SITE PREPARATION FOR LONGLEAF PINE RESTORATION ON HYDRIC SITES: TREE- AND STAND-LEVEL RESPONSES 15 YEARS AFTER PLANTING

Connor D. Crouch, Benjamin O. Knapp, Michael C. Stambaugh, Susan A. Cohen, Joan L. Walker, and G. Geoff Wang

Extended abstract—Longleaf pine (*Pinus palustris* Mill.) restoration is an important land management goal throughout the Southeast. On hydric sites within the Atlantic Coastal Plain, restoration may involve site preparation prior to planting in order to overcome challenges to seedling establishment, such as abundant competition and poor soil drainage (Brockway and others 2006). An earlier study of longleaf pine plantations on hydric flatwoods sites in Onslow County, NC, indicated that site preparation improved seedling growth but not survival through 2 years after planting (Knapp and others 2006). Although investment in site preparation assumes that treatments will result in long-term benefits to stand establishment, lasting impacts of site preparation on longleaf pine are not well understood. Therefore, we sampled the same study 15 years after planting to determine impacts of site preparation on stand development. Eight treatments were applied prior to planting the seedlings. These treatments included an untreated control (flat-planting), six combinations of two initial vegetation control treatments (chopping or herbicide) with three planting site treatments (flat-planting [no treatment], mounding, or bedding), and an herbicide-chopping-bedding treatment. Study treatment codes used throughout this abstract indicate the type of site preparation used: C = chop, H = herbicide, F = flat, M = mound, B = bed.

Our findings indicate that site preparation significantly improved long-term establishment of longleaf pine on hydric flatwoods sites. One-way analysis of variance (ANOVA) indicated that basal area significantly differed among the eight study treatments ($p < 0.001$). Mean basal area for CHB and HB, which approached 3.5 m^2/ha, was significantly greater than that of CM, CF, and F, which were near or below 1 m^2/ha (fig. 1). Two-way factorial ANOVA, excluding the F and CHB treatments, indicated that planting site treatments ($p = 0.009$) and vegetation control treatments ($p = 0.001$) affected basal area, while there was no significant interaction between the treatment types ($p = 0.848$). Bedding resulted in significantly greater basal area than flat-planting, and herbicide application resulted in significantly greater basal area than chopping 15 years after planting.

We also conducted stem analysis to determine if these stand-level differences among treatments were the result of earlier emergence from the grass stage or increased growth after emergence. One-way ANOVA indicated that there were significant differences in age of emergence from the grass stage among the eight study treatments ($p < 0.001$). CF, which had a mean emergence age of 9.25 years after planting, emerged significantly later than the other seven study treatments (table 1). The other treatments had mean emergence ages ranging from 3.72 to 5.46 years and did not significantly differ from each other. One-way ANOVA also found significant differences in mean annual height growth after grass stage emergence among the eight study treatments ($p < 0.001$). HM and HB, with mean height growth exceeding 0.5 m/year, grew significantly faster than F and CF, which had mean growth rates of 0.33 m/year and 0.23 m/year, respectively (table 1). CF had significantly lower annual height growth than all treatments except for F and CM. These findings indicate that increased height growth after grass stage emergence seemed to contribute more directly to long-term stand establishment outcomes than did the timing of grass stage emergence.

Restoration may encompass a range of objectives, and if improved long-term growth or survival of planted seedlings is an important aspect of a restoration effort, then herbicide application and/or soil manipulation may be necessary on hydric flatwoods sites. However, maximizing tree growth and stand density may not be necessary for reaching restoration objectives. For example, longleaf pine savannas are characterized by

Author information: Connor D. Crouch, Graduate Research Assistant, University of Missouri-Columbia, School of Natural Resources, Columbia, MO 65211; Benjamin O. Knapp, Associate Professor, University of Missouri-Columbia, School of Natural Resources, Columbia, MO 65211; Michael C. Stambaugh, Associate Research Professor, University of Missouri-Columbia, School of Natural Resources, Columbia, MO 65211; Susan A. Cohen, Associate Director, University of North Carolina Chapel Hill, Institute for the Environment, Chapel Hill, NC 27517; Joan L. Walker, Emeritus Scientist, U.S. Department of Agriculture, Forest Service, Southern Research Station, Clemson University, Clemson, SC 29634; and G. Geoff Wang, Professor, Clemson University, Department of Forestry and Environmental Conservation, Clemson University, Clemson, SC 29634.

Citation for proceedings: Bragg, Don C.; Koerth, Nancy E.; Holley, A. Gordon, eds. 2020. Proceedings of the 20th Biennial Southern Silvicultural Research Conference. e–Gen. Tech. Rep. SRS–253. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 338 p.

scattered trees and occur within site types similar to our study location. Our findings indicated that high levels of longleaf pine seedling mortality occurred without site preparation, but the control stands resulted in upwards of 100 trees/ha that were out of the grass stage by 15 years after planting. Longleaf pine ecosystem restoration typically seeks to not only establish an overstory of longleaf pine but also maintain or improve the ground layer plant community (Walker and Silletti 2006). Therefore, a balance must be struck between site preparation that promotes longleaf pine establishment and minimizing detrimental impacts of those treatments on native flora (Johnson and Gjerstad 2006). Our future work seeks to address this tradeoff by examining the long-term effects of site preparation on the understory plant community in longleaf pine plantations.

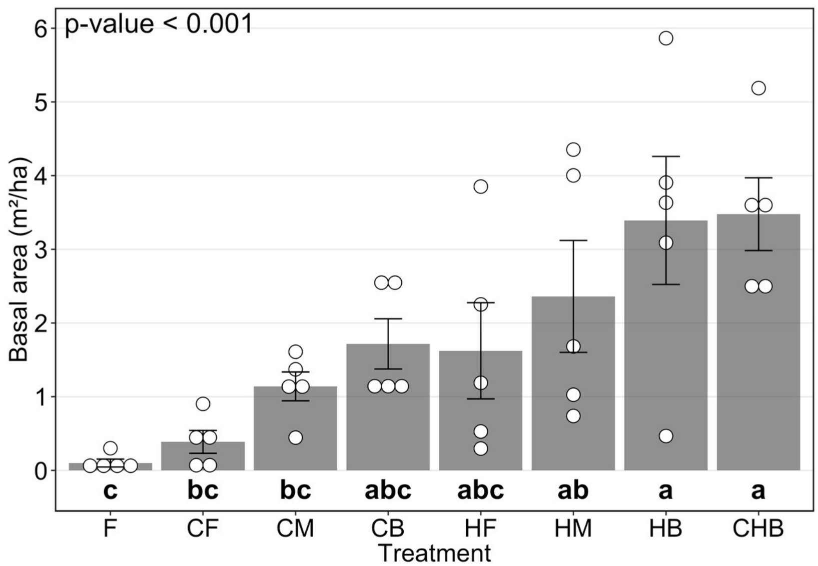

Figure 1—Mean longleaf pine basal area for each site preparation study treatment 15 years after planting. Bars show treatment means and standard errors; points show means of each experimental unit. Same letters indicate no significant difference α = 0.05) among treatments based upon Tukey-adjusted pairwise comparisons; *p*-value is from one-way ANOVA. C = chop; H = herbicide; F = flat; M = mound; B = bed.

Table 1—Mean tree-level responses to site preparation study treatments 15 years after planting

Treatment	Age of grass stage emergence	Mean annual height growth after emergence (*m/year)*
F (control)	5.07 b	0.33 bc
CF	9.25 a	0.23 c
CM	4.93 b	0.40 abc
CB	5.29 b	0.45 ab
HF	5.46 b	0.44 ab
HM	3.77 b	0.52 a
HB	3.72 b	0.53 a
CHB	4.82 b	0.45 ab
p-value	<0.001	<0.001

Same letters indicate no significant difference (α = 0.05) within a response variable based upon Tukey-adjusted pairwise comparisons; p-values are from one-way ANOVA tests.

C = chop, H = herbicide, F = flat, M = mound, B = bed.

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