FIFTH-YEAR HEIGHT AND SURVIVAL OF LOBLOLLY PINE ACROSS TENNESSEE FOLLOWING VARIOUS SILVICULTURAL TREATMENTS

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Abstract—Loblolly pine (*Pinus taeda*) was planted at nine experiment stations located across Tennessee in 1993-94 and 1994-95 using a customized fractional factorial design. Two sites, good and poor, were chosen on each experiment station to compare effects of soil productivity on height and survival. At each site, three treatments were evaluated: spacing (8X8, 8X10, and 10X10 feet), post-planting herbicide application after spring green-up (2.0 oz/ac Oust and 4.0 oz/ac Arsenal), and fertilization at planting (three, 9 gm, 22-8-2 fertilizer tablets per tree). Height measurements and survival counts were taken after the fifth growing season. The least square estimates of mean height and survival over all treatments and sites after five growing seasons were 11.9 feet and 83 percent, respectively. Results indicate that herbicide application increased tree height by 8 percent (11.4 vs. 12.4 feet). Survival increased 13 percent (77 vs. 87percent) when herbicide was used. Significant differences ($P < 0.05$) among experiment stations were found for height and for survival. Mean height estimates ranged from 9.5 feet at the West Tennessee Experiment Station to 13.5 feet at Ames Plantation and the Highland Rim Forestry Station. Survival ranged from 59 percent at the Dairy Experiment Station to 99 percent at the Highland Rim Forestry Station. No significant differences were found between good and poor sites. The herbicide treatment increased survival significantly more ($P < 0.05$) on poor sites than on good sites.

INTRODUCTION

The native range of loblolly pine (*Pinus taeda*) extends into only 13 of Tennessee's most southerly counties (see p. 497, Baker and Landgon 1990). However, it has been planted extensively in the state. These plantations were reflected in the number and distribution of U.S.D.A. Forest Service, Forest Inventory and Analysis plots with loblolly pine in the late 1980's (see p. 7, Beltz and Bertelson 1990). More evidence comes from the two most recent inventories of Tennessee's forest resources (table 1). The area of loblolly plantations was about 280,000 acres in the late eighties, increasing to about 385,000 acres in the late nineties (U.S.D.A. Forest Service 2001). The areas reported above are for loblolly pine, not loblolly-shortleaf pine as published in the state statistics. This increase of approximately 105,000 acres is about equally divided between forest industry and private non-industrial ownership. Thus, loblolly pine is an important species in Tennessee even though it has a limited native range in the state.

In the early 1990's, Dr. Edward Buckner and Mr. John Mullins of the University of Tennessee Department of Forestry, Wildlife and Fisheries, conceived a study to help Tennessee landowners more effectively grow loblolly pine. Specifically, this study was designed to determine the effects of various silvicultural treatments on the establishment and growth of loblolly pine on various sites commonly found in Tennessee.

METHODS

Tennessee has a wide range of growing conditions across its many diverse physiographic regions. For the results to be widely applicable, loblolly pine was planted at nine experiment stations located in five physiographic regions (figure 1). A good site and a poor site, based on the performance of agronomic crops, were chosen on each location (experiment station) to compare effects of soil productivity on height and survival. Only three sites were in forest cover immediately before study establishment: the good site and the poor site at the Forestry Experiment Station (Oak Ridge) and the poor site at Ames Plantation. The other sites had been in agriculture, including corn (2 sites), soybeans (2), alfalfa (2) and pasture (9).

Three treatments were evaluated: spacing (8X8, 8X10, and 10X10 feet), fertilization at planting (three, 9 gm, 22-8-2 fertilizer tablets per tree (22-8-2)), and post-planting

Table 1—Area of Tennessee forests and of pure loblolly pine plantations in 1989 and 1999 (USDA Forest Service 2001)

	Area (thousands of acres)	
	1989	1999
Timberland	13,265	13,965
Loblolly plantations	280.2	385.6
Public	16.6	15.7
Forest Industry	184.6	235.4
Private non-industrial	79.0	134.5

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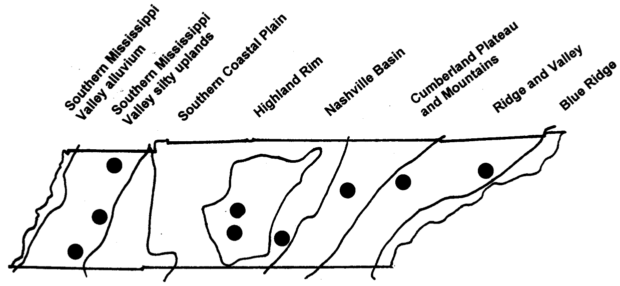

Figure 1—Physiographic regions of Tennessee and Agricultural Experiments Stations that served as study locations. In the Southern Mississippi Valley silty uplands from south to north, Ames Plantation (AMES), West Tennessee Experiment Station (WTES), and Martin Experiment Station; in the Nashville Basin from south to north, the Dairy Experiment Station (DES), and the Middle Tennessee Experiment Station (MTES); in the Highland Rim, the Highland Rim Forestry Station (HRFS); in the Cumberland Plateau and Mountains, the Plateau Experiment Station (PES); in the Ridge and Valley from west to east, the Forestry Experiment Station (FES) and the Tobacco Experiment Station (TES).

herbicide application after spring green-up (2.0 oz/ac Oust and 4.0 oz/ac Arsenal). The study was installed in 1993-94 and 1994-95 using a customized fractional factorial, incomplete block design. The first year's installations had nine plots per site, while in the second year there were 10 or 11 plots per site. Height and survival obtained after the fifth growing season are presented in this paper. A significance level of 0.05 was used. SAS PROC MIXED was used to analyze the data. Significant differences were tested using the PDIFF option.

RESULTS AND DISCUSSION

The least square estimates of survival and height over all treatments and sites after five growing seasons were 83 percent and 11.9 feet, respectively. Survival increased from 77 percent to 87 percent with herbicide application. Tree height increased from 11.4 feet to 12.4 feet when herbicide was used. Effects of herbicide on survival and height were statistically significant.

Significant differences among experiment stations were found for survival and for height. Survival ranged from 99 percent at the Highland Rim Forestry Station to 59 percent at the Dairy Experiment Station (figure 2). Survival at the Dairy Experiment Station was significantly lower than at all other sites. Most experiment stations had a small number of trees damaged by deer or winter weather. Damage due to snow and ice in the winter between the fourth and fifth growing season was more extreme at the Plateau Experiment Station. While 79.1 percent of the trees survived, only 59.2 percent were free of damage at this location.

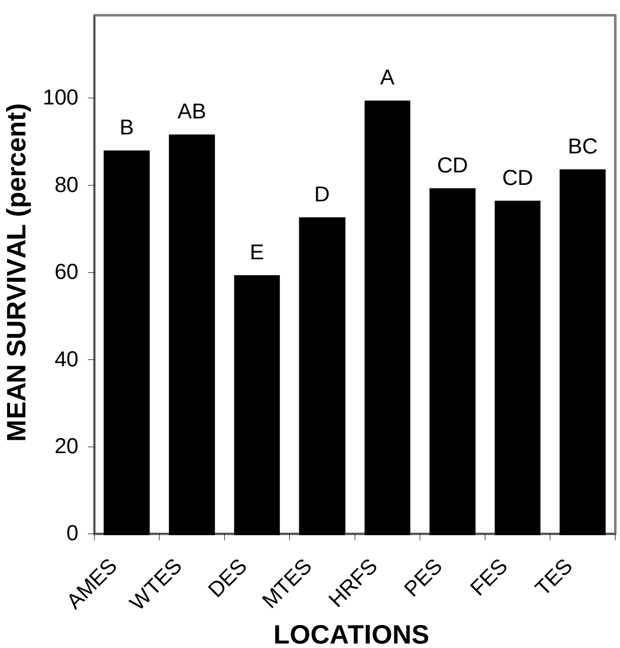

Figure 2— Least square estimates of mean survival for each location. Locations with the same letter were not significantly different (P > 0.05).

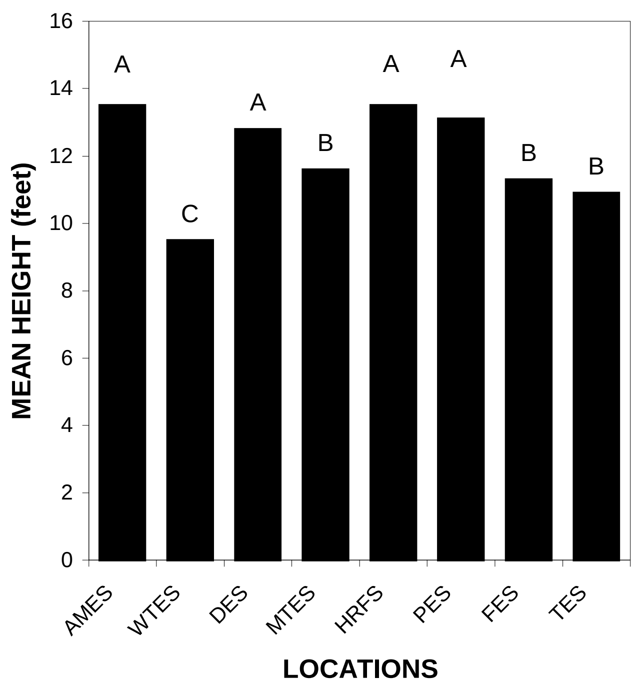

Figure 3— Least square estimates of mean height for each location. Locations with the same letter were not significantly different (P > 0.05).

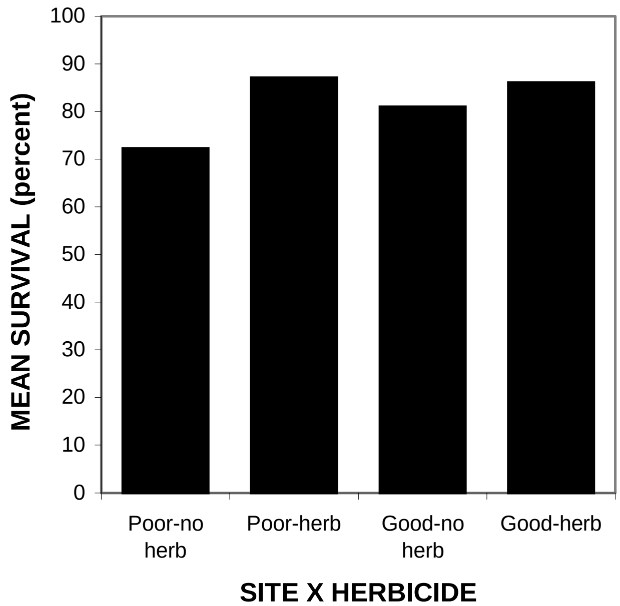

Figure 4— Least square estimates of mean survival for combinations of site and herbicide application.

Mean height estimates ranged from 13.5 feet at Ames Plantation and the Highland Rim Forestry Station to 9.5 feet at the West Tennessee Experiment Station (figure 3). Three nonoverlapping groups were found for height. Group one included Ames Plantation (13.5 feet), the Dairy Station (12.8), the Highland Rim Forestry Station (13.5) and the Plateau Station (13.1). Group two included the Middle Tennessee Station (11.6), the Forestry Station (11.3), and the Tobacco Station (10.9). Finally, group three consisted of only the West Tennessee Station (9.5). The height at the West Tennessee Station was low because the mean height for the poor site was only 6.5 feet. However, that for the good site was 12.5 feet.

The herbicide treatment increased survival significantly more on poor sites than on good sites (figure 4). Survival increased by 14.8 percentage points when herbicides were used on the poor sites as compared to an increase of 5.1 percentage points on the good sites. No such effect was found for height.

Although no significant differences were found between good and poor sites, some observations may be useful to others. Sites were selected and assigned to “good” or “poor” based on the performance of agronomic crops in consultation with the Superintendent of each experiment station. In the process of analyzing this study, we determined the soil type or types from soil surveys, and the loblolly pine site index and capability class based on soil type(s) for each site. There was little relationship between site index and capability class, and “good” or “poor” site. At two locations, the poor site had a higher site index than the good site, while at three locations both sites had the same site index. One site in the latter group was the Tobacco Experiment Station where survival and height were considerably higher on the poor site as compared to the good site.

RECOMMENDATIONS

Based on five years results, establishment and growth of loblolly pine can be successful throughout most of Tennessee. The treatment that showed promise for improving survival and height growth is the use of herbicides in association with planting. Their use on poor sites appears to have a greater effect on improving survival than on good sites. One factor limiting the success of loblolly pine is the occurrence of snow and ice frequently enough and in sufficient amounts to cause considerable mortality and damage.

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