SURFACE SOIL ROOT RESPONSE TO SEASON OF REPEATED FIRE IN A YOUNG LONGLEAF PINE PLANTATION

Mary Anne Sword Sayer and James D. Haywood

The potential exists for interaction between naturally high soil bulk density and low soil water content to create root-growth limiting soil strengths. This problem is commonly remedied by soil structural attributes, old root channels and other perturbations, and periods of wetness during which soil strength is favorable for root elongation. Because the application and season of repeated fire affect understory plant structure in southern pine forests (Haywood 2009), they may also affect the quantity and distribution of understory roots. On sites where understory roots play a significant role in alleviating extreme soil strength by perturbing the soil and generating old root channels, awareness of how fire-induced changes in vegetation affect understory rooting and soil strength is warranted. Our objective was to evaluate the relationship between vegetation changes induced by fire and soil strength on a site where the potential exists for pine rooting to be limited by both soil bulk density and soil strength.

In a 14-year-old stand of longleaf pine (*Pinus palustris* Mill.) on the Kisatchie National Forest in Louisiana, an investigation is under way to quantify distributions of pine and understory roots and soil strengths in response to no burning and biennial prescribed burning in March, May, and July. The soil is a complex of Beauregard silt loam and Malbis fine sandy loam. These soil series are characterized by subsoil bulk densities that may exceed 1.4 g/cm^3 (Patterson and others 2004, Scott and others 2007) which is considered root-growth limiting (da Silva and others 1994, Pritchett 1979). As soil water is depleted, bulk densities below this threshold could also contribute to root growth limitations if soil strength exceeds 2 megapascals (MPa) (Bennie 1996, Taylor and other 1991). After four biennial prescribed fires, understory roots were sampled in three replications of four subplots per treatment. Understory root biomass at the 0 to 7.5 cm depth was significantly affected by the application and season of prescribed fire (Figure 1), while that between 7.5 and 20 cm was not significantly affected by burn treatments. Overall, understory root biomass near the surface of the soil was greater on the July- and March-burn plots compared to the May-burn and non-burned plots. Grass and forb cover was greater on the July- and March-burn plots compared to the May-burn plots, and all burned plot had greater grass and forb cover compared to the non-burned plots (Haywood 2009).

Soil strength at 16 percent volumetric soil water content (SS16) which represents field capacity for this soil complex, was estimated in three replications of four subplots per treatment by the method of Sword Sayer (in press). The collection of soil strength and volumetric water content data was delayed by prolonged drought in 2010-2011. Preliminary estimates of SS16 using existing data indicate that at this location, root growth limiting soil strengths are possible at the 5 to 20 cm depth (Table 1). Thus, an understanding of how SS16 responds to fire-induced changes in understory rooting is justified. Once estimates of SS16 are completed, the potential of understory rooting to ameliorate high soil strengths and benefit pine rooting in the 5 to 20 cm depth will be assessed for the March-, May-, July- and non-burned plots.

LITERATURE CITED

Bennie, A.T.P. 1996. Growth and mechanical impedance. In Plant Roots: the Hidden Half. 2nd ed. Waisel, Y., Eshel, A., and Kafkafi, U., eds. New York: Marcel Dekker: 453-470.

da Silva, A.P., Kay, B.D., and Perfect, E. 1994. Characterization of the least limiting water range of soils. Soil Science Society of America Journal. 58: 1775-1781.

Haywood, J.D. 2009. Eight years of seasonal burning and herbicidal brush control influence sapling longleaf pine growth, understory vegetation, and the outcome of an ensuing wildfire. Forest Ecology and Management. 258: 295-305.

Patterson, W.B., Sword Sayer, M.A., Haywood, J.D., and Brooker, S. 2004. Effects of vegetation management with prescribed fire on soil physical properties in a young longleaf pine stand. In: Proceedings of the twelfth biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-71. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 74-78.

Pritchett, W.L. 1979. Properties and management of forest soils. New York: John Wiley. 500 p.

Mary Anne Sword Sayer, Plant Physiologist, USDA Forest Service, Southern Research Station, Pineville, LA 71360
James D. Haywood, Supervisory Research Forester, USDA Forest Service, Southern Research Station, Pineville, LA 71360

Scott, D. A., Novosad, J., and Goldsmith, G. 2007. Ten-year results from the North American long-term soil productivity study in the Western Gulf Coastal Plain. In: Advancing the fundamental sciences: Proceedings of the Forest Service national earth sciences conference. Gen. Tech. Rep. PNW-689. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station: 331-340.

Sword Sayer, M.A. (in press) Surface soil root distribution and possible interaction with site factors in a young longleaf pine stand. In: Proceedings of the fifteenth biennial southern silvicultural research conference. Hot Springs, AR: Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station.

Taylor, H.M., Robertson, G.M., and Bristow, K.L. 1991. Soil strength-root penetration relations for medium to coarse-textured soil materials. Soil Science. 102: 18-22.

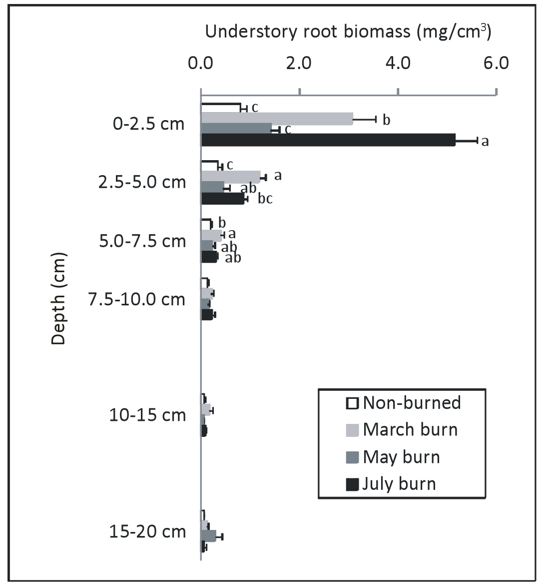

Figure 1—Vertical distribution of understory root biomass in the 0 to 20 cm depth in response to four burn treatments. Means within each depth associated with a different letter are significantly different by the Tukey test at α = 0.05. Error bars are one standard deviation of the mean. Burn treatment did not significantly affect understory root biomass at the 7.5 to 20 cm depths.

Table 1—Mean and standard deviation of SS16 at five depths between 2.5 and 20 cm estimated with data available through December 2010. Values in parentheses represent the percentage of data yet needed before estimates can be finalized. Estimates of SS16 at the 0-2.5 cm depth were not possible by the methods used (NA)

Depth (cm)	Non-burned	March burn	May burn	July burn
	--------------------------Soil Strength (MPa[1]) --------------------------			
0-2.5	NA	NA	NA	NA
2.5-5.0	1.59 ± 0.37 (17)	1.31 ± 0.26 (33)	1.51 ± 0.35 (25)	1.34 ± 0.19 (50)
5.0-7.5	2.16 ± 0.49 (8)	1.70 ± 0.32 (42)	1.91 ± 0.50 (17)	1.49 ± 0.12 (75)
7.5-10.0	2.26 ± 0.45 (8)	1.80 ± 0.34 (50)	2.08 ± 0.51 (8)	1.47 ± 0.04 (83)
10-15	2.25 ± 0.43 (17)	1.69 ± 0.27 (42)	2.41 ± 0.56 (25)	2.40 ± 0.59 (25)
15-20	1.92 ± 0.33 (25)	1.38 ± 0.21 (42)	1.98 ± 0.46 (42)	2.37 ± 0.54 (42)

[1]MPa: megapascals.