Title: Recovery of plant communities and soil biogeochemistry following high-intensity fire

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Abstract:

To restore oak savannas in the Midwestern US, ecosystem stewards and managers cut invasive brush and thin trees, creating woody debris brush piles. Brush pile burning is the top strategy for dealing with this debris. Though individual piles are generally small (2-5 m in diameter), burning them can produce extreme soil temperatures that adversely affect soil processes and biota beneath the piles. Brush piles are often produced at high density in small management units undergoing ecological restoration, which may have consequences for ecosystem functioning and regional biodiversity conservation; approximately 5,000 brush piles are built and burned annually throughout the Chicago region. However, the ecological effects of these "burn scars," which may include long-term changes in plant communities and soil biogeochemistry, are virtually unexamined. Furthermore, burn scars represent a unique study system for examining plant and soil successional dynamics following high-intensity fire. Burn scars can be used to evaluate plant and soil responses to high-intensity fires, characterize recovery trajectories, and identify possible remediation solutions. In this study, we used a unique chronosequence of burn scars created between 2015 and 2023 at The Morton Arboretum (Lisle, IL, USA) to evaluate the effects of brush pile burning on plant communities and soil biogeochemistry and track their successional recovery dynamics.

Brush pile burning had dramatic effects on plant communities and soil biogeochemistry, much of which persisted for at least eight years following burning. Recently-produced brush pile scars contained an average of 94% bare ground. It took seven years for scar vegetation cover to approximate that found in unburned areas ($P<0.001$). While plant communities overlapped between burn scars and control plots, burn scars had reduced variation in their plant communities compared to unburned controls ($P=0.001$). Additionally, older burn scars harbored distinct and more variable plant communities than younger burn scars ($P=0.001$). Belowground, nitrate and phosphate concentrations approximated values observed in unburned controls over time while pH and microbial biomass effects persisted for at least eight years. Brush pile burning increased soil nitrate and phosphate concentrations for one and four years respectively before returning to control levels ($P<0.001$). In contrast, brush pile burning increased pH from an average of 6.1 to an average of 7.9 and dramatically decreased microbial biomass – effects that persisted throughout the chronosequence ($P<0.001$). Collectively, our results suggest that while nutrient dynamics may recover unaided, soil pH, microbial populations, and vegetation communities likely require active remediation following high-intensity fires.