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Machine Planting Costs are Influenced by Site Characteristics and Preparation Practices

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SUMMARY

An analysis of 14 contracts for planting southern pine seedlings by machine on 1,781 acres of industrial land shows that 4 factors explain 90 percent of the variation in costs.

Additional Keywords: regeneration, southern pine, site preparation

INTRODUCTION

Planting southern pine seedlings with a tree planting machine pulled behind a small crawler tractor is an alternative to planting by hand. Approximately 30 percent of the seedlings planted southwide in 1980 were set out by machine. The effects of preparation intensity and costs on the subsequent cost of planting southern pine seedlings by machine are reported here.

DATA

In collecting data to study influences of site characteristics and preparation practices on contract hand planting costs, several cooperators also provided machine planting costs. The data were obtained from 4 forest products firms active in the coastal plain and piedmont of Alabama, Louisiana, Mississippi, and South Carolina in the 1980 planting season.

Cost Data

The data collected represent costs paid contractors for planting and site preparation (table 1). They were market-determined values, which are preferable to accounting costs for analysis.

Seedling costs were excluded from total planting costs because the land-owning firms either provided seedlings from their own nurseries or purchased seedlings from state nurseries. Seedling costs per 1,000 vary considerably between public and private nurseries, reflecting differences in cost accounting practices. Seedling costs were excluded to eliminate this variation and focus the analysis on contract service costs.

Site preparation costs included the cost of all treatments including prescribed burning.

Number of Seedlings

The analysis used considered the number of seedlings per acre specified in the contract rather than the number planted. On 12 of the 14 sites, 726 seedlings per acre were specified, although 2 different spacings were used. Eight of the 12 used 6 × 10 foot spacings; 4 specified 5 × 12 spacings. The remaining 2 sites used 8 × 8 and 7 × 10 foot spacings. The number actually planted varied from 5 to 7 percent less than specified because the contracts provided for 10 percent leeway, and contractors planted the fewest seedlings necessary to meet the minimum acceptable stocking level.

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Table 1.-*Summary statistics for 14 industrial machine planting contracts for the 1980 planting season.*

	Mean	Standard deviation	Minimum	Maximum
Machine planting cost (dollars per acre)	28.74	4.21	21.00	38.04
Site preparation cost (dollars per acre)	85.97	31.11	27.60	135.00
Prescribed burning cost (dollars per acre)	1.14	1.46	0.00	3.00
Number of seedlings planted per acre	718.43	38.78	622.00	786.00
Total acreage offered for planting	127.21	100.14	21.00	360.00
Number of machine passes to complete site preparation	2.07	0.47	1.00	3.00

Table 2.-*Combinations of treatments used to prepare sites for contract machine planting*

Treatment combination	Number of contracts	Acreage
Shear		
+ Bed	1	41
+ Burn + Bed	4	361
+ Chop + Burn	1	360
+ Disc	2	312
+ Rake	2	142
+ Rake + Bed	3	544
Chop + Burn	1	21

Total Acreage

The total acreage offered for planting represented the scale of the operation. The total acreage actually planted may have been reduced because of equipment breakdowns, and insufficient seedlings. Such reductions in acreages could not be anticipated prior to bidding.

Number of Machine Passes

The intensity of mechanical site preparation was measured by the times machines traversed the site. Shearing and piling was counted as a single machine pass because both steps are generally accomplished under a single contract for a single price. Shearing and raking were counted as 2 machine passes because the contractor usually charges additionally for raking following shearing because of the time involved and machinery adjustments.

Prescribed burning done by the land-owning company was not counted as a machine pass, even though fire lines were plowed around the perimeter and occasionally through the site. Also, burning slash piles or windrows following shearing or raking was considered a part of those treatments and not a separate one.

Eight treatment combinations were used (table 2). Shearing was the initial treatment on 98.8 percent of the acreage treated. Bedding was the final treatment on 53 percent of the acreage.

Zero-One Variables

Some site characteristics and site preparation variables were assigned code numbers: 1 if present, 0 otherwise. The terrain of the planting site had a slope exceeding 5 percent in 7 of the 14 cases, rating a 1. Broadcast burns were used in 6 of the 14 cases. Bedding was the final site preparation treatment in 9 of the 14 cases. Only 1 site was injected with herbicides as a part of preparation. Each of these zero-one variables was included in the analysis to test whether they had a significant effect on machine planting costs.

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ANALYSIS

Machine planting cost per acre is the dependent variable. Regression analysis of the data yielded the following equation:

$$
\begin{aligned}
\text{MACHINE\$} = \; & \$38.08 - \underset{(4.49)}{\$0.03}(\text{TOTLACRE}) \\
& + \underset{(6.34)}{\$22.24}(\text{BURNED}) \\
& - \underset{(5.66)}{\$7.22}(\text{BURNCOST}) \\
& - \underset{(3.93)}{\$7.35}(\text{TWOPASS})
\end{aligned}
$$

where:

MACHINE$ = machine planting cost, dollars per acre

TOTLACRE = total acreage offered for planting

BURNED = 1 if a broadcast burn is prescribed, 0 otherwise

BURNCOST = cost of a broadcast burn, dollars per acre

TWOPASS = 1 if two or more machine passes were used to mechanically prepare the site for planting, 0 otherwise

The F-statistic for the equation is 19.72, having a probability value of 0.001. The coefficient of multiple determination (R^2) is 0.90, and the standard error of the estimate is 1.62. The t-statistics, shown in parentheses beneath the coefficients, are all significant and have probability values less than 0.003.

DISCUSSION

Smith (1962) noted that the 3 major goals of site preparation are: (1) to control competing vegetation; (2) to provide a more hospitable growing location; and (3) to simplify planting. Every site preparation treatment is directed at one or more of these goals. Dollar benefits from the first 2 goals normally accrue from increases in future harvest value. Expected future harvest value can be discounted to present worth benefits. Present worth benefits from simplified planting, the third goal, are measured by reduction in planting cost. The sum of the present worth benefits obtained from all 3 goals must exceed the cost of the treatments to justify them.

Even though changes in independent variable values induce changes in benefits from all 3 goals, the equation estimates benefits only from the simplified planting goal. Only the effect on MACHINE$ of changes in the values of the independent variables will be discussed. Competition control and site amelioration benefits require a separate analysis.

The negative sign for the coefficient of TOTLACRE indicates that economies-of-scale result from adding more acreage to the planting contract. MACHINE$ drops $0.03 for each acre added to the planting contract.

The combined effect of the 2 variables, BURNED and BURNCOST, is to increase MACHINE$ when BURNCOST is less than $3.08 per acre. For each $0.01 below $3.08, MACHINE$ rises $0.07. In no case was BURNCOST greater than $3.00. Benefits from competition control and site amelioration must exceed both the cost of burning and the increase in planting cost for burning to be economically justified.

The variable TWOPASS relates to the number of machine passes. Preliminary analysis of the data revealed a significant reduction in MACHINE$ when a second mechanical treatment was added to the first treatment. But adding a third mechanical treatment did not result in further MACHINE$ reductions. Therefore, machine pass data were expressed as a zero-one variable to better reflect the effect of increased machine passes on MACHINE$. If 2 or more mechanical site preparation treatments are used, MACHINE$ is reduced by $7.35 per acre.

Comparison with Hand Planting Cost

The comparable equation for hand planting cost per acre, HANDPLT$, is (Guldin 1982):

$$
\begin{aligned}
\text{HANDPLT\$} = \; & \$2.00 - \$0.04(\text{TOTLACRE}) \\
& + \$17.20(\text{LOGACRE}) \\
& - \$3.75(\text{\#MACHPAS}) \\
& + \$7.91(\text{BURNED}) \\
& - \$0.49(\text{BURNCOST}) \\
& + \$20.43(\text{OWNER})
\end{aligned}
$$

The equation differs from the one for MACHINE$ in 3 ways. First, it includes variable LOGACRE (the logarithm, base 10, of TOTLACRE). The machine planting cost data showed no curvilinear trend because variables for acreage squared and log of acreage were both insignificant in the analysis. Second, the variable #MACHPAS is the total number of machine passes during site preparation, and not a zero-one variable as in the MACHINE$ equation. Third, the HANDPLT$ equation is based on data from both national forest and industry. The OWNER variable equals 1 if the case is a national forest contract, and 0 if it is an industrial contract.

Site characteristics and preparation data for the machine planting contracts were inserted into the HANDPLT$ equation to calculate predicted HAND-

PLT$. When predicted HANDPLT$ was subtracted from observed MACHINE$ and the difference plotted over the size of the parcels planted, the results indicated that the machine planting was always more expensive than handplanting for parcels less than 100 acres. Other considerations undoubtedly led forest managers to plant these small parcels by machine. Machine planting is justified when total benefit to the operation balances the added cost of planting by machine.

Land managers can use the results of this analysis as guidelines for evaluating the efficiency of their regeneration programs, where machine planting is used, and as a benchmark for future regeneration investment decisions.

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