EFFECTS OF SIMULATED PRESCRIBED FIRE ON AMERICAN CHESTNUT AND NORTHERN RED OAK REGENERATION

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ABSTRACT

Introduction

American chestnut (*Castanea dentata* [Marsh.] Borkh.) was a dominant species in the forests of eastern North America prior to the importation of chestnut blight (*Cryphonectria parasitica* [Murr.] Barr) in the early 1900s and ink disease (*Phytophthora cinnamomi* Rands) in the 1800s (Anagnostakis 2012). Historical accounts and phylogeny (Manos et al. 2001) suggest chestnut may have certain disturbance adaptations similar to oak (*Quercus* spp.), including the ability to prolifically sprout following topkill (Paillet 2002). However, the response of chestnut to fire has only been observed in mature individuals, not in seedlings which would be used during restoration attempts. The objective of this study was to compare American chestnut's response to prescribed fire to that of the closely related red oak (*Q. rubra* L.). We hypothesized that available light and initial stem diameter would positively affect the vigor of sprouts produced (Dey 1991, Johnson et al. 2002).

Methods

We simulated the morphological effects of surface fire and associated topkill on 143 red oak and 94 chestnut seedlings using a burn chamber. Seedlings underplanted in April 2007 and May 2009 at three sites in north central Indiana were selected to provide a wide range (5.2-49.0 mm) of ground line diameters (GLD). Canopy photos were taken adjacent to each seedling to estimate canopy openness. Treatments were designed to simulate surface fire conditions optimal for releasing oak advanced regeneration (Brose and Van Lear 1998) while ensuring topkill of all seedlings (Peter et al. 2009) and occurred just prior to leaf out. Before ignition, we cleared the vegetation from the area around each seedling and placed a Kaowool™ (Thermal Ceramics, Inc., Augusta, GA) combustion chamber filled with dry leaf litter around the base of the stem. The litter was ignited and stems were heated using a plumber's torch, subjecting stems to temperatures of 200–300 °C for 60 seconds from each of two diametrically opposite directions. Individual sprout height (Ht), ground line diameter, and first order lateral branch (FOLB) count were monitored throughout the 2013 growing season. Ground line diameter was recorded 5 cm above ground line to allow for taper and curvature at the point of attachment, and only on sprouts ≥7.5 cm total height.

Results

Both species sprouted consistently in response to topkill with no difference in number of sprouts per stump ($p = 0.66$). Total sprout productivity (TSP) was calculated for both species as $TSP = BA \times Ht + (2 \times FOLB)$ where BA = basal area. Red oak responded with a greater TSP compared to American chestnut (58.0±11.4 cm^3 compared to 117.6±17.7 cm^3; $p = 0.006$), though there was little difference between species in the final size of the tallest, most dominant sprouts.

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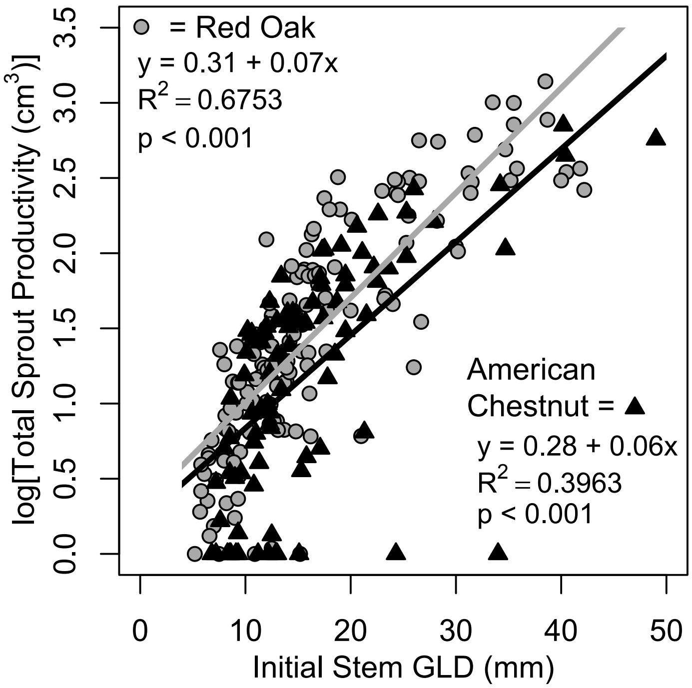

Figure 1.—Initial stem ground line diameter (GLD) regressed with log transformed total sprout productivity of American chestnut and northern red oak seedlings following heat induced topkill.

Initial stem GLD was positively related to the variation in TSP (Fig. 1) and both sprout height and sprout GLD after topkill for both species (Fig. 2). Initial GLD was also positively correlated with number of sprouts produced per stump ($r = 0.54$, $p < 0.001$). Correlations between canopy openness and both TSP and dominant sprout size for both species (all $r > 0.55$, $p < 0.001$) indicated that light availability positively influenced an individual's ability to recover following topkill. However, original stem size may have been confounded with light environment, as seedlings in high light conditions were larger after a given interval than those in low light environments. Additionally, our sample may be biased because the most open site contained only red oak but was included to provide seedlings of comparable size to the largest American chestnuts. When we restricted analysis to only the trees in comparable light environments, species differences in average TSP reversed, presumably due to red oak's considerably smaller average diameter at those sites.

Discussion

The tendency of larger seedlings to produce more and larger sprouts after topkill by fire is probably related to their more extensive root systems providing greater access to nutrient and water resources. The results suggested that both species had highly productive sprout responses following topkill by fire, producing sprouts up to 200 cm tall after one growing season. Both species also responded favorably to increased light availability and may, therefore, benefit from fire, harvesting, natural canopy mortality, or other disturbances that increase light availability at the forest floor (McCament and McCarthy 2004, Paillet 2002). Red oak had greater TSP, height, and GLD following topkill across initial GLD sizes compared to American chestnut, suggesting it might be slightly more productive than chestnut following topkill by fire. Our results implied that larger oak and chestnut seedlings can produce sprouts above browse line and can be considered advance regeneration in the growing season following a single prescribed fire. However, it is still unclear whether chestnut seedlings can tolerate multiple burns that are sometimes used for understory management in oak dominated forests (Dey and Hartman 2005).

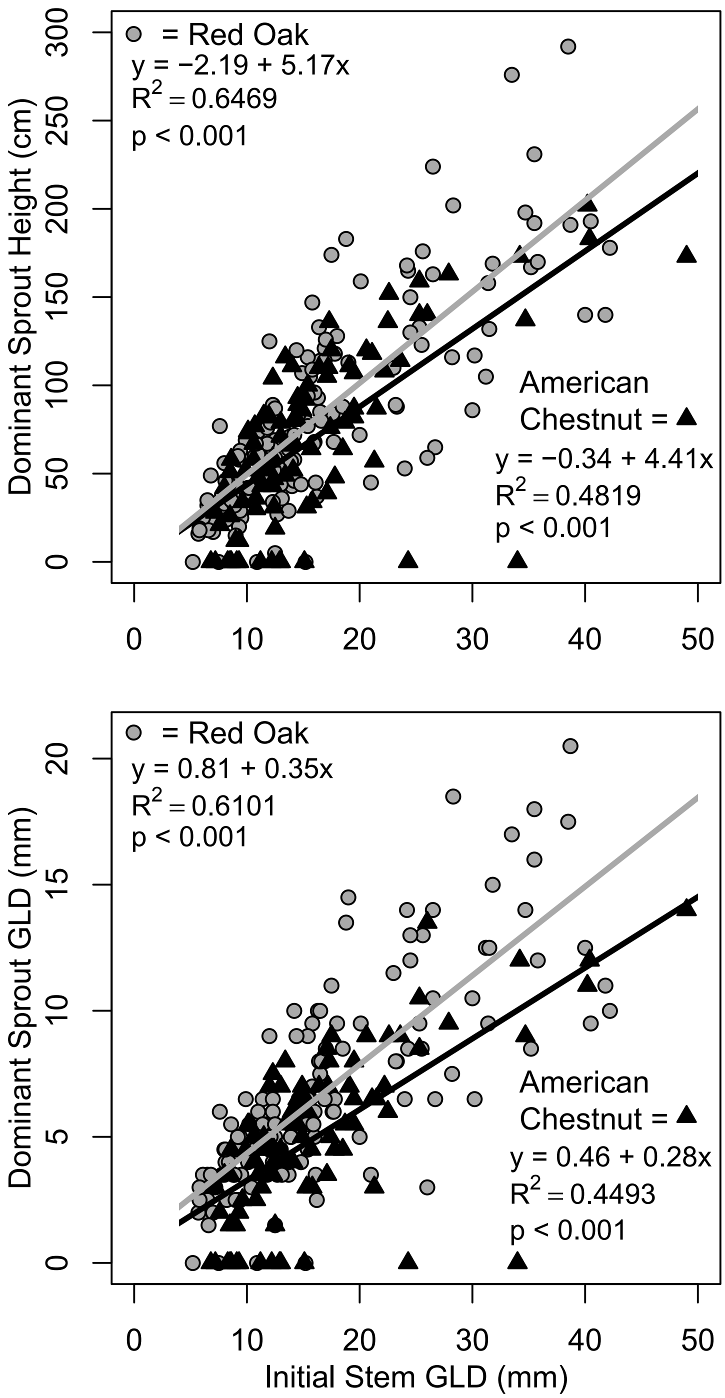

Figure 2.—Initial stem ground line diameter (GLD) regressed with height and GLD of dominant sprouts of American chestnut and northern red oak seedlings following heat induced topkill.

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