Vegetation recovery in slash pile scars following restoration of an Ozark woodland

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Introduction

Restoration often involves the removal of invasive and undesirable woody biomass. Slash pile burning is one method for efficiently removing large quantities of woody debris during the restoration process. Slash piles are created by stacking large amounts of woody biomass in a single location and then allowing them to burn until all biomass has combusted (Fig. 1a). However, the prolonged extreme temperatures from pile burning is often lethal to microbial communities, vegetative propagules, and seeds that lie dormant in the upper soil horizon (Korb *et al*., 2004, Busse *et al*., 2013). These burns create slash pile scars distributed across the restored site. Further, the combustion of biomass and extreme temperatures can alter soil structure, moisture, and nutrient availability. The rate of native vegetation recovery on slash pile scars depends on burn intensity, pile area, and properties of the surrounding plant community. At degraded sites with low abundance and diversity of native plant species and without active seeding, native plant communities are expected to recover slowly. If the native plant community recovers slowly over time, it raises the concern that slash pile scars could serve as a foci for the reestablishment and spread of invasive or undesirable species.

In Ozark woodlands, little is known about how pile burning affects native plant community recovery. The objective of this study was to determine how pile burning changes the biotic and abiotic microenvironment and whether the establishment of native plant species are facilitated or inhibited in slash pile scars. We asked the following questions:

1. How does pile burning alter soil nutrient, moisture, and compaction compared to unburned areas?
2. Are some native species superior than others at colonizing burn-scars during the first-growing season?
3. What is the relative importance of the soil biotic and abiotic environment in determining initial germination and establishment rates in slash pile scars?

Experimental Design

Field Study

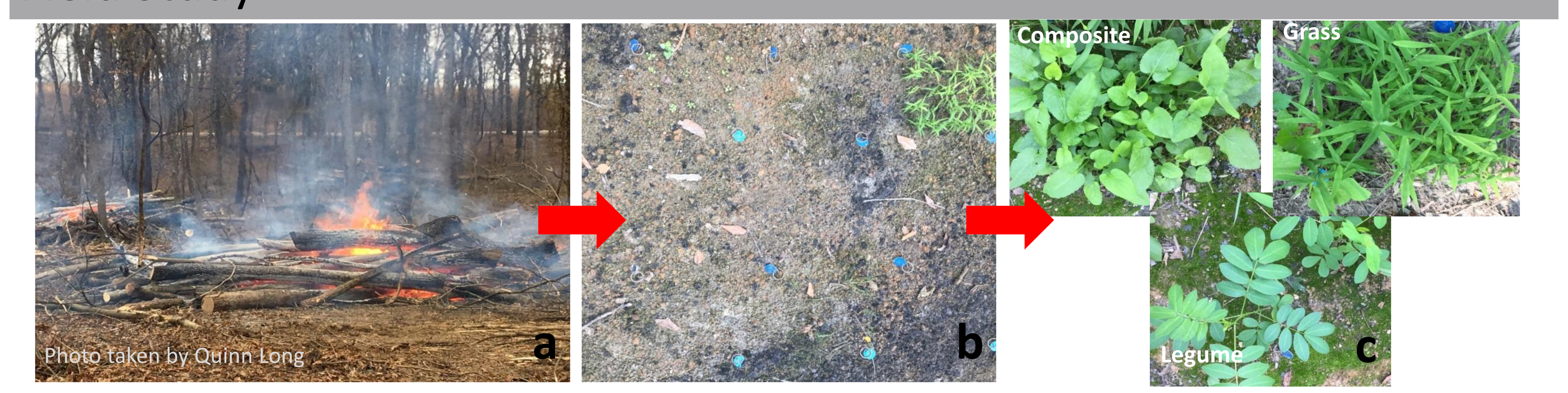


Figure 1. a) A slash pile being burned in Shaw Nature Reserve Dec 13th, 2016. **b**) A burn pile scar five months after the burn and six weeks after a 1 m^2 plot was established in the burn scar and seeded. **c)** Subplots with each of the three functional groups 12 weeks after the seed addition.

The seed addition study used four sites located in an Ozark woodland at Shaw Nature Reserve. Each site contained a high intensity pile scar and an adjacent control area with similar canopy cover and slope. At each site four 1 m^2 plots were established (n = 2 pile scar center and n = 2 adjacent controls). One plot each in the pile scar and control was assigned as a seed addition plot while the other plot was left unseeded. The 1 m^2 seed addition plots were divided into six 25 cm^2 subplots, with each subplot being randomly assigned to one of six species: two legumes (*Lespedeza violacea* and *Senna marilandica*), two composites (*Solidago ulmifolia* and *Symphyotrichum drummondii*), and two grasses (*Bromus pubescens* and *Chasmanthium latifolium*). Occupancy in 5 cm^2 cells of each subplot was recorded approximately every other week for 10 weeks. Soil moisture, spherical densiometer, and penetrometer were also quantified in the burn and control plots.

Germination Experiment

To differentiate between the impact of abiotic and biotic factors on vegetation recovery, a germination experiment was conducted using four soil types: burn pile soil, control soil, sterilized burn pile soil, and sterilized control soil. Burn pile soil and control soil were sterilized using an autoclave. For the experiment, each species had 15 Petri dishes, three dishes of each soil type and three additional dishes that used filter paper as the medium. Thirty seeds of a single species were placed in each dish. Germination in the dishes was monitored approximately every 2-3 days for 4 weeks.

Figure 2. Petri dishes with different soil types and 30 seeds per dish monitored over 4 weeks (Soil type from left to right: control soil, burn soil, sterile control soil, sterile burn soil

Native Species Information

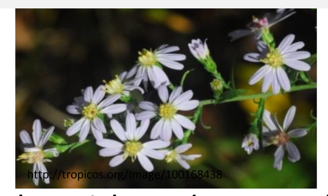
Native Species Used in Field Study

Grasses

Bromus pubescens (Brpu)

Chasmanthium latifolium (Chla)

Composites



Symphyotrichum drummondii (Sydr)

Solidago ulmifolia (Soul)

Legumes

Lespedeza violacea (Levi)

Senna marilandica (Sema)

Native Species Cover in Burn and Control Piles

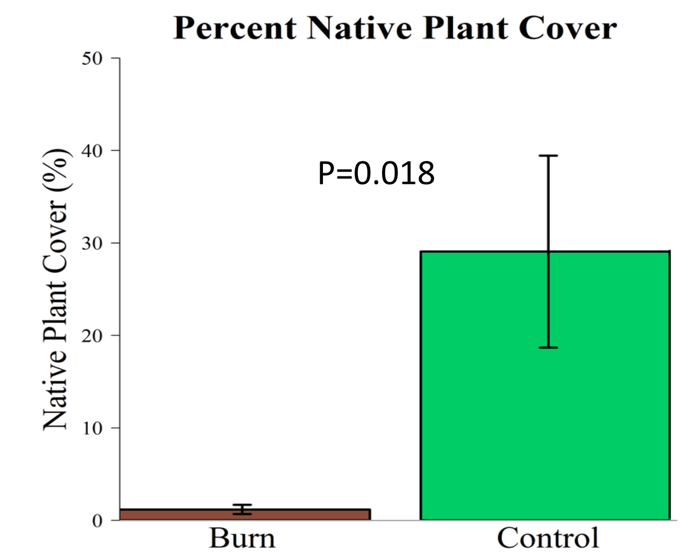


Figure 3. Average percent native vegetation cover. Cover was sampled in passive restoration burn plots and adjacent control plots. Native vegetation cover is significantly lower in burn piles than control piles (t-test, P=0.018).

Results – Lab Study

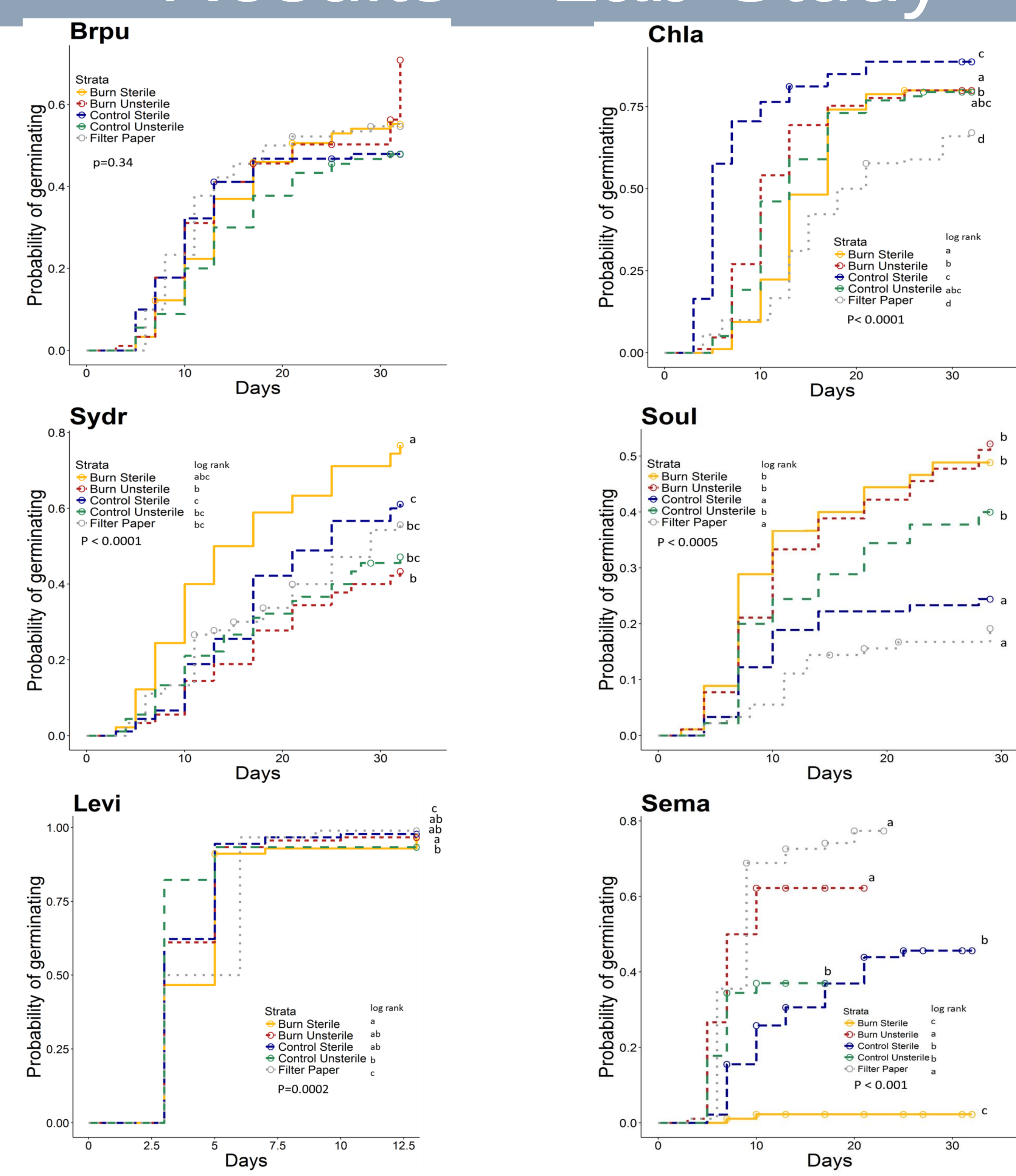


Figure 4. Germination probability curves for each species with log rank analysis. Different letters identify significantly different germination probability curves. Soil type and treatment have a significant effect on germination probabilities for all species but *Bromus pubescens*. For all other species , there is a significant difference between the germination probability curves; however, no uniform trend exists among the species to distinguish one soil type and treatment as having the highest probability of germination.

Results – Field Study

Soil Chemistry

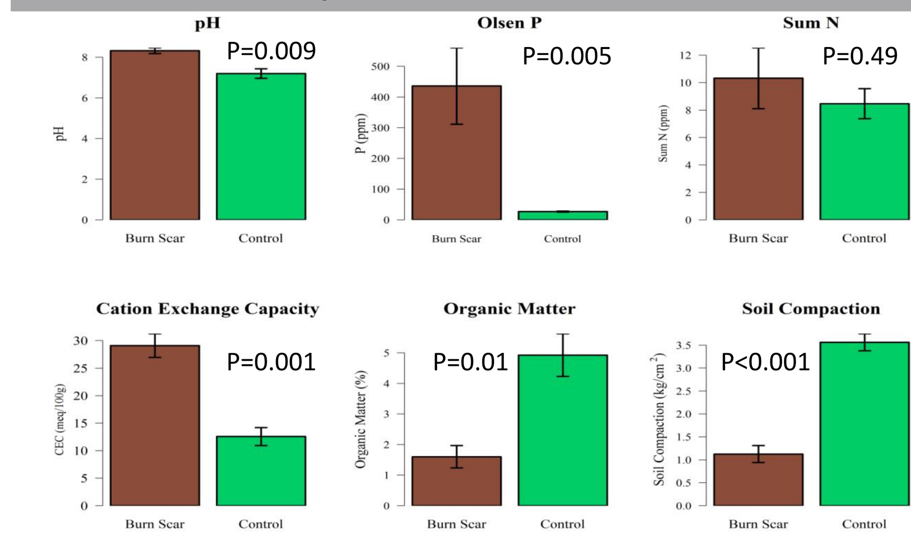


Figure 5. Soil chemical properties from soil samples of the top 4 cm of burn pile and control soil. Soil sampling occurred six months after the slash pile burn. Differences between soil collected from burn scar plots and soil collected from control plots are apparent. Burn scars have significantly higher pH, P content, cation exchange capacity and significantly less organic matter and soil compaction.

Species Establishment in Control and Burn Plots

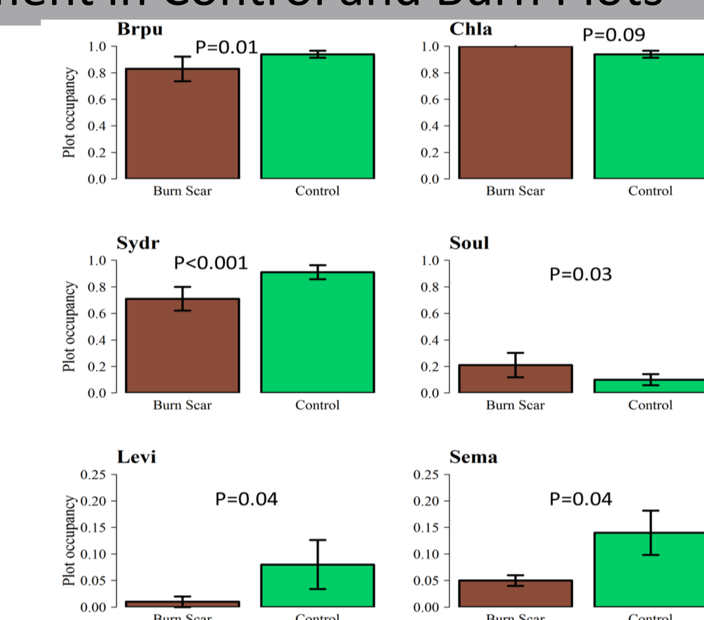


Figure 6. Average plot occupancy for each species in the control and burn piles displayed with standard error bars and P values generated form a generalized mixed linear model. Species establishment rates varied between species, functional groups, and plot treatment . The highest average establishment rate occurred in the grasses and lowest establishment rates in the legumes. Four of the six species (*Chasmanthium latifolium*, *Lespedeza violacea*, *Senna marilandica*, and *Solidago ulmifolia*) established better in the control plots than the burn plots.

Conclusions

Burn pile scars do alter soil chemistry, nutrients, moisture, and compaction. The burn piles sampled showed a dramatic increase in soil pH and nutrients such as P, Ca, Mg, and K. Along with the altered soil chemistry, there is a physical change in the soil. The ash layer that is formed is significantly less compact than the surrounding soil. Ultimately, slash pile burns create a distinct microenvironment that presents a challenge for land managers attempting to restore native vegetation in burn scar areas.

Differences in establishment rates existed among treatments, functional groups, and species. While four of the six species established better in the controls, all species were able to establish in the burn piles. One species, *Solidago ulmifolia*, showed consistently greater germination and establishment in burn scars in the field and lab study. Among functional groups, grasses had the highest establishment rates while legumes had the lowest in the field study.

While the germination experiment showed soil type and treatment are significant factors in germination probability, between the species, there was no consensus as to which soil and treatment type was best for germination. The results from the field study suggest native plants preform better in control soil, however, the results form the lab germination experiment are inconclusive. Inconclusive germination experiment results make it challenging to determine to what degree the environmental filter created by the slash pile burn is a result of biotic changes to the soil or alterations to the microbial community.

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