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Cost Comparisons for Three Harvesting Systems Operating in Northern Hardwood Stands

Chris B. LeDoux
Neil K. Huyler

Abstract

Production rates, break-even piece (tree) sizes/costs (BEP), and operating costs were compared for a Koller K-300 cable yarder, a cut-to-length (CTL) harvester, and an A60F Holder tractor operating at three machine utilization rates (MUR) in northern hardwood stands. The stand prescription for the three systems was primarily a thinning (light to medium) to reduce the stand basal area to a range of 70 to 95 ft^2. Mean daily/annual production was 3,360/840,200 ft^3 for the Koller K-300, 1,825/456,250 ft^3 for the CTL system, and 1,108/277,200 ft^3 for the Holder tractor. At an average product price of \$0.40/ft^3, the BEP size at an MUR of 90 was 7.64 ft^3 for the Koller yarder, 4.63 ft^3 for the CTL harvester, and 3.74 ft^3 for the A60F tractor, respectively. At MUR's of 75 and 60 percent, the break-even piece size was 9.18 and 10.82 ft^3 for the Koller, 5.64 and 8.31 ft^3 for the CTL harvester, and 4.55 and 5.74 ft^3 for the Holder tractor. The most important attributes of these systems are reduced soil compaction and disturbance, ease of movement to and from the logging site, and minimal residual stand damage.

The Authors

CHRIS B. LEDOUX, supervisory industrial engineer, received a B.S. degree in forest management from the University of Idaho, and M.S. and Ph.D. degrees in forest engineering from Oregon State University. He joined the Northeastern Research Station in 1983 and currently is engaged in forest engineering research at Morgantown, West Virginia.

NEIL K. HUYLER, research forester (retired), received a B.S. degree in forestry from West Virginia University in 1969 and a M.S. degree in industrial wood management and science in 1971. He joined the Northeastern Research Station in 1963, and most recently was engaged in research on timber harvesting with sustainable forestry management concepts at Burlington, Vermont. He retired from the Forest Service in June 2000.

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Introduction

Rubber-tired skidders have long been used to extract timber from northern hardwood sites, but public concern about environmental damage from logging systems and current forest practices/regulations have forced managers, planners, and forest-land owners to consider alternative harvesting technologies to minimize adverse effects on the harvest site, watershed, and residual stand. This is particularly true in the Northeastern United States, where logging is a key activity.

To remain viable in the global wood market, woodland owners in the Northeast are seeking logging systems that are cost-effective in meeting standards for timber stand improvements, cuts and water quality. At the same time, loggers face tremendous economic pressures and typically work under conditions of intense competition and narrow profit margins. Thus, it is important to evaluate the performance of various harvesting systems to ensure a profitable operation.

In a series of time and motion studies, we documented the production rates and costs of small tractors, a cable yarder (Huyler and LeDoux 1997), and a CTL system (Huyler and LeDoux 1996). Tractors are effective in removing timber on hardwood sites with little residual stand damage (Huyler and LeDoux 1989). However, in a study of partial cuts in New York, Nyland and Gabriel (1971) found that conventional logging damaged about 30 percent of the residual trees; nearly 20 percent incurred major injuries.

In this study, we used ECOST (LeDoux 1985) and ECOST 3.0, stump-to-mill logging models for eastern hardwoods, to compare the costs of three harvesting systems that are effective in northern hardwood stands: an A60F Holder articulated diesel tractor, a single-grip CTL harvester with bi-directional forwarder, and a Koller K-300 uphill cable yarder. The most important attributes of these systems are reduced soil compaction and disturbance, ease of movement to and from logging jobs, and minimal damage to the residual stand (Huyler and LeDoux 1994, 1999).

Methods

Harvesting Systems

The 48-hp Holder tractor, manufactured in Germany, was equipped with an Igland-Jones 3000 double-drum winch with a rated pulling capacity of 6,000 lb. The 55-hp CTL harvester with a 48-gal/min hydraulic pump system is a Peninsula-design roller processing sawhead (RP1600) mounted on a modified 988 John Deere 70 tracked excavator platform. It has a maximum cutting diameter of 14 inches (limb diameter 0.5 to 9 inches). The system included a Valmet 524 forwarder equipped with a small clam loader and an 8-foot log bunk. The Koller yarder, manufactured in Austria, has a minimum power source of 40 hp, a 23-foot tower, and a payload capacity of 3,500 lb. The trailer- or tractor-mounted yarder is used mostly for commercial thinning and smallwood harvesting.

In selecting these systems for study, we specified only that they be less than 60 hp and that the two conventional ground-based systems have 4-wheel drive capability. The stand prescription was primarily a thinning (light to medium) to reduce stand basal area to range between 70 and 95 ft^2. Typically, the long-range plan for the stands in this study was to grow high-quality hardwoods and provide for other nontimber uses. Harvesting was conducted during the summer and early autumn. Skid trails generally were dry and in good condition. Average skid distances were 927 feet for the A60F and 402 feet for the CTL forwarder. The Koller yarder had an average slope yarding distance of 426 feet (lateral yarding distance of 27 feet).

The hourly machine rate for the Holder tractor was $21.75 (average slope yarding distance of 1,000 feet), $115 for the CTL system and $30 for the forwarder (500 feet), and $65.92 for the Koller K-300 (400 feet).

Study Site 1

The pre-test inventory on the study site for the Holder tractor (Huyler and LeDoux 1989) recorded 287 stems per acre with a mean stand diameter of 8.6 inches and a basal area of 116.2 ft^2. The large pole stand was in need of a thinning to eliminate suppressed, poorly formed, and overmature trees. The soil was generally well drained but rocky. About 35 ft^2 of basal area were removed to bring the postharvest stand basal area to 81 ft^2.

Study Site 2

The study site for the CTL harvester (Huyler and LeDoux 1996) had 256 trees per acre (mostly eastern white pine and northern red oak) and a mean stand diameter of 11.2 inches. The stand prescription was primarily a thinning to reduce the basal area from 128 to 90 ft^2. The site was nearly flat except for a small area with a side slope of about 3 percent.

Study Site 3

The study site for the Koller cable yarder (Huyler and LeDoux 1997) consisted of overmature, good-quality red oak trees. The thinning reduced the volume from 12.5 to 9 Mbf per acre with a residual basal area of 70 ft^2. The soil was well drained and dry and the mean slope was 40 to 50 percent. Although the side slope was much greater than on Sites 1 and 2, it was not excessive for cable yarding.

ECOST Costing Models

Average piece sizes and hourly machine rates were used as inputs to the ECOST models. ECOST 3.0 differs from previous versions in that it includes skidding cost and productions for four small farm/skidding tractors and for some skidder sizes. These programs enable users to estimate costs for felling, bucking, limbing, yarding/skidding, loading/unloading, and hauling. Costs can be estimated as components or stump to mill for most of the conditions encountered in eastern hardwood stands. Estimates from ECOST were graphed to determine the impact of average piece size, machine used, and machine utilization rate (MUR) on stump-to-landing costs and break-even piece sizes/costs.

Machine Utilization Rate

Nonproductive time—scheduled and unscheduled maintenance, changing landing areas, and "miscellaneous" delays – can reduce the MUR substantially. Scheduled maintenance includes regular servicing of skylines and rigging as well as parts replacement. This work usually is scheduled during long delays or outside of the normal work shift. Unscheduled maintenance refers to repairs and downtime due to equipment, skyline, or rigging failure. Miscellaneous delays include scheduling delays, time lost to poor weather, crew breaks, and operator inefficiencies.

Results and Discussion

Figures 1-3 show stump-to-landing cost curves by piece size for the harvesting systems at MUR's of 90, 75, and 60 percent. At 90 percent, the effect of size on cost was most pronounced for the Koller-300. Yarding pieces that average 3.88 ft^3 cost \$1.0419/ft^3 vs. \$0.7168/ft^3 for pieces that average 4.94 ft^3. The cost to harvest the same 3.88 ft^3 piece was \$0.4403 for the CTL system and \$0.3826/ft^3 for the Holder tractor. At MUR's of 75 and 60 percent, the Koller's operating costs were \$1.2503 ft^3 (Fig. 2) and \$1.5629 ft^3 (Fig. 3). At 90 percent, BEP sizes were 3.74 ft^3 for the tractor, 4.63 ft^3 for the CTL harvester, and 7.64 ft^3 for the cable yarder, i.e., loggers operating in stands with average tree sizes that exceed the BEP would realize a profit. Cost decreased at decreasing rates (flatter slopes) as piece size increased from 6 to 11.30 ft^3 (Fig. 1).

BEP sizes for the three harvesters at MUR's of 75 and 60 percent were, respectively, 9.18 and 10.82 ft^3 for the Koller K-300, 5.64 and 8.31 for the CTL system, and 4.55 and 5.74 for the Holder tractor. Reducing delays and/or downtime can greatly affect the logger's profit margin. In stands where the average piece size is 11.30 ft^3, the operating cost for the cable yarder at an MUR of 60 percent is \$0.3729/ft^3 versus \$0.2486/ft^3 at a utilization rate of 90 percent.

Koller K-300 Yarder

Mean daily/annual production for the Koller K-300 cable yarder was 3,360/840,200 ft^3. Because cable yarding is more costly than ground-based systems, this technology requires a multiproduct market and a site with a large volume of quality timber. The Koller K-300 is suitable for commercial thinnings and selection cuts in young, high-quality sawlog stands, and for uphill yarding in steep terrain in precommercial thinnings of small, roundwood products such as firewood. Cable yarding is a good alternative to ground-based skidding where side slopes are greater than 30 percent. In a study that compared the cost of applying specific standards for water quality, the cost advantage of ground-based skidding over cable yarding was reduced from 30 to 15 percent (Huyler and LeDoux 1995). This advantage will become less important as stumpage prices escalate and restrictions are placed on ground-based systems.

CTL Processor/Forwarder

Mean daily/annual production for the CTL harvester with forwarding system was 1,825/456,250 ft^3. An important advantage of CTL system is its ability to lay a mat of limbs and woody debris in front of the machine to travel on. As a result, this technology should be considered for operations in wet and/or muddy areas and where soil erosion, compaction, and water quality are concerns, e.g., small suburban woodlands. Also, damage to the residual stand during thinning operations is minimized because trees can be felled directionally and whole trees are not pulled through the stand, as usually is the case with rubber-tired skidders. The CTL harvester/processor also is efficient in softwood stands (Huyler and LeDoux 1996).

The CTL system is highly flexible in that it can: 1) be used as a feller-buncher where whole trees are felled and bunched for grapple skidding to the landing, 2) produce tree-length material by delimbing in the woods (a rubber-tired skidder would be used to move the stems to the landing), and 3) be programmed to process trees into specific log lengths that meet specific factory-grade log requirements or pulpwood lengths.

The greatest drawbacks with this system are high initial investment and operating costs, reduced productivity on steep slopes, and the possibility of machine rollover when processing large hardwood trees. Also, harvesting large stems can place excessive strain on the processor head. We observed a high incidence of hydraulic line failure during extremely cold weather and in deep snow.

A60F Holder Tractor

The Holder tractor is highly maneuverable over most terrain in dense, small-diameter stands. It operates efficiently in stands with medium or large stems and skid distances up to 1,000 feet (Huyler and LeDoux 1991). This tractor should be considered in pole and sawtimber stands on small parcels where large equipment would not be cost effective and/or pose a high risk of soil disturbance and residual stand damage. The Holder tractor also is recommended for thinning small farm woodlots and in areas where there is a strong local market for firewood or wood chips.

It is sometimes difficult to locate spare parts for the A60F Holder and similar tractors. Also, tractor systems cannot produce sufficient volumes over time to be a sole source of income for the owner. However, an acceptable income can be produced by combining the tractor's use with forestry activities such as prebunching and forwarding to main skid trails, or with other farm activities.

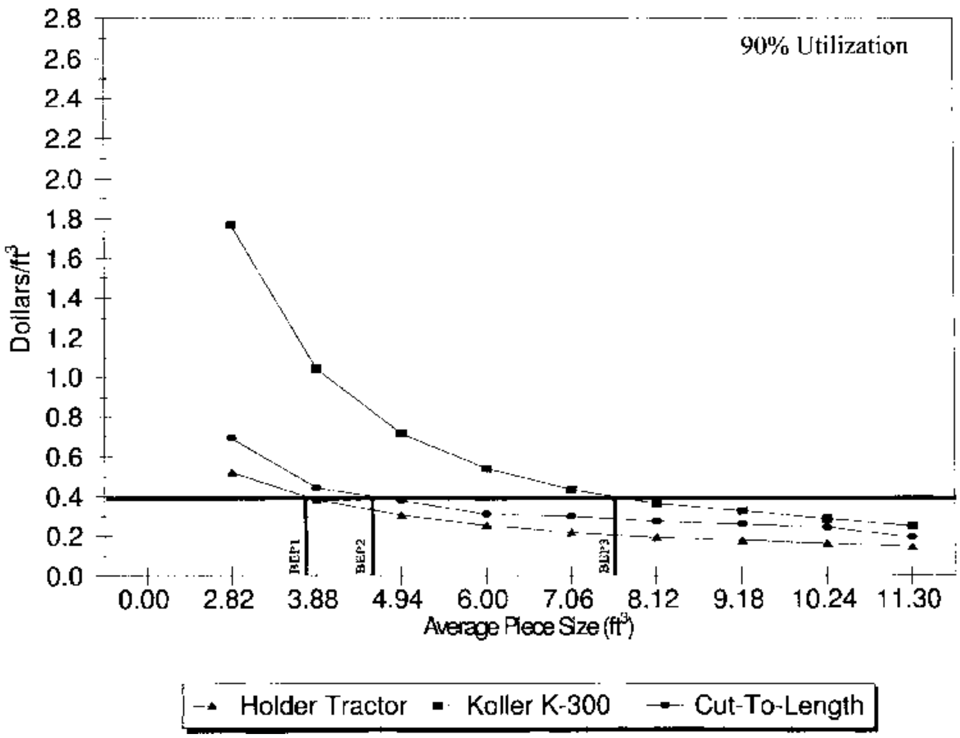

Figure 1.—Stump-to-landing costs curves and break-even piece (tree) sizes (BEP) for the A60F Holder tractor, Koller K-300 cable yarder, and cut-to-length (CTL) processor with forwarding system at a machine utilization rate of 90 percent.

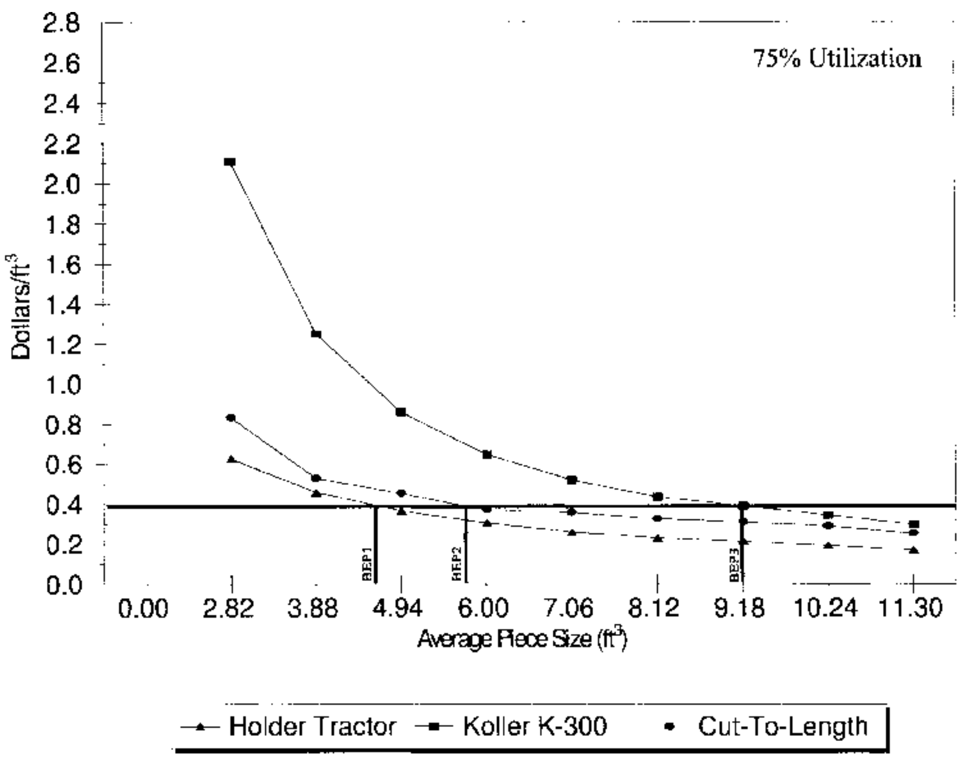

Figure 2.—Stump-to-landing costs curves and break-even piece (tree) sizes (BEP) for the A60F Holder tractor, Koller K-300 cable yarder, and cut-to-length (CTL) processor with forwarding system at a machine utilization rate of 75 percent.

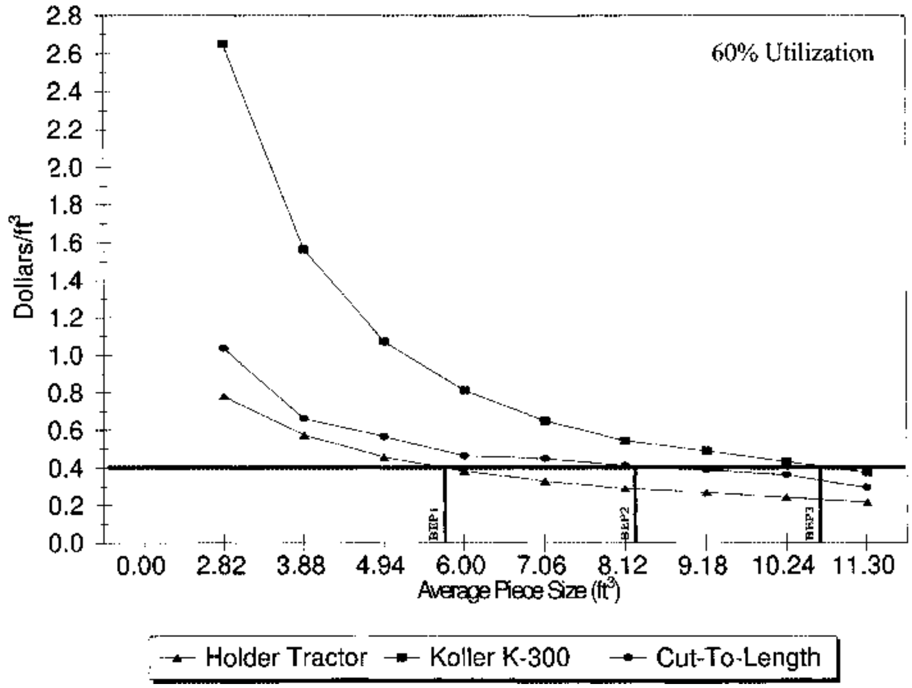

Figure 3.—Stump-to-landing costs curves and break-even piece (tree) sizes (BEP) for the A60F Holder tractor, Koller K-300 cable yarder, and cut-to-length (CTL) processor with forwarding system at a machine utilization rate of 60 percent.

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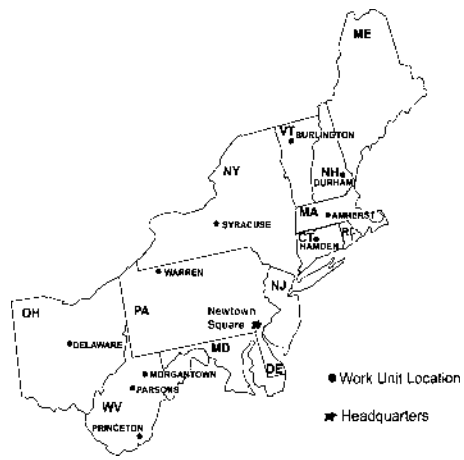
Keywords: CTL systems, cable yarder, tractors, thinning, economics



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