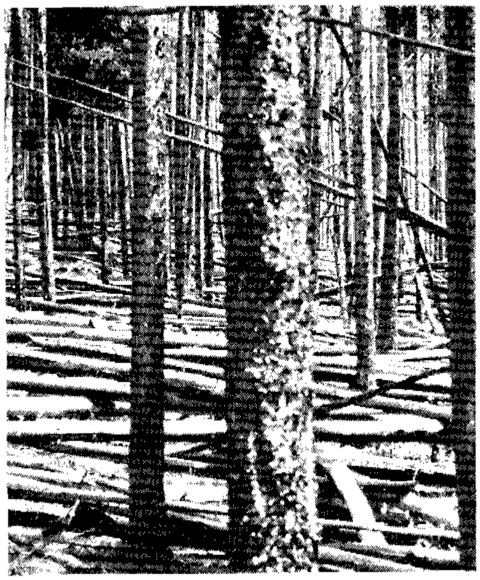
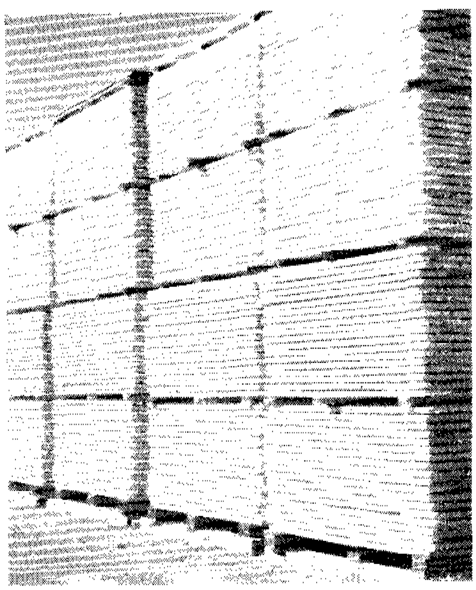
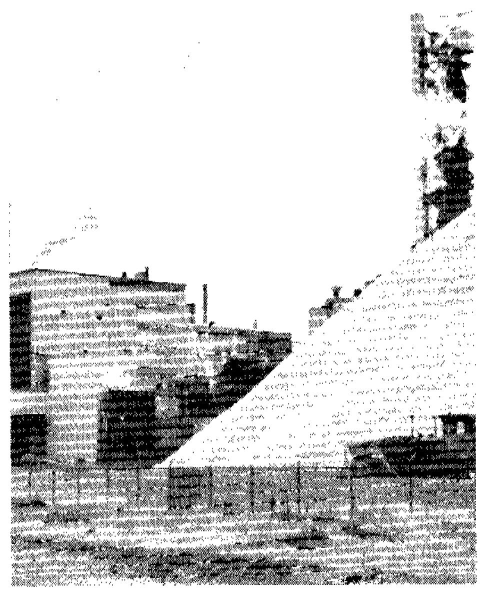
HARVESTING AND UTILIZATION OPPORTUNITIES FOR FOREST RESIDUES in the northern rocky mountains







Symposium Proceedings Nov. 28-30, 1979, Missoula, Mont.

USDA Forest Service General Technical Report INT-110
Intermountain Forest and Range Experiment Station
U.S. Department of Agriculture, Forest Service

USDA Forest Service
General Technical Report INT-110
March 1981

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Sponsored by:

Intermountain Forest and
Range Experiment Station,
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INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
U.S. Department of Agriculture
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Ogden, Utah 84401

EVALUATING IN-WOODS CHIPPING FEASIBILITY

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ABSTRACT

Economic analysis of data from a demonstration test showed that in-woods debarking-chipping was only marginally competitive with conventional methods of harvesting roundwood for pulp chips. The future for in-woods chipping appears to be whole tree chipping. Cost of delivered chips may not be much different from conventional roundwood systems unless credits are taken for increased utilization and slash disposal.

KEYWORDS: chipping machines, logging economics

In-woods chipping has received attention as an inexpensive means of producing pulp chips. Today, there is interest in using in-woods chipping in producing wood for energy. Whatever the intended use of the product, the technical and economic feasibility of in-woods chipping should be carefully evaluated before a commitment is made.

In 1973 the Rocky Mountain Forest and Range Experiment Station and National Forest and Range Experiment Station and National Forest System Regions 2 and 3 (Rocky Mountain and Southwestern), Four Corners Regional Commission, and Southwest Forest Industries, Inc. cooperated in a demonstration test of in-woods chipping. This paper presents an evaluation of the test results and uses the results to predict the future of in-woods chipping. The details of the demonstration test were reported in three published papers (Markstrom, Worth, and Garbutt, 1977; Sampson and Worth, 1976; Sampson, Worth and Donnelly, 1974).

IN-WOODS CHIPPING DEMONSTRATION TEST

The demonstration of in-woods chipping was a summer-long test in Arizona and Colorado. The chips produced were to be used for pulp. The receiving mill required that the chips be essentially bark-free.

System Used

The portable debarking-chipping machine used in the demonstration test was the Nicholson Logger Model Utilizer.1/ Trees were felled, limbed, and bucked with chainsaws by contract cutters, then bunched and skidded with rubber-tired and tracked skidders. Logs were stacked at the landing, partially by the skidders, and partially by a front-end loader. The self-loading debarker-chipper usually worked from a cold deck, although occasionally logs were skidded directly to it. Chips were blown directly into chip vans which hauled the chips either to the pulp mill or to a rail transfer point.

Study Area

The Arizona study area was part of an ongoing multiproduct sale in uneven-aged ponderosa pine timber marked for partial cutting. Sawtimber tops and trees smaller than sawtimber size (12 inches dbh) were being taken for pulpwood. Sawlogs and pulpwood were bucked at the stump and were skidded and decked together. Sawlogs were loaded and hauled from the decks leaving the pulpwood to be debarked and chipped at the landings. Some reskidding and consolidation of the pulpwood was necessary to obtain sufficient volumes in individual log decks. Chip haul distance from the woods to the pulp mill was about 75 miles.

The Colorado study area was an Engelmann spruce-subalpine fir tract marked for silvicultural thinning. It had been logged for sawtimber more than a year earlier. This area had a large volume of down and standing dead timber. All dead timber that was judged to be at least 50 percent sound was brought in along with the spruce-fir thinnings. Chips produced at the Colorado study area were truck hauled 146 miles to Gallup, New Mexico and reloaded on railroad cars for shipment the last 116 miles to the pulp mill.

Initial Concerns

Early questions about the feasibility of in-woods debarking-chipping were segregated into environmental concerns and economic concerns. While preliminary analyses had indicated in-woods debarking-chipping should be economically feasible, some problems were expected in the environmental realm.

ENVIRONMENTAL CONCERNS

It was expected that in-woods debarking-chipping would result in increased utilization and hence more wood removed per acre, but it was anticipated there would be little difference between the proposed system and conventional multi-product harvesting systems up to the point of debarking-chipping. Adverse environmental impacts from this part of the operation were not a major concern. However, there was concern about the size of forest openings necessary to accommodate the log deck, the debarker-chipper, chip vans, and turn around areas.

1/ The use of trade, firm, or corporation names does not constitute an official endorsement of or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others which may be suitable.

Another major environmental concern was possible soil sterilization (nitrogen starvation) caused by disposing of bark on site. We developed data showing the bark depths that would likely occur if the bark were uniformly spread around the landing. However, there was no previous research which could be used to accurately predict the biological effects of spreading the bark and leaving it.

ECONOMIC CONCERNS

While it was anticipated that actual debarking-chipping cost would be slightly higher in the woods than at a permanent installation, it was believed that lower costs in the other functions would more than offset this. Under the in-woods operation, measuring and bucking to bolt lengths could be eliminated, allowing some efficiency in limbing and bucking, and utilization could be improved slightly. Skidding is affected only slightly because volume per turn is increased by about 1 percent. With in-woods debarking-chipping, loading of roundwood is eliminated. Also, hauling of bark (10 to 12 percent of the volume) is eliminated. Offsetting these advantages in part, chip vans are slightly less maneuverable on forest roads than log trucks, which increases haul time.

Considering all functions except debarking-chipping, it was estimated that the in-woods system should provide a cost advantage of $0-$5.00 per bone dry unit. (A bone dry unit is 2,400 pounds of chips at zero moisture content.) At that time, the assumed mill chipping cost was $3.20 per unit. Thus, an in-woods debarking-chipping cost of $8.20 or less per unit should result in an overall cost that could be competitive with the conventional system. Preliminary analyses had indicated an in-woods cost of $5-$6.00 per unit.

Methods

During the demonstration test, most effort was devoted to monitoring the operation of the debarker-chipper. The nature of the environmental concerns was such that numerical data could not be taken for analysis. Instead, general observations were made about environmental problems identified earlier.

Detailed data were taken on the debarking-chipping operation throughout the demonstration test period. Planned starting and stopping times were recorded each day. Delays of one minute duration or longer were noted along with the cause. Estimated dimensions of each piece chipped (end diameters to the nearest inch and length to the nearest foot) were recorded. Taking such detailed data was important for a fair analysis to be made.

To determine probable costs under improved conditions, estimates of production when the machine as actually operating were developed and then realistic delays representing optimum conditions were applied. The debarker-chipper's production was significantly affected by the lineal feed rate and the rate at which the operator loaded individual pieces onto the machine. The mechanics of the debarking operation required that only one piece could be processed at a time, and design of the machine resulted in a 6-foot space between pieces as they fed into the debarker. A computer simulation model incorporationg these characteristics was developed to predict chipping rate for various loading rates using data from the logs actually chipped as input.

Results

ENVIRONMENTAL IMPACTS

In the ponderosa pine type the landing sizes that resulted were acceptable to forest managers. Ten landings were used for chipping in the ponderosa pine type with an average of 48 units of chips produced at each landing. Landing sizes were, at the largest, 215 feet by 55 feet and were about what had been predicted. The open nature of the ponderosa pine type made the landings unobtrusive. In the spruce-fir type in Colorado, only one landing was used for producing the 421 units of chips. This landing was on a hill top which was not forested. Landings as large as those in the ponderosa pine type might have an adverse esthetic impact in some areas of dense spruce-fir.

Bark disposal was probably the environmental factor of greatest concern to forest managers prior to the field test. In the ponderosa pine type, bark was spread on the landing and in the adjacent residual timber stand by a front-end loader. After the debarking-chipping operation, it was not apparent that any bark had been spread, however, and further study of the long range effects of spreading the bark was not considered necessary. In the spruce-fir type, the bark was piled adjacent to the landing where it remained until after the field test, when it was spread on the landing with no apparent detrimental effect.

ECONOMIC ANALYSIS

Actual chip production averaged only 15 bone dry units per day over the 63 working day period for the debarker-chipper. At this rate, the cost of chipping alone would be about $38 per unit. However, the 63 day period included much time lost to various kinds of mechanical and logistic delays, some of which should be eliminated or reduced in an ongoing operation.

Excluding all delays, production rates were 7.9 bone dry units per net operating hour in Arizona and 7.6 units in Colorado (points A and B, respectively fig. 1). Maximum production was only about two-thirds of what had been predicted in the analysis done before the demonstation test. The debarking-chipping costs per bone dry unit for net production rates are shown in figure 2.

The abscissa scale of figure 2 is in terms of R and the different curves represent four combinations of the remaining variables as shown below:

Curve	T	U	M
Arizona (actual)	0.54	48	1.08
Colorado (actual)	0.54	-	None
Arizona (potential)	0.80	48	0.40
Colorado (potential)	0.80	-	None

For each curve it was assumed H (time per day available for chipping or moving) = 7.5.

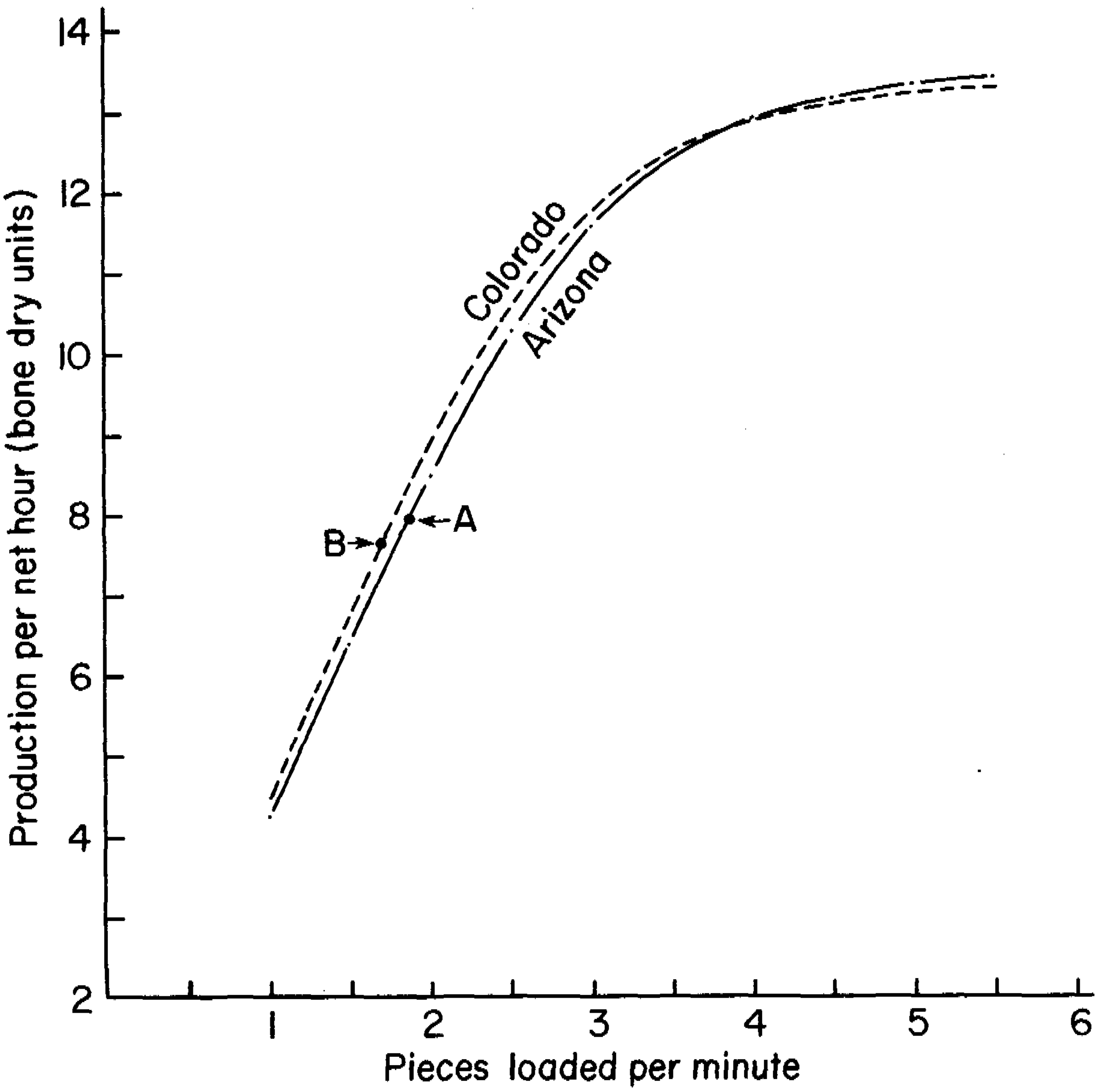

Figure 1.--Theoretical chipping rate in bone dry units per net hour at a feed rate of 85 feet per minute for actual pieces chipped.

The Arizona (actual) curve represents conditions similar to those that would have been encountered on the Arizona test area if startup problems and weather delays were eliminated. Point A on this curve represents the 7.9 bone dry units per net production hour experienced in actual operation. The Colorado (actual) curve represents conditions that would have been encountered in the Colorado test without startup and weather delays. Point B on this curve represents the 7.6 bone dry units per net production hour experienced during the field test. Moving time was not deducted since all production was at a single landing.

Curves Arizona (potential) and Colorado (potential) portray production and cost levels that would be achievable by increasing the porportion of net operating time from 54 to 80 percent and for curve Arizona (potential) decreasing the average time for moving the chipper from 65 to 24 minutes (Colorado (potential) assumes no moving). Points C and D, on these curves represent production when production per net hour is 11 bone dry units, which is probably near the maximum possible production for the size of pieces being chipped.

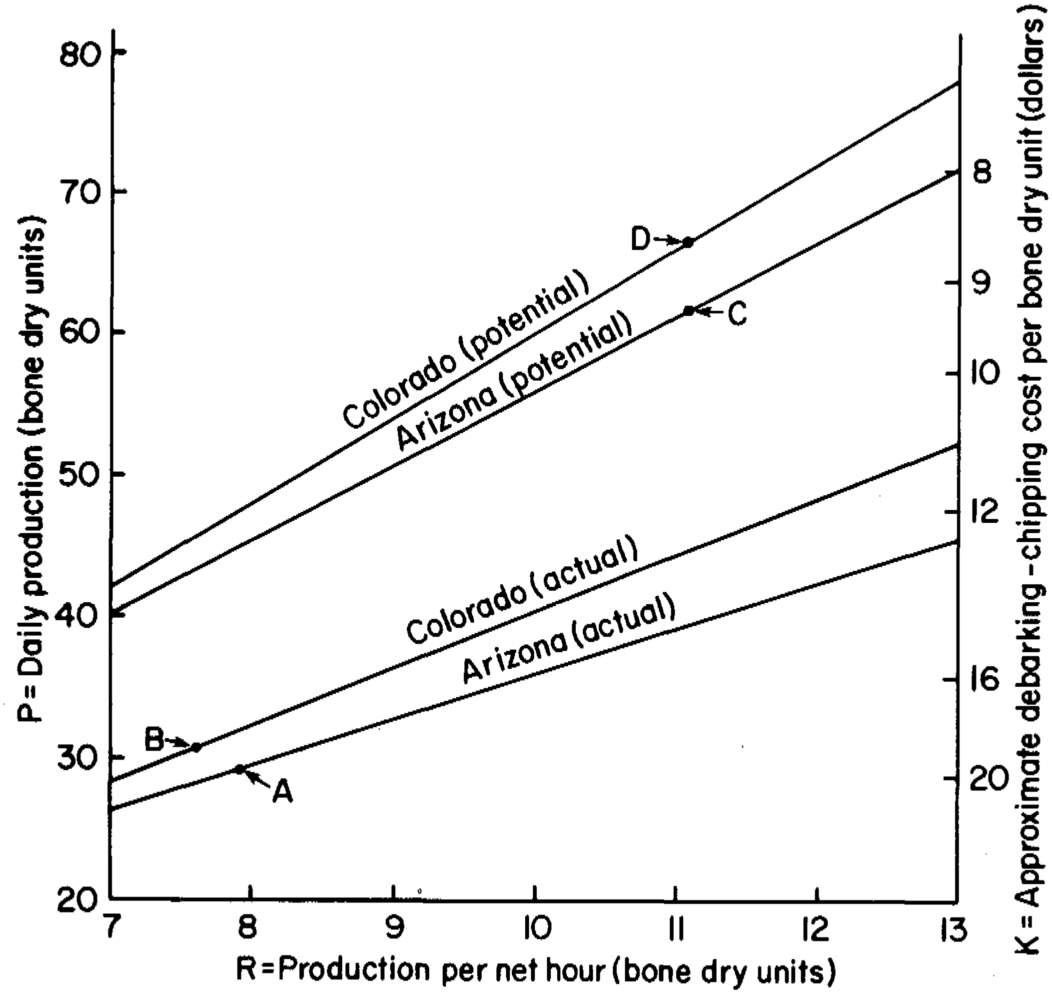

Figure 2.--Daily chip production and approximate cost by net production rate, size of log deck, proportion of available time in production, and moving time between log decks.

Daily productivity and cost are based on the following:

$$\text{Time per log deck} = \frac{U}{R\,T} + M$$

and

$$\text{Log decks per day} = \frac{H +}{\frac{U}{R\,T} + M}$$

Thus the equations for the two ordinate (vertical) scales of the curves in figure 2 are given by:

$$P = \left[\frac{H}{\frac{U}{R\,T} + M}\right] U \text{ or } P = \frac{HRT}{1 + \frac{MRT}{U}} \text{ and } K = \frac{572.16}{P}$$

Where: P = daily production in units of chips.

H = hours per day available for chipping and moving the machine.

R = units of chips produced per net production hour.

T = percent of time available for chipping that the machine is actually in production, expressed as a decimal.

M = moving time (in hours) between decks.

U = number of bone dry units per deck.

K = cost per bone dry unit.

572.16 = average daily cost of operating the debarker-chipper system, in dollars.

Conclusions

The conclusion we reached after this study was that in-woods debarking-chipping, at best, was only marginally competitive with producing chips from stem wood transported to the mill. We also recognized that a promising way to lower chip costs was to eliminate the requirement for debarking. There is no doubt that whole-tree chipping can deliver chips to the mill at a lower cost than in-woods debarking-chipping. Disadvantages of whole-tree chipping are: possible greater damage to the residual stand during harvesting, possible long term growth potential reduction due to nutrient depletion, and cost of bark separation if bark cannot be tolerated in processing and use of the chips for pulp or fuel.

ECONOMIC COMPARISON OF CHIPPING SYSTEMS

Cost comparisons among chipping systems are difficult because of the scarcity of data and the variation among situations encountered. The subjective comparison we developed was based on our experience of in-woods debarking-chipping of stem wood, conventional debarking-chipping of stem wood at the mill, and whole tree chipping in the woods. The cost for each function within the conventional system was assigned the index value of 1.0. A comparative index number was developed for each function in the other two chipping systems (table 1). Cost comparisons of the three systems were then developed.

The productivity of the in-woods debarking-chipping system was assumed to be equivalent to point C on figure 2. The ratio of at-plant chipping costs to in-woods debarking-chipping costs was assumed to be the same as that determined during the 1973 study. Current average costs for felling, limbing, and bucking, skidding, and loading pulpwood applied to timber sales by Forest Service Region 2 were used (United States Department of Agriculture, Forest Service, 1979). Chipping costs at a mill were estimated after consulting several sources (Bonneville Power Administration, U.S. Forest Service, Pacific Northwest Region and Pacific Northwest Region and Pacific Northwest Forest and Range Experiment Station, 1979[2/], Folkema, 1977: U.S Forest Service, North Central Forest Experiment Station, 1978). Hauling costs were assumed to be 8.8 cents per ton mile for logs. Extra handling costs were included for log handling when chipping was done at the mill. For whole tree chipping, extra costs were included for bark and wood separation (which might not be necessary depending on the use to be made of the chips). The results are graphed in figure 3.

Conclusions

For the costs used, whole tree chipping was comparable with conventional roundwood harvesting with chipping at the plant. If barky chips can be used, the bark and chip separation cost can be eliminated, making whole tree chipping even more attractive. The cost of whole tree chipping can be reduced even further if credits can be taken for removing material that would otherwise have to be piled and burned or removed in some other manner.

2/ Bonneville Power Administration Branch of Power Resources and U.S. Forest Service Pacific Northwest Region and Pacific Northwest Forest and Range Experiment Station, 1979. Progress report, feasibility of a forest residue power plant. Unpubl. Rep. 14 p + app. Bonneville Power Admn. Portland, Ore.

Table 1. Cost comparison index for harvesting/chipping systems

FUNCTION	SYSTEM		
	At-plant	In-woods	
	Debark and chip stem wood	Debark and chip stem wood	Chip whole tree
	- - - - - -cost index- - - - - -		
Fell, limb and buck	1.00	.65	0.40
Skid	1.00	1.05	1.20
Load	1.00	0.00	0.00
Chip	1.00	2.70	1.50
Haul	1.00	0.90	1.05
Extra handling	1.00	0.00	2.00

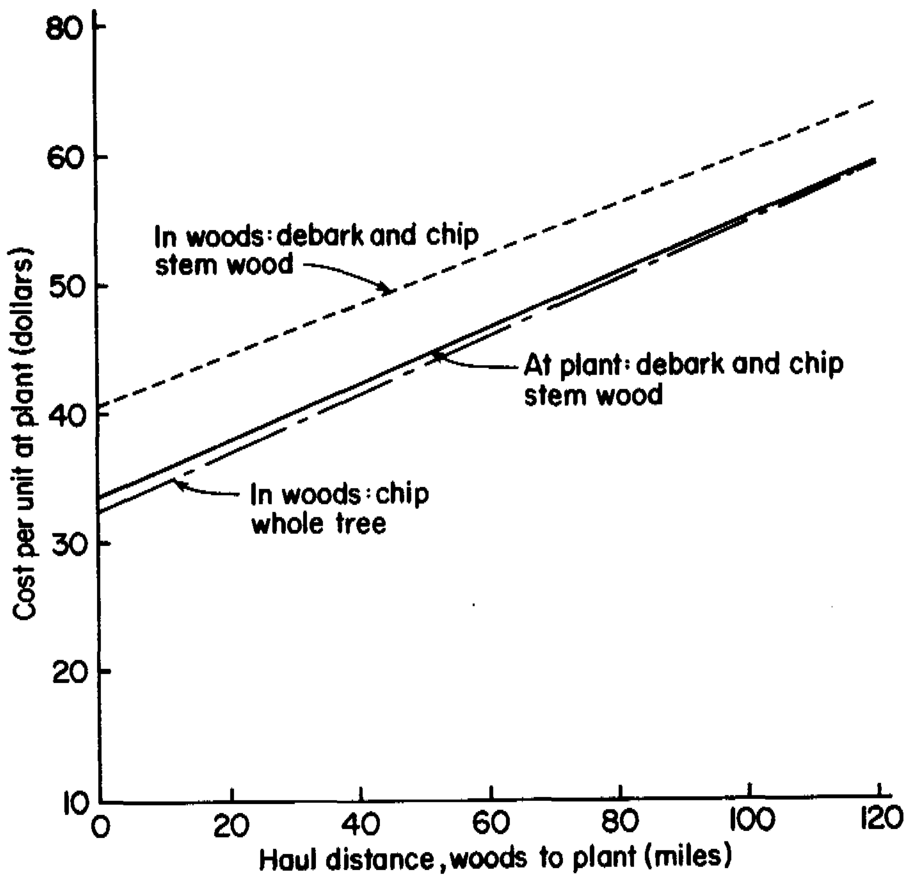

Figure 3.--Cost comparisons for harvesting/chipping systems for short haul distances.

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