



## CHAPTER 12: REESTABLISHING AMERICAN CHESTNUT ON MINED LANDS IN THE APPALACHIAN COALFIELDS

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### INTRODUCTION

American chestnut was formerly a major component of forests throughout the Appalachian coalfields and beyond. Chestnut's strong, lightweight wood was naturally rot-resistant, making it a preferred timber tree for many purposes. Unlike many nut-producing trees that flower early in the year, American chestnuts flower in June and July, so they were less susceptible to a late freeze or frost that could damage the flowers. Due in part to its late flowering, American chestnuts produced a reliable and abundant nut crop that was an important source of nutrition for wildlife, livestock, and humans.

However, American chestnut has suffered severe decline throughout the United States; today, few living and mature American chestnut trees remain. This Forest Reclamation Advisory discusses

efforts to develop new American chestnut varieties, and describes reclamation and planting techniques for chestnut on mined lands.

### American Chestnut's Demise and Restoration

Beginning in the early 1900s, an introduced fungus known as the chestnut blight devastated chestnut populations. (Please see the Appendix starting on p. A-1 for scientific names of species mentioned in this chapter.) American chestnut was virtually eliminated as a canopy tree throughout its native range by the 1950s.

Early attempts at breeding disease-resistant trees that could restore chestnuts to the forest failed to produce a tree with sufficient disease resistance and the ability to compete against other hardwoods. In 1983, The American Chestnut

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### Publication History

This chapter is based on Forest Reclamation Advisory No. 12, which originally appeared in June 2015 on the Appalachian Regional Reforestation Initiative's Web site (<http://arri.osmre.gov>) hosted by the U.S. Department of the Interior's Office of Surface Mining Reclamation and Enforcement. (Note that authors' affiliations were current when the Advisory was originally written.)

Foundation (TACF) was founded with the mission to restore American chestnut to eastern forests to benefit the environment, wildlife, and society. The foundation focused on a breeding strategy to create a population of chestnuts that would

incorporate the disease resistance of Chinese chestnut and retain the form and functional characteristics of American chestnut (Fig. 12-1). This strategy crosses Chinese chestnuts and American chestnuts, then takes those offspring

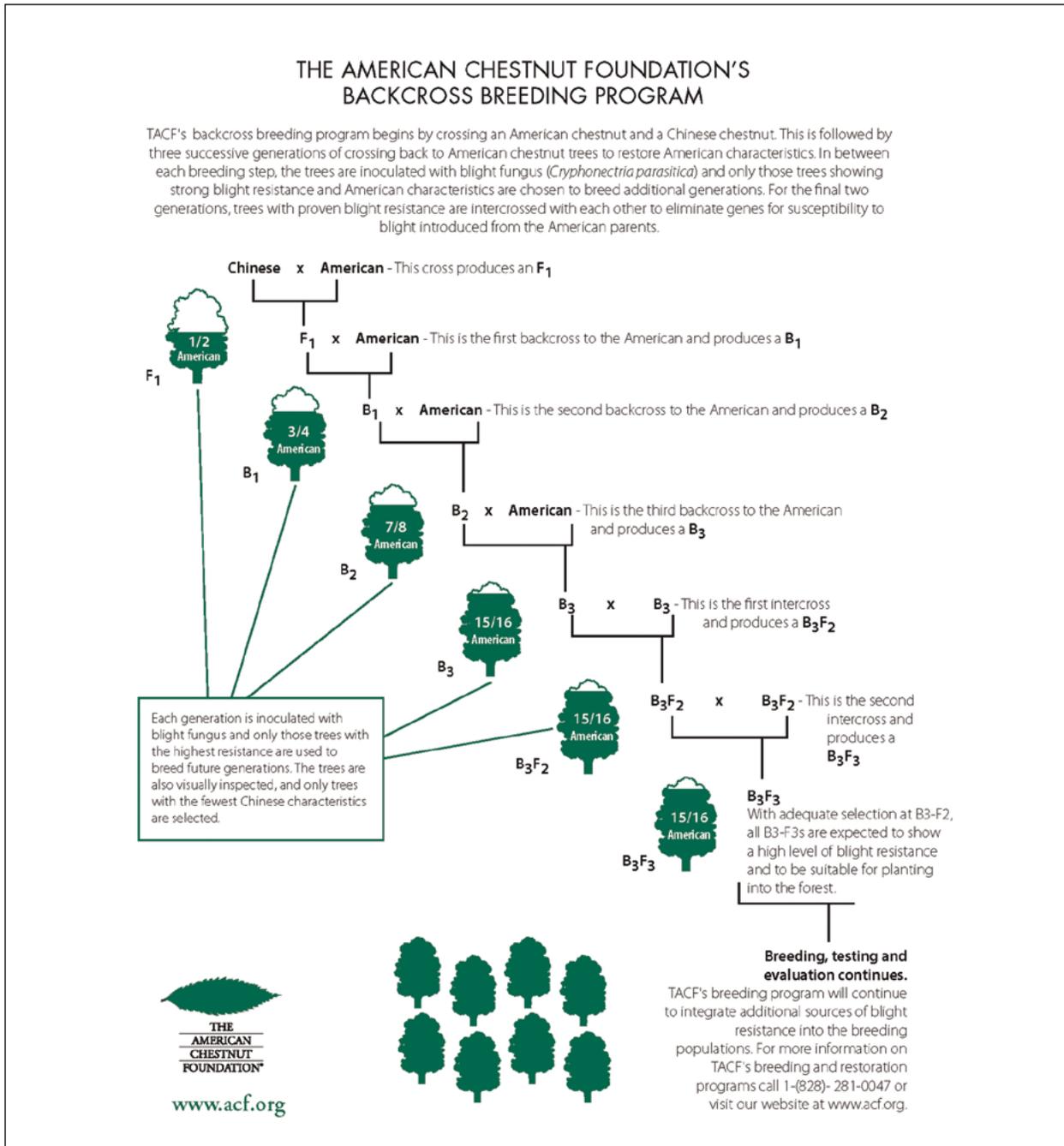


Figure 12-1.—The American Chestnut Foundation's breeding strategy to develop a population of chestnuts that will display the growth and form characteristics of American chestnut while retaining the blight resistance of Chinese chestnuts. (Courtesy of The American Chestnut Foundation.)

through a series of backcrosses and intercrosses to create trees with American traits and high levels of disease resistance.

At each step of the process, trees are intentionally infected with the disease so that only trees with high levels of disease resistance and American characteristics are used for further breeding. In 2005, TACF began producing trees that are about 15/16 American chestnut, 1/16 Chinese chestnut in character and expected to have a high level of disease resistance (specifically, the  $B_3 F_3$  generation). TACF is calling this generation “Restoration Chestnuts 1.0,” which implies that breeding efforts are expected to continue to improve both disease resistance and American characteristics into the future. The foundation is now testing Restoration Chestnuts 1.0 for their disease resistance and other characteristics.

### **AMERICAN CHESTNUT’S ECOLOGY, DISTRIBUTION, AND ABUNDANCE**

Historical literature and examination of sprouts and remnants of older trees indicate that American chestnut preferred rich, noncalcareous, well-drained, acidic to slightly acidic soils (pH about 4 to 6); it was a dominant component of slopes and ridgetops throughout the Appalachian region but grew poorly in wet soils (Abrams and McCay 1996, Abrams and Ruffner 1995, Braun 1950, Burke 2011, Frothingham 1912, Paillet 2002, Russell 1987, Wang and others 2013). Chestnut’s abundance on the landscape varied with many factors including land use history, but it reportedly accounted for about 25 percent of the virgin timber in the southern Appalachian Mountains and more than 50 percent of the timber in some second-growth forests (Braun 1950, Buttrick 1915, Frothingham 1912).

By all accounts, American chestnut’s sheer dominance in many stands made it eastern North America’s most important nut producer and one of the most important timber producers. The loss of American chestnut from our forests is often described as the greatest ecological disaster of the 20th century.

### **THE FORESTRY RECLAMATION APPROACH FOR CHESTNUT RESTORATION**

During the early 2000s in anticipation of disease-resistant chestnuts, cooperators and researchers with the Appalachian Regional Reforestation Initiative (ARRI) began testing the suitability of mined lands reclaimed with the Forestry Reclamation Approach (FRA) for chestnut introduction. Cooperators and researchers have planted and monitored pure American chestnuts and backcross chestnuts on FRA-reclaimed lands throughout the Appalachians. Once chestnut varieties with disease resistance and American characteristics become widely available, mine operators will be able to plant those seedlings along with other Appalachian hardwoods and reclamation species on mine sites.

The TACF strategy for chestnut restoration includes early establishment of small populations throughout the chestnut’s former range. These initial groups of trees (“founder populations”) are intended to serve as seed sources and to aid natural dissemination to other areas.

Establishing founder populations of chestnuts on mined lands has been of interest to TACF researchers for many reasons. The first is the overlap of American chestnut’s native range and the Appalachian coalfields (Fig. 12-2). Furthermore, many mining disturbances occur on upper slopes and ridgetops where chestnuts were formerly a dominant component of the forest, potentially making former surface mines ideal locations for chestnut introduction. In addition, research has demonstrated that chestnut can be successful when planted on mines that have been reclaimed by using the FRA. Mining disturbances reclaimed with the FRA may also limit the establishment of root-rot pathogens, such as the water mold *Phytophthora*, which have hindered TACF’s breeding efforts in the southern Appalachians (James 2011). *Phytophthora* is a water mold that favors wet soils or those with a high water-holding capacity; the well-drained soils

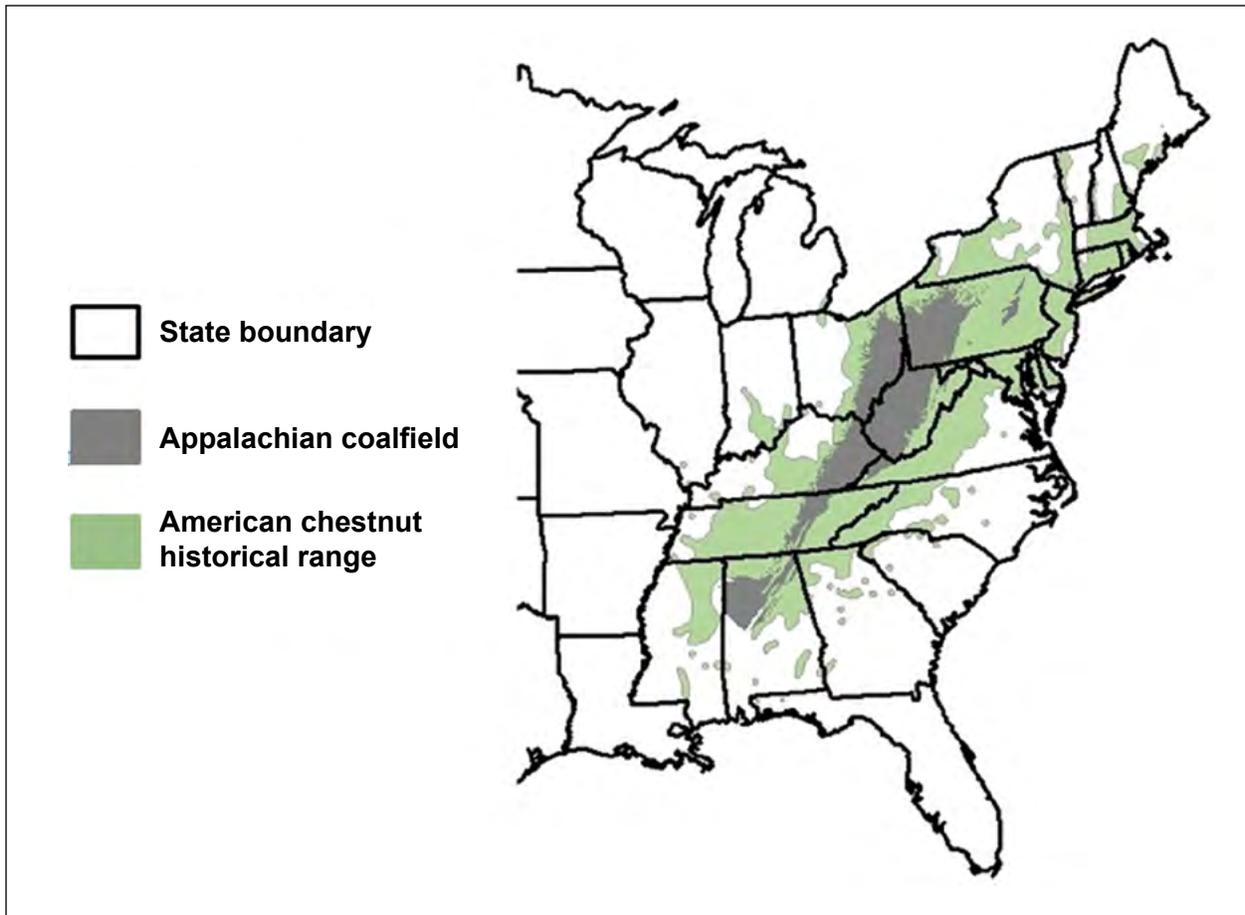


Figure 12-2.—The native range of American chestnut (Little 1977) overlaid on the Appalachian coalfields. (Map prepared by P. Donovan, Virginia Tech.)

created by the FRA may limit its establishment. Last, surface mines reclaimed with the FRA are essentially “blank slates,” where conditions benefiting chestnut establishment can be created. Vegetative competition for nutrients, sunlight, and water can be reduced through the proper implementation of Step 3 of the FRA (Chapter 6, this volume). In contrast, chestnuts planted in existing forests and old fields face competition from established vegetation.

### PRIOR RESEARCH AND WORK

Studies of the growth and survival of early backcross chestnut ( $B_1 F_3$ ,  $B_2 F_3$ , and  $B_3 F_2$ ) on sites that implemented FRA techniques as a part of active mining operations have offered encouraging results. Two studies in West Virginia found survival rates of 40 to 70 percent for backcross

chestnuts planted as seed (“direct-seeded”) after four growing seasons; the authors noted that the survival for the total chestnut stock fell within the survival range of other hardwoods in similar planting trials (Skousen and others 2013). A study in eastern Kentucky found survival rates from 41 to 60 percent for sheltered, direct-seeded backcross chestnuts after five growing seasons (Barton and others 2013). Similar trials on FRA sites in Ohio, Pennsylvania, and Tennessee exhibited similar survival rates (more than 40-percent average survival for backcrosses after five growing seasons) (Bizzari 2013). A study comparing groundcover effects on backcross chestnut survival on an FRA site in southwestern Virginia showed 48- to 73-percent survival after two growing seasons and showed that bare-root seedlings initially performed better than chestnuts

that were direct-seeded (Fields-Johnson and others 2012). Bare-root seedlings also performed better than chestnut seeds in an Ohio study (McCarthy and others 2010). Several planting methods have been shown to give adequate initial survival, including potted seedlings, direct seeding, and bare-root plantings; all of these methods are suitable for introducing chestnuts to mined lands (Fields-Johnson and others 2012, French and others 2007, Skousen and others 2013). A Tennessee study found dense ground cover of annual ryegrass inhibited chestnut growth (Klobucar 2010).

Legacy surface mines (those reclaimed by using conventional reclamation methods under the federal Surface Mining Control and Reclamation Act of 1977 [SMCRA] and not reforested with native trees) and abandoned mine lands are also potential launching points for blight-resistant chestnut introduction, although less work has been done to identify establishment methods that are most suitable for such sites. Restoration Chestnut 1.0 ( $B_3 F_3$ ) plantings on abandoned mine sites in 2012 and 2013 used a limited quantity of seed and seedlings and early success varied from 32- to 100-percent survival after one season.<sup>1</sup> Bauman and others (2013a) found that a cross-ripped legacy site in Ohio had 73-percent survival of bare-root chestnuts after six growing seasons and that the chestnuts began producing nuts in the fourth growing season. The authors and collaborators from ARRI have observed similar chestnut seed production by the fourth or fifth growing season (Fig. 12-3) on active FRA sites in Ohio, Kentucky, Tennessee, and West Virginia. Mitigation of compaction on a legacy mine in Ohio enabled greater colonization of chestnut root-tips by beneficial mycorrhizal fungi, which probably led to higher survival and growth rates when compared to the untreated controls (Bauman and others 2013b).



Figure 12-3.—A 5-year-old backcross chestnut on a reclaimed mine in West Virginia. Many of the trees on this site were producing male and female flowers. Photo by M. French, The American Chestnut Foundation, used with permission.

TACF is currently creating mixed hardwood/American chestnut forests on mined lands that implement the FRA as a part of a Conservation Innovation Grant (CIG) awarded to TACF by the U.S. Natural Resources Conservation Service in 2011. Each of the 12 CIG plantings is about 30 acres in size and has a mixed hardwood component with Restoration Chestnuts 1.0 planted randomly throughout. The Restoration Chestnuts 1.0 are planted at 20 per acre as 1-year old (1-0) bare-root seedlings in a mix with other 1-0 bare-root hardwoods for a total of 680 trees per acre. This will demonstrate how Restoration Chestnuts 1.0 compete against other commonly used native

<sup>1</sup> Unpublished data on file with TACF, Asheville, NC.

hardwoods in a mixed hardwood reforestation planting. A direct-seeded, 1-acre progeny test to examine varying degrees of blight resistance in the Restoration Chestnut 1.0 population is also a component of each of these plantings. Several of these plantings have had greater than 80-percent germination and survival for direct-seeded chestnuts and greater than 90-percent survival for bare-root planted chestnuts after one growing season.<sup>2</sup>

### **BIOTIC AND ABIOTIC CONSIDERATIONS FOR ESTABLISHING CHESTNUTS ON MINED LANDS**

Many active mine sites that implement the five steps of the FRA (Chapter 2, this volume) meet the criteria of American chestnut's site requirements in historical accounts. Although every step of the FRA is important, pay particular attention to avoiding compaction on areas to be reforested with chestnuts. Compacted soils are often poorly drained, and chestnuts are known to perform poorly in wet soils (Rhoades and others 2003). Phytophthora root rot on American chestnut seedlings was found to be greater in soils with higher moisture content (Rhoades and others 2003).

Additionally, soil pH varies greatly on mined lands and should be tested before planting to ensure that it is near chestnut's preferred range (pH of about 4 to 6). These soil pH levels can usually be achieved through use of salvaged soil, weathered overburden, or a combination for soil reconstruction, following FRA recommendations (Chapter 3, this volume). New mine soils constructed of unweathered overburden usually will not be suitable for American chestnut plantings due to high soil pH, high salinity, or both.

Take into account microsite factors when planting as well. Gilland and McCarthy (2012) found that chestnut seedlings planted near the edge of existing forest (within about 16 feet) showed significantly lower growth and survival than seedlings planted away from the forest edge (75 to 150 feet). They also found that chestnuts fared better when some ground cover was present, and that seedlings survived better when planted on the sides of end-dumped FRA piles than when planted on the tops of the piles.

When planting bare-root chestnuts, no special handling is necessary. ARRI recommendations for preparing, handling, storing, and planting hardwoods are sufficient for chestnuts (Chapter 9, this volume). Chestnuts are known to be fast-growing and 1-0 seedlings are generally of adequate size to be vigorous. However, take care to obtain seedlings from nurseries that do not have *Phytophthora*, if such assurance can be obtained.

When direct-seeding chestnuts, use 18- to 24-inch tree shelters to prevent unacceptable losses from rodent predation and to avoid the problems associated with the use of tall tree shelters (Fig. 12-4) (McCarthy and others 2010, Sena and others 2014, Skousen and others 2013). Deer, rodents, and other herbivores are known to consume chestnut foliage, bark, and seeds. In areas with dense deer or elk populations, it may be necessary to construct fencing or wire cages around seedlings to prevent browsing and seedling losses. In Tennessee, fertilizer application at the time of planting was found to increase growth rates in the first 2 years (de Lima and others 2011, Miller and others 2011).

For establishing chestnut plantings on legacy mines, refer to recommendations in Chapter 10 of this volume. Again, soil pH should be tested before planting; apply soil amendments if necessary. Control competition from existing vegetation.

<sup>2</sup> Unpublished data on file with TACF, Asheville, NC.



Figure 12-4.—A Restoration Chestnut 1.0 planted as seed emerging from a 24-inch-tall tree shelter after 3 months on an active mine in Ohio. Photo by M. French, The American Chestnut Foundation, used with permission.

## SUMMARY AND FUTURE WORK

Many field planting trials have shown that Appalachian mined lands reclaimed with the FRA provide an opportunity for introducing blight-resistant chestnuts into eastern U.S. forests. The level of disease resistance in TACF's population of backcross chestnuts will not be known for several years, so continued monitoring will be necessary. However, TACF will continue increasing blight resistance in the chestnut seedlings that it is distributing for planting. Research has found that mine reclamation sites can be planted to establish founder populations of blight-resistant chestnuts that could then spread by natural processes into surrounding forests (Jacobs 2007). There is still much to be learned about establishing chestnuts as a part of a mixed hardwood forest on mined lands; research is ongoing.

The lessons learned from these trials may also play a role in reestablishing other native tree species that are being threatened by nonnative pests and diseases. For example, mined lands are currently being tested to reintroduce American elms that are resistant to Dutch elm disease.

Assisting ARRI and other organizations such as Green Forests Work in creating productive and biodiverse forests on active mining operations, legacy mines, and abandoned mine lands is a high priority for TACF.

As more Restoration Chestnuts 1.0 are produced, TACF intends to contribute more of these chestnuts for reclamation projects. However, demand for blight-resistant chestnuts will outpace supply for many years to come. Full implementation of the FRA will be important to TACF decisions concerning allocation of blight-resistant chestnut stock for mine reclamation plantings.

## ACKNOWLEDGMENTS

This Advisory was prepared with cooperation and assistance provided by Green Forests Work (<http://greenforestswork.com/>) and The American Chestnut Foundation (<http://www.acf.org/>).

Thanks to Patricia Donovan, Virginia Tech, for preparing the map in Figure 12-2.

Photo of chestnut tree on p. 12-1 is courtesy of Michael French, The American Chestnut Foundation.

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