volume of each tree, and the time required to create the bunch. Timing began when a tree was cut to create a bunch and ended when a new bunch was started. The number of trees was recorded for each bunch along with the length and small- and large-end-diameter of each piece in the bunch.

[2]Most of the trees had to be remarked higher on the tree (10 to 12 feet up the stem) so that the harvester could see the paint marks.

Table 1.—Sawlog volume by species, number of trees and volume per tree

Species/product	Volume	Number of trees	Volume/tree
	Board feet		*Board feet*
Spruce/fir	67,730	727	93
Yellow birch	12,080	105	115
Red maple	4,120	37	111
Sugar maple	1,660	19	87
White birch	1,600	23	69
Total or average	87,190	911	95

Table 2.—Pulpwood volume by species, number of trees, and volume per tree

Species	Volume	Number of trees	Volume/tree
	Cords		*Cords*
Hardwood	279	1,759	6
Softwood	35	322	9
Total or average	691	2,081	7.5

Results

The average volume per bunch was 66.19 ft^3. The average piece size within the bunch was 5.6 inches at the small end and 7.07 inches at the large end. The mean length of the pieces was 10.6 feet. Each bunch contained about 4.9 trees with an average volume of 13.4 ft^3 per tree.

The CTL harvester produced 523 ft^3 of material per productive machine hour (PMH) with a range of 463 to 734 ft^3 per PMH. The harvester cut about 47.48 trees per PMH (range: 35 to 56 trees per PMH). The average delay-free cycle time to travel to the tree, cut and delimb it, and cut the stem to length was about 1.29 minutes per tree (range: 1.01 to 1.72 minutes). This is consistent with similar sites as reported by the operator where 350 to 450 trees are harvested per day.

Several factors that may influence the productivity of the harvester include tree size, species (hardwood or softwood), branchiness and/or size of branches, topography, and operator skill. We analyzed tree size to determine its effect on machine productivity. The data indicated a significant relationship between tree volume (size) and cubic feet of production (R^2 of 86 percent). The influence of tree size on machine productivity per PMH is shown in Figure 2.

Estimated daily and annual production for the CTL harvester over a range of tree volumes are shown in Table 3. At an average tree size of 16 ft^3, daily production is about 4,933 ft^3 per PMH. Assuming an average machine utilization rate of 80 percent, the annual production for the same tree size totals 986,600 ft^3. Estimated hourly owning and operating costs for the CTL system are shown in Table 4. These include fixed, variable, and labor costs for scheduled hours (SMH) and PMH. With regard to the latter, the total fixed cost was $60.29 per PMH and the total variable cost was $51.23 per PMH. This is typical for a machine that requires a high capital investment. When the labor cost of $35 per PMH is added to the other costs, the total owning and operating cost of the CTL harvester is $146.52 per PMH. The owner estimated that $80 per PMH should be added for forwarding the material to the landing.

Figure 3 shows the influence of tree size on the cost of production. As size increases, the cost of production decreases; however, as tree size approaches the limitation of the machine, the cost rises at an increasing rate. In our study, large trees were felled manually with a chain saw and skidded to the landing with a cable rubber-tired skidder. As a result, the machine's limitation was not reached so there is no indication of the cost increasing at an increasing rate. Also, it should be noted that when young to mature hardwoods are being harvested, the heavier hardwood trees cause excessive wear on the processing head over time.

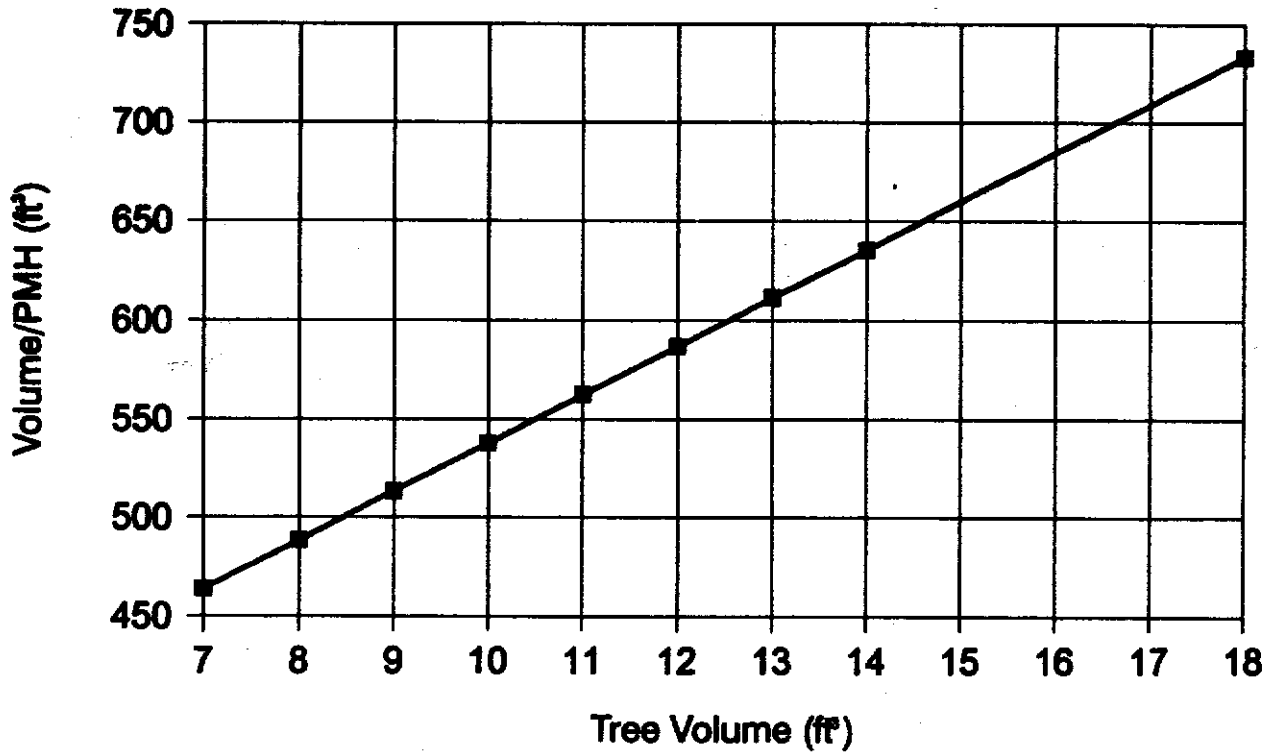

Figure 2.—Effect of tree size on CTL harvester.

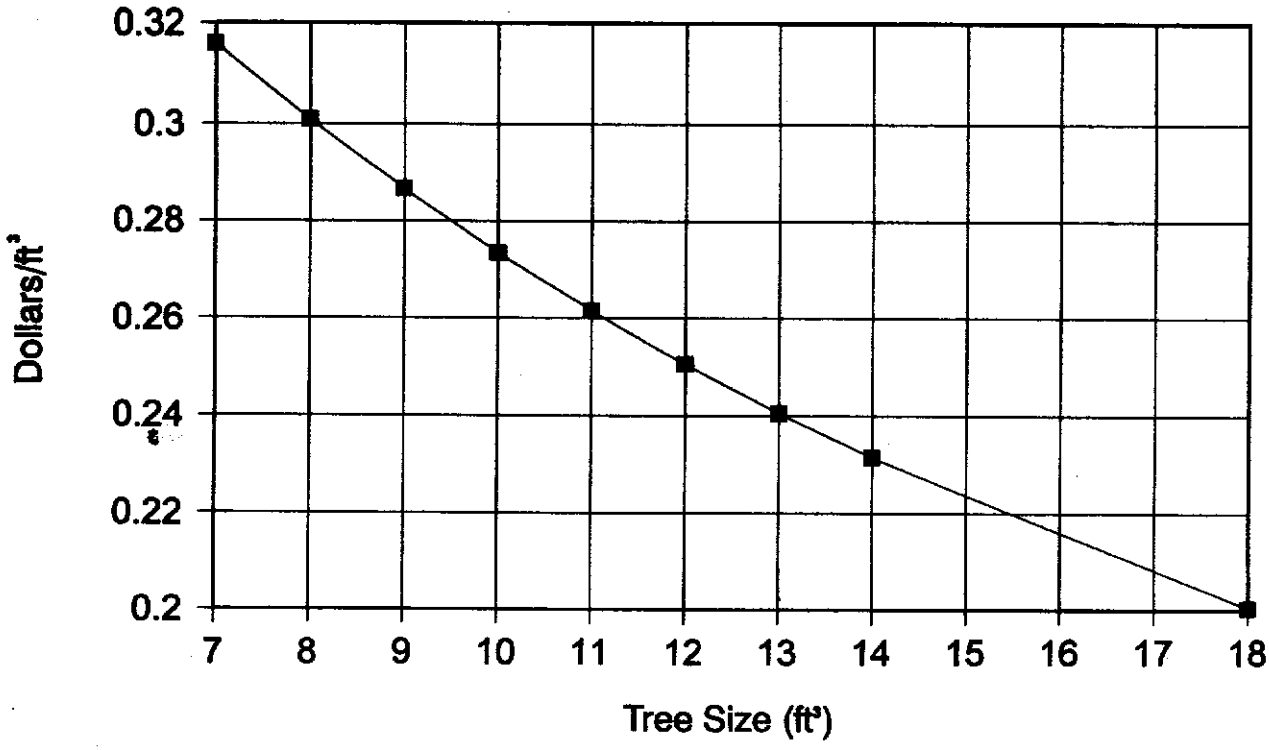

Figure 3.—Effect of tree size on cost.

Table 3.—Estimated daily and annual production for the CTL harvester

Tree volume (ft^3)	Production (ft^3)	
	Daily[a]	Annual[b]
8	3,516	703,200
12	4,225	845,000
16	4,933	986,600
20	5,642	1,130,000

[a]Based on 7.2 productive machine hours.
[b]200 productive days per year.

Table 4.—Estimated hourly owning and operating cost for Timbco T425 harvester with Ultimate 5600 processing head.

Cost element	Machine hours	
	Scheduled	Productive
	Dollars	
Fixed		
Depreciation	31.95	39.95
Interest, insurance and taxes	16.28	20.34
Total	48.23	60.29
Variable		
Maintenance & repair	29.65	37.07
Fuel and lubrication	11.33	14.16
Total	40.98	51.23
Labor		
Wages and salaries	20.00	25.00
Fringe benefits	8.00	10.00
Total	28.00	35.00
Total machine cost	117.21	146.52

Summary

The study results indicated that the CTL system could be an effective harvesting tool in the Northeast. Preliminary analysis of residual stand damage on the site revealed only 2 percent of the residual trees had stem wounds with wood exposed. These generally were wounds to the first log that probably were caused by the feller head. These wounds did not exceed 20 percent of the stem, according to Ron Kelly, forest protection specialist, with the Vermont Department of Forests, Parks, and Recreation. Kelly reported that 14 percent of the residual trees had root wounds that probably were caused by the forwarder; all root wounds were confined to one side of the tree. The analysis indicates that the CTL system causes fewer root and stem wounds than conventional harvesting systems. The CTL harvester/processor also is flexible: it can be used as a feller only and combined with a grapple skidder for whole-tree logging, or it can fell the trees and delimb them and, with a cable or grapple skidder, be a part of a full-length logging system.

With increasing emphasis on sustainable forest management and the ability to meet the regulations for Best Management Practices, that are required in most states, the CTL harvester can assist in making forest management and business decisions with respect to lengthening the normal operating season, stabilizing production, and low inventory volumes.

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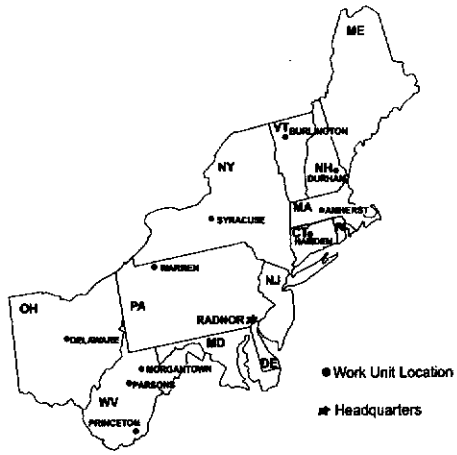
Keywords: harvesting, production, costs, cut-to-length



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