2013

American Chestnut's Role in the Ecological Restoration of Coal-Mined Landscapes

Jenise Bauman
Western Washington University, jenise.bauman@wwu.edu

Caleb Cochran
Miami University - Oxford

Brian C. Murphy
Ohio University - Main Campus, mccarthy@ohio.edu

Carolyn H. Keiffer
Miami University - Middletown, keiffech@miamioh.edu

American Chestnut's Role in the Ecological Restoration of Coal-Mined Landscapes

Jenise M.Bauman[1], Caleb Cochran[1], Brian C. McCarthy[2] and Carolyn Keiffer[1]

[1] Miami University Department of Botany, Oxford, Ohio, 45056 and [2]Ohio University, Department of Environmental and Plant Biology, Athens, Ohio, 45701

Background

The American chestnut's fast growth rate, early nut production, and quality of timber make it a valuable tree for use in coal mine restoration projects (Figure 1). This species tolerates a wide range of ecological conditions, including dry soils and low pH, which are typical of some sites previously mined for coal. Experimental planting methods are currently being studied to determine protocols most conducive for establishing chestnut trees on these sites. The Forestry Reclamation Approach (FRA) proposed by the Appalachian Regional Reforestation Initiative (ARRI) recommends the selection of proper soil substrate, a deep rooting zone, appropriate herbaceous vegetation, and the proper planting of ecologically valuable trees (Zipper et al. 2011). The premise is that established trees, like chestnut, can accelerate native forest recovery by adding organic matter to the soil, attracting seed-carrying wildlife, and providing reservoirs for beneficial soil microorganisms.

Coupling FRA planting protocols with the goals of The American Chestnut Foundation's (TACF) restoration program accomplishes two objectives. For one, this partnership introduces a valuable native tree for the restoration of Appalachian landscapes impacted by mining. Second, large-scale ecological restoration projects provide an opportunity for the directed experimental plantings of various chestnut seed lines. The ultimate goal is the successful establishment of founder populations of chestnut that can potentially produce blight-resistant offspring that migrate into surrounding forests (Jacobs 2007). This paper summarizes a portion of a long-term study in southeastern Ohio that is evaluating FRA soil ripping as a preparation method for the planting of pure American and backcrossed chestnut lines (B1-F3 and B2-F3) on a reclaimed coal mine site. Growth and survival of the different chestnut seed lines and the presence of chestnut blight cankers are reported.

Figure 1. Dr. Jenise M. Bauman standing next to a seven-year-old chestnut on a reclaimed mine site in southeastern Ohio. Chestnut trees are responding well to the soil conditions and the planting methods. When assessing the plots in summer 2013 it was noted that many trees were tall enough to escape herbivory from deer and impose shade on the surrounding vegetation. Photo by Caleb Cochran

Methods

The field site is located in southeastern Ohio and was mined for coal in the 1970s and reclaimed in 1978-79. Three experimental blocks were installed in the spring of 2007 each containing four treatments: (1) a control (C) that was left undisturbed, (2) a plot cross-ripped (R) at a depth of approximately 1 m created by a D-6

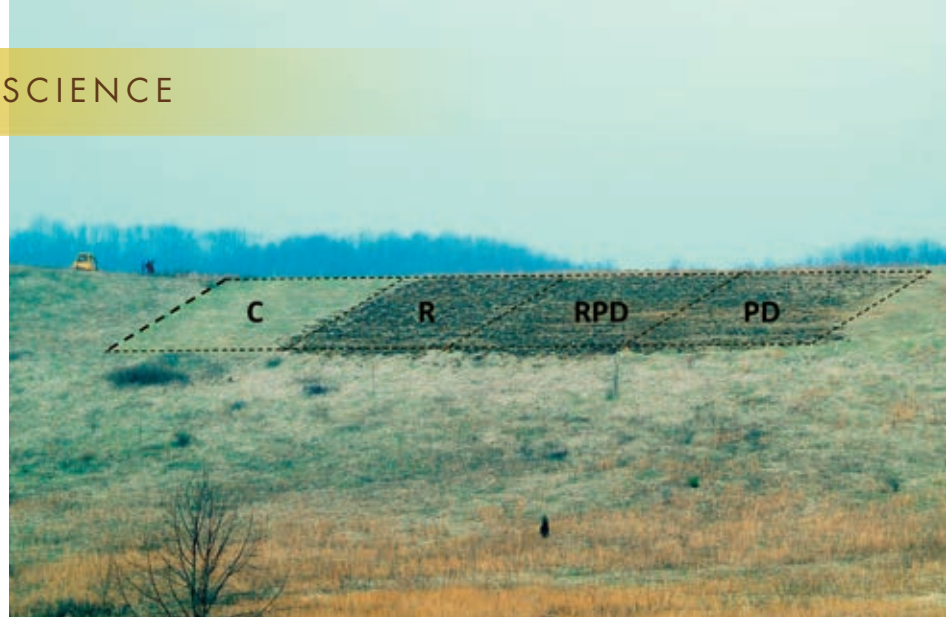

Figure 2. Design of one field block consisting of four treatments: control (C), ripped (R), ripped + plowed and disked (RPD), and plowed and disked (PD). Each block was 73 x 36 m with each treatment 18 x 36 m within. There were three replicated blocks. Photo by Dr. Brian C. McCarthy

dozer with steel ripper bar, (3) a ripped + plowed and disked plot (RPD), and (4) a plowed and disked (PD) plot by a conventional tractor (Figure 2). A total of 1,200 one-year-old chestnut seedlings spaced 2.15 x 2.15 m were planted in the treatment plots as bare rootstock in March of 2007, 400 in each block.

The seed types were randomly placed in treatment plots in the following quantities: 520 pure American, 257 B1-F3 (3/4th American chestnut progeny of P-11 × open), and 423 B2-F3 seedlings (7/8th American chestnut progeny of SA417 × open). The backcross seed were obtained from the Meadowview Research Farms of The American Chestnut Foundation. In August of 2012, survival data were recorded and the height of each chestnut seedling was measured. An analysis of variance (ANOVA) followed by a Tukey's post hoc test was used to determine significant differences. All seedlings were scored for the presence or absence of natural chestnut blight cankers as evidenced by the presence of the orange fruiting bodies called stroma (Figure 4A). A sub-sample of cankers was selected for culturing to confirm the presence of chestnut blight fungus, *Cryphonectria parasitica* (Figure 4B).

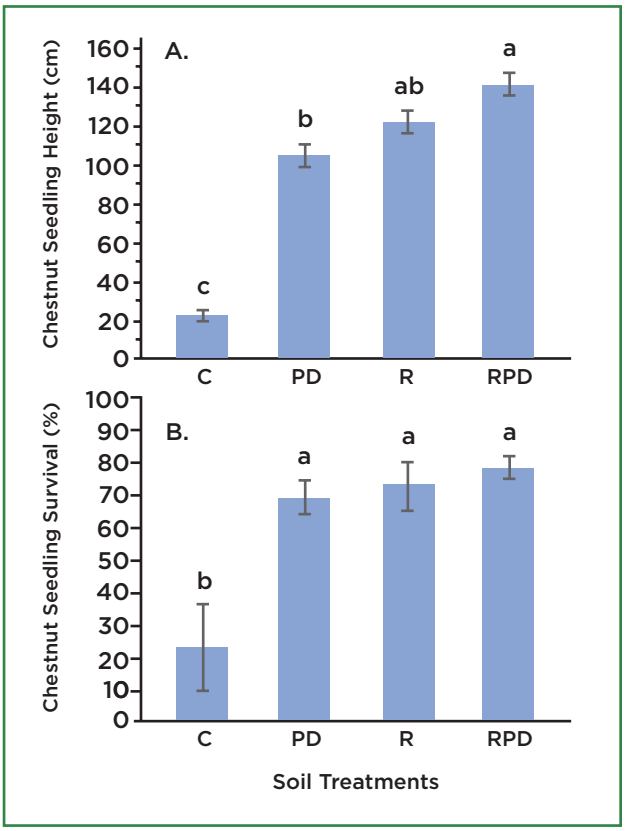

Figure 3. Panel A. Seedling height (cm) compared among the treatments: control (C), ripped (R), and ripped + plow and disk (RPD), and plow and disk (PD). Plots that applied the ripping techniques (R and RPD) had significant increases in seedling growth when compared to the PD and the C plots ($F = 115.3$, $P < 0.0001$). **Panel B.** Chestnut seedling survival compared among soil treatments. Plots that applied some form of soil preparation (PD, R, RPD) had significantly higher survival than the control plots ($F = 9.38$, $P < 0.005$). Error bars are ± 1 SE, bars sharing common letters do not differ significantly from each other (alpha = 0.05) as determined by Tukey's HSD.

Results

Seedling Growth and Canker Production

Plots that applied some type of mechanical treatment bore trees that were significantly taller than seedlings in the untreated control plots (Figure 3A). Of the treatments, the plots that employed FRA recommended ripping (R and RPD) performed the best. Although the chestnut trees in the ripped plots were the tallest, seedlings in the PD plots also outperformed the seedlings in the untreated controls. When seedling types were compared, no significant differences existed between

Figure 4. Field cankers and cultured fungi documented from chestnut bark in the study plots. **Panel A.** Photograph is of a basal canker with evident orange stroma protruding from the bark of a pure American chestnut tree. **Panel B**. Bark samples that were extracted from a sub-sample of field cankers yielded chestnut blight fungus *C. parasitica in vitro*. Photos by Dr. Jenise M. Bauman

the pure American chestnut and B2-F3. Both were slightly taller than the B1-F3 seedlings (data not shown).

Survival resulted in the same pattern: highest survival in the RPD plots (80%), high survival in the R plots (73%), adequate survival in the PD plots (69%) and very low survival in the control plots (22%; Figure 3B). When seed types were compared across the treatment plots (control plots not included), B2-F3 had the highest survival (ranging 86-75%), followed by B1-F3 (75-68%) and the pure American seedlings (75-63%). When cankered trees were compared, the majority of infected seedlings were pure American chestnut, with just a few documented cankers on the B2-F3 seedlings, and no cankers on the B1-F3 seed types at this time. Bark plugs extracted from canker margins verified the presence of the chestnut blight fungus (Figure 4).

Summary

The results of this study suggest that after five field seasons: (1) chestnut growth was increased in plots that had some type of soil surface mechanical treatment, (2) chestnut seed types were similar with regard to height, and (3) cankers were found predominately on the pure American seedlings. Chestnut seedlings in plots that employed FRA recommended ripping performed the best. Enhanced seedling growth and survival after soil ripping has been reported in other projects in southeastern Appalachia (reviewed in Zipper et al. 2011). Proper site selection was equally as important as soil preparation. Historically, chestnut was adapted to acidic and well-drained upland habitats. Because coal mine reclamation sites vary in soil chemistry, we were mindful to select sites that had an average pH of 5.5. Other silvicultural treatments were applied, such as individual weed mats, spot treatments of herbicide, and individual deer fencing to prevent browse (McCarthy et al. 2010).

Chestnut seedlings began reproducing seed by the fourth field season. After the fifth growing season, one- and two-year-old chestnut recruits were documented in the test plots. Although we do not know the parentage of these seedlings, some offspring will inevitably be the progeny of the backcross chestnut trees. As chestnut blight spreads through the stand we predict increased mortality of pure American seedlings and anticipate loss of the backcross seed types. Cankers often begin to appear on chestnut trees around the same time they begin to produce nuts. Therefore, we can hypothesize that seed types that lack genes for resistance may eventually fail to reproduce while trees with adequate blight resistance will increase in population. Once forming an established chestnut

Figure 5. Caleb Cochran collects data for his Senior Capstone project for the Department of Biology at Miami University. In addition to evaluating growth among chestnut seed lines, he is currently analyzing seed production and viability on this mine site. Photo by Shanon Wise

restoration stand, we anticipate that nuts will be carried into the adjacent forests by birds and mammals. Future studies are required to better understand how chestnut will compete with invasive plant species, survive other introduced pests, respond to heavy populations of white-tailed deer, and adapt to changing climate conditions.

Data reported here suggest that when implementing the proper methods and site selection, American chestnut is a valuable tree for use in coal mine restoration. Other studies from this site are currently being analyzed; these include seed production, vegetation community composition, and beneficial mycorrhizal fungi. The value of this project has been multidimensional; using chestnut as a pioneer forest tree may aid natural forest recovery, provide habitat for wildlife, and produce a valuable timber commodity for areas where soils are in a state of recovery. In addition, this project provided exciting opportunities for students to learn valuable research techniques while they took part in advancing the mission of TACF (Figure 5). And last, the love for this tree species continues to bring together a multitude of people all working toward the common goal of restoring American chestnut to the Appalachian forests.

Acknowledgements

This work was supported by The American Chestnut Foundation Research Support Grant, the Ohio Chapter of TACF, Miami University Research and Grants, and National Technology and Transfer funds from the US Department of Interior (Office of Surface Mining). Authors thank Dr. William MacDonald and Mark Double of West Virginia University for their assistance with culturing fungi from bark samples. We also thank The Wilds student interns Jessica Spencer, Andrea Renshaw, Jason Capello, Samantha Zelenka, and Dana Dudra for their field support.

Literature Cited

Jacobs, D.F. 2007. Toward development of silvical strategies for forest restoration of American chestnut (*Castanea dentata*) using blight-resistant hybrids. *Biological Conservation* 137: 497-506.

McCarthy, B.C., Gilland, K.E., Bauman, J.M ., and Keiffer, C.H. 2010. Factors affecting the performance of artificially regenerated American chestnut on reclaimed mine sites. In R. I. Barnhisel (Ed.), Proceedings of the 27th Annual Meeting of the American Society of Mining and Reclamation, Lexington, Kentucky, pp.582-597.

Zipper, C.E., Burger, J.A., Skousen, J.G., Angel, P.N., Barton, C.D., Davis, V., & Franklin, J.A. 2011. Restoring forests and associated ecosystem services on Appalachian coal surface mines. *Environmental Management* 47: 751- 765.