HEIGHT RESPONSE TO HARVESTING INTENSITY AND SITE PREPARATION IN FOUR YOUNG LOBLOLLY PINE PLANTATIONS

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Abstract—A study was conducted to analyze the general effects of harvesting intensity and postharvest treatments on the average, three-year height of loblolly pine (*Pinus taeda* L.). This was accomplished by analyzing treatment effects across four study sites by treating the locations as random effects in the statistical model. Whole-tree harvesting using conventional methods had no distinguishable effect on the three-year average height. The main effect of bedding on height was not significant, but within the hand-felled harvest treatment, it significantly reduced height growth 0.12 meter. Herbaceous weed control increased three-year average height by 0.26 meter, and its effect on height was greater when the previous stand was harvested by conventional methods. Fertilization was the only treatment that increased three-year average height and did not interact with harvesting intensity. Across both harvesting treatments, fertilization increased three-year average height by 0.36 meter. Based on this analysis, effects observed here should be applicable to other similar sites across the Southeast.

INTRODUCTION

A study was initiated in 1993 to evaluate the impacts of the compaction and biomass removal associated with timber harvesting on the growth of the next plantation planted on that site. One of the goals of this study named Cooperative Research in Sustainable Silviculture and Soil Productivity, or CRiSSSP for short, is to evaluate this impact in as near of an operational setting as can be achieved while maintaining statistical control of treatments. Consequently, compaction as a treatment effect is the increase in bulk density and soil strength that harvesting equipment produced while moving across the site, and biomass removal as a treatment effect is the biomass intentionally or unintentionally moved from the site during harvesting. The actual treatments in this study are conventional, whole-tree harvesting with saw shears and grapple skidders and hand felling and lifting out only the merchantable portion of the stem. The movement of harvesting equipment across the site and the different removal restrictions produced differences in soil compaction and biomass removal that were measured after the harvest. This study contrasts the USDA Forest Service Long-term Study where compaction and biomass removal are directly and quantitatively manipulated (Powers and Avers 1995). Site preparation practices are included in this study to investigate their impact on growth, their role in correcting detrimental harvesting impacts, as well as their possible interaction with harvesting intensity.

This basic study has been replicated on four sites across the southeastern United States (table 1), and tree height has been measured annually for at least three years at each location. This creates the opportunity to evaluate the general impact of harvesting intensity and site preparation on early growth of newly established loblolly pine (*Pinus taeda* L.) plantations. By treating the various sites as random locations, any of these treatments that produce a change in height is evidence that the effect would occur at any random location across the Southeast. The objective of this paper is to determine whether general statements are possible concerning the effect of harvesting intensity, bedding, fertilization, and herbaceous weed control within the first three-years of height growth in loblolly pine plantations in the Southeast.

METHODS

At each study location, harvest intensity is factorially combined with bedding, fertilization, and herbaceous weed control. The combinations with the site preparation and early cultural treatments is incomplete because not all of the postharvest treatments were applied at each location. Each postharvest treatment was used at two locations at a minimum, however (table 2). Each study location was blocked according to soil type and drainage, and the treatments randomly assigned to 14 x 14 tree plots, each covering approximately 0.15 hectare. Three years of annual height measurement on 100 trees within each plot and location were analyzed using a linear model that mixed fixed and random effects (Littell and others 1966). The study locations and blocks within locations were considered random.

Exact postharvest treatment protocols varied by location. Complete descriptions are given by Wang and others (in press). Each site received an aerial application of imazapyr mixed with either triclopyr or glyphosate for minimum competition control. Bedding was performed with a single pass of two 85-centimeter disc pulled behind a tractor. Herbaceous weed control consisted of spraying a mixture of imazapyr and sulfometuron in a 1.2-meter band over the top of the seedlings. Fertilization consisted of either broadcast application of diammonium phosphate at 250

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Table 1—Locations and characteristics of study sites (all sites have a mean July temperature of 27°C)

Location	soil series	soil subgroup	Average Rainfall (mm)
Fred, TX	Kirbyville	Oxyaquic Paleudult	1360
Bryceland, LA	Mahan	Typic Hapludult	1370
Pine Grove, LA	Toula	Typic Fragiudult	1680
Bainbridge, GA	Hornsville	Aquic Hapludult	1670

kilogram/hectare or a complete fertilizer with micronutrients banded around each seedling. All seedlings were hand planted.

RESULTS AND DISCUSSION

Analysis was performed on all main effects and selected interactions in order to obtain interpretable results. The only treatment that did not interact with harvest intensity was fertilization (table 3). During the first three years of growth after treatment, fertilization significantly increased height growth by an average of 0.36 meter.

Both bedding and herbaceous weed control interacted with harvest intensity in their effects on average, three-year height. Bedding caused a significant reduction in height where the previous stand was hand-felled and removed by lifting the boles from the plot, and it had no effect on the average, three-year height where the previous stand was harvested by conventional means (figure 1a). The negative effect of bedding on height in the hand-felled plots was probably due to debris that was incorporated into the beds. During dry summers, this would reduce the moisture holding capacity of the beds as well as tree growth. With little or no debris in the beds, tree growth was unaffected.

Table 2—Distribution of treatments between study sites

Location Treatment	Fred TX	Bryceland LA	Pine Grove LA	Bainbridge GA
Harvest intensity	X	X	X	X
Fertilization	X			X
Bedding	X		X	
Herbaceous weed control	X	X	X	

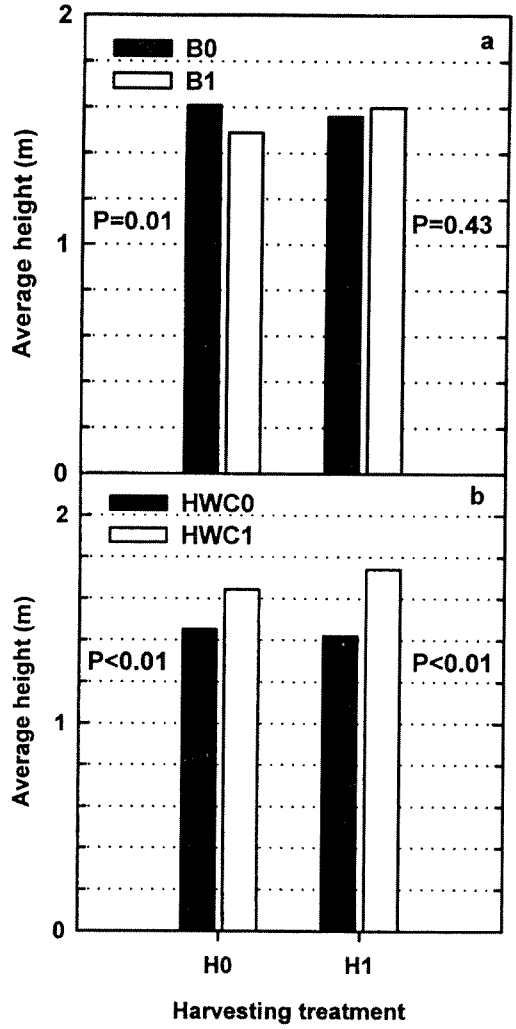

Figure 1—Interaction of harvesting intensity with bedding (a) and with herbaceous weed control (b) on three-year average height. B0 and B1 are not bedded and bedded; HWC0 and HWC1 are not sprayed for herbaceous weed control and sprayed; and H0 and H1 are hand-felled boles only harvesting and conventional, whole-tree harvesting, respectively. P values are for bedding or herbaceous weed control effects within specific harvesting treatments.

Table 3—Statistical summary of treatment effects and selected interactions

Effect	F value	Prob > F
Harvest (H)	0.21	0.64
Fertilization (F)	82 .0	<0.01
Bedding (B)	1.35	0.25
Herbaceous weed control (HWC)	48.2	<0.01
H x F	0.59	0.44
H x B	5.89	0.02
H x HWC	3.17	0.08

Herbaceous weed control significantly increased the average, three-year height in both types of harvest. The significant interaction occurred because the difference in height due to herbaceous weed control was greater when conventional harvesting methods were used than when the stand was harvested using minimum impact techniques. The slight reduction in height that seemed to occur when the stand was harvested with conventional methods with no postharvest control of herbaceous weeds was more than compensated when plots were sprayed for herbaceous weed control.

CONCLUSIONS

These results indicate that the impacts of conventional, whole-tree harvesting do not cause deleterious effects on average height over the first three years of growth on sites similar to those used in this study. Early fertilization results in significant increases of 0.36 meter in average, three-year height. Bedding significantly reduced height when the previous stand was hand felled and had no significant effect on height after harvesting with conventional means. Herbaceous weed control significantly increased the average height growth over three years, and its effect was greater when the previous stand was harvested by conventional methods. By treating the different locations as random effects in the analysis, the results seen here would apply to sites that are similar to the site used in this study.

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