IMPLEMENTINGHEALTH IMPROVEMENT CUTTINGS IN CONIFER STANDS IN SOUTHWESTERN HIGHLANDS

by

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ABSTRACT

This study evaluated the costs of mechanized harvesting systems being used on forest health improvement projects on the Mescalero Reservation in New Mexico. Three feller bunchers with diiering slope capabilities were used. Grapple skidders delivered whole trees to a flail/chipper for processing into pulp quality chips.

Key Words: Harvesting, Flail, Chipping, Forest Health, Thinning

INTRODUCTION

The Forestry Department of Mississippi State University, the U. S.F. S. Forest Engineering Project at Auburn Alabama and the Bureau of Indian Affairs entered into a cooperative study to gain a better understanding of the factors influencing productivity, cost and utilization in the woodlands chipping operations working on the Mescalero Reservation in New Mexico. Woodlands chipping crews have been employed to carry out forest health projects on the Mescalero Reservation over the past few years. A thinning silvicultural treatment is being carried out where basal area on the forested site is being reduced, and dying trees and trees highly susceptible to mortality are being harvested.

This study consisted of several components that were carried out simultaneously. Three test blocks were established to monitor actual removals and machine utilization required to harvest the block. This data was used to estimate the actual cost of harvesting each block and to verify the accuracy of utiiization predictors. Concurrently, intensive time and motion studies were conducted on the various machines utilized in the woodlands chipping operations. This information was used to develop production predictors for the machines under varying conditions.

HARVESTING SYSTEM

The harvesting system being utilized on the Mescalero Reservation was centered around the use of a flail/chipper to delimb, debark and convert the roundwood into pulp quality chips to be used by Stone Container at their pulp mill in Snowflake, Arizona. The flail/chipper unit observed in this study was a Peterson-Pacific 5000.

The trees were felled using several different machines. A self-leveling excavator type track machine (Timbco Feller Buncher) was used on the steepest slopes. A tri-trac wheel machine (Hydro Ax 12 1) was used on the least severe slopes. During the course of this study, an intermediate sized track machine (Wolverine Feller Buncher) was introduced in the operation and was studied on intermediate slopes.

The transport of the felled trees fi-om the stump to the flail/chipper was carried out with rubber-tired grapple skidders. Timberjack 450 and 380 models were in use in this operation.' A Caterpillar D7H dozer was used in the operation to move debris from the. flail/chipper.

Sawlogs were bucked out of the larger stems removed during the study. This was carried out with chainsaws. The dozer operator would work in the bucking operation when he was not piling flail rejects.

The approximate replacement prices and the estimated ownership and operating costs of the various machines are reported in Table 1. The machine costs estimates were calculated using methods reported by Brinker, Miller, Stokes and Lanford (1989). In addition to the owning and operating costs, a loaded labor rate of $16.00 per hour was assumed for each machine.

TEST BLOCKS

The test blocks for the study were located just off of State Highway 24 about 10 miles south of U.S. 70. Foresters with the Mescalero Agency, Branch of Forestry established the block boundaries and determined the acreage in each block. They also conducted a cruise of each of the test blocks. Line plot cruise methods were employed with the plot size being 0.1 acres. The data collected in the cruise included the species, diameter at breast height, total height, and if marked for cut or leave for each tree of 4 inches or larger, DBH, on the plot. The slope at point center was also recorded for each plot. A summary of descriptive information on each block is contained in Table 2. Weight prediction. equations were prepared in an earlier study and were used to estimate the weight of the trees that would be removed. The estimattd weight to be removed is shown for each block in Table 3.

PRODUCTION STUDIES

Prior to any machine entering a test block, a Servis Recorder was mounted on each machine to be used in harvesting the block. A fresh disc was installed on the Servis recorder as a machine started operation on a test block and the disc was removed when a machine completed operation on a block. Labor hours were also recorded for each machine on each test block.

An observer was assigned to monitor the flail/chipper during the entire study. The observer recorded the actual time required for the flail/chipper to fully load each van. This observer also recorded the number of stems of each species that were processed and included in each van. Stems which had a sawlog removed were tallied separately. The dimensions of the logs bucked out were recorded and the weight of these logs was estimated using tables prepared in the earlier study. The amount of wood in each log was estimated by reducing each log's weight by the bark content observed in the previous study. The observer also noted the trip ticket issued for each van of chips loaded from each test block. The weight of the load for each van was obtained from records of van weights at the Snowflake facility. A summary of the stem counts and weight of the stems processed by the flail/chipper is reported in Table 4.

The cost information from Table 1 was combined with the observations on machine hours and labor time to give an estimate of the cost of harvesting each test block. This information is summarized in Table 5.

Note that Block 1 had the steepest slope contributing to its high cost; especially for the felling and skidding components. Block 2 had an unusually long skid distance leading to a high cost of skidding. The harvested stems from Block 3 were mostly ponderosa pine which processed through the flail/chipper easily and have high chip yield, hence chipping cost was least for this block.

PRODUCTION STUDIES

Flail/Chipper

Data was collected on the number of stems of each species processed in each load of chips. The number of logs that were bucked out was also recorded along with the weight of chips in the load. The best predictor for the time (in minutes) to process a load of chips was :

$$Time = 27.2 + 0.909(NumberSawlogs)$$

with r^2=68.4% and with both coefficient significantly different from zero at the .05 level. This means that almost one additional minute was added to the time to fill a chip van for each sawlog that was bucked from a stem delivered to the flail chipper. The cost of the flail/chipper processing these stems would be $2.41 per stem when the machine and operator's time is accounted for. The best predictor of productivity (in tons of chips produced per operating hour) for the flail/chipper was:

$$Productivity = 50.9 - 0.558(NumberSawlogs)$$

with r^2=18.6% and the coefficient for the number of sawlogs handled being significantly different from zero at the .074 level.

Felling

Detailed time studies were carried out on each of the three feller bunchers used in the study. Part of the time study on the Hydro Ax 12 1 was conducted outside the test blocks so that sufficiently gentle slopes could be found to accommodate this machine. Information was collected on the tree being felled and the surface conditions in the area as the time study was conducted. Observations were made on the species of the tree being felled, the slope at the tree's location, and the DBH of the tree. A table of average height by diameter class was constructed for each species. This estimate of total height was used with the observed DBH to estimate the chip yield of each tree felled.

Each machine's felling cycle was broken into the following elements:

Time spent moving to a tree,
Time swinging to cut the tree and severing the tree,
Time moving to lay the tree down,
Time swinging to lay the tree down and laying the tree down.

A summary of the and observed times and operating conditions for each machine is reported in Table 6.

A regression equation was fitted to estimate the total cycle time for all of the machines. The best fit was:

$$TotalCycle(Timbco) = 0.395 + 0.0304(DBH)$$
$$TotalCycle(Wolverine) = 0.395 + 0.0247(DBH)$$
$$TotalCycle(HydroAx) = 0.395 + 0.0187(Slope)$$

The three models were fitted simultaneously\ and the r^2 for the combined fit was 5.5%.

Note that the cycle times of the Timbco and Wolverine machine were not sensitive to slope but that the influence of slope on the Hydro Ax overshadowed the size difference of the trees. The Hydro Ax had to be pulled from test block 3 because the slopes were too severe for this machine to function safely..

A regression-was fitted for the productivity of the feller. bunchérs by -using the -chip yield estimates for the trees that were felled. Productivity is defined here as the tons of chips that could be produced from the trees that were felled in an hour of operating time. The best fit for this felling productivity was:

$$TimbcoProductivity = -40.4 + 8.50(DBH)$$
$$WolverineProductivity = -40.4 + 8.58(DBH)$$
$$HydroAxProductivity = -40.4 + 9.98(DBH)$$

with r^2=56.6%. Note that the machines were not tested in similar conditions and that this productivity in no way reflects what would happen if the machines were operating in similar conditions. However, it is likely that each machine will be assigned to operate in conditions similar to those in which it was observed. Thus, the predictors would be useful in estimating productivity of the machines in future applications.’

Skidding

The skidders in use in the logging crew were observed as each test block was being harvested. Observers were placed at the flail/chipper and at the points were the skidders assembled their loads. The cycle time for the load, time-the-skidder- spent on the flail/chipper deck, the number of stems in the load, the number of bundles included in each load, and the distance the load was skidded could be derived from the combined observations. Cycle time was defined in this study as beginning when the skidder left the flail/chipper deck and ending when the skidder returned to the flail/chipper deck. A summary of these observations is reported in Table 7.

A regression equation was constructed to predict the total cycle time for the skidders using the data from all of the test blocks. This predictor should be indicative of the average cycle time across all conditions. The best fit for this model was:

$$Cycle = 3.32 + 0.00265(Dist.) + 0.670(No.Bundles)$$

with r^2=26.1%.

DISCUSSION

The cost of producing chips into the chip van in this situation was comparable with costs observed for operations in the southeastern United States (Watson et.al. 1991 and Watson and Stokes 1994). The track type feller bunchers were well suited for felling on the steeper slopes and the felling cost rose only slightly in these adverse conditions. The rubber tired skidders. functioned well in all conditions, but it was obvious that maximum precautions were needed on the steepest slopes. The greatest impact on chipping production was the fact that the loader on the flail/chipper was being used to sort stems with sawlogs from the flail/chipper infeed. Each stem handled cost almost one minute of chipping time and a little over a half ton of chip production.

The preharvest cruise did not accurately predict the removals that were observed during-the production study: The test blocks yielded between 12% and 65% more wood than was predicted (Table 8). This was in part because the cruise did not reflect the number of trees in the 4 inch and smaller DBH classes that would be removed and processed. The cruise data indicated that there were 1099.

1509, and 465 trees respectively on the 3 blocks in the smaller classes. However, there was no indication in the cruise data as to these smaller trees being cut or left. An accurate assessment of the number of smaller trees that would be utilized would improve the preharvest estimate.

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Table 1. Approximate replacement price and cost per hour for the machines in the operation

MACHINE	APPROXIMATE REPLACEMENT PRICE	COST OF OWNING AND OPERATING THE MACHINE PER HOUR
Peterson-Pacific 5000	$450,000	$138.84
Timbco Feller Buncher	200,000	$85.71
Hydro Ax 121	$85,000	$26.48
Wolverine Feller Buncher	$155,000 .	$57.18
Timberjack 3 80	$110,000	$44.75
Timberjack 450	$125,000	$51.20
Caterpillar D7H	$285,000	$80.06
Chainsaw	$600	$1.75

Table 2. Descriptive information on the test blocks

Block	1	2	3
Acres	13.8	7.7	12.4
Average Slope	38%	24%	17%
Plots Cruised	29	25	20
Date Harvested	Oct 17, 18 & 20	Oct 19,28 & 29	Oct 18,19,20 & 28
Tres per Acre Cut/Leave	39/19	70/28	48/17
Average DBH (Inches) Cut/Leave	8.5/12.0	7.6/9.3	8.6/11.7

Table 3. Estimated weight (pounds) to be removed from cruise data by species for each test block

Species	Block 1	Block 2	Block 3
Douglas-fir	176,986	123,055	8,994
Ponderosa Pine	129,343	88,204	364,439
White Pine	7,707	25,614	0
TOTAL	313,405	236,870	373,433
TONS PER ACRE	11.4	15.4	15.1
AVERAGE WEIGHT OF THE HARVESTED TREES	565	439	670

Table 4. Weight and counts of stems removed for the test blocks

		BLOCK 1	BLOCK 2	BLOCK 3
WEIGHT OF PRODUCTS PRODUCED (Pounds)	chips	413,375	327,126.	'388,988
	Estimate Weight of Wood in Logs Bucked out	104,640	20,498	29,435
	Total	518,015	347,624	418,423
	Tons per Acre	18.8	22.6	33.7
	Average Weight per Stem	458	465	514
NUMBER OF STEMS	Douglas-fir - Entirely Chipped	671	416	12
	Douglas-fir - Top Chipped	68	4	0
	Total Douglas-fir	739	420	12
	Ponderosa Pine - Entirely Chipped	324	249	767
	Ponderosa Pine - Top Chipped	33	19	35
	Total Ponderosa Pine	357	268	802
	White pine - Entirely Chipped	35	19	0
	White pine - Top Chipped	0	0	0
	Total White Pine	35	19	0
	BLOCK TOTAL	1131	747	814

Table 5. Cost summary for the test blocks; $/ton

	BLOCK 1	BLOCK 2	BLOCK 3
AVERAGE SLOPE	38%	24%	17%
AVERAGE SKID DISTANCE (feet)	981	2509	942
CHIPPING COST	$4.66	$3.08	$3.11
FELLING COST	$5.3 1	$2.60	$2.27
SKIDDING COST	$6.29	$4.55	$3.56
BUCKING COST	$0.48	$0.02	$0.02
PILING COST	$1.58	$1.18	$1.08
TOTAL COST	$18.32	$11.43	$10.05

Table 6. Summary of observations and operating conditions for the various feller bunchers

		TIMBCO	WOLVERINE	HYDRO AX
Percent Slope	Average	23	20	12
	Maximum	40	26	24
DBH of Felled Trees (inches)	Average	8.5	8.1	7.7
	Maximum	19.1	18.5	17.6
Average Cycle Elements (minutes)	Move to Tree	0.2348	0.2828	0.2967
	Swing & Cut	0.2222	0.1541	0.1711
	Move to Dunip			0.05 13
	Swing & Dump	0.2079	0.1624	0.0910

Table 7. Summary of observations on the skidder

	Block 1	Block 2	Block 3
Average Skid Distance (feet)	981	2509	942
Average Number of Bundles in the Loads	1.52	2.26	2.79
Average Number of Stems in the Loads	7.1	12.1	9.7
Estimated Weight of Chips Produced from the Average Load (pounds)	3232	5614	5002
Average Cycle Time (minutes)	7.75	10.52	7.19
Average Time on Deck (minute)	1.73	1.15	2.18

Table 8. Comparisons of the estimated removals and observed removals for the various test blocks.

		Block 1	Block 2	Block 3
Total Weight Removed (tons of wood)	Observed	259.0	173.8	209.2
	Predicted	156.7	118.4	186.7
	Difference	65%	47%	12%
Number of Stems Removed	Observed	1131	747	814
	Predicted	554	539	557
	Difference	104%	39%	46%
Average Weight of Chips in a Removed Stem (pounds)	Observed	458	465	514
	Predicted	565	439	670
	Difference	-19%	6%	-23%