CHANGES IN SOIL CHEMISTRY SIX MONTHS AFTER PRESCRIBED FIRE IN A LONGLEAF PINE PLANTATION IN MISSISSIPPI

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Prescribed fire is used to reduce hardwood competition, enhance herbaceous biodiversity, and improve forage quality in longleaf pine stands. These are primarily low intensity, dormant season burns, during which a portion of the biomass in shrub, herb, and the forest floor layers are combusted. Burning releases elemental nutrients bound in biomass, and there are several potential short-term outcomes: 1) volatilization, 2) surface deposition, 3) uptake by autotrophs, 4) stabilization in soil, and 5) leaching. Several studies have examined long-term effects of repeated burn cycles in southern pine stands [e.g., Binkley and others (1992)] or periods of 1 to 3 years post-burn [e.g., Lavoie and others (2010)], though no significant changes in mineral soil C or N have been reported after one year. There are no detailed reports of intra-annual effects of prescribed fire on soil chemistry in longleaf pine stands. Dormant season burns are followed by leaf-out and the growing season, when uptake of newly released nutrients would be likely to occur.

We sought to quantify changes in forest floor mass and mineral soil nutrients (0–5 and 5–10 cm depths) during the first 6 months after fire in a 53 year-old longleaf pine study located on the Harrison Experimental Forest near Saucier, MS (Schmidtling 1973). After an absence of fire of more than seven years, the plantation was burned in 2010 and thinned in 2011. Sixteen plots were sampled pre-burn (January 2014) and repeated 1, 3, and 6 months post-burn. Forest floor and soil samples (0–5 cm, 5–10 cm depths) were collected at 4 cardinal points 1 m from plot center and composited for nutrient analysis. Bulk density was measured before and after the experiment by determining the dry mass of a known volume of soil. Prescribed fire occurred on February 28, 2014. Forest floor mass loss, soil bulk density, and soil C contents (dry combustion) were analyzed at Forestry Sciences Laboratory in Research Triangle Park, NC. Micronutrients (P, K, Ca, Cu, Fe, Na, Mg, Mn) were analyzed at Spectrum Analytic, Washington Court House, OH. Repeated Measures Analysis (RMA) was used to evaluate change over time with SAS® 9.4 software (SAS Institute Inc. 2013).

After the fire, the residual forest floor mass had enriched C (46.3 percent) and N (0.66 percent) concentrations compared to initial concentrations of forest floor C (38.5 percent) and N (0.54 percent). The fire reduced forest floor mass by >70 percent compared to the mean pre-burn condition (16,413 kg biomass ha^{-1}), releasing 4,122 kg C ha^{-1}. There were no changes in mineral soil C concentration at either depth 1, 3, or 6 months after burning, indicating a loss of forest floor C to combustion and subsequent leaching\surface flow of residual char and soot with precipitation. Removal of the forest floor may also stimulate oxidation of labile soil C as forest floor temperatures increase, further reducing C contents. It is interesting that soil C was unaffected by burning as pyrogenic transformation of organic matter to biochemically stable black carbon has garnered much interest for C sequestration. Current thinking is that unless the residual material is mixed or incorporated into soil, it is rapidly transported off site. Soil pH increased significantly after burning at both depths: 4.37 to 4.55 at 0–5 cm and 4.58 to 4.78 at 5–10 cm. This was anticipated due to the liming effect of calcium carbonate released from the forest floor. Burning of organic matter mineralizes a portion of nutrients making them readily available. Analysis of soil micronutrients at 0–5 cm shows several elements (P, K, Mg, Mn) spike immediately after the fire, peaking at months 1 or 3, and decline by month 6, while increases in Ca persist in the upper 5 cm of soil (fig. 1). The site is P deficient making the spike in available soil P well timed at the beginning of the growing season. Changes in soil micronutrients were less pronounced at depths of 5–10 cm. Soil N concentrations were lower than our analyzer was able to measure (< 0.1 percent) and will be examined once the analyzer has been reconfigured for low-range analysis (>0.01 percent) . Although there is transfer of nutrients from forest floor to soil associated with burning, a portion is volatilized based on temperature-specific nutrient sensitivities (DeBano 1991). Nitrogen is very sensitive to volatilization at temperatures as low as 200 to 375°C (DeBano 1991), P and K are moderately sensitive (e.g., 774°C) (Raison and others 1985), while Ca, Mg, and Mn are insensitive

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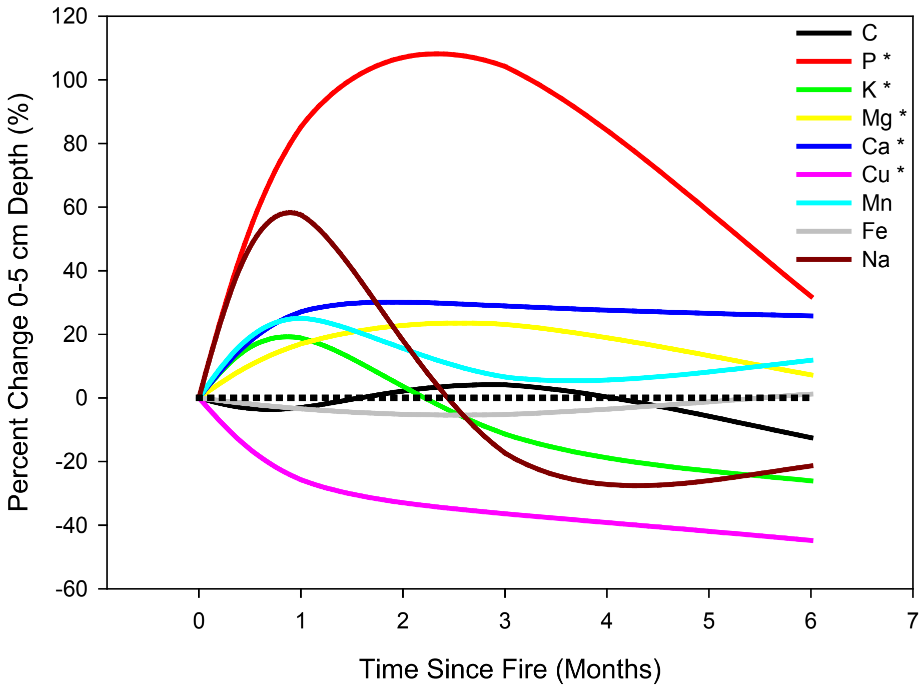

Figure 1—Percent change in soil C and soil micronutrients at 1, 3, and 6 months post-fire in the upper 5 cm of soil collected from a 53 year-old longleaf pine stand (n=16). Element concentration over time (4 data points) was fitted to a spline curve for ease of viewing. No change from initial condition is represented by the dotted black line. Element concentrations that have significantly changed in the months following burning are indicated by an asterisk.

with volatilization temperatures higher than observed for flaming woody biomass >1100°C (DeBano 1991).

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