LOBLOLLY PINE SAPLINGS AFFECTED BY HURRICANE HUGO RETAINED GROWTH

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Abstract—This study evaluated the effectiveness of staking upright Hurricane Hugo-impacted, 3-year-old loblolly pine (*Pinus taeda* L.) saplings. Three replications of four combinations of site preparation and seedling-release treatments were installed in two clearcut areas in coastal South Carolina. Shortly after Hugo, saplings in a subplot within each treatment plot were staked upright, and the remaining saplings were not staked. The groundline diameter, diameter at breast height (d.b.h.), and total height were measured on unstaked trees between the eighth and ninth growing season following Hugo, and staked trees were measured during June and August of the ninth growing season after Hugo. Paired t-tests indicated that groundline diameter and d.b.h. were not significantly different between staked and unstaked saplings in any site preparation/release treatment in either area. The height of staked trees in plots site prepared by one-pass bedding in one area was significantly greater than unstaked trees in similar plots.

INTRODUCTION

Hurricane Hugo came ashore as a class 4 hurricane just north of Charleston, SC on September 21, 1989. The immediate tree damage was obvious; tree boles were broken, trees were tipped over without being broken, or there was major branch damage. Trees near the coast that remained standing received salt spray that killed the foliage. This damage was easily visible either immediately or shortly after the hurricane made landfall. Internal damage including wood shake, and twist was noticed in trees following Hurricane Camille (Nonnemacher 1970, Toulialos and Roth 1971) and later (Barry and others 2001), but little was found following Hurricane Hugo (Faust and others 1996). This external and internal damage is seen immediately after the storm or shortly afterward when the area is salvage logged, and the logs are sawn.

Little research has been reported on the long-term effect of a hurricane on tree growth. Gerhardt (1996) reported that in 5-year-old loblolly pine (*Pinus taeda* L.) plantations, severely leaning saplings grew less than saplings with less lean. The present research seeks to answer the question; do saplings with a hurricane-induced lean grow less than saplings without a lean? The ideal experiment to answer this question would involve monitoring leaning and straight saplings of the same age on the same site. However, if Hugo affected any saplings in a plantation, then all the saplings were affected, thus not allowing a comparison. MeadWestvaco personnel did stake upright sets of saplings in Hurricane Hugo-damaged young loblolly pine plantations, and I measured the staked and adjacent unstaked saplings eight growing seasons later. The purpose of this research was to compare the groundline diameter, diameter at breast height (d.b.h.), and total height of staked upright and unstaked saplings, in plots established with a range of site-preparation techniques.

STUDY AREAS

Two loblolly pine plantations in South Carolina's outer Coastal Plain were selected for study. The Snow Mill plantation is in northern Georgetown County, about 4.4 km northwest of Plantersville. This area is on the Pamlico terrace and is in the Atlantic Coastal Flatwoods section, Lower Terraces subsection (Keys and others 1995). The soil is a poorly drained Bladen loam, a clayey, mixed, thermic Typic Albaquult (Stuckey 1982). The 25-year site index of the first rotation, intensively site-prepared, P-fertilized, unthinned, loblolly pine plantation was 24.4 to 25.9 m (Trousdell and others 1974) or 22.9 to 24.4 m (Pienaar and Shiver 1980). Mild winters and hot humid summers characterize the Georgetown area climate. January air temperature averaged 9.0 °C, August temperature averaged 26.8 °C, and mean annual precipitation averaged 1315 mm for the period 1930 -95 (temperatures) or 1930 -96 (precipitation).

The Greeleyville plantation is in southwestern Williamsburg County, about 3.5 km east-northeast of Greeleyville. This plantation is on the Talbot terrace and is located in the Atlantic Coastal Flatwoods section, Upper Terraces subsection (Keys and others 1995). The soil is a somewhat poorlydrained Lynchburg fine sandy loam, a siliceous, thermic Aeric Paleaquult (Ward 1989). The 25-year site index of the first rotation, intensively site-prepared, P-fertilized, unthinned, loblolly pine plantation was 21.3 to 22.9 m (Trousdell and others 1974) or 19.8 to 21.3 m (Pienaar and Shiver 1980).

The Snow Mill plantation was clearcut harvested and burned in June 1986, and three replications of the site preparation treatments were installed in July 1987. Site preparation treatments were: preplanting proprietary herbicide treatment of all residual stems (herbicide), rebed over old beds (rebed-with), rebed perpendicular to old beds (rebed-perpendicular), and three-pass shear, rake, and bed (intensive). The Greeleyville plantation was clearcut and burned in July 1987, and three replications of the site-preparation treatments were installed in August 1987. Site-preparation treatments consisted of: preplanting proprietary site-preparation herbicide treatment of residual stems (herbicide), rebed over old beds (rebed-with), and three-pass shear, rake, and bed (intensive). Both plantations were planted on a 1.8-m spacing along the old or new beds, with improved, coastal, 1-0, bare-root loblolly pine in

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December 1987. Each treatment plot was split, and a proprietary chemical release treatment was applied to one-half of each plot during the spring and summer of the first growing season following planting. Neither plantation was fertilized. The eye of Hurricane Hugo passed within 80 km of the Snow Mill area and within 27 km of the Greeleyville area on September 22, 1989, which was 2 growing seasons following planting.

METHODS

There were 30 saplings in each treatment plot; half were righted and attached to oak stakes in the winter of 1989. The remaining saplings in each plot were left as they leaned. In December 1997, 8 growing seasons after Hugo, 15 unstaked saplings per treatment plot were measured, and, in June through August 1998, 8.5 growing seasons since Hugo, 7 staked saplings per treatment plot were measured. Diameter at groundline, d.b.h., and total height were measured with either a diameter tape or sectional aluminum poles with an attached fiberglass tape. We measured saplings in the released and unreleased halves of the herbicide site-preparation treatment, and unreleased only half of the rebed-with, rebed-perpendicular, and intensive site-preparation plots. The measurements were averaged for each plot to produce three paired (staked and unstaked) values for each treatment measured in each stand. Paired t-tests with Bonferroni-adjusted probabilities were used to test for a difference due to staking.

RESULTS

Table 1 summarizes the parameter averages, standard errors, and t-test probabilities by metric, site-preparation treatment, and stand. Groundline diameter was greater for the unstaked saplings in three of the four treatments in Snow Mill and showed no pattern in the Greeleyville treatments. No differences were significant. Breast-height diameters were very similar in each stand for the staked and unstaked saplings,and no differences were significant. Heights were greater for the staked saplings compared to the unstaked, and the difference was significant for the saplings in the rebed site-preparation plots of Greeleyville.

DISCUSSION

These results are biased because only those saplings that survived eight growing seasons after Hugo were measured. A more complete description of the long-term damage from Hugo would incorporate survival. The only significant difference between staked and unstaked saplings was the total height of Greeleyville saplings in the rebedded plot. The other 23 comparisons were not significant. From this

Table 1—Average (and standard error of the mean) groundline diameter, d.b.h., total height, and t-test P values for staked and unstaked saplings in the Snow Mill and Greeleyville plantations eight growing seasons after Hurricane Hugo passed nearby when the saplings were 3 years old

		Site preparation and release treatment			
Stand	Condition	Intensive unreleased	Rebed unreleased	Herbicide unreleased	Herbicide released
		Groundline diameter (cm)			
Snow Mill	Staked	6.5 (1.8)	19.4 (1.5)	20.6 (1.2)	19.8 (1.3)
	Unstaked	19.8 (2.1)	20.7 (0.7)	19.6 (1.2)	21.1 (0.2)
	P-value	0.16	0.32	0.67	0.46
Greeley-ville	Staked	18.9 (0.6)	16.7 (0.4)	14.2 (0.7)	16.3 (2.5)
	Unstaked	17.0 (1.4)	17.4 (0.0)	14.2 (0.6)	16.2 (0.6)
	P-value	0.13	0.19	0.98	0.96
		Diameter at breast height (cm)			
Snow Mill	Staked	11.6 (1.7)	15.1 (1.2)	15.7 (0.5)	14.4 (1.0)
	Unstaked	14.1 (1.7)	15.1 (0.5)	14.1 (0.8)	14.5 (0.4)
	P-value	0.15	0.97	0.38	0.97
Greeley-ville	Staked	14.3 (0.4)	12.7 (0.4)	10.5 (0.8)	11.9 (2.0)
	Unstaked	12.7 (1.1)	13.6 (0.1)	10.5 (0.2)	11.9 (0.4)
	P-value	0.29	0.18	1.0	1.0
		Total height (m)			
Snow Mill	Staked	9.2 (1.4)	12.4 (0.5)	11.4 (0.5)	11.2 (0.7)
	Unstaked	10.1 (1.3)	10.9 (0.5)	10.3 (0.8)	10.4 (0.5)
	P-value	0.13	0.13	0.29	0.55
Greeley-ville	Staked	12.2 (0.6)	12.0 (0.2)	8.7 (0.8)	9.5 (1.1)
	Unstaked	10.8 (0.2)	10.9 (0.2)	7.8 (0.2)	8.9 (0.2)
	P-value	0.21	0.01	0.41	0.67

we can conclude that either there truly was no effect after eight growing seasons, or that the combination of natural variation and sampling error was greater than the hurricane's effect. Comparing the standard error of staked saplings (which was calculated from 3 plot means, each the average of 7 saplings) to the standard error of unstaked saplings (calculated from 3 plot means, each the average of 15 saplings) indicated that neither sample size had consistently higher or lower errors. Thus, it appears that if there was an effect of the hurricane, it was small in comparison to the natural variation in each treatment plot.

MANAGEMENT IMPLICATIONS

Two 'take home' points can be drawn from these results. First, remedial actions following the hurricane, like staking the saplings upright, is not clearly effective and is feasible only on small tracts. Staking saplings upright on large tracts would be labor intensive and probably not profitable. Secondly, saplings left in a leaning (ca. 45 degrees) position following a hurricane do not lose measurable growth compared to those staked upright immediately after the hurricane. It is quite possible that leaning saplings will grow slower than those not impacted by a hurricane, perhaps due to being whipped back and forth, but this conjecture is beyond these data. From personal observation of saplings in both stands, there is a noticeable crook at the base of many trees, indicating that the trees were once leaning and have since righted themselves. The growth rings of one of these saplings in the region of the crook showed the classic compression wood response.

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