Restoration of the American Chestnut Will Require More Than a Blight-Resistant Tree

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ABSTRACT.—The American chestnut (*Castanea dentata*) was a keystone species that was decimated by nonnative diseases, most notably a fungus (*Cryphonectria parasitica*) that causes chestnut blight disease, during the early 20th century in eastern North America. Breeding for a blight-resistant tree began over 100 years ago, and a backcross breeding approach that incorporated blight-resistant genes from Chinese chestnut (*C. mollissima*) was initiated in the 1980s. Field trials to test pure American chestnuts and hybrid trees from different breeding generations were established from 2009 to 2017. These research plantings were established as a collaborative effort among the USDA Forest Service's National Forest System (Eastern and Southern Regions) and Research and Development (Southern Research Station, Northern Research Station) branches, a state agency (Connecticut Agricultural Experiment Station), state universities (The University of Tennessee, The University of Vermont), and a nonprofit organization (The American Chestnut Foundation). The goals of this paper were to: (1) summarize the present status of chestnut restoration research plantings established on the NFS using the most advanced breeding material currently available, and (2) summarize NFS field managers' insights on potential obstacles and contributions affecting future restoration efforts.

In the Southern Region, 13 research plantings were established on three national forests (Cherokee, Nantahala, and Jefferson) from 2009 to 2015 to test hybrid seedlings from the most advanced generation (i.e., BC_3F_3) (Clark et al. 2012). Ten plantings were in relatively open sites treated with low residual basal area (BA) shelterwood-with-reserve regeneration harvests and three plantings were in high residual BA stands treated with a midstory removal (Loftis 1990). Survival ranged from 41 to 61 percent for the oldest (age 10) plantings in the shelterwood harvests, where trees averaged 10–16 feet in height after eight growing seasons. Limitations to successful establishment were root rot disease caused by *Phytophthora cinnamomi*, browsing of terminal buds by whitetail deer (*Odocoileus virginianus*), shading by competitors, and chestnut blight disease (Clark et al. 2016). The BC_3F_3 seedlings had higher levels of blight resistance compared to American chestnut seedlings, but were less resistant than Chinese chestnut seedlings (Clark et al. 2019).

In the Eastern Region, 40 research plantings were established on four national forests (Wayne, Allegheny, Monongahela, and Green Mountain) from 2009 to 2017 in a variety of management conditions, but most plantings were in relatively low residual BA regeneration harvests. Four-year old plantings on the Wayne and Allegheny had 29 to 85 percent survival and low blight incidence (less than10 percent). Mortality was attributed to poor drainage and deer browsing. Direct-seeding resulted in substantially lower survival (50 percent) than planting bare-root seedlings (92 percent) after 2 years. Six-year-old plantings on the

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Monongahela had 25 to 53 percent survival, and mortality was primarily related to soil compaction, suspected root rot, and chestnut blight; BC_3F_3 seedlings had blight resistance more similar to Chinese chestnut than American chestnut seedlings (Thomas Van-Gundy et al. 2017). In the Green Mountain planting, 7-year-old pure American chestnut trees had 70 to 90 percent survival, and mortality was affected by shading for trees planted under full canopy conditions and affected by blight for trees planted in open canopy conditions. On a separate planting on the Green Mountain, 5-year-old BC_3F_3 seedlings had 85 percent survival, with mortality related to poor germination and vole damage, as these trees were from direct-seeded nuts.

Feedback from 16 NFS managers in the Eastern and Southern Regions, at the district, forest, and regional level, was received on both potential challenges and assistance to chestnut restoration, and on the cohesion of chestnut restoration with existing policy, plans, and capacity. Major perceived challenges were: (1) uncertain blight resistance levels from external breeding programs (Steiner et al. 2017); (2) mortality from root rot; (3) lack of silvicultural knowledge to implement prescriptions; (4) animal damage (e.g., deer and rabbit [*Sylvilagus floridanus*]) browsing, bear [*Ursus americanus*] nut consumption); and (5) coordinating harvests with availability of planting material. The ability to prioritize chestnut restoration while also conforming to National Environmental Policy Act processes were generally not viewed as obstacles. Some forest plans and decision memos already include chestnut planting and were met with little opposition. Public sentiment for chestnut restoration using hybrid seedlings is generally favorable, although there was some concern that more widespread chestnut restoration might be opposed if concurrent with increased timber harvests. The planting of genetically modified (GM) chestnuts will probably be opposed by some private citizens or nonprofit organizations even if the GM tree is federally approved for release. Managers preferred that chestnut restoration be implemented as part of existing plans of work and not mandated. Adequate funding for planting establishment and associated maintenance (e.g., deer protection, herbicide release) and monitoring of plantings would be required, and there was concern that this might detract from existing underfunded programs of work. Strong partnerships with nongovernmental organizations or volunteer groups already exist, and they could assist with planting implementation and monitoring. The use of Knutson-Vandenberg funds (USDA Forest Service 2019a), traditional contracting, and newly delegated stewardship contracting (USDA Forest Service 2019b) could be utilized where appropriate.

Development of a blight-resistant tree is only part of the solution for restoring this once dominant and ecologically important species. Information gleaned from silvicultural research and collaborative partnerships will improve the efficiency of future restoration; however, challenges from native animals and insects and nonnative pests are not easily mitigated. Important future research questions include: (1) determining differences in cross-site genetic tests; (2) examining the relationships between site quality and silvicultural treatment; and (3) relating seedling quality and stock type to tree competitive abilities over time. Dependent variables should include shoot winter injury, leaf phenology, growth form, and competitive ability, in addition to the more commonly measured variables of survival, growth, and blight resistance. Substantial long-term investments in chestnut restoration have already been made (Clark et al. 2014). Success will require both maintaining existing and developing new partnerships among organizations and agencies in order to maximize existing infrastructural capacities, as resources are limited for long-term research and restoration programs.

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