COMPARISON OF THREE SITE PREPARATION TECHNIQUES ON GROWTH OF PLANTED LOBLOLLY PINE 6 YEARS AFTER A SOUTHERN PINE BEETLE EPIDEMIC

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Abstract—Three site preparation treatments: (1) complete removal of woody debris—drum chopped, raked, and disked; (2) drum chopping leaving woody debris; and (3) no site preparation—planting among dead standing trees were compared by evaluating the growth and survival of planted loblolly pine (*Pinus taeda* L.) after six growing seasons following a southern pine beetle (*Dendroctonus frontalis* Zimmermann) epidemic. Each treatment was replicated three times at one location on the Cumberland Plateau in Tennessee. Each treatment had the same number of planted seedlings (681) per acre, and was sprayed with herbicide to control hardwood residuals before planting and to release seedlings one growing season after planting. Results indicate that the growth (height and diameter) of seedlings was not significantly different between the treatments. However, survival was only slightly, but significantly different, for the no-mechanical-site-preparation (standing-dead) treatment which may be a reflection of difficult planting conditions. A cost evaluation of the different site preparation treatments is also discussed.

INTRODUCTION

The Cumberland Plateau and east Tennessee suffered a major southern pine beetle epidemic in 1999 to 2001. More than 30 percent of the pine (90,000 acres) on the Cumberland Plateau was impacted and killed by southern pine beetle (Clatterbuck and others 2006). With the presalvage and salvage operations that occurred during this time, pine was in high supply, but demand was low resulting in low stumpage prices. Some salvage of dying and dead pine stands occurred, but many dying stands were left uncut because harvest costs were greater than the potential revenue.

What is happening to this forest land where pines succumbed to southern pine beetle, especially those areas where trees were not harvested and dead standing trees remain? Three scenarios are possible: (1) some will be replanted to pine, (2) some will be left alone and through natural regeneration will transition to hardwood or mixed hardwood-pine forest types, and (3) some will be converted to nonforest uses. One of the major obstacles to replanting with pine is the cost of site preparation in these standing-dead, pine beetle areas. The objectives of this study were to (1) evaluate three site preparation treatments for survival and growth of planted loblolly pine after 6 years in uncut stands that had succumbed to southern pine beetle and (2) determine the cost-effectiveness of each treatment based on pine growth and survival.

METHODS

Study Area

This study was conducted on the Cumberland Plateau in Cumberland County, TN (longitude 84.46° W, latitude 35.54° N). The area is considered the “true plateau” where the surface is undulating and rarely exceeds slopes of 10 percent (Smalley 1982). The working unit is in several tracts composing an estimated 5,000 acres and was formerly owned by Bowater Incorporated. Presently, the area is in its third rotation of pine plantation. Southern pine beetle attacked the area in 1999 to 2000 during the second rotation when the trees were 18 years old. The third rotation was planted at 8- by 8-foot spacing during the spring of 2002. Soils are moderately productive (site index for yellow pine at 50 years ranged from 70 to 80 feet) and belong to the Lily-Gilpin-Jefferson soil series complex (mesic, typic hapludults) (McGowan 2006). Climate, geology, topography, and forest site classification of the study area may be referenced in Smalley (1982). A timeline of events that occurred in the study is presented in table 1.

Table 1—Timeline of events occurring for the site preparation study of standing-dead pine trees, Cumberland County, TN

Season and/or year	Event
1999–2000	Pine beetle infestation
Summer 2001	Mechanical-site preparation
Fall 2001	Initial herbicide application before planting
Early spring 2002	Hand planting pine
Late summer 2002	Pine-release herbicide application
Fall and winter 2007–08	Data collection

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Treatment Implementation

Three site preparation treatments were distributed in separate stands across the tracts: (1) drum chopping where residual material remained fairly evenly dispersed on the ground; (2) drum chopping, raking, and disking where little residual material was left on the ground surface; and (3) no site preparation where dead trees were left standing. Stands were only sampled where dead trees were left standing prior to the implementation of the site preparation treatments.

Experimental Design and Data Collection

The three site preparation treatments were located in separate stands within the working area. Three stands were sampled for each treatment with 6 plots per stand yielding 54 total plots.

Transects were established in each stand with plots taken every 150 feet starting at least 50 feet from the edge of the stand. Multiple, parallel transects were used (at least 100 feet apart) in a stand if all the plots could not be established on one transect. Each plot consisted of 4 rows of 7 trees (28 trees at 8- by 8-foot spacing) or a 32- by 56-foot rectangular plot (approximately 1/25-acre plot). Data collected at each plot were tree survival counts, total height of the four corner trees (if available, otherwise an adjacent tree was measured if a corner tree was missing), and diameters of the same four trees.

Site Preparation Costs

Average site preparation costs were formulated from standard regional data (Smidt and others 2005) and from surveys of contractors implementing the practices or treatments in the area. All tracts, and thus all treatments, incurred the following costs: initial herbicide application before planting, release herbicide application the first growing season after planting, planting labor, and seedling cost (table 2). There was no differentiation in planting costs between the three treatments even though planting was more difficult and time consuming in the standing-dead (control or no-site-preparation) treatment. The same number of trees (681 trees per acre at 8- by 8-foot spacing) was planted for each treatment. The cost of site preparation treatments is quite different ranging from no cost for the standing-dead or control treatment to $250 per acre for the most intensive treatment (drum chop, rake, and pile) (table 2).

RESULTS

Total height and diameter of loblolly pine were not different between treatments averaging 16 to 18 feet and 2.3 to 3.1 inches, respectively, after six growing seasons (table 3). However, tree survival did differ between the control (standing-dead) and the more intensive treatments. Tree survival averaged 78 percent in the control and 86 to 89 percent in the other two site preparation treatments (table 3). Survival was similar between the drum chop only and the drum chop, rake, and disk treatments.

DISCUSSION

The impact of competition control (whether mechanical, chemical, or both) and its positive effects on loblolly pine growth and development are well documented (Haines and others 1975, Minogue and others 1991, Neary and others 1990) and thoroughly reviewed (Fox and others 2008). Generally, chemical treatments for site preparation are used to deter herbaceous growth and hardwood sprouting and growth prior to pine planting. Herbicides are also used after planting for pine release. Mechanical methods of site preparation provide greater accessibility for planting through slash disposal as well as incorporating organic material into the soil and improving soil physical properties. Aerial chemical treatments were used on all stands in the study to control hardwoods and herbaceous growth both prior to and after planting pine seedlings (table 2). Thus, the question in this study was whether the cost of removing standing-dead trees through mechanical site preparation was justified through potential increases in growth and survival of planted pine trees. The cost of physically knocking down the standing-dead trees can be expensive and excessive (table 2) considering that the cost is compounded annually for at least 12 to 18 years before a return from the first thinning is attained.

Table 2—Average pine establishment costs for the site preparation study of standing-dead pine trees, Cumberland County, TN

Cost category	Practice	Cost per acre
		dollars
Costs incurred for all site-preparation treatments	Initial herbicide application (Imazapyr and Metsulfuron-methyl)	100
	Pine release herbicide application (Imazapyr)	60
	Planting labor	35
	Seedling cost	20
Costs of mechanical-site-preparation treatments	Standing-dead (control)	No cost
	Drum chop	100
	Drum chop, rake, and disk	250

Table 3—Survival, total height, and total diameter means of pine trees by site-preparation treatment after six growing seasons for the site-preparation study of standing-dead pine trees, Cumberland County, TN

Treatment	Survival[a]	Total height	Total diameter
	percent	*feet*	*inches*
Standing-dead (control)	78 a	16 a	2.3 a
Drum chop only	89 b	18 a	2.8 a
Drum chop, rake, and disk	86 b	18 a	3.1 a

[a] Treatment means with different letters within a column are significantly different at $P = 0.05$.

Results from this study indicate that diameter and height of loblolly pine were not affected by the site preparation treatments (table 3). The planted pines from a single nursery and on fairly uniform plateau sites grew similarly regardless of treatment. This outcome is in contrast to other research (Fox and others 1989, Morris and others 1983) where the topsoil and nutrients on the site were unevenly displaced by raking, piling, and burning windrows creating “waves” of different site productivities. The sites in this study were not windrowed and burned, but the residual, standing-dead material was raked, disked, and incorporated into the soil. The drum chop-only treatment left all residual material on the ground surface rather than incorporating the residual material into the soil. These differences in site preparation techniques as well as the differences between plateau, Piedmont, and Coastal Plain sites may contribute to the different results found in this study and the literature.

Survival of loblolly pine in the standing-dead control treatment was significantly lower (78 percent) compared to the two more intensive mechanical-site-preparation treatments (table 3). Poorer survival could be attributed to several factors. First, planting conditions were difficult. The control stands were within standing-dead pine trees (dead for 12 to 24 months), chemically treated hardwood midstory, and a dense understory of herbaceous vegetation with many briers that resulted from increased light penetration when the pine overstory died. These conditions may have affected the quality of the planting. The decaying standing-dead trees were safety hazards to planting crews. Second, crown debris and decaying dead stems often fell on new seedlings affecting their growth and survival. Planting among standing trees caused the planting rows to be more irregular and space between planted seedlings to be more variable than on the site-prepared stands. Third, the aerial herbicide application to control hardwoods and herbaceous vegetation in the control treatment prior to planting was probably not totally effective. The standing-dead pine overstory and the living hardwood midstory intercepted some of the herbicide such that the herbicide did not impact the ground vegetation as much as when the standing stems were removed.

A detailed, quantitative cost analysis was not performed in this study. The survival, diameter, and height results by treatment made the economic analysis rather intuitive. Removal of the dead-standing pine and the live hardwood midstory had little effect on the diameter and height growth of planted loblolly pine seedlings after six growing seasons. Thus, the added expense of removing these trees ($100 per acre for drum chopping only and $250 per acre for drum chopping, raking, and disking—table 2) is questionable. Seedling survival was less in stands that were not mechanically site prepared. However, at 78-percent average survival with more than 500 stems per acre after 6 years, the standing-dead, control stand has more than sufficient stocking for future management. The added expense of treating the overstory and midstory through mechanical-site preparation and the compounded interest before future revenues are received may not justify the expense. A fallacy of this study is that the cost of planting the control area was the same as planting the site-prepared area. The planters were paid per seedling regardless of ease of planting. The control, standing-dead stands made planting operations much more difficult and probably were more expensive and time consuming to plant.

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