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MECHANIZED RED PINE TREE PLANTING OPERATION—A TIME STUDY

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ABSTRACT.—Projected softwood shortages and high costs of mechanized tree planting indicate that more efficient planting equipment and systems are needed. This paper presents cost and productivity data for mechanically planting red pine seedlings on a site previously occupied by hardwoods in northern Wisconsin.

KEY WORDS: Reforestation, softwood, site preparation, cost analysis, productivity.

It is generally believed that there will be shortages of softwoods in the near future. If past trends continue, the demand for softwood in the north-central region could exceed the supply by 21 percent in 1990 and 33 percent by 2030 (USDA 1982). In anticipation of these coming shortages and the associated economic opportunities, efforts are being made to increase the inventory of softwood.

Past logging and forest management practices have greatly reduced the softwood inventories in the Lake States region. Large areas that were previously covered by softwoods have reverted to low-value pioneer species (Benzie 1982). The north-central region has about 10.5 million acres of poorly stocked, low value hardwoods that would be economically attractive for conversion to red pine (USDA 1982). Reclaiming the softwood sites and replanting them with higher yielding conifers can be a slow, expensive process. A survey of four National Forests in the Lake States region revealed that in 1982, typical planting costs ranged from about $40 to $70 per thousand red pine seedlings planted by hand and $80 to $130 per thousand planted by machine[2]. For meaningful improvements in cost and productivity to be realized, the current "state of the art" has to be defined. Our objective in this study was to build a data base against which future developments in site conversion can be measured.

METHODS

In cooperation with the Consolidated Paper Company of Wisconsin Rapids, Wisconsin, we continuously time studied the planting of red pine seedlings on a site previously occupied by hardwoods. For the operation we used a bulldozer, a mechanical tree planter, and a crew that varied between four and five people.

Site Description and Prior Treatment

The site was located in Oneida County, Wisconsin. Prior to planting, the site was covered by a mixed hardwood stand consisting of a predominately light overstory of overmature aspen with an understory of small pole-sized hardwood, predominately elm. The terrain was basically level and strewn with large rocks and buried stump remains. The soil was a silt loam type and was fairly wet at the time of planting.

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[2] *Van Aken, R. C. Personal communication. Director of Timber Management, Region 9, Milwaukee, WI: U.S. Department of Agriculture, Forest Service; 1983.*

The normal sequence for the site conversion would be to log, shear, rake into piles, burn, treat with herbicide after a season's growth and plant the following spring. However, because of equipment scheduling problems, herbicide application timing, and inadequate burning conditions, the site preparation was not conducted as planned.

The site was logged and the residual saplings and brush sheared with a K-G blade[3] as planned. The logging yield was approximately 7 cords/acre for the aspen and 12 cords per acre for the remaining hardwoods. However, due to the equipment scheduling problems and the need for a full season of regeneration development, the raking and burning steps were delayed until after the planned herbicide treatment. The debris was raked into piles during the dormant season with the intention of burning them prior to planting in the spring. Unfortunately, due to unfavorable weather conditions the burning could not take place as planned. This meant that either the planting had to be done among the randomly scattered piles or delayed another year. We decided to plant among the piles rather than lose the fresh effect of the treatment. This study covered the planting of 14.1 acres on this site (fig. 1).

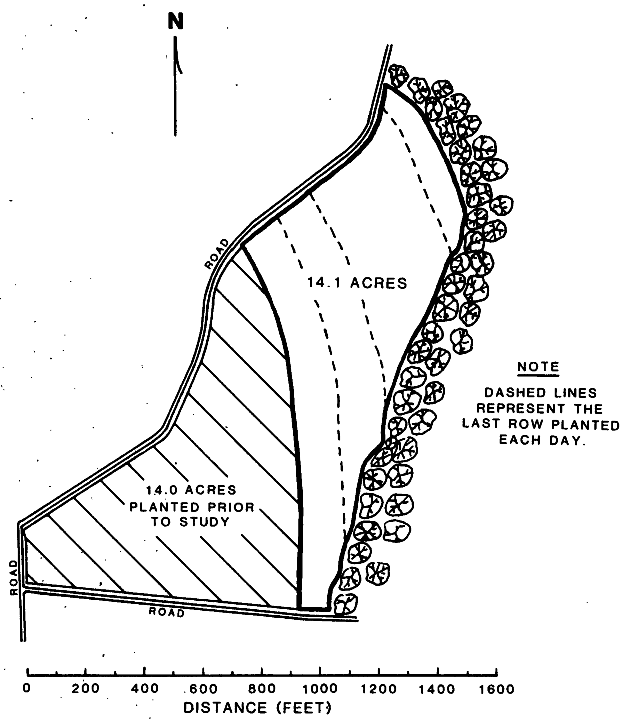

Figure 1.—*Map of planting area showing the orientation of the rows.*

[3]*The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. It does not constitute an official endorsement or approval of a product or service by the United States Department of Agriculture.*

Figure 2.—*Fesco Model VP-540 V-plow used to make a continous furrow planting bed.*

Equipment Used

The tractor was a 140 hp Caterpillar model D6D. In front, mounted to the dozer C-frame, was a 54-inch wide Forest Equipment Sales Co. model VP-540 V-plow (fig. 2). Mounted to the rear of the tractor was the tree planting machine, a modified Taylor model 44D (fig. 3).

The planter modifications involved the operator's seating arrangement. We widened the cab on the left side and moved the packing wheels rearward. This repositioned the operator lower and to the left of the planting slot. In this position, the operator is in a more

Figure 3.—*Taylor Model 44D tree planter as modified to give a wider cab and the lower operator position.*

stable and less fatiguing position while planting. The planting stock was 3-0 red pine bare root seedlings.

Working Principle

The dozer with planter basically traveled back and forth across the site in a northwest-southeast direction with each new pass adjacent and parallel to the previous pass (dashed lines in fig. 1). When a brush pile was encountered, the operator ran the dozer up to the pile, stopped, raised the planter, traveled around the pile, and resumed planting on the far side.

One to two people followed the machine to plant trees by hand wherever the planter missed—near stumps, boulders, or brush piles—or could not reach—such as along the southeast border of the site. The hand planters also corrected any trees that were improperly planted by the machine.

RESULTS

The planting operation was studied continuously for 3-½days during May 1981. During this time, 14.8 hours were spent planting and 5.4 hours consumed by delays. This results in a 73-percent machine utilization rate as shown in the following time study results:

Productive activities	**Time** (Hours)	**Part of total** (Percent)
Planting	11.1	55
Resupplying planter	.2	1
Turning around	1.8	9
Avoiding brush piles	1.1	5
Avoiding stumps and boulders	.6	3
Productive time	14.8	73
Delays		
Personal	1.2	6
Mechanical	3.2	16
Miscellaneous	1.0	5
Delay time	5.4	27
Total	20.2	100

During the 14.8 hours, 14.1 acres were planted. However, 23 brush piles, each averaging 47 feet in diameter, were scattered over this 14.1 acres. These piles reduced the area actually planted to 13.2 acres. Based on this reduced acreage, the productivity was calculated to be 0.9 acre/productive hour. From average row and tree spacings, the average planting density was calculated to be 939 trees/acre.The productivity data are shown in the following tabulation:

Net area planted	13.2 acre
Average row spacing	7.0 ft. (1.2 ft. std. dev.)
Average tree spacing in row	6.6 ft. (1.4 ft. std. dev.)
Average tree density	939 trees/acre
Productivity	0.9 acre/productive hour
	835 trees/productive hour
Average tractor planting speed	116.8 ft/min. (16.8 ft/min. std. dev.)

We calculated planting costs assuming typical machine and labor costs (Miyata 1980). Total planting cost (in 1982 dollars) was estimated to be $103.02 per 1,000 trees or $96.73 per acre planted (excluding seedling cost) (table 1).

DISCUSSION AND CONCLUSIONS

The large boulders and stumps caused delays, limited travel speeds, and required the use of a large tractor. However, we see several places in the operation where savings could be realized.

One improvement would be to burn the brush piles before planting. By eliminating the time lost maneuvering around them, we estimate the original unit cost could be reduced by 5 percent. Also, without the brush piles, the hand planting would be reduced. We feel that this could allow better utilization of personnel, and the second part-time hand planter could be eliminated. If this were possible, the planting labor could be reduced by 9.8 hours, resulting in another 5 percent reduction in the original unit cost. Then, if the planting was begun on the southeast edge of the area and the rows made parallel to the woods, fewer and longer rows could be planted. This would result in fewer and more efficient turnarounds. We estimate that there would be 40 percent fewer turnarounds, resulting in about an 8 percent reduction in the original unit cost. Combined, these three reductions would reduce the estimated cost to $84.48 per 1,000 trees planted, or $79.32 per acre with 939 trees per acre.

McKenzie (McKenzie *et al.* 1981) and others (Larson and Hallman 1980, Page 1973, USDA 1967) have reported the survival rate for machine-planted seedlings is generally higher than that for hand-planted seedlings. However, machine planting costs twice as much as hand planting. In this paper we presented a work measurement analysis of the mechanical planting operation and pointed out the places in the operations where productivity could be improved or cost

Table 1.—*Estimated planting costs including a breakdown between machines and labor*[1]

Item	Initial value	Itemized rates[2]			Total time	Total cost	Portion of total cost	Unit cost
		Fixed	Operating	Total				
	Dollars		*Dollars/hr*		*Hours*	*Dollars*	*Percent*	*Dollars/1,000 trees*
Machine								
Cat D6D Dozer	124,000	21.74	19.45	41.19	14.8	609.61	48	
Taylor tree planter	6,000	.88	.05	.93	14.8	13.76	1	
Fesco VP-540 V-plow	7,600	1.12	.05	1.17	14.8	17.32	1	
					Sub total	640.69	50	51.69
Labor								
Field supervisor	—	—	—	12.00	17.0	204.00	16	
Dozer operator	—	—	—	10.00	17.0	170.00	13	
Planters	—	—	—	6.00	43.7	262.20	21	
					Sub total	636.20	50	51.33
					Total	1276.89	100	103.02

[1]*Costs and values shown were assumed typical for 1982 and are not necessarily those of the cooperator. Also, cost of trees is not included.*
[2]*Miyata 1980.*

could be reduced. The challenge to reduce cost and increase productivity for mechanical planting is so clear that continuing engineering research is needed to develop economically efficient planting equipment and systems.

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