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Survival and Growth of Planted Loblolly Pine Seedlings on a Severely Rutted Site

K.W. Farrish, J.C. Adams, and C.G. Vidrine

Associate professor of forest soils, professor of silviculture, and professor of forest mechanization, Louisiana Tech University, School of Forestry, Ruston, Louisiana

Survival and growth of planted loblolly pine (Pinus taeda *L.) seedlings on a severely rutted site were evaluated over a 3-year period. The soil rutting caused by wet weather logging of the previous stand was divided into three categories of severity (severe, moderate, and light). Four plots, each containing 15 planted seedlings, were monitored for each of the severity categories. Seedling survival was actually greater in the severely rutted plots, probably because competition was reduced by the logging disturbance. However, during the second growing season, height and diameter growth of seedlings in the severely rutted areas was 26 and 21%, respectively, less than that of seedlings in the other two categories. By the end of the third growing season, cumulative height growth was 17% less on the severely rutted plots than on the other two categories.* Tree Planters' Notes 46(1):28-31; 1995.

Wet weather logging with ground equipment usually causes more soil disturbance than similar activities during dry periods (Hatchell and others 1970, Moehring and Rawls 1970, Reisinger and others 1988). Soil compaction and rutting displacement are frequent consequences of operating heavy equipment on wet soils that have reduced strength. Deep rutting displacement occurs when loads applied by wheeled equipment exceed the ability of the soil to support the resulting stress. The situation is further aggravated when four-wheel-drive articulated-frame tractors (typical of wheeled logging skidders) are used, and the rear wheels track in the same path made by the front wheels. The resulting ruts can last for many years, forming potential barriers that interfere with shallow root development. Because most fine tree roots occupy the near-surface soil layers, deep ruts may reduce forest productivity (Moehring and Rawls 1970). Seedlings growing some distance from the ruts may be affected, so that the effect may be greater than the area covered by ruts might indicate. Seedlings that are partially submerged for extended periods in surface water in the ruts also may show reduced growth. In this study, we evaluated the effects of deep rutting on survival and growth of planted loblolly pine *(Pinus taeda* L.) seedlings.

Methods

Study site. The study area was located in a recently logged site in northern Louisiana. Soils of the study area were classified as fine-loamy, siliceous, thermic Typic Paleudults (Soil Survey 1975). The soils are well drained, moderately permeable, strongly acid, low in natural fertility, and moderate in available water capacity. The A and E horizons have sandy loam textures, and the B_t1 is clay loam.

A loblolly pine stand was conventionally harvested on the site using chainsaws for felling and rubber-tired skidders for primary transport. The logging activity occurred during an unusually wet period in late June 1990. Precipitation for the month totaled 13.8 cm (5.4 in), 53% above the 30-year mean for that month. The soils were at or near saturation at the time of the logging activity, and the wheeled skidders created deep ruts on the primary skidtrails and lesser ruts on secondary skidtrails. No attempts were made to restore the rutted areas after the logging activity ceased. Site preparation consisted of herbicide application followed by burning to control competing hardwood vegetation. The site was replanted by hand with 1+0 bareroot loblolly pine seedlings during January 1991 at a 2.5- x 2.5-m (8- x 8-ft) spacing.

Study plots were established on the site during early March 1991. Three categories of rutting severity were identified— severe, moderate, and light. Most severe rutting occurred on primary skidtrails and was typified by deep ruts (figure 1) and considerable subsoil exposure (red B_t soil horizon). Most moderate rutting occurred on secondary skidtrails with clearly identifiable ruts, but little subsoil exposure. Light rutting occurred away from the main skidtrails and consisted of shallow ruts caused by a single pass of a skidder.

Figure 1—*View of a severely rutted area.*

Four plot centers (figure 2) were established in areas of each rutting severity category. The nearest 15 planted seedlings to the plot center were marked with wire flags and numbered tags (figure 3). Seedling location, relative to nearby ruts, was also recorded.

Seedling measurements. Each seedling was measured for height and groundline diameter at the beginning of the study before growth initiation, and again at the end of the first, second, and third growing seasons. First-year growth was calculated as the difference between the respective measurements for each tree at the beginning and end of the first growing season. Second-year and third-year growth was similarly calculated using the differences between measurements at the end of the previous and current growing seasons. Total 3-year growth was calculated as the sum of the growth in the first, second, and third growing seasons. Seedling survival was determined at the end of each growing season.

Figure 2—*Plot center in severely rutted area.*

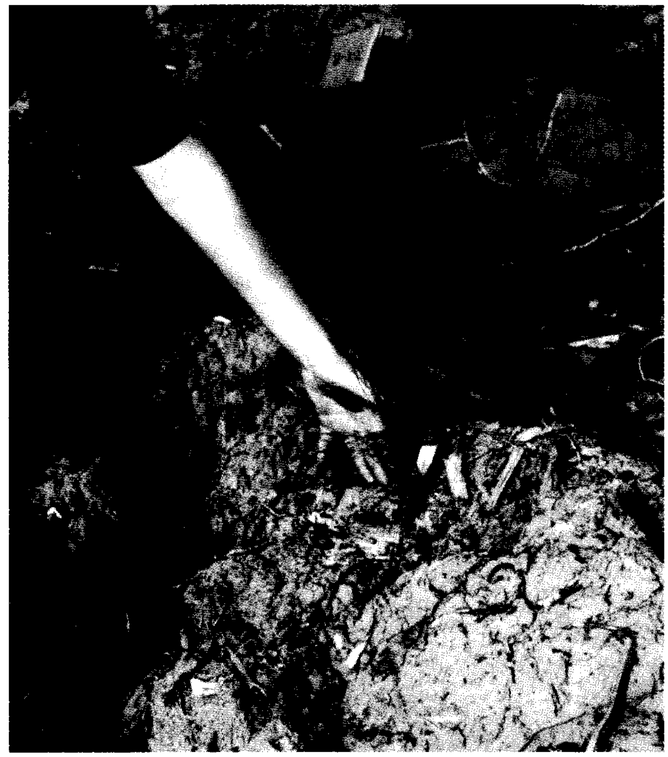

Figure 3—*Seedling growing on a berm showing flag and tag.*

Soil physical properties. Three representative ruts in each plot were measured for depth and width dimensions at the beginning of the study. The rutted microtopography was divided into three descriptive categories— ruts, berms (the frequently uplifted and disturbed edges of the ruts), and flats (the unrutted and relatively undisturbed areas of the plots). A soil bulk-density sample was taken, using a cylinder core sampler, from each of the microtopography positions on each plot, producing nine samples per plot.

Data analysis. Tree height and diameter growth data for the rutting severity categories and microtopography positions, and soil bulk density values were analyzed using analysis of variance and Tukey's mean separation procedure. Seedling survival data were analyzed using chi-square tests.

Results and Discussion

Rut characterization. Mean rut widths ranged from 67 cm (26 in) on the lightly rutted plots to 77 cm (30 in) on the moderately and severely rutted plots. Mean rut depths were 12, 20, and 24 cm (4.7, 7.9, and 9.4 in) on the light, moderate, and severe rutted plots, respectively. Soil bulk densities were significantly greater in the berm and rut microtopography positions compared to the relatively undisturbed flats (table 1).

Table 1 -*Mean soil bulk density values after harvesting on flats, berms, and in ruts on three levels of rutting intensity*

Rutting	Soil bulk density (g/cm^3)		
intensity	Flat	Berm	Rut
Light	0.91 a	1.06 a	0.96 a
Medium	1.00 a	1.22 ab	1.13 a
Severe	1.03 a	1.29 b	1.24 a

Note: Means in a column followed by the same letter are not significantly different at the 0.05 level of probability.

However, with the exception of berms, there was no significant difference in soil bulk densities among rutting intensities, probably due to a combination of three factors. First, the greatest increase in soil bulk density occurs during the first pass of heavy equipment. Repeated passes increase bulk density at decreasing increments (Hatchell and others 1970, Burger and others 1985). Secondly, because these soils were saturated during the disturbance, this moisture content was probably higher than the critical level that would result in maximum compaction (McKyes 1989). Finally, the sample size may have been inadequate to provide for detection of small differences among rutting intensities.

Seedling survival and growth. Seedling survival was not significantly different among the three rutting severity categories at the end of the first growing season (table 2). By the end of the second growing season, however, significant differences in survival among the rutting intensities did exist. Unexpectedly the highest survival was in the severely rutted areas. One possible explanation is that the greater soil disturbance on the rutted plots reduced the number of competing plants and thereby enhanced seedling survival. This also indicates that soil displacement from rutting, even when severe, does not impact survival of planted loblolly pine seedlings. However, during the first two growing seasons, favorable precipitation patterns existed, providing good survival conditions for the newly planted seedlings.

Rutting severity did not significantly affect seedling height or diameter growth during the first growing season (table 3). However, height and diameter growth during the second growing season was reduced by 26 and 21 %, respectively, on the severely rutted areas compared to the lightly rutted areas. Cumulative height growth over three growing seasons was reduced 17% on the severely rutted areas (figure 4).

Within each of the rutting severity categories some seedlings were planted on the undisturbed flat areas between ruts, others were located in berms immediately adjacent to ruts, and others were planted directly in ruts. To determine the effect of these microtopography positions on seedling survival and growth, data for these three locations, combining the three rutting severities, were compared (table 4). Seedling survival after three growing seasons was not different among microtopography positions. Seedling mean height was 15.6% lower among trees planted in ruts than those on undisturbed flats, but the difference was not statistically significant, probably due to insufficient sample size in the rut located seedlings. Trees growing on berms were intermediate in growth.

Table 2-*Survival (number and percentage of original number) of loblolly pine seedlings at the end of the first, second, and third growing seasons*

Rutting	Year 1		Year 2		Year 3	
intensity	No.	%	No.	%	No.	%
Light	48	80	43	72	43	72
Moderate	53	88	53	88	53	88
Severe	56	93	56	93	54	90

Note: Chi-square *P*-values were 0.09, 0.003, and 0.01 for years 1, 2, and 3, respectively.

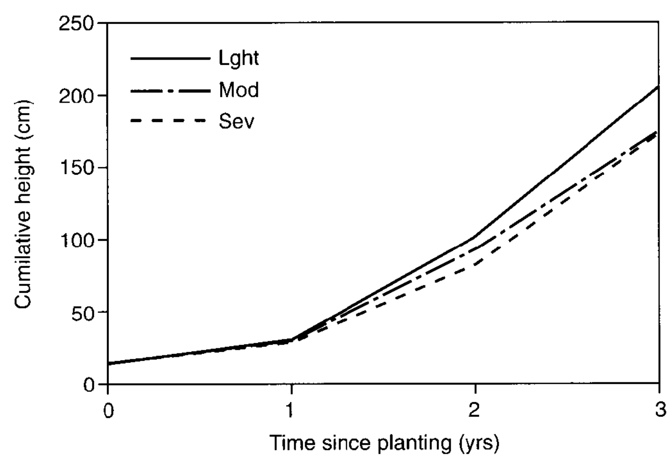

Figure 4—*Cumulative height growth of planted loblolly pine seedlings on areas of three intensities of rutting soil disturbance.*

Table 3-*Height and diameter growth over 3 years of planted loblolly pine seedlings on three different intensities of rutted soil*

Rutting severity	Year 1		Year 2		Year 3		Total	
Height	(cm)	(in)	(cm)	(in)	(cm)	(in)	(cm)	(in)
Light	15.4 a	5.9	70.4 a	27.7	98 .1 a	38.6	185.8 a	73.1
Moderate	16.4 a	6.5	60.7 ab	23.9	88.0 ab	34.6	155.8 b	61.3
Severe	13.2 a	5.25	2.0 b	20.5	79.6 b	31.3	153.7 b	60.5
Diameter	(mm)	(in)	(mm)	(in)	(m m)	(in)	(mm)	(in)
Light	1.9 a	0.07	12.5 a	0.49	22.3 a	0.88	35.7 a	1.41
Moderate	1.9 a	0.07	9.5 b	0.37	19.3 a	0.76	30.6 b	1.20
Severe	2.1 a	0.08	9.9 ab	0.39	20.8 a	0.82	32.9 ab	1.29

Note: Means in a column followed by the same letter are not significantly different at the 0.05 level of probability.

Table 4-*Three-year survival, height, and diameter growth of planted loblolly pine seedlings on flats, berms, and in ruts*

Seedling location	No. seedlings planted	% survival	Height		Diameter	
			cm	in	cm	in
Flat	79	86	71.3 a	67.4	13.0 a	5.1
Berm	62	81	165.4 a	65.1	13.1 a	5.2
Rut	39	82	144.5 a	56.9	10.0 a	3.9

Note: Means in a column followed by the same letter are not significantly different at the 0.05 level.

Conclusions

Severe rutting of forest sites should be avoided because of probable site productivity decline, as well as for apparent aesthetic reasons. Harvesting and site preparation operations should be carried out when the soils are dry enough to prevent rutting or with specialized equipment that minimizes soil displacement. On severely rutted sites, seedlings should probably not be planted directly in the ruts themselves to avoid possible growth reductions.

Address correspondence to John C. Adams, Louisiana Tech University, PO Box 10138, Ruston, LA 71272.

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