

FINAL REPORT FOR: AMERICAN CHESTNUT RESEARCH IN THE SOUTHERN REGION (14-CO-11330134-004)

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NARRATIVE

Background

American chestnut (*Castanea dentata*) restoration is of national importance as an ecological keystone species, a food source for humans and wildlife, a versatile tree for wood-products, and its popularity in the public. Restoration will require that putative blight-resistant strains from TACF are properly tested in forest settings to determine if they can survive harsh conditions, compete with natural competitors, and maintain blight resistance to ultimately reproduce in the wild. The USDA Forest Service is currently testing this material from TACF in forest field tests across the southern Appalachians, and has completed the only research to date studying nursery production of chestnut planting material (Clark et al. 2009, 2012a, 2014a). More work is needed, however, to make reliable predictions for how BC₃F₃ progeny will survive, compete, and grow once progeny with stable blight resistance are released for general reforestation. Additional alternatives to bare-root nursery production, including containerized seedlings also needs to be tested to ensure restoration of the species is conducted using the most advanced techniques possible.

Southern Research Station, Research Work Unit 4157 has led the most comprehensive and multidisciplinary research to date to understand barriers and mechanisms controlling forest restoration of the species on National Forest System (NFS) lands in the Southern Region (Region 8). Resources for this research are extremely limited and are growing more limited in the face of declining federal budgets. The Forest Service is one of the most important partners in chestnut restoration at a national level due to our ability to conduct long-term research and provide appropriate land for restoration plantings using material from breeding programs like TACF. The research we conducted as part of this proposal was consistent with the Memorandum of Understanding signed by TACF and the Forest Service in 2010, and further strengthened the partnership between these two agencies.

SRS-RWU-4157, in collaboration with the University of Tennessee, has planted 4,389 chestnut seedlings from TACF in 11 forest test plantings and 2 seed orchard plantings in the Southern Region since 2009 (Table 1). This work represents the largest and most comprehensive research in North America using the most advanced chestnut material currently available. Previous publications outlined the preliminary status of plantings and the potential barriers associated with American chestnut restoration (Clark et al. 2012b, 2014a, 2014b).

The goal of our research was to 1) provide progeny test results to TACF to help them in their breeding efforts, 2) to provide important recommendations to managers for the proper production of chestnut for planting and the correct silvicultural procedures to manage chestnut, and 3) to provide predictions for American chestnut survival and adaptability in the forest. Since the inception of this work, our research has popularized the work of TACF, the Forest Service, and other partners in the research community and in the general public.

Accomplishments

The requested funds were used to provide resources to continue data collection of plantings for one year and to conduct technology transfer activities. We collected measurements on the 13 plantings we have established using TACF material (Table 1). We visited each planting site at least once, and we visited some sites 3 times or more. Results are being analyzed and the first-four year results from the 2009 plantings will be submitted this month to Forest Ecology and Management.

Core measurements of the planted tree included the following: stem height, ground-line diameter, diameter at breast height (dbh, for seedlings ≥ 4 cm), stem dieback, deer browse, and chestnut blight. Overall survival was high for the 2009 plantings, but varied greatly for the 2010 and 2011 plantings due primarily to root rot related mortality (Table 1). Survival has been related to non-blight effects, including deer browse, *Phytophthora* root rot, and seedling size at planting. Survival was best for the 2009 forest plantings, averaging 73 percent (Table 1). Survival was moderate for the 2011 plantings (57 percent), and was generally highest for shelterwood harvest sites compared to midstory removal sites. Growth was highly variable and was exceptional for some seedlings with some trees attaining over 5 m height. Seedling size at planting affected overall size of seedlings with larger size seedlings maintaining height advantages after 5 growing seasons. Competition was fierce on these plots, but many trees were still free-to-grow and were outcompeting even *Liriodendron tulipifera* seedlings. On most sites, the American chestnut seedlings were taller than the BC₃F₃ seedlings, revealing a potential deviation from desired growth characteristics.

We assessed bud break phenology for all 2009 plantings and one 2010 planting. Each tree was assigned a bud-break ranking to the terminal bud using methods adapted from West and Weins (1971). The ranking was 0-no development of bud to 5-Internodes visible, leaves enlarged. We visited each site once when bud-break was approximately half-way completed across the planting location. Results indicated that the American was slightly less developed compared to the BC₃F₃ seedlings on most sites.

From 2009 to 2012, we collected data on blight occurrence on each tree, but our assessments were restricted to presence/absence on live trees. Blight was conservatively identified; positive identification was only made if *Cryphonectria parasitica* stromata were present or mycelial fans in the cambium could be seen with a hand lens (Griffin and Elkins 1986). In summer 2013, we incorporated more refined measurements and testing to ascertain field blight resistance than has been previously conducted. We assigned each tree a canker ranking 1 (no canker) to 4 (tree dead from canker). For cankers where blight identity was in question, we collected samples in the field and grew cultures for positive identification of blight strains. We coordinated and cooperated with Mississippi State University to conduct the blight assays. To date, blight infection was higher for the American chestnut compared to the BC₃F₃ for all but one site (Table 1). Surprisingly, blight incidence was not necessarily higher for the older plantings compared to the younger plantings. We speculate blight occurrence and resistance will be highly correlated to growth conditions.

For most plantings, we collected measurements on the natural vegetation competition within a 1.3 m radius surrounding each planted seedling. The most dominant competitors were *Liriodendron tulipifera*, *Acer pensylvanicum*, and *Betula lenta* (Table 1). Competition control will be an important aspect to continuation of this study.

Technology Transfer

Results from this study were disseminated via publications, presentations, and websites (<http://www.srs.fs.usda.gov/uplandhardwood/research-topics/duplicates/american-chestnut.html>). Through this research, we continued to publish results in peer-reviewed journals and the TACF journal, and provide presentations to professional and lay organizations. We provided consultations to TACF and others as requested. Specific outputs are:

Presentations

1. Clark, S.L. 2013. American Chestnut Research and Management in the National Forest System. Clark was invited to give presentation summarized the status of American chestnut research on NFS lands in the Southern Region at Purdue University, Department of Forestry and Natural Resources Seminar Series, November 19, 2013, West Lafayette, IN.
2. Clark, S.L. 2013. American Chestnut Research and Management in the National Forest System. Clark was invited to provide a presentation that summarized the status of American chestnut research on NFS lands in the Southern Region to Notre Dame University, Department of Biological Sciences, Dr. Jeanne Romero-Severson's Lab Group Meeting, November 21, 2013, Notre Dame University, West Bend, IN.
3. Clark, S.L., S.E. Schlarbaum, and F.V. Hebard. 2014. Research updates on the American chestnut field plantings on national forests in the Southern Region. Clark was invited to give presentation that summarizes the status of American chestnut research on NFS lands in the Southern Region to the American Chestnut Foundation's Fall Science Cabinet Meeting, March 22, 2014, Abington, VA.
4. Clark, S.L. 2014. American chestnut restoration: Can we bring back the mighty giant? Clark was invited to give presentation summarizes the status of the scientist's research on American chestnut to the University of Tennessee's Science Forum, <http://scienceforum.utk.edu/events/>, April 11, 2014, The University of Tennessee, Knoxville, TN.
5. Clark, S.L., S.E. Schlarbaum, and F.V. Hebard. 2014. Research updates on the American chestnut field plantings on national forests in the Southern Region. Clark was invited to give oral presentation that summarized the status of American chestnut research on NFS lands in the Southern Region to the American Chestnut Foundation's Georgia Chapter Annual Meeting, April 26, 2014, Blairsville, GA.
6. Clark, S.L., S.E. Schlarbaum, R. Makowski, and B. Crane. 2014. American chestnut (*Castanea dentata*) restoration: Can we bring back the mighty giant? Clark was invited to give an oral presentation that summarized status of American chestnut research and to discuss methods of restoration to the Technological Society of Knoxville, July 14, 2014, Knoxville, TN.
7. Clark, S.L., Sclarbaum, S.E. Hebard, F.V., Makowski, B., Crane, B., Van-Gundy, M., and Berrang, P. 2013. American Chestnut (*Castanea dentata*) Research and Management

in the Southern and Eastern Regions of the National Forest System. Oral presentation by Clark at the National Silviculture Workshop, October 25, 2013, Charleston, SC.

Publications:

1. Clark, S.L. S.E. Schlarbaum, A.M. Saxton, F. Hebard. 2014. The First Research Plantings of Third-Generation, Third-Backcross American Chestnut (*Castanea dentata*) in the Southeastern United States. *In* Proceedings of the Fifth International Chestnut Symposium, Double, M.L. and MacDonald, W.L. (eds.). ISHS. *Acta Horticulturae* 1019: 39-44.
2. Pinchot, C.C., S.E. Schlarbaum, S.L. Clark, C.J. Schweitzer, A.M. Saxton, and F.V. Hebard. 2014. Impact of Silvicultural Treatment on Chestnut Seedling Growth and Survival *In* Proceedings of the Fifth International Chestnut Symposium, Double, M.L. and MacDonald, W.L. (eds.). ISHS. *Acta Horticulturae* 1019: 191-198.
3. Knapp, B.O., G.G. Wang, S.L. Clark, L.S. Pile, and S.E. Schlarbaum. 2014. Leaf physiology and morphology of *Castanea dentata* (Marsh.) Borkh., *Castanea mollissima* Blume, and three backcross breeding generations planted in the southern Appalachians, USA. *New Forests* 45(2): 283-293. REFEREED.
4. Clark, S.L., S.E. Schlarbaum, C.C. Pinchot, S.L. Anagnostakis, M.R. Saunders, M. Thomas-Van Gundy, P.G. Schaberg, J. McKenna, J. Bard, P. Berrang, D.M. Casey, C.E. Casey, B. Crane, B. Jackson, J. Kochenderfer, R. Lewis, R. MacFarlane, R. Makowski, M. Miller, J. Rodrigue, J. Stelick, C. Thornton, and T. Williamson. 2014. Reintroduction of American Chestnut in the National Forest System. *Journal of Forestry* 112(4): 502-512. REFEREED.
5. Clark, S.L. S.E. Schlarbaum, A.M. Saxton, and F.V. Hebard. To be submitted in November 2013. Four-year field performance of American chestnut, Chinese chestnut, and backcross generations planted in the southeastern United States. *Forest Ecology and Management*.

BUGET

We requested and spent \$6850 to support activities associated with this research program (Table 2). We spent in cost-share expenditures.

Explanation of Budget

Contributed costs included a portion of the scientist salary. Other contributed costs include supplies for field measurements (write-in-rain paper, height pole, calipers, safety equipment, flagging, tags, flags). Some travel for the scientist was incurred to visit planting sites and to conduct technology transfer (presentations or training). Forest Service vehicles were used to visit sites and associated costs are estimated. Requested costs included a cost reimbursable agreement (14-CR-11330134-009) with the University of Tennessee to hire and provide support to a summer student worker for approximately 12 weeks to assist in data collection, data entry, and

data quality control. Approximately \$6,000 was used to pay for the student worker salary, and \$500 was used to pay for the student worker to travel to the planting sites.

Table 1. Overall results for growing season 2013 for each planting location.

Planting Location	Number of trees planted	Year planted	Mean percent survival for American and BC3F3 seedlings	Mean height (cm) for American and BC3F3 seedlings	Average bud-break ranking (1-lowest to 5-highest) for American and BC3F3 seedlings	Average blight ranking (1-no blight to 4 dead from blight) for American and BC3F3 seedlings	Primary competitor to planted chestnut seedlings
Clinch Ranger District, George Washington and Jefferson National Forest	369	2009	AM=66; B3=67	AM=263; B3=256	AM=1.5; B3=1.7	AM=1.7; B3=1.2	<i>Liriodendron tulipifera</i>
Tusquittee Ranger District, Nantahala National Forest	344	2009	AM=82; B3=84	AM=340; B3=300	AM=1.4; B3=1.9	AM=1.7; B3=1.4	<i>Betula lenta</i>
Nolichucky Ranger District, Cherokee National Forest	442	2009	AM=75; B3=74	AM=332; B3=293	AM=1.9; B3=2.1	AM=1.2; B3=1.1	<i>Betula lenta</i>
Beech Creek Seed Orchard, Nantahala National Forest	244	2009	AM=17; B3=26	NA	NA	NA	NA
Clinch Ranger District, George Washington and Jefferson National Forest	579	2010	AM=3; B3=2	NA	NA	NA	NA
Nolichucky Ranger District, Cherokee National Forest	513	2010	AM=55; B3=51	AM=287; B3=316	AM=1.9; B3=2.2	AM=1.3; B3=1.1	<i>Liriodendron tulipifera</i>
Beech Creek Seed Orchard, Nantahala National Forest	161	2010	AM=24; B3=13	NA	NA	NA	NA
Cheoah Ranger District, Nantahala National Forest (Shelterwood harvest site)	302	2011	AM=47; B3=70	AM=245; B3=235	NA	AM=1.1; B3=1.2	<i>Liriodendron tulipifera</i>
Cheoah Ranger District, Nantahala National Forest (Midstory removal site)	284	2011	AM=32; B3=41	AM=139; B3=134	NA	AM=1.2; B3=1.1	NA
Eastern Divide Ranger District, George Washington and Jefferson National Forest (Shelterwood harvest site)	254	2011	AM=47; B3=49	AM=144; B3=176	NA	AM=1.8; B3=1.5	<i>Castanea dentata</i> (native)

Eastern Divide Ranger District, George Washington and Jefferson National Forest (Midstory removal site)	305	2011	AM=64; B3=67	AM=116; B3=114	NA	AM=1.6; B3=1.0	NA
Watauga Ranger District, Cherokee National Forest (Shelterwood harvest site)	304	2011	AM=67; B3=76	AM=239; B3=207	NA	AM=1.7; B3=1.2	<i>Acer pensylvanicum</i>
Watauga Ranger District, Cherokee National Forest (Midstory removal site)	288	2011	AM=38; B3=51	AM=120; B3=100	NA	AM=1.4; B3=1.1	NA

Table 2. Budget for American chestnut project

Item	Expenditures from grant	Cost-share from Forest Service
Scientist Salary		50,715
Supplies	350	1,500
Travel		2,000
Vehicle costs including gas		2,400
University of Tennessee cost- reimbursable agreement 14-CR- 11330134-009	6,500	
Total	6,850	56,615

REFERENCES

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