



AMERICAN CHESTNUT: A PRIMER ON AN EASTERN FOREST ICON

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EXECUTIVE SUMMARY

At the turn of the 20th century, an estimated 4 billion American chestnut trees (Figure 1) thrived in the eastern forests of the United States. American chestnut had numerous beneficial qualities including providing wood products and food for humans, livestock, and wildlife. Then in the early 1900s a deadly fungus struck. By 1950 the American chestnut was essentially eliminated as a forest canopy tree. Today, efforts are underway to return this tree to the landscape and restore the many environmental and societal benefits it provided.



Figure 1. American Chestnut
Source: The American Chestnut Foundation

BACKGROUND

Imagine straight hardwood trees up to 100 feet tall, 5 feet in diameter, and branch-free for 50 feet. In some eastern forests more than a century ago over 25 percent of the canopy was comprised of American chestnut (*Castanea dentata*). Chestnut trees had a range of over 200 million acres from Maine to Georgia and west to the Ohio Valley (a range that extended approximately 1,600 miles) (Figure 2). Estimates are that in the center of its natural range one in every four hardwood trees was American chestnut. The American chestnut grows from seed and also sprouts prolifically. Through these methods, chestnut was able to occupy abandoned agriculture fields, and it is possible that agricultural, grazing, and other land clearing activities associated with European settlement contributed to the abundance of the species (Wang 2013). In the early 20th century, American chestnut was abundant, beautiful, and a source of various products for humans, livestock, and wildlife, from nutritious nuts to straight-grained lumber (Figure 3).



Figure 2. Range of American Chestnut
Source: The American Chestnut Foundation

BLIGHT

In 1904 a lethal fungus—referred to as chestnut blight—was discovered in New York City. The fungus (*Cryphonectria parasitica*), accidentally imported from Asia, apparently on



Figure 3. American Chestnut, Connecticut, 1905
Source: www.apsnet.org/publications/apsnetfeatures/Pages/ChestnutBlightDisease.aspx

seedlings of Japanese or Chinese chestnut, spread quickly by wind-borne spores, precipitation, and animals. The disease (a wound pathogen) is a canker that forms on branches and boles, causing discoloration and deformation of smooth young bark, and longitudinal cracking in older fissured bark. The fungus also destroys the chestnut's underlying phloem and sapwood. The canker is aggressive and can rapidly girdle young stems, essentially choking off the flow of nutrients. This girdling leads to the sudden onset of foliar (leaf) discoloration and wilting (also called flagging), which is why the disease is known as a blight (Wengert and Kruger 2012; The American Chestnut Foundation 2015).¹

Within 40 years the blight was found throughout the range of American chestnut. By 1950 all that remained in the wake of the disease were dead, ghostly chestnut trees. To this day, some chestnut stumps still send up sprouts; unfortunately, they also quickly succumb to the blight with few living long enough to produce chestnuts. Although there are still thousands of understory chestnut sprouts throughout its historic range, since it rarely reaches maturity, the American chestnut is listed as an endangered species in Canada and in the states of Kentucky and Michigan, while it is identified as a species of special concern in Maine and Tennessee (Wang 2013).

Returning Chestnut Trees to the City Where Blight Was First Found

[Andy Newman](#), March 23, 2011

"All Chestnut Trees Here Are Doomed" read the headline in The New York Times.

The year was 1911, "here" was greater New York, and the great chestnut blight, which was first discovered in the Bronx Zoo in 1904, was well on its way to wiping out four billion of the trees that once made up a quarter of the Northeast's hardwoods.

Now, blight-resistant American chestnuts, 22 years and six generations in the breeding, are coming to New York City.

Source:

www.cityroom.blogs.nytimes.com/2011/03/23/planting-chestnuts-in-city-where-the-trees-blight-began/?_r=0

WOOD PRODUCTS GLORY DAYS

Prior to the blight spreading throughout the natural range of American chestnut, the tree was important both locally and regionally. According to Youngs (2000), chestnut was used more than any hardwood in Connecticut in the early 20th century. In the early 1900s, American chestnut made up about a quarter of the hardwood lumber production in New England. In the Appalachian region, 15 percent or more of hardwood output was American chestnut. A 1948 report noted that chestnut production peaked in 1907 when over 650 million board feet of lumber was recorded. In 1920, during a period of high lumber prices, chestnut lumber sales (nationally) reached a high of \$16 million. Annual production declined gradually over the next couple decades to less than 100 million board feet. By the end of World War II—the mid-1940s—chestnut production had dropped off nearly everyone's radar screens (Youngs 2000).

The wood of American chestnut was popular in the early 20th century for many reasons beyond just its abundance. It has many properties that led to its high degree of versatility. For example, the wood is straight grained and moderately light (its specific gravity—a measure of wood density—is less than red

¹ Also beginning in the 1800s, American chestnut was struck by a root rot caused by *Phytophthora cinnamomi* that primarily impacted chestnuts growing in lowland or riparian areas (Wang 2013).

oak but greater than yellow-poplar). It is prized by woodworkers as it can be easily shaped with tools, glues well, and finishes nicely. It has moderate shrinkage and minimal warping and checking in drying. The heartwood of American chestnut is high in tannin, making it quite resistant to decay. During its glory days, American chestnut was used for virtually everything—fences, shingles, fine furniture, telegraph poles, railroad ties, and even musical instruments such as pianos.²

FOOD

Nutritious nuts were another important product from the American chestnut. Wildlife, livestock, and humans all benefited from the reliable nut crop (mid-summer blossoms were unaffected by late frosts, unlike other forest nut trees).

Wildlife such as birds, bears, squirrels, and deer depended on the tree’s abundant nut crop. As winter approached, farmers and other rural dwellers stacked attics to the rafters with overflowing bags of tasty nuts. Smokehouses were filled with hams and meat products from livestock fattened on the harvest. As the year-end holidays neared, the glossy dark nuts were shipped to major eastern cities where street vendors sold them as a fresh-roasted favorite (Figure 4).³



Figure 4. A street vendor roasts chestnuts near his wagon in this historical photograph from the USDA Southern Research Station Archive. *Source: USDA Forest Service Southern Research Station, USDA Forest Service, SRS, Bugwood.org*



Figure 5. Chestnut harvesting in a commercial orchard
Source: Chestnut Growers of America

When chestnut disappeared from American forests, many mountain farmers were denied food and livestock feed. This untimely event made it more difficult to weather the Depression years (Youngs 2000). Today, there are chestnut growers throughout the U.S. with orchards that include American chestnut as well as Japanese, Chinese, European and hybrid varieties (Chestnut Growers of America

² One saying goes that American chestnut was a “Cradle to Coffin” material, commonly being used to produce both products and many others in between.

³ Forest products typically aren’t romanticized by the music industry but the “Christmas Song,” composed in 1946 and popularized by Nat King Cole, begins with the famous lyrics “Chestnuts roasting on an open fire...”

2015) (Figure 5). These growers provide a valuable product as well as play a role in the restoration of American chestnut.

OTHER PRODUCTS

For several years, chestnut was the source of tannin for leather products. The tannin was obtained by soaking wood and bark in water and evaporating the extracted solution. Sometimes bark was simply striped from dead and living trees and sold as tan bark.⁴ In areas where it was plentiful, chestnut was used as fuel wood. Due to its density, it was inferior to oak, hickory, and beech. However, it was easy to split, worked well as kindling, and was often readily available. Chestnut heated many homes and stills and fueled many factories—brickyards for example—until its supply dropped and other woods and fuels took its place.

RESTORATION

Early efforts to save and restore the American chestnut were largely ineffective, in part due to inadequately developed breeding programs. It would have been easy for researchers and other advocates to give up the fight to save the tree. However, in the 1980s the American chestnut found its champion. Advanced breeding programs (using multiple backcrosses) began in 1981, and in 1983 a group of visionary scientists and caring citizens established The American Chestnut Foundation (TACF) to restore the tree to eastern woodlands to benefit the environment, wildlife, and society.



THE AMERICAN CHESTNUT FOUNDATION®

Restoring the American chestnut tree to our eastern woodlands to benefit our environment, our wildlife, and our society.

THE AMERICAN CHESTNUT FOUNDATION

The American Chestnut Foundation (<http://www.acf.org/>) is a non-profit conservation organization headquartered in Asheville, North Carolina, with three regional offices located in Charlottesville, Virginia; South Burlington, Vermont; and State College, Pennsylvania. The organization's research farm in Meadowview, Virginia has more than 50,000 chestnut trees planted in various stages of development. The Foundation is comprised of 16 state chapters, more than 5,500 members, and a network of volunteers and partner organizations. TACF is dedicated to making the native chestnut tree a true American success story. Since 1986, over 135,000 blight resistant chestnut varieties have been planted across the native range of American chestnut (Wang 2013).

One of the initial goals of TACF was to establish a conventional tree-breeding program that combined genes from the American chestnut and its blight-resistant Asian cousins. Today, scientists are well on

⁴ Tannin currently used in most industrial processes is chemically synthesized rather than extracted from tree bark (Haygreen and Bowyer 1989).

their way to developing a tree that is American in every way without the susceptibility to being killed by the chestnut blight.

THE TACF BACKCROSS METHOD

The American chestnut evolved in the absence of the chestnut blight. Consequently, the species lacked the genetic material to protect it from the fungus. In Asia, however, where the pathogen originated, most native chestnut species are well defended against the blight. Over the course of millennia of coexisting with the fungus, Chinese chestnut trees acquired the genetic material that confers resistance.

The goal of TACF's breeding program is two-fold: to introduce into American chestnut the genetic material responsible for blight resistance in the Chinese tree, and at the same time, preserve in every way the genetic heritage of the American species.

"So often in conservation, it is about fighting against, or reacting to, new and seemingly insurmountable threats, and we are constantly on the defensive. I was reminded of this when I introduced myself to a TACF member who remarked, 'What attracted me to this organization was that, for once, we are on the offensive.' Although we are still fighting the blight that can destroy this tree, our scientists are working tirelessly on methods to prevent infection to ensure chestnuts can grow to their former glory."

Lisa Thomson, President and CEO
The American Chestnut Foundation

TACF's tree-breeding program uses a "multiple backcross" technique and can be summarized as follows: blight-resistant Chinese chestnut trees are crossed with American chestnuts, and then the resulting trees from this cross are subsequently "backcrossed" with American chestnuts multiple times to restore the genetics of the American species. Although the Chinese genes for resistance are incompletely dominant, they nonetheless usually express themselves clearly when present in seedlings purposely inoculated with a virulent form of the blight fungus. Therefore, each backcross generation is tested by inoculation with blight. Only those seedlings that show the greatest resistance are used for further backcrossing to an American parent. The first backcross results in a tree that is one-half American and one-half Chinese. The second backcross yields a three-fourths American tree and a one-fourth Chinese, and so on. It is necessary also to "intercross" (blight-resistant American tree crossed with another blight-resistant American tree) with the goal of producing a "true" blight-resistant American tree without the American genes for susceptibility to blight.⁵

To date, TACF has developed a variety of chestnut that is 94 percent American with the supposed blight-resistance of Chinese chestnut. Since the breeding program is based on a minimum of six generations, it may be until 2020 before confirmation that harvested nuts are truly blight-resistant.

⁵ For more information on the backcross method, see www.acf.org/r_r.php

TESTING TREES AT RESEARCH SITES

TACF's scientists test trees for blight-resistance, naturally occurring viruses that weaken the blight fungus, and other diseases and pests that impede chestnut's successful reintroduction into the wild at various research sites. The Meadowview Research Farm in Virginia, which contains the Glenn C. Price Laboratory, is the primary testing site for TACF. The 166-acre-farm is home to thousands of chestnut trees at various stages of breeding. Not only are TACF scientists involved in the long process of restoring American chestnut to eastern forests, but other partners—particularly university researchers—are also part of the process. For example, TACF's and the State University of New York's College of Science and Forestry, in Syracuse, have been working together for over twenty years on research efforts to insert the gene that would confer blight resistance. As a result of this collaboration they have developed a promising blight-resistant American chestnut using biotechnology.⁶

BREEDING TECHNIQUES AND GENE THERAPY FOR AMERICAN CHESTNUT

The backcross method has been the key breeding technique used to develop blight resistance in American chestnut trees that are being planted today as part of widespread restoration efforts. However, there is speculation that more advanced biotechnology breeding techniques, including gene therapy or genetic modification could provide significant benefits to chestnut restoration efforts as well as other trees that are facing threats from exotic pests, such as American elm (*Ulmus americana*) impacted by Dutch elm disease, or ash trees (*Fraxinus spp.*) impacted by the Emerald ash borer. However, to date, it has not been possible to fully isolate the gene(s) responsible for blight resistance in chestnut species. Progress is expected in the coming years and efforts on behalf of the chestnut may provide insights that are useful for forest restoration efforts in response to emerging threats involving other species. The TACF annual meeting in 2015 focused on genomic tools in American chestnut restoration in an effort to more fully understand the opportunities and limitations of advanced technologies.⁷

TESTING TREES IN THE FIELD

Universities, private foundations and businesses, state and federal governments, and private citizens have partnered with TACF and planted chestnut trees in 114 locations across the eastern U.S. A few of these efforts are highlighted below.

The USDA Forest Service and TACF have been partners for a quarter-century. The American chestnut's native range is located within Region's 8 and 9 of the Forest Service (eastern U.S.). To date, more than 10,000 American chestnuts have been planted in national forests in 10 states: Tennessee,

⁶ Numerous universities have partnered with TACF over the years. The SUNY example serves as an illustration of one collaborative effort. For more information about TACF and SUNY-ESF's work on chestnut genetics, see:

<http://www.acf.org/pdfs/resources/New%20Fact%20Sheets/Transgenics%20FAQ.pdf>

⁷ For more information, see: www.acf.org/AM2015.php

North Carolina, Georgia, Virginia, West Virginia, Pennsylvania, Indiana, Ohio, Maine, and Vermont (Figure 6).

USDA Natural Resources Conservation Service (NRCS) and TACF have established forest plantings, including American chestnut, on reclaimed mine sites in Appalachia. During the three-year project (2011-2014), reforestation projects occurred in Pennsylvania, Ohio, West Virginia, Virginia and Kentucky.

The Appalachian Regional Reforestation Initiative (ARRI) and TACF planted American chestnut and other high-value hardwood tree species on strip mined lands in Appalachian coalfields. One of the goals of the partnership was to heal the land by planting fast-growing hardwoods.

The National Wild Turkey Federation (NWTF) and the Potomac Appalachian Trail Club (PATC) are two other organizations that have teamed with TACF in recent years. The NWTF works with TACF to plant blight-resistant chestnut trees in orchards to provide a future source of American chestnut trees and food resources for wild turkeys. The PATC, working with TACF scientists and volunteers, trains PATC volunteers to collect data on American chestnut trees identified along the Appalachian Trail.



Figure 6. Leila Pinchot, great granddaughter of the USFS First Chief stands with an American chestnut sapling planted as part of research on large-scale chestnut restoration.

Source: www.blogs.usda.gov/tag/grey-towers/

BOTTOM LINE

American chestnut was once an iconic tree of the eastern forest. The chestnut was prized for a variety of reasons including its wide diversity of timber products and nutritious food source for humans, livestock, and wildlife. However, an imported fungus ravaged the American chestnut, virtually rendering it extinct after World War II.

Research, spearheaded by the American Chestnut Foundation, focuses on a technique called “backcrossing.” To date, the backcrossing technique, where American chestnut trees are “crossed” with Asian varieties resistant to the fungus, looks promising. The ultimate goal of backcrossing is to produce a blight resistant American chestnut that can be returned to its native range. A side benefit of the chestnut restoration effort is that it creates a template that possibly could be used for the restoration of other species adversely impacted by exotic pests.

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