Assessing the Influence of Fire History on Wild American Chestnut (*Castanea dentata*) Populations on Pine Mountain, Kentucky

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NSF-Research Experiences for Undergraduates, Disturbance Ecology in Central Appalachia, 2021

Introduction:

In 1904, C*ryphonectria parasitica*, a fungus known as the chestnut blight, was discovered in the United States (Paillet, 2002) and triggered massive mortality of American chestnuts (*Castanea dentata* (Marshall) Borkh.- Hereafter "chestnuts") (Griffin, 2000). By 1950 the species was considered functionally extinct due to how infrequently individuals reproduce sexually (Paillet, 2006). Surviving chestnuts were mainly juveniles, which were less susceptible to the blight than larger trees due to their smaller bark area and lack of bark fissures (Paillet, 2002). As these individuals mature, aboveground tissue succumbs to the blight, but these individuals bud at the root collar, remaining in a cycle of re-sprouting and stem mortality which has led to their "perpetually juvenile" appearance and function (Paillet, 2006).

The chestnut is of high conservation interest as a foundational and mast fruiting species (Paillet, 2006) and timber crop (Paillet, 2002). One effort to restore populations is a breeding program that aims to produce a hybrid that retains the structural and ecological traits of American chestnuts and the blight resistance of Chinese chestnuts (Griffin, 2000). One priority of The American Chestnut Foundations's breeding program is to "capture and use the diversity of native germplasm" (Fitzsimmons, 2017). Wild native germplasm is rare and often inaccessible; germplasm from southern Appalachia is especially valuable as the area hosts the highest chestnut diversity (Fitzsimmons, 2017).

Management techniques to open canopies have been used in attempts to increase germplasm production since chestnut growth is positively correlated with increased light (Paillet, 2002; Paillet, 1993). Chestnuts have also been found to resprout vigorously following fires (Belair, 2014). With this in mind, we investigated the influence of fire on chestnuts. We hypothesized that fire increases canopy openness, thus increasing chestnut growth and allowing chestnuts to reach maturity before infection. We also hypothesised that fire wounds chestnuts, increasing levels of blight in burned areas.

Our study sites were Hi Lewis Pine Barrens and Bad Branch State Nature Preserves on the southeastern slope of Pine Mountain, Kentucky. Hi Lewis experienced arson fires in 2000, 2010, and 2018. In addition, one area of Hi Lewis was subject to a prescribed burn and clearing of aggressive native plants in the fall of 2020. Bad Branch served as a control as it has not experienced any fire events in many decades.

Methods:

Twenty-six transects were plotted, 13 in each site, starting at the ridge and running 90° from the ridge bearing down the southern slope. Transects were 50 meters long, 4 meters wide, and 50 meters apart.

Biological data collected at each chestnut included height, diameter at ankle height, number of stems, severity of bight, and presence of flowers. Abiotic data included coordinates and canopy openness using hemispherical photography.

Chestnut stem volume was calculated using a conical volume equation; this variable was omitted from our analyses as the number of stems showed a similar trend with less variation. Hemispherical photos were binarized in imageJ to determine the canopy openness at each individual. ANOVA-style analyses performed in RStudio and graphs created in Excel were used to explore the associations between fire history or site and canopy openness, chestnut density, blight status, and stem number. Arcmap was used for visual analysis.

Results and Discussion:

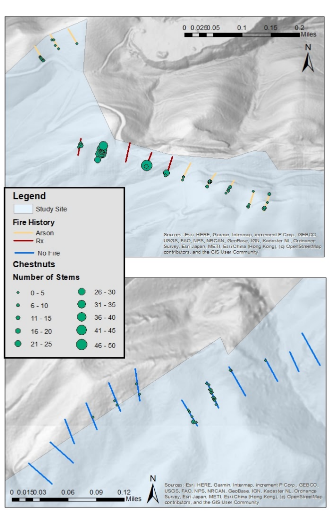

Figure 1: Map depicting data collected in the field. Transect color shows fire history while chestnut point sizes represent number of stems.

Trees in areas that had been cleared and subject to prescribed fire experienced much more open canopies (82% ± 7.5) than areas only burned by arson (12% ± 2.0) or not recently burned (6% ± 0.2, $F_{2,82} = 147$, $p < 0.001$). Trees subject to each fire history type showed significantly different numbers of stems. Trees in the arson and no burn areas were biologically similar in stem number when compared to the prescribed burn areas where trees had much more stems. Visual representations showed no distinct pattern between canopy openness and number of stems, leading us to believe that additional factors are influencing stem number. Chestnut density did not vary across fire history ($F_{2,23} = 0.649$, $p = 0.532$) or site ($F_{1,24} = 1.1$, $p = 0.305$), suggesting that fires are not negatively impacting chestnut density. Trees in both fire areas were found to have more severe blight infection than those at the site with no fire history ($\chi^2 = 11.586$, $p = 0.003$); this supports Belair's findings, showing that fire wounds chestnuts which can serve as an entry point for the blight.

Only one flowering chestnut was found in our transects. Despite this, it should be noted that including this individual, 9 flowering chestnuts were observed in the prescribed burn area while none were observed in the arson or prescribed burn sites.

Conclusions:

Overall, this study supported and supplemented the findings of Belair's study by looking into the influence of fire and feasibility of fire management for wild pure American chestnuts. Further research into the relationship between canopy openness and stem number as well as maturity is recommended. Additionally, more transects in future studies may better represent environmental variability. Monitoring the prescribed burn area is recommended to shed light on whether trends will continue throughout succession. The results of this study will be shared with the Kentucky Chapter of The American Chestnut Foundation.

References:

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The study was conducted as part of the NSF Research Experience for Undergraduates and Research Experience for Teachers program: Disturbance Ecology in Central Appalachia — a ten-week summer research program hosted by Eastern Kentucky University.