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Technoeconomic Analysis of Conventional Logging Systems Operating from Stump to Landing

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Abstract

A technoeconomic analysis of timber harvesting systems was conducted to obtain key information for estimating longrun supply trends of roundwood materials from eastern woodlands. Productivity and cost factors for six stump-to-landing systems were developed from operational data for 47 harvesting operations. Technical factors and the effects of financial considerations were also assessed. Combined with the productivity and cost factors, they provided better perception of the forces impacting longrun roundwood supplies and logging contractors' business options.

Introduction

Harvesting is one of the most expensive activities in the production of wood products, and harvesting costs directly influence the demand for stumpage and the supply of roundwood material. Therefore, one key piece of information needed to predict the longrun supply of roundwood materials from eastern woodlands is an analysis of the different systems that are or may be used to harvest timber. In this paper, we have analyzed stump-to-landing functions of six different logging systems employed in eastern forests. Our intent is to obtain a broad perspective of productivity and cost factors for them and to combine this information with technical, financial, and other considerations important in the selection of logging equipment and systems.

This paper is presented in four sections. The first section presents technical and economic information developed from operational data from 47 harvesting studies. The second section presents technical factors that influence the use of a particular harvesting system on a particular site. Section 3 of this paper introduces the effect of the real-world considerations that loggers must face and their potential effect on selection of harvesting equipment and systems. The concluding section summarizes the materials presented in the previous sections and makes suggestions for future research.

Comparative Analysis of Conventional Logging Systems

Six conventional logging systems—horse, mini-tractor, crawler tractor, cable skidder, grapple skidder, and cable yarder—are compared in this section. The data for this analysis came from 25 published and unpublished reports. Altogether, the reports yielded information for 47 logging operations including 6 horse, 5 mini-tractor, 8 small crawler tractor, 10 cable-skidder, 9 grapple-skidder, and 9 small cable-yarder systems. For each logging operation, information was extracted on location, terrain, type of cut, species, mean stand diameter, roundwood products cut, yarding distance, load size per turn, capital cost of equipment, crew size, system cost per day, output per day and per man-day, and cost per unit of output (Appendix, Tables 1 to 6).

Volume of wood harvested was calculated in cords of wood plus bark. If outputs were recorded in other units, appropriate factors were used to convert them to cords. Cost per unit of output for each logging system was developed by summing daily labor and equipment costs and dividing this sum by daily output. For comparison purposes, all wages were fixed at $6/hour plus 31 percent for employer-paid taxes and insurance (= $7.86), and all capital equipment costs were standardized to 1983 dollars using Producer Price Indexes for construction equipment. Machine rates for new equipment were based on ownership and operating costs per hour as determined by Cubbage (1980), or from data given in the cited reference. Machine utilization factors were based on data in the abstracted papers or from Miyata (1980).

The data base includes terrain that ranges from flat to mountainous and many species, including hardwoods and softwoods. Conditions differ widely among the studies analyzed, but each operation was a legitimate harvest of trees found in forest stands. In that sense, the studies are representative of a population of forest harvesting operations, and the analyses reported here are based on this underlying assumption. Reported inputs and outputs for like harvesting systems were collated and analyzed, means and ranges of data for the six logging systems were compared, and relative inputs, outputs, and costs were assessed.

Description of Logging Operations

Six horse-logging operations, including both single and team hitches of draft horses, were analyzed. All operations were in mountainous terrain, and except for one in New Zealand, all were in the United States. Most were harvests of tree-length hardwoods from a variety of cuttings: thinnings, selection, and clearcuts. The usual crew size was two men—a faller and a teamster. On steep slopes in Montana, the crew used two horses, resting one while the other worked.

Five mini-tractors, ranging in size from 12 to 48 horsepower, extracted tree-length poles from thinnings in the Northeastern States. In all cases, the crew was two men—a faller and a tractor operator.

Small crawler tractors of 42 to 78 hp operated on mountainous logging shows in the central Appalachians, British Columbia, and Washington state, where they thinned and clearcut stands of hardwoods and softwoods. Logging crews consisted of two men—a faller and a tractor operator.

Rubber-tired cable skidders operated on 10 logging shows in West Virginia, Montana, and Mississippi on hilly to mountainous terrain. The skidders were equipped with winches for logging tree-length hardwoods and softwoods. Their engines ranged from 60 to 125 hp; however, most were 90-hp machines. Harvests were thinnings, diameter-limit selection, and clearcuts. Crew size ranged from two to three men—a faller, a chokersetter, and a skidder operator.

Rubber-tired grapple skidders working in conjunction with mechanical fallers of various makes were used on nine whole-tree chipping operations in New England and the Lake States. The terrain was flat to moderately steep (slopes seldom over 15 percent). These skidders ranged from 90 to 152 hp. Harvests were mostly thinnings, extracting whole trees in hardwood and pine stands. Crew size varied from two to four men—one man operating the mechanical faller[1] and up to three men operating grapple skidders.

Small cable-yarding systems were operated on nine logging shows in the Appalachians and the Northwest. The equipment included two jammers and four skyline yarders. Five operations were thinning jobs and the others were clearcuts and residue relogging. Both log-length and tree-length removals were made from stands of hardwoods and Douglas-fir. Crew sizes ranged from three to seven men, including fallers, yarder operators, chokersetters, chasers, and tractor operators on three jobs where swing operations were necessary.

Production and Costs for Logging System Operations

Analyses of production and costs were limited to the two basic, yet complex, logging functions—felling and extraction. (Log loading and transport functions were not included in our analysis.) The analyses were structured so that inputs of labor and machines were restricted to the number of each necessary for a producing unit within a given system. For example, one faller and one chain saw plus one crawler tractor and operator were considered one producing unit in the crawler-tractor system. Production data were based on the unit's output. Cost data were based on the sum of wages and fringe benefit costs for workers and the machine rates for equipment. Auxiliary equipment such as crew trucks, service trucks, bulldozers, welders, spare parts, etc., were not included in determining investment or production costs; nor were costs of stumpage, roadbuilding, landing construction, supervision, or overhead included in any of our cost calculations.

Production and cost data were developed by the method described above for each logging operation within each of the six systems analyzed (Appendix, Tables 1 to 6). Within each system, production and cost data from the individual operations were summed, and means and ranges were calculated. Means and ranges of production and cost data are presented in tabulations and bar charts in the following pages of this section.

[1] Mechanical fallers included both tree-to-tree (TT) and limited-area (LA) types. TT fallers and faller-bunchers must move from tree to tree; LA faller-bunchers have the felling mechanism mounted on a boom that can swing to reach several trees from one position of the carrier.

Average capital investment ranged from a low of $2,318 for horse logging to $256,000 for grapple skidders coupled with mechanical fallers (Fig. 1). Grouped by average dollar investment, the six logging systems rank roughly as shown in the following tabulation:

Capital Investment Categories (thousands)

<$4	$10–39	$40–69	$70–139	>$264
horse	mini-tractor	crawler cable skidder cable yarder	cable yarder-plus-swing operation	mechanical-faller/grapple-skidder

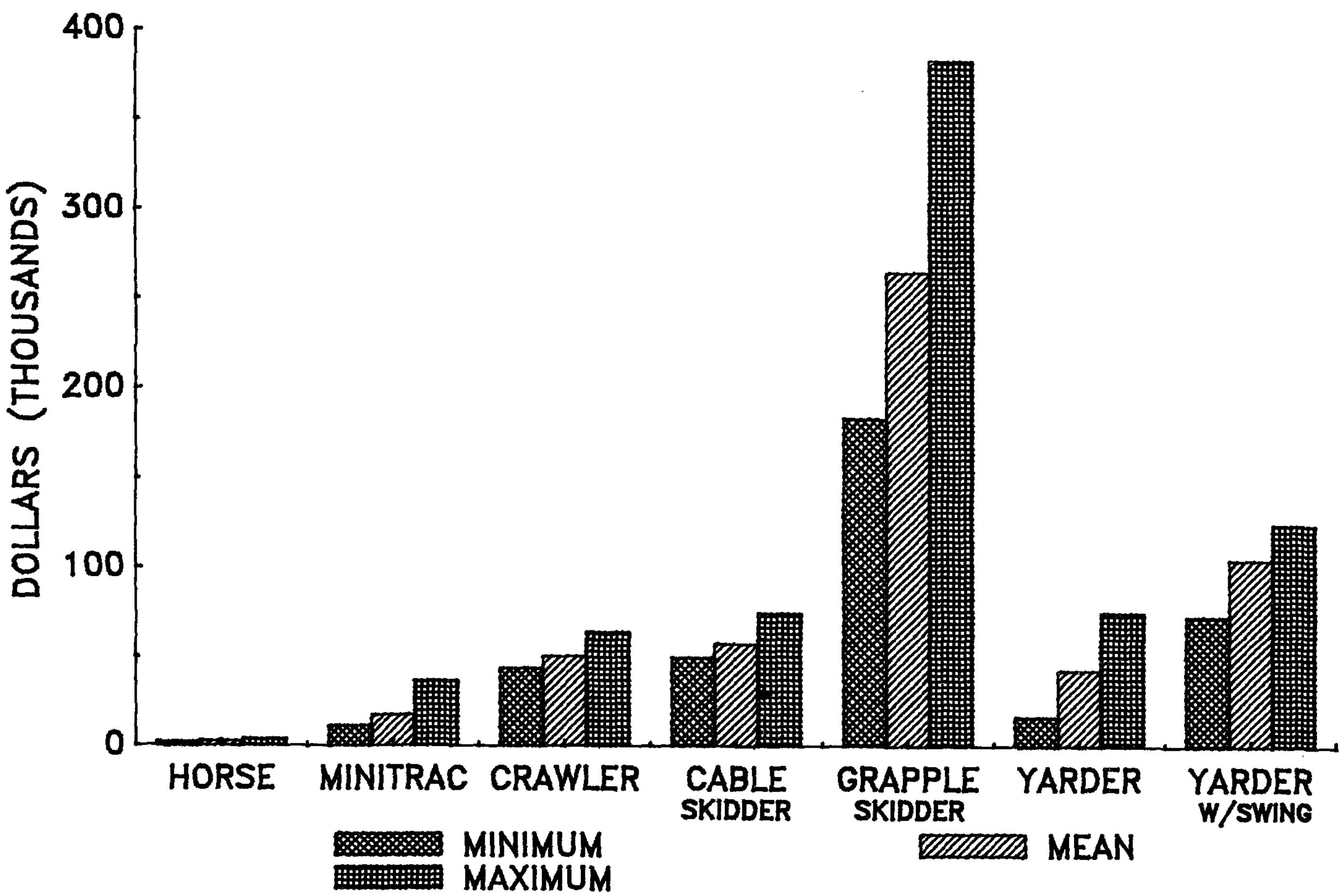

Figure 1.—Capital investment for equipment

Evaluation of dollars spent for labor per hour compared to the hourly cost to own and operate equipment shows that the horse, small cable yarder, and mini-tractor systems are the most labor intensive (Fig. 2). Mechanical-faller/grapple-skidder systems, on the other hand, while requiring the largest capital investment, are the least labor intensive. This system has the highest productivity, with output averaging about 28 cords per man-day (Fig. 3). Systems with low productivity—horse, mini-tractor, and small cable yarder—average 5 cords or less per man-day. And, with the exception of the small cable yarder, these systems rank in the lowest capital investment classes.

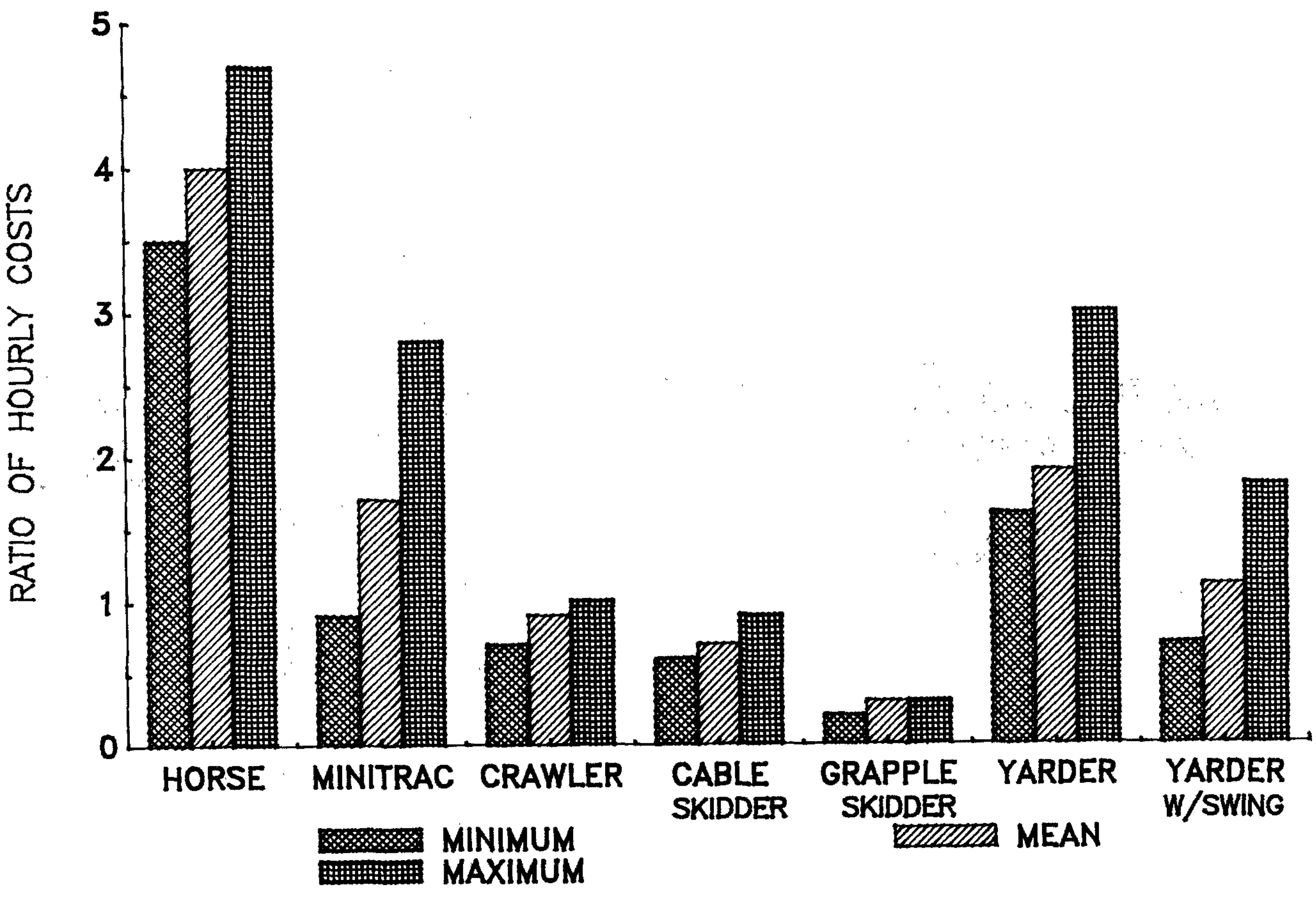

Figure 2.—Ratio of hourly labor costs to hourly equipment costs

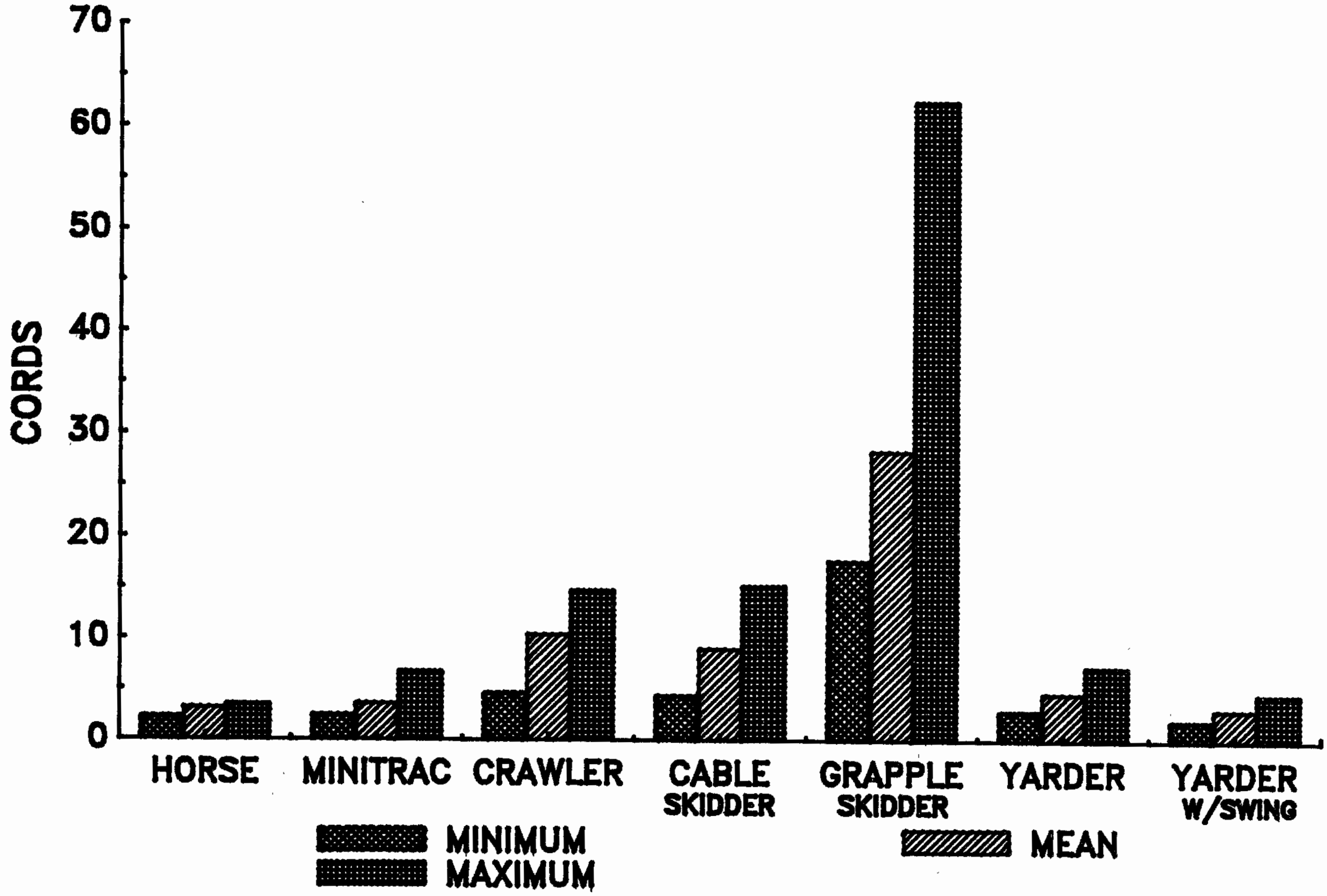

Figure 3.—Production rate per man-day

The daily production rate (Fig. 4) follows much the same pattern as production per man-day. The mechanical-faller/grapple-skidder system produces, on the average, more than three times as much wood as the next most productive system. Average production per day is:

Production Per 8-Hour Day

<10 cords	*10–19 cords*	*20–29 cords*	*>70 cords*
horse mini-tractor	cable yarder cable yarder-plus-swing operation	crawler cable skidder	mechanical-faller/grapple-skidder

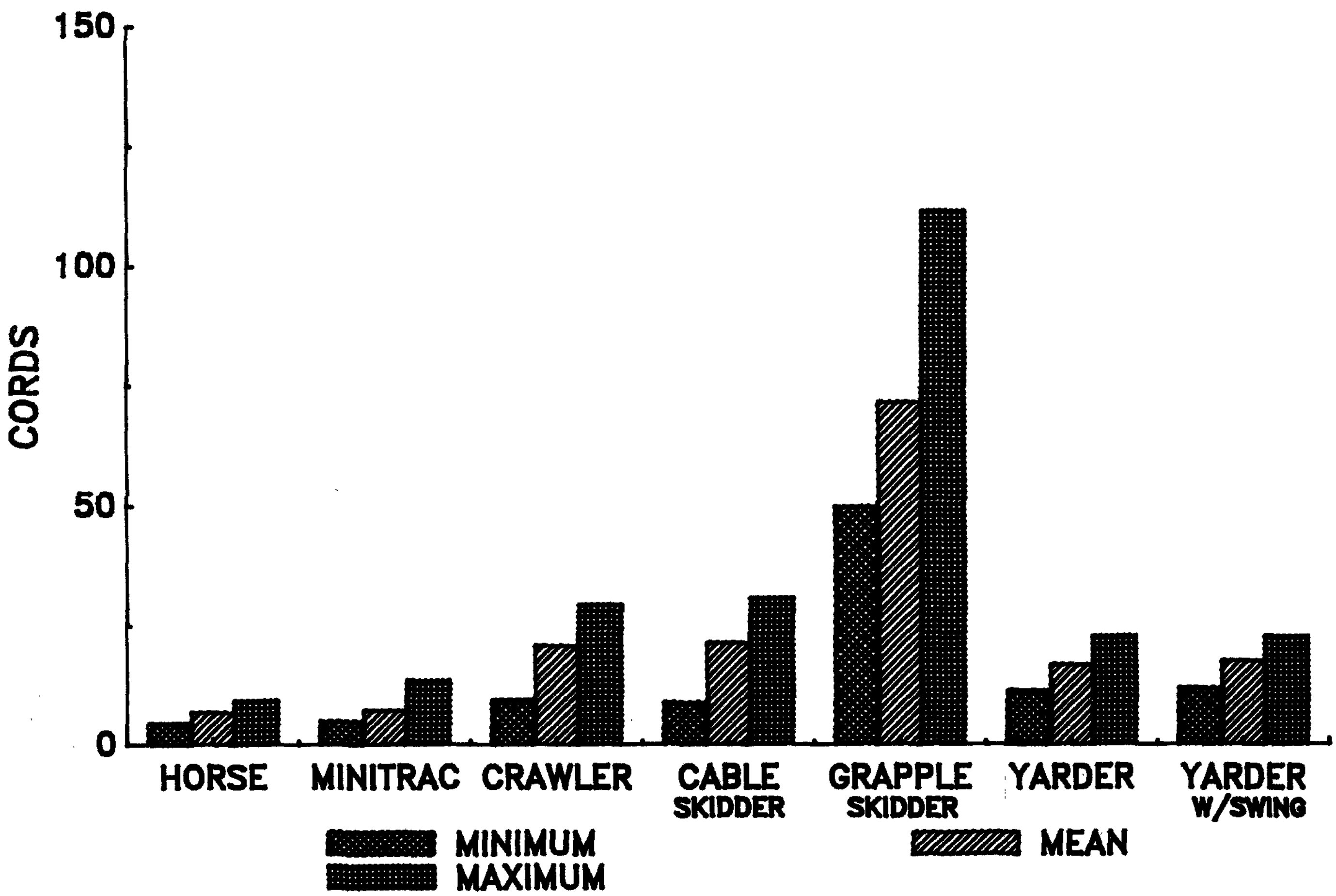

Figure 4.—Production rate per day

The mechanical-faller/grapple-skidder system is, on the average, the most expensive to own and operate, at close to $900 per day, while horse logging averages less than $200 (Fig. 5). The range of average daily costs among the six systems is:

Logging System Owning-and-Operating Cost Per Day

<$200	*$200–299*	*$300–399*	*$600–899*
horse	mini-tractor crawler	cable skidder cable yarder	mechanical-faller/grapple-skidder cable yarder-plus-swing operation

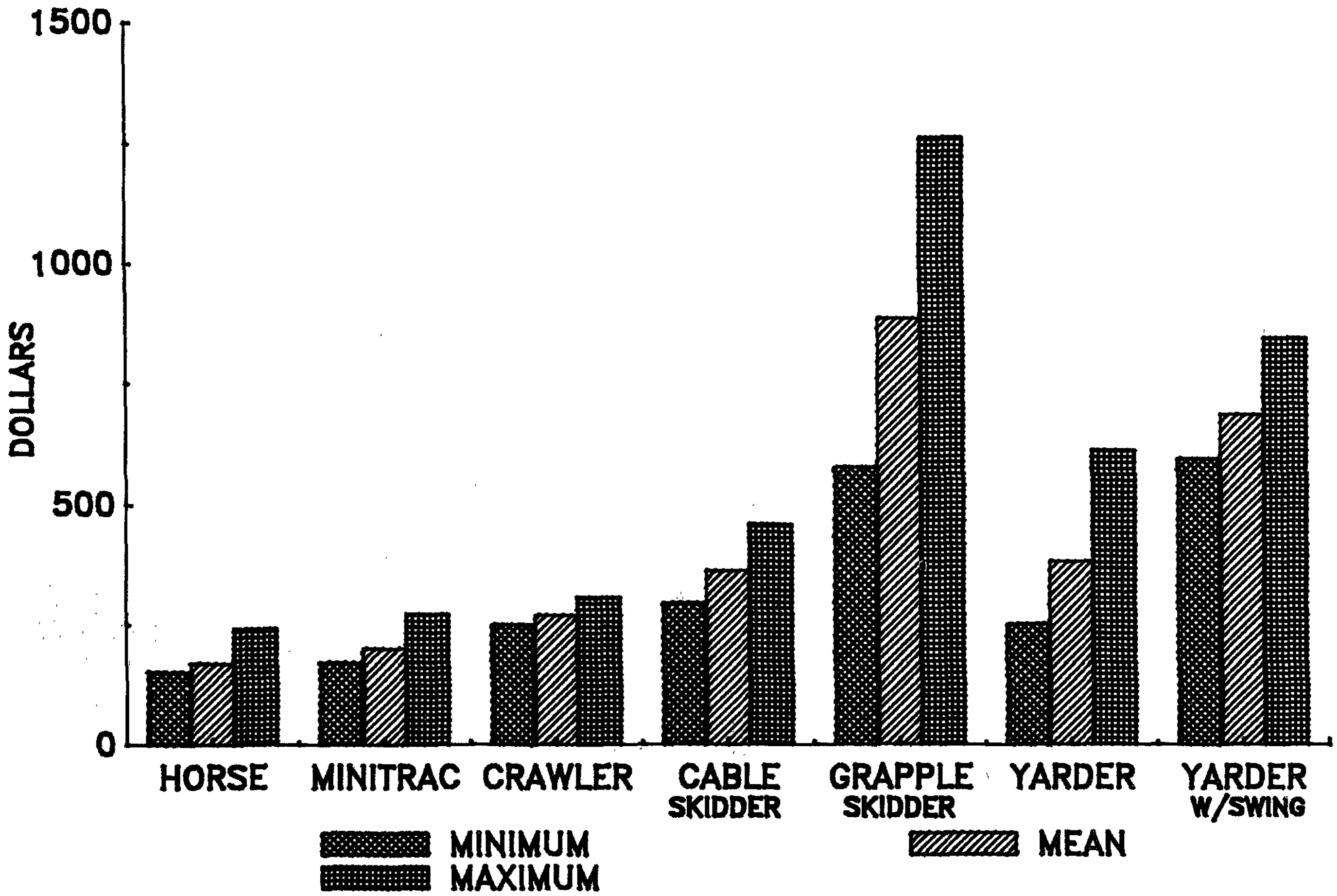

Figure 5.—Logging system cost per day

For each system, manpower and equipment are functions of the balance between the productivities of felling and skidding operations. With chain-saw felling, the usual balance appears to be one faller per producing unit (but this can vary significantly with tree size and skid distance). Productivity of mechanical fallers is two to three times that of chain-saw felling; one faller-buncher unit can keep two to three grapple skidders supplied with whole trees. Hence, instead of two men per producing unit, three to four are required. Nonetheless, productivity per man-day is highest for mechanical-faller/grapple-skidder systems even though larger crews are necessary to man the greater number of machines.

Cable yarding crews are also somewhat larger than skidding crews because of the addition of a chokersetter and a chaser to the usual crew of faller and equipment operator. If a swing operation supplements the cable yarder, a skidder and operator must be added to the crew. In summary, typical crew sizes for felling and yarding operations fall into three categories:

Typical Crew Size

2 to 3 persons	*2 to 4 persons*	*3 to 7 persons*
horse	mechanical-faller/ grapple-skidder	cable yarder
mini-tractor		cable yarder-plus-swing operation
crawler		
cable skidder		

Daily production in cords and total daily costs of labor and equipment were used to determine cost per cord. Average cost per cord among the six logging systems was lowest ($13.03) for the mechanical-faller/grapple-skidder system. Highest average costs were $30.98 and $41.69 per cord for the mini-tractor system and the small cable yarder-plus-swing operation (Fig. 6). Average costs per cord for the other systems fell in between these extremes:

Logging System Cost Per Cord

<$15	*$15–19*	*$20–29*	*>$29*
mechanical-faller grapple-skidder	crawler	horse	mini-tractor
	cable skidder	cable yarder	cable yarder-plus-swing operation

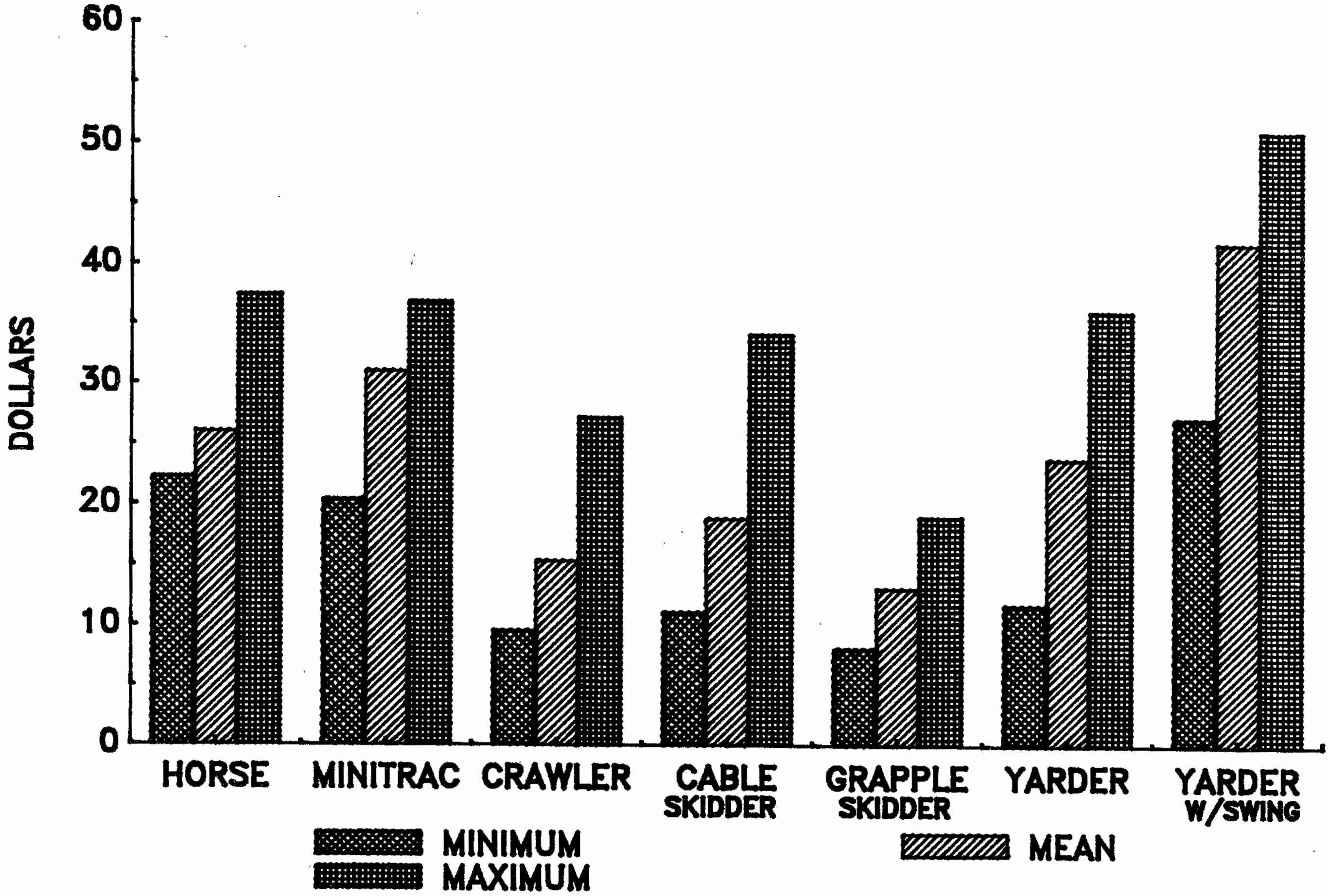

Figure 6.—Logging system cost per cord

Technical Factors Affecting Skidding and Yarding Operations

Although logging system productivity and costs are important considerations in determining the type of system to be used, technical factors may supersede these considerations. Important ones are terrain, environmental considerations, size of tract, type of cut, mean stand diameter, load capacity, skidding or yarding distance, and contract requirements. The effects of these factors on the suitability and economics of the six different logging systems are discussed in this section.

Terrain. Tractor and skidder logging systems are severely handicapped when skidding uphill on slopes in excess of 10 percent (for each 1 percent of adverse grade, maximum payload volume decreases by 2.5 percent). For this reason, ground skidding is preferably done downhill to truck roads located in the valleys. On the other hand, most cable systems are rigged to yard uphill to truck roads located on the ridges or contours (Sundberg 1976).

In addition to steepness of terrain, ground roughness and tractive capacity of soils affect the choice of logging method. Depending on the degree of these conditions, horses, tractors, and skidders can operate on a range of slopes as shown in Appendix, Table 7. Where slopes are excessively steep or rough, skid roads must be built for these systems to be used, and this increases costs. When the terrain is too steep and rough for ground skidding, cable yarding systems are to be preferred.

Environmental issues. Soil erosion and sedimentation are the most serious environmental problems associated with timber harvesting. Patric (1978) states that the "soil erosion hazard is increased most when logging is conducted on steep slopes, in wet soils, and along streams. Highest rates of erosion usually occur on logging roads and skid trails."

Section 208 of the Federal Water Pollution Control Act of 1972 requires the control of nonpoint sources of water pollution from forestry activities, including logging. The most direct approach for reducing soil erosion on timbered areas is to build as few roads as possible and to exercise all recommended guidelines for proper road construction, including erosion-control measures and revegetation after logging (Patric 1978).

Selection of logging equipment and preplanning of road layouts affect the amount of area in roads and trails exposed to erosion. In mountainous terrain, wheeled skidders are noted for the dense road network needed to move logs to landings. An estimate of timber acreage logged per mile of road built in the central Appalachians was reported by Kochenderfer and Wendel (1978). Skyline yarders, for example, create the least disturbance in the forest. They can log about 80 acres per mile of road constructed. For jammers the figure is about 31 acres, and for skidders, about 20 acres.

Ground skidding coupled with downhill logging results in more area disturbed and greater chance of erosion because the pattern of skid trails and roads tends to be fan-shaped with the apex at the bottom. Thus, water flows are concentrated and accelerated in their downhill movement. The opposite tends to be true with uphill logging methods, and they are preferable for that reason. However, one must consider the cost of building haul roads at midslope and ridgetop locations to accommodate these uphill logging systems.

Size of tract. Too big or too small a tract of timber can limit a contractor's choice of logging systems. Timber contract termination dates set the time frame for harvest completion. On large tracts of timber, the obligation to meet the completion date more or less restricts the choice of logging systems to one of the higher production systems. On the other hand, tracts smaller than 30 to 40 acres are often considered too small for economic operation by whole-tree chipping contractors because moving in a big spread of equipment is too costly for the harvestable volume.

Type of cut. Forest stands are subject to two principal kinds of cutting: partial cuttings and clearcuttings. Thinnings, timber stand improvement cuttings, and selection harvests—all partial cuts—are conducted in dense to well-stocked stands. In these stands, there is concern for potential damage to tree boles, tops, roots, and soil. Avoidance of stand damage often dictates that smaller, lighter, more maneuverable equipment be used. Where the terrain is relatively level, horses and mini-tractors are appropriate. On moderately steep to steep terrain, small crawlers, small skidders, or small cable yarders are necessary. With the ability to control tree felling and placement, feller-bunchers have advantages over chain saws for partial cuttings in immature stands. And, although safer to use, they require considerably larger investments.

Large rubber-tired skidders are better suited to clearcut harvests than to thinnings. A survey of 174 Minnesota loggers in 1979 found that the chain-saw felling/cable-skidder system was the most common type of operation reported in that state (Sinclair and Bolstad n.d.). It is also the most common in the central Appalachians. However, on both clearcut and partial cuts, skidders usually work from bulldozed skid roads on sites with slopes no greater than 40 percent (Gochenour and Hartman 1968).

Small crawler tractors are an attractive alternative to wheeled skidders for salvaging bug-killed lodgepole pine. Working on steep, sensitive terrain in the Rockies of British Columbia, the crawler had less skid trail impact than rubber-tired skidders and operated at lower costs than cable systems. Furthermore, operators found that the crawlers were more stable on steep slopes, were not dependent on a large tractor for trail construction and clearing, and were available a higher percentage of time than were skidders (McMorland 1980).

Mean stand diameter (MSD). Timber size has a direct bearing on equipment selection and productivity. For most logging systems, production rates are lower and costs are higher for small trees than for large trees (this is axiomatic within the logging industry). However, logging small timber can be profitable with systems employing faller-bunchers and grapple skidders. Berti (1984) found, for example, that faller-bunchers were essential in stands with harvestable trees averaging 10 inches or less in diameter at breast height (d.b.h.). In a 1979 study of Minnesota loggers, Bolstad and Sinclair (1981) reported that among 79 logging firms, mean productivity (in cords per man-hour) averaged 38 percent more for mechanical-faller/grapple-skidder systems than for chain-saw felling/ cable-skidder systems.

Rubber-tired skidders and crawler tractors are available to handle all sizes of timber logged in the Northeast. Even the small crawler tractors reported in this paper handled loads comparable to those of cable skidders. Horses, mini-tractors, and small mobile yarders are more restricted in the size of logs they can handle, and this is directly reflected in their productivity.

Load capacity. Load capacity is an important factor in selecting skidding and yarding equipment; it is a function of machine configuration and horsepower. Coupled with skidding distance, load capacity pretty well determines the potential productivity of skidding and yarding machines. Actual productivity, however, is more a function of how well machine load capacity is utilized, and that is directly related to the size, density, and number of logs hooked up for each turn from stump to landing.

Data from some of the operations used in this study illustrate the point about load size per turn and machine load capacity. For example, Figure 7 shows that the average maximum load per turn for small (42 to 78 hp) crawler tractors exceeds the average maximum load per turn for both cable and grapple skidders having more horsepower than the crawlers! The specific crawler-tractor operation involved (Adams 1967) was a thinning in second-growth Douglas-fir with a mean stand d.b.h. of 13.4 inches. The trees were large, and the logs were sizable—0.24 cords per log. The 65-hp tractors on this operation averaged 10 logs per turn, for an average load size of 2.45 cords. The 50-hp tractors, on the same operation, averaged six logs per turn for an average load of 1.47 cords. These two west coast operations increased the overall average load size per turn for all small crawler tractors to 1.05 cords per turn—close to the average load size for cable and grapple skidders. However, the median load size per turn for all eight small crawler-tractor operations (Appendix, Table 4) was 0.74 cords per turn—more typical of load sizes one would expect for small crawler tractors logging second-growth eastern forests.

A similar example on the other extreme is the load size of the Bitterroot yarder working in Kentucky (Appendix, Table 6). Average loads of only 0.12 cords per turn were the result of the Bitterroot yarder's low mainline pull capacity (1,150 pounds). The only smaller load size in the data set was 0.09 cords per turn on a "logger's choice"[2] operation logged with a horse in West Virginia (Appendix, Table 1). In contrast to these examples of small loads per turn, the minimum load size on mechanical-faller/grapple-skidder operations was 0.59 cords, almost six times the minimum loads of the Bitterroot cable yarder and horse operations.

Skidding and yarding distance. On operable terrain, distance is the most important physical factor affecting skidding and yarding cycle times and, ultimately, productivity. On a particular logging chance, skidding and yarding distances can be good or bad depending on how much planning was done to provide the best combination of truck roads, skid roads, and landings for least total cost. Other factors to be considered in the planning process include volume and size of timber, skidding and yarding machines on hand or available, road construction feasibility, etc. Extensive determinations of this order, however, cannot be made on the basis of physical factors alone. They must include economic analyses based on the principles set forth by Matthews (1942).

As a result of such analyses, it may be found that a combination of skidding and yarding machines may be the best solution. For example, if long skidding distances are required it may be that skidders, in combination with crawler tractors for short hauls, may give the lowest overall skidding cost. Or on steep terrain, uphill logging with jammers on contour roads, in combination with small crawler tractors logging downhill, may be the best mix of equipment for maximum production and lowest cost. Grafton[3] points out that

[2] Logger cuts only trees yielding products he can sell.
[3] Personal communication.

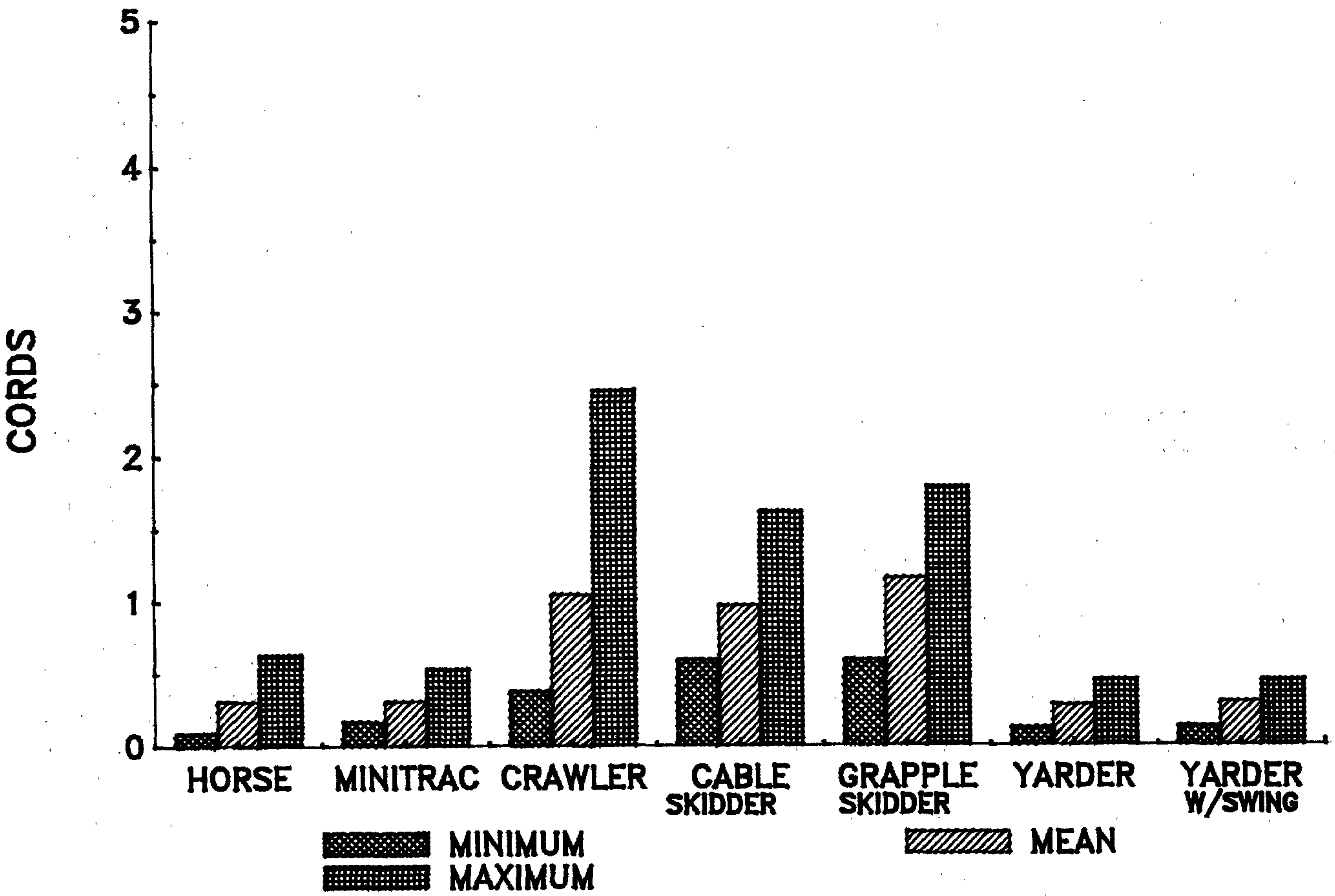

Figure 7.—Load size per turn

animals and skidders are a potentially useful combination. He reports that in Zimbabwe, bunching logs with oxen or mules works well in combination with rubber-tired skidders for the long skid distances.

The efficiency and productivity of a skidding method depend on a combination of factors—some of which (load size and terrain) have already been discussed. Travel speed and hooking methods are also important. They are the principal factors in how fast or slow cycle times are. Rubber-tired grapple skidders have the advantage of good travel speed plus fast hooking and unhooking. These features and others have made grapple and cable skidders the most popular skidding machines in the woods. However, there are harvesting situations where other machines are preferable. For example, in Holland, Leek and Schaafsma (1981) found that there is no need for skidders. Skidding can be done with horses or with agricultural tractors modified for logging. They recommend horses for thinning young stands where average skidding distances are 165 feet or less. Where skidding distances are greater, bunching with horses in combination with skidding by grapple-equipped tractors is recommended.

Choices among skidding and yarding machines are difficult to make on a subjective basis alone. Selection of machines for harvesting operations can begin with matching technical features to requirements of the job. But final selection should be based on a unit-cost analysis to determine break-even points among machines or combinations of machines for skidding distances, load size, and slopes that occur on the job.

Contract requirements. Many roundwood and chip purchasers prefer to deal solely with large-volume producers. This is more efficient and less costly for them than dealing with numerous small producers. Thus loggers seeking contracts with these firms are limited in their choice of logging systems. Out of necessity, they must choose one of the more costly high-production systems or forgo producing for these buyers.

The Effect of Economic Factors on System Selection

The six systems represent a broad range of required inputs in manpower, invested capital, and necessary operating funds. The farmer and son who own a team of horses, a set of harness, and a chain saw can be in the logging business with the purchase of log chains and fuel for the saw, and the hire of a trucker to haul logs to markets. Though production may be only 4 to 6 cords per day, if they can cover out-of-pocket costs and make wages for themselves, they are in business as loggers with a minimum outlay of capital.

The other extreme in the logging business today is the large whole-tree chip logging contractor outfitted with a faller-buncher, grapple skidders, a whole-tree chipper, several chip trailers and highway tractors, plus a couple of support vehicles, maintenance equipment, and spare parts. Investment in such an equipment spread can total $750,000 or more. Operating with a contract to deliver large tonnages (200 to 300 tons) of pulp chips to the mill each day, the contractor must produce wood at a cost below current prices ($19 to $20 per ton) or go out of business.

In the short run, a logging contractor must cover his variable costs of fuel, maintenance, and labor in order to stay in business. In the long run, the logger must also cover the fixed cost of his investment. The ability of a system to develop enough revenue to cover both fixed and variable costs is a necessary condition for equipment selection but is not the only condition governing equipment selection. Two other very important real-world economic questions are: (1) How much money can be obtained to purchase equipment, and what interest rate must be paid on this money? and (2) What degree of financial risk does the logger want to assume?

The availability of funds is a critical factor in purchasing logging equipment since many banks are reluctant to lend money to logging contractors. This means that loggers must use their own funds to purchase equipment or must borrow money from secondary processors or equipment companies at above-average interest rates. The combined effects of low accessibility of funds and high interest rates reduce the amount of money a logging contractor will or can borrow and thus decrease the number of state-of-the-art logging systems used. The less capital-intensive systems, such as cable skidders, small crawler tractors, or even horses, may be employed instead of grapple skidders and faller-bunchers, even though their average cost per cord is higher.

Owning logging equipment is risky because of the variability of timber markets and weather conditions. In idle periods or periods of reduced production, loggers who have borrowed money must still make payments, and loggers who invested their own money are losing the interest that money could earn in other investments. Risk emanates from capital or fixed costs rather than variable cost. Therefore, a logger may be more inclined to purchase a system with a relatively high variable cost and low fixed cost over a system with a high fixed cost and low variable cost.

The risk problem is associated with cash flow of incoming revenue versus outgoing costs. The degree of risk an individual is willing to take depends on his own personality and the amount of time his equipment can remain idle before he can no longer afford to make payments on it. The risk factor, like the availability of money, tends to encourage the purchase of less capital-intensive systems even though the operating cost of these systems may be higher.

Summary and Conclusions

Harvesting is a key and expensive process in the transformation of standing timber into wood products. From the analyses conducted in this study, we can draw several conclusions about the effects of harvesting on future stumpage and roundwood supplies and prices in the eastern forest regions, and on the realities logging contractors face in choosing and using harvesting systems.

With the exception of the cable yarder, the most efficient (lowest cost per unit of output) harvesting systems are the most capital-intensive systems. They are the systems with the highest fixed cost and the most risks for the contractors to finance and protect during unscheduled idle periods or periods of reduced production. The mechanical-faller/grapple-skidder system, the most capital intensive of current operating systems, produces wood at the least cost per unit but is restricted by steep and rough terrain. The implication for stumpage and roundwood supplies and prices is that as long as timber is available on sites accessible to mechanical-faller/grapple-skidder logging, stumpage prices will be firm and roundwood prices moderate. As less timber is available on accessible lands, average stumpage prices will edge lower, harvesting costs will go up because of lower productivity of systems employed, and roundwood prices will rise as far as market strength permits.

Harvesting steep and environmentally sensitive lands will require the use of systems with lower productivity and higher unit costs. Stumpage prices for timber on these lands will be lower and contractors' revenues will be slimmer. If supplies of more accessible timber are sufficient to meet marketplace demands, less accessible timber will continue to go begging for a market.

The realities of the timber marketplace and harvesting systems' production and costs present a real dilemma for the logging contractor. To achieve high output and low unit costs, he's driven to use capital-intensive systems that are costly to finance and risky to keep solvent in the face of long, unexpected idle periods due to log-buying suspensions, mill closings, and so forth.

Loggers fortunate enough to have favorable long-term contracts and financing help from wood-using industries are those most able to employ capital-intensive, state-of-the-art logging systems. Loggers not so favorably connected must seek other options, such as more favorable financing arrangements, buying used equipment, and/or employing less costly systems. All logging contractors, regardless of system used, must strive for maximum production, while maintaining a tight rein on costs.

A paradox of timber economics exists at the interface between stumpage supplies and harvesting costs. Higher stumpage prices and increased supplies are possible at lower harvesting costs. Lower harvesting costs are achievable with current harvesting technology—but at a price. The price is higher cost, capital-intensive systems that are restricted in use by the inability of loggers to finance them at "reasonable" risk, and by forestlands too steep, rough, or environmentally sensitive for these systems to operate on. Much of the forestland in the Appalachian Mountains, for example, is too steep for the highly productive mechanical-faller/grapple-skidder system.

The challenge for future research as we see it is to develop financing arrangements that will allow loggers to invest in highly productive, capital-intensive systems with some protection against business failures due to the vagaries of weather, unstable markets, mill closures, and other causes of unscheduled idle periods. A second challenge for research is to develop state-of-the-art systems that will increase productivity and lower production costs on the steeper, rougher timberlands.

Literature Cited

Anon. **Hay-powered logging on trial.** LIRA. Rotorua, New Zealand: Logging Institute Research Assn.; 1981; 6(3).

Adams, Thomas C. **Production rates in commercial thinning of young-growth Douglas-fir.** Res. Pap. PNW-41. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1967. 35 p.

Baumgras, John E.; LeDoux, Chris B. **Costs of harvesting forest biomass on steep slopes with a small cable yarder: results from field trials and simulations.** In: Proceedings, Third Southern Biomass Energy Research Conference; 1985 May 12–14; Gainesville, FL. Gainesville, FL: University of Florida, Center for Biomass Energy Systems; 1985.

Berti, Robert J. **An assessment of biomass harvesting on small woodlots in New Hampshire.** [Place of publication unknown]: [Publisher unknown]; 1984. 51 p.

Biller, Cleveland J.; Peters, Penn A. **Testing a prototype cable yarder for tree thinning.** Transactions of the ASAE. 25(4):901–905; 1982.

Biltonen, Frank E.; Hillstrom, William A.; Steinhilb, Helmuth M.; Goodman, Richard M. **Mechanized thinning of northern hardwood pole stands.** Res. Pap. NC-137. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1976. 17 p.

Bolstad, Kip; Sinclair, Steven A. **Larger, mechanized loggers score highest productivity.** Forest Industries. 107(12):48–49, 1981.

Brennan, Terry. **Horse logging—an alternative.** Northern Logger. 33(2):18–19; 1984.

Brock, Samuel M.; Jones, Kenneth D.; Miller, Gary W. **Costs of commercial thinning in yellow-poplar and upland oaks: a time study analysis for northern West Virginia.** [Unpublished manuscript on file at West Virginia University, Morgantown, WV.] 1984. 17 p.

Cubbage, Frederick W. **Machine rate calculations and productivity rate tables for harvesting southern pine.** Staff Pap. Series 24. St. Paul, MN: University of Minnesota; 1981. 16 p.

Davis, Lawrence S.; Pabst, Heiner R. **Hardwood pulpwood harvesting in western Virginia: costs and production requirements.** Res. Pap. 114. Blacksburg, VA: Virginia Polytechnic Institute and State University; 1966. 16 p.

Gochenour, Donald L., Jr.; Hartman, Robert L. **How wheeled skidders work on 40% hardwood slopes.** Canadian Forest Industries. 88(7):26–29; 1968.

Hoffman, Benjamin F. **Skidding with small tractors.** Northern Logger. 28(10):18-20; 1980.

Host, John; Schlieter, Joyce. **Low-cost harvesting systems for intensive utilization in small-stem lodgepole pine stands.** Res. Pap. INT-201. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1978; 20 p.

Huyler, Neil K. **The cost of thinning with a whole-tree chip harvesting system.** Northern Logger. 28(11):8-9, 14, 28-29; 1982.

Huyler, Neil K. **The production potential and cost of the Vermont cable yarder.** In: Proceedings, Industrial Wood Energy Forum '83; 1983 September 19-21; Nashville, TN. Madison, WI: Forest Products Research Society. [In press]

Huyler, Neil K.; Koten, Donald E.; Lea, Richard V.; Quadro, Anthony P. **Productivity and cost of three small fuelwood skidders.** Journal of Forestry. 82(11):671-674; 1984.

Johnson, James A.; Hillstrom, William A.; Miyata, Edwin S.; Shetron, Stephen G. **Strip selection method of mechanized thinning in northern hardwood pole size stands.** Res. Note No. 27. Houghton, MI: Michigan Technological University; 1979: 13 p.

Kochenderfer, J. N.; Wendel, G. W. **Skyline harvesting in Appalachia.** Res. Pap. NE-400. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1978. 9 p.

Leek, N. A.; Schaafsma, A. H. **Methods and productivity standards for skidding in thinnings.** Nederlands Bosbouw Tijdschrift. 53(10):315-321; 1981.

McMorland, Bruce. **Skidding with small crawler-tractors.** Tech. Rep. No. TR-37. Vancouver, B.C., Canada: Forest Engineering Research Institute of Canada; 1980. 89 p.

Matthes, R. Kenneth; Watson, William F.; Clair, Oliver A. **Production rate of rubber-tired cable skidders in Southern forests.** Presented at 1976 Winter Meeting of the American Society of Agricultural Engineers; 1976 December 14-17; Chicago, IL. St. Joseph, MI: American Society of Agricultural Engineers; 1982. 18 p.

Matthews, Donald Maxwell. **Cost control in the logging industry.** New York: McGraw-Hill; 1942. 374 p.

Miller, Gary W.; Sarles, Raymond L. **Costs, yields, and revenues associated with thinning and clearcutting 60-year-old cherry-maple stands.** Res. Pap. NE-582. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station. 1986; 8 p.

Miyata, Edwin S. **Determining fixed and operating costs of logging equipment.** Res. Pap. NC-55. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1980. 16 p.

Patric, J. H. **Harvesting effects on soil and water in the eastern hardwood forest.** Southern Journal of Applied Forestry. 2(3):66-73; 1978.

Putnam, Nathan E.; Kellogg, Loren D.; Olsen, Eldon D. **Production rates and costs of whole-tree, tree-length, and log-length skyline thinning.** Forest Products Journal. 34(6):65-69; 1984.

Ruault, Bob. **Small tractors successfully skid logs.** Journal of Logging Management. 10(7):2040-2042; 1979.

Sarles, Raymond L.; Whitenack, Kenneth R. **Costs of logging thinnings and a clearcutting in Appalachia using a truck-mounted crane.** Res. Pap. NE-545. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1984. 9 p.

Sinclair, Steven A.; Bolstad, Kip. **A profile of Minnesota loggers.** St. Paul, MN: Department of Forest Products, University of Minnesota. 39 p. [n.d.]

Stuart, William B.; Rossie, Michael K. **Production study of the Koller K300 cable yarder operating in the mountains of Virginia.** In: Proceedings, Mountain Logging Symposium; 1984 June 5-7; Morgantown, WV. Morgantown, WV: West Virginia University; 1984; 351-362.

Sundberg, Ulf. **Harvesting man-made forests in developing countries: a manual on techniques, roads, production and costs.** Rome: Food and Agriculture Organization of the United Nations; 1976. 185 p.

U.S. Department of Agriculture, Forest Service. 1978, 1979. **[Unpublished data on file at Forestry Sciences Laboratory, Princeton, WV.]**

Wartluft, Jeffrey L.; Sarles, Raymond L. **Fuelwood thinning—a marginal operation in West Virginia study.** Northern Logger. 30(12):16-17, 28-29; 1982.

Information cited in these tables was obtained from the following sources:

1 Anonymous 1981.

2 Adams 1967.

3 Baumgras and LeDoux 1985.

4 Berti 1984.

5 Biller and Peters 1982.

6 Biltonen and others 1976.

7 Brennan 1984.

8 Brock and others 1984.

9 Davis and Pabst 1966.

10 Hoffman 1980.

11 Host and Schlieter 1978.

12 Huyler 1982.

13 Huyler 1983.

14 Huyler 1984.

15 Johnson and others 1979.

16 McMorland 1980.

17 Matthes and others 1982.

18 Miller and Sarles 1985.

19 Putnam and others 1984.

20 Sarles and Whitenack 1984.

21 Stuart and Rossie 1984.

22 U.S. Department of Agriculture 1978, 1979.

23 Wartluft and Sarles 1982.

Appendix

Table 1.—Data for six horse logging operations

Type of logging system	Ref. No.	Location	Terrain (% slope)	Type of cut	Species	Mean stand dia.	Round-wood product harvested	Skid./yard. dist.	Load size per turn	Capital cost of equip.	Crew size	System cost per day	Production rate per day	Production rate per man-day	Cost per cord
Draft horse:						*in*		*ft*	*cord*	*$*		*$*	*cord*	*cord*	*$*
single	(22)	WV	mountain-ous	thinning	oak hickory	NA	tree lengths	NA	NA	1681	2	152.64	6.67	3.33	22.88
team	(1)	NZ	0 to 50%	thinning	radiata pine	NA	tree lengths	NA	NA	3362	3	242.40	9.22	3.07	26.29
team	(7)	PA	5 to 30%	selection	oak cherry	NA	sawlogs	100 to 1000[a]	.50 to .75[a]	2752	2	160.32	3.75 to 5.00[a]	1.87 to 2.50[a]	32.06 to 42.75[a]
single	(22)	WV	mountain-ous	loggers choice	oak hickory	NA	tree lengths	169[b] 400	.09	1681	2	152.64	6.87 4.31[c]	3.43 2.81[c]	22.22 35.42[c]
single	(9)	VA & WV	mountain-ous	commer-cial clear cut	oak hickory	NA	tree lengths	NA	NA	1681	2	152.64	6.49	3.24	23.52
single	(11)	MT	22%[b]	clearcut	lodgepole pine	6.4	tree lengths	164[b] 400	.20	2752[d]	2	160.32	6.75 4.45[c]	3.37 2.23[c]	23.75 36.03[c]

[a] Range of values.
[b] Mean value.
[c] Value when skidding 400 feet.
[d] Two horses used alternately.

Table 2.—Data for five mini-tractor logging operations

Type of logging system	Ref. No.	Location	Terrain (% slope)	Type of cut	Species	Mean stand dia.	Roundwood product harvested	Skid./yard. dist.	Load size per turn	Capital cost of equip.	Crew size	System cost per day	Production rate per day	Production rate per man-day	Cost per cord
Mini-tractor:						*in*		*ft*	*cord*	*$*		*$*	*cord*	*cord*	*$*
Pasquali 986 21 hp	(10)	ME	level but w/ undulating surface	thinning	spruce aspen	NA	tree lengths	400	.21	10989	2	171.04	4.78	2.39	35.78
Pasquali 991 24 hp	(23)	WV	mountainous	thinning	oak hickory	7.1	tree lengths	400	.17	11489	2	179.20	4.87	2.43	36.80
Pasquali 993 30 hp	(14)	NY	0 to 14% slopes w/ scattered rock outcrops	thinning	oak hickory	8.6	tree lengths	400	.25	14467	2	195.76	5.52	2.76	35.46
Forest Ant 12 hp	(14)	NY		thinning	oak hickory	8.4	tree lengths	400	.38	12710	2	182.56	6.88	3.44	26.53
Holder A60 48 hp	(14)	NY		thinning	oak hickory	8.6	tree lengths	400	.53	36177	2	271.84	13.36	6.68	20.35

Table 3.—Data for eight crawler-tractor logging operations

Type of logging system	Ref. No.	Location	Terrain (% slope)	Type of cut	Species	Mean stand dia.	Roundwood product harvested	Skid./yard. dist.	Load size per turn	Capital cost of equip.	Crew size	System cost per day	Production rate per day	Production rate per man-day	Cost per cord
						in		*ft*	*cord*	*$*		*$*	*cord*	*cord*	*$*
Crawler tractor:															
42 hp	(23)	WV	0 to 33%	thinning	oak hickory	7.1	tree lengths sawlogs	351[a] 400	.39	43345	2	248.96	9.44 9.18[b]	4.72 4.59[b]	26.37 27.12[b]
50 hp	(2)	WA	0 to 40%	thinning	Douglas-fir	13.4	long logs (28′-40′)	400	1.47	47375	2	260.96	27.46	13.73	9.50
65 hp	(2)	WA	0 to 40%	thinning	Douglas-fir	13.4	long logs (28′-40′)	400	2.45	51405	2	273.44	27.11	13.55	10.09
65 hp	(22)	WV	0 to 65%	thinning	cherry maple	NA	tree lengths	166[a] 400	.38	51405	2	273.44	19.01 11.76[b]	9.50 5.88[b]	14.38 23.25[b]
65 & 78 hp	(16)	Interior BC	0 to 80%	thinning	lodgepole pine	NA	tree lengths	400	1.32	57550[c]	2	288.96	24.77	12.38	11.66
78 hp	(22)	WV	0 to 37%	loggers choice	white pine	NA	tree lengths	217[a] 400	.79	63696	2	305.76	40.76 29.29[b]	20.38 14.64[b]	7.50 10.44[b]
42 hp	(22)	WV	0 to 23%	diameter limit	oak hickory	NA	tree lengths	235[a] 400	.56	43345	2	248.96	33.89 22.46[b]	16.94 11.23[b]	7.35 11.08[b]
42 hp	(9)	VA & WV	mountainous	commercial clear-cut	oak hickory	NA	tree lengths	NA	NA	43345	2	248.96	12.97	6.48	19.20

[a] Mean value.
[b] Value when skidding 400 feet.
[c] Price of 65 and 78 hp tractors averaged.

Table 4.—Data for ten cable-skidder logging operations

Type of logging system	Ref. No.	Loca-tion	Terrain (% slope)	Type of cut	Species	Mean stand dia.	Round-wood product harvested	Skid./yard. dist.	Load size per turn	Capital cost of equip.	Crew size	System cost per day	Production rate per day	Production rate per man-day	Cost per cord
						in		*ft*	*cord*	*$*		*$*	*cord*	*cord*	*$*
Cable skidder:															
90 hp	(8)	WV	mountain-ous	thinning	oak hickory	7.5	tree lengths	650[a] 1000	1.13	56730	2	343.20	30.80 20.02[b]	15.40 10.01[b]	11.15 17.14[b]
90 hp	(18)	WV	0 to 10%	thinning	cherry maple	6.0	tree lengths	500[a] 1000	1.53	56730	3	389.36	20.96 19.91[b]	6.99 6.64[b]	18.58 19.56[b]
90 hp	(22)	WV	0 to 36%	thinning	cherry maple	NA	tree lengths	450[a] 1000	.70	56730	3	390.24	21.98 16.43[b]	7.33 5.48[b]	17.75 23.75[b]
90 hp	(22)	WV	0 to 23%	thinning	cherry maple	NA	tree lengths	912[a] 1000	.72	56730	3	391.12	17.41 16.61[b]	5.80 5.53[b]	22.47 23.55[b]
90 hp	(22)	WV	0 to 45%	selection	oak hickory	NA	tree lengths	876[a] 1000	1.04	56730	2	334.00	19.83 19.68[b]	9.91 9.84[b]	16.84 16.97[b]
90 hp	(22)	WV	0 to 26%	diameter limit	oak hickory	NA	tree lengths	808[a] 1000	1.62	56730	2	334.00	36.98 30.22[b]	18.49 15.11[b]	9.03 11.05[b]
75 hp	(17)	MS	flat to hilly	commer-cial clearcut	S. pine & hard-woods	Total pine & hard-wood merch. & non-merch. range	tree lengths	800[a] 1000	NA	49410	2	298.96	24.94 22.85[b]	12.47 11.42[b]	11.99 13.08[b]
100 hp	(17)	MS	flat to hilly	commer-cial clearcut	"	2.5 to 13.0	tree lengths	800[a] 1000	NA	58255	2.5	375.42	29.09 27.02[b]	11.64 10.81[b]	12.91 13.89[b]
125 hp	(17)	MS	flat to hilly	commer-cial clearcut	"		tree lengths	800[a] 1000	NA	74420	3	458.00	33.25 30.65[b]	11.08 10.22[b]	13.77 14.94[b]
70 hp	(11)	MT	19%[a]	clearcut	lodgepole pine	6.4	tree lengths	254[a]	.59	49410	2	294.16	8.64	4.32	34.04

[a] Mean values.
[b] Values when skidding distance is 1000 feet.

Table 5.—Data for nine grapple-skidder logging operations

Type of logging system	Ref. No.	Loca-tion	Terrain (% slope)	Type of cut	Species	Mean stand dia.	Round-wood product harvested	Skid./yard. dist.	Load size per turn	Capital cost of equip.	Crew size	System cost per day	Production rate per day	Production rate per man-day	Cost per cord
						in		*ft*	*cord*	*$*		*$*	*cord*	*cord*	*$*
Grapple skidders: (plus mechan.-fallers)															
2-90 hp	(4)	NH	flat	thinning (in a plan-tation)	white pine	8.2	whole trees	725[a]	.59	184220	3	809.52	67.58	22.53	11.97
2-90 hp	(4)	NH	3 to 15%	"	red pine	7.3	whole trees	650[a]	.96	184220	3	809.52	72.90	24.30	11.07
2-120 hp	(4)	NH	flat	"	red pine	10.1	whole trees	1250[a]	1.01	277100	3	941.20	68.97	22.99	13.65
2-120 hp	(4)	NH	0 to 30%	salvage & thinning (nat. stand)	mixed hard-woods	7.4	whole trees	1500[a]	NA	277100	3	941.20	49.70	16.57	18.94
3-120 hp	(4)	NH	3 to 15% (rocky)	weed & thinning (nat. stand)	mixed northern hard-woods	7.8	whole trees	600[a]	1.25	382100	4	1259.44	71.72	23.91	17.56
2-120 hp	(4)	NH	flat	clearcut (nat. stand)	white pine	8.4	whole trees	400[a]	1.48	266686	3	897.60	111.52	37.17	8.05
144 hp	(6)	MI	flat	thinning	maple	9.2	whole trees	1518[a]	.89	183000	2	572.80	53.12	26.56	10.78
152 hp	(15)	MI	flat	thinning	maple elm	9.2	whole trees	321[a]	1.66	297354	2	854.18	95.82	62.38	8.91
152 & 110 hp	(12)	VT	5 to 25% but mostly 8 to 10%	thinning	northern hard-woods	9.2	whole trees	2657[a]	1.79	325710	3	861.84	52.63	17.54	16.38

[a] Mean skidding distance.

Table 6.—Data for nine cable-yarder logging operations

Type of logging system	Ref. No.	Location	Terrain (% slope)	Type of cut	Species	Mean stand dia.	Roundwood product harvested	Skid./yard. dist.	Load size per turn	Capital cost of equip.	Crew size	System cost per day	Production rate: per day	Production rate: per man-day	Cost per cord
						in		*ft*	*cord*	*$*		*$*	*cord*	*cord*	*$*
Cable yarders:															
A. Jammers															
Appalachian thinner	(5)	WV	40 to 70%	thinning	oak hickory	NA	tree lengths	134[a]	.28	63279	5	487.76	15.68[b]	3.14[b]	31.11[b]
Truck-mounted crane	(20)	WV	≤ 35%	thinning	cherry maple	6.5	tree lengths	150[a]	.28	16277	3	250.64	21.52	7.17	11.65
B. Skyline yarders															
Vermont	(13)	VT	20 to 55%	thinning	northern hardwoods	8.5	tree lengths	377[a]	.22	35460	3	256.40	11.07	3.69	23.16
Skagit SJ2	(19)	OR	5 to 50%	thinning	Douglas-fir	12.8	log lengths	600[c]	.32	74693	6	610.88	16.96	2.83	36.02
Koller K300	(21)	VA	20 to 40%	commercial clearcut	oak	10 to 12	tree lengths	328[a]	.45	43200	4	397.84	22.67	5.67	17.55
Bitterroot	(3)	KY	mountainous	residue relogging	oak yellow-poplar	7.5	tree lengths & logs up to max. of .26 cd.	285[a]	.12	22080	3	275.68	11.89	3.96	23.19
C. Skyline yarders w/swing operations															
Skagit SJ2	(19)	OR	5 to 50%	thinning	Douglas-fir	12.8	tree lengths & whole trees	600[c]	.32	124103	7	842.32	17.93	2.56	46.98
Koller K300	(21)	VA	20 to 40%	commercial clearcut	oak	10 to 12	tree lengths	328[a]	.45	116620	4	615.52	22.67	4.53	27.15
Bitterroot	(3)	VA	15 to 40%	clearcut	oak hickory	NA	tree lengths & logs up to max. of .26 cd.	208[a]	.13	72875	6	592.80	11.64	1.94	50.93

[a] Mean yarding distance.
[b] Includes bucking and decking.
[c] Maximum yarding distance.

Table 7.—A selection guide for methods of log and tree extractions, given a range of terrain and soil conditions in temperate forests[a]

Terrain and Soil Conditions				Skidding and Yarding Extraction Methods[b]						
Steepness[c]	Ground roughness[d]	Relative traction capacity[e]	Slope direction	Horse	Mini-tractor	Crawler tractor	Cable skidder[f]	Grapple skidder[f]	Jammer[g]	Skyline yarder[g]
Slopes $\leq$ 10%	smooth to rough	good	uphill	X[h]	XX[i]	XX	XX	XX		
		bad	uphill	X	X	XX	XX	XX	XX	XX
	very rough	good	downhill	X		X	XX	XX	XX	XX
		bad	downhill	X		X	XX	XX	XX	XX
Slopes 11% to 50%	smooth to rough	good	uphill		X < 15%	XX < 35%	XX < 25%	XX < 25%	XX	XX
		bad	uphill			X < 25%	XX < 20%	XX < 20%	XX	XX
		good	downhill	XX < 30%	XX < 25%	XX	XX < 40%	XX < 30%		X
		bad	downhill	X < 30%	X < 15%	X	X < 40%	X < 30%		X
	very rough	good	uphill			X < 35%	X < 25%	X < 25%	XX	XX
		bad	uphill			X < 25%	X < 20%	X < 20%	XX	XX
		good	downhill	X < 30%		X	X < 40%	X < 25%		X
		bad	downhill			X	X < 40%			X
Slopes > 50%	smooth to rough	good	uphill						XX	XX
		bad	uphill						XX	XX
		good	downhill			XX < 60%				X
		bad	downhill							X
	very rough	good	uphill						XX	XX
		bad	uphill						XX	X
		good	downhill			X < 60%				X
		bad	downhill							

[a] Adapted from scheme by Rudolf Meyr in Sundberg 1976.
[b] When operating with normal loads.
[c] Refers to slopes longer than 150 feet; short slopes and pitches disregarded.

[d] Refers to the occurrence or lack of obstacles more than 20 inches high; very rough includes numerous obstacles less than 10 feet apart.

[e] "Good" refers to friction soils; "bad" to cohesive soils. Practical local experience, taking into account season and precipitation, is included in this classification.

[f] Operating on adequately prepared skid roads.

[g] These methods are designed for steep, rough slopes. On flat group or moderate slopes, they are suitable only if ground skidding is impractical, uneconomical, or restricted for environmental reasons.

[h] X—Operations are suitable under stated conditions.
[i] XX—Operations are possible under stated conditions.

Sarles, Raymond L.; Luppold, William G. **Technoeconomic analysis of conventional logging systems operating from stump to landing.** Res. Pap. NE-577. Broomall, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station; 1986. 23 p.

Analyzes technical and economic factors for six conventional logging systems suitable for operation in eastern forests. Discusses financial risks and business implications for loggers investing in high-production, state-of-the-art logging systems. Provides logging contractors with information useful as a preliminary guide for selection of equipment and systems. Discusses economic effects of harvesting systems on future stumpage prices and longrun supply of roundwood material.

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