Project title: Assessing phenological differences among American chestnut sources in a range-wide progeny planting in Vermont

Project summary: We established an American chestnut planting near the northern limit of the species' range to assess how genetics and silvicultural treatment influence growth and physiology in this region. Preliminary analyses indicate that both genetic source and silvicultural treatment affect growth and shoot winter injury. However, possible influences of leaf/shoot phenology on these and other attributes remain unexplored. We received 25% of the cost of a deer exclusion fence from TACF to reduce bud/shoot browse damage, and improve the speed and accuracy of phenological assessments. Knowledge of phenological differences will help identify sources that are well-adapted to the current northern climate and the future environment as the climate changes.

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Duration of project: Spring 2012 through spring 2015.

Objectives: In addition to ongoing measurements of growth and winter shoot injury, we will assess the spring phenology (timing of bud break and leaf expansion) for American chestnut saplings from 13 genetic sources (5 northern, 4 central and 4 southern sources) growing in a common garden on the Green Mountain National Forest in Leicester, VT. We will evaluate whether there are differences in phenology attributable to genetic source (either alone or as grouped by "region" or "temperature zone"; Saielli et al. 2014). Furthermore, we will monitor and score trees for any signs of spring foliar frost injury, and assess relationships between the timing of budbreak/leaf expansion and source vulnerability to frost injury.

Methods and monitoring: The deer exclusion fence was installed in 2012. A spring phenology guide was developed in 2012 (Figure 1 below) and phenology assessments were conducted in spring of 2012, 2013, 2014 and 2015. Diameter and height growth as well as shoot winter injury and foliar spring frost damage were also measured each year so that relationships between growth (bud break, leaf expansion, height and diameter growth) and injury (shoot winter injury and leaf spring frost injury) could be evaluated.

Actual results: Significant differences in growth and shoot winter injury attributable to genetic source and silvicultural treatment were detected (Saielli et al. 2014, Clark et al. 2014). Furthermore, significant differences in the timing of spring leaf expansion among seed sources were found for every year, though the start and length of the expansion cycle varied from year-

to-year depending on spring temperature conditions (Murakami et al. in preparation). In general, seed sources from the warm temperature zone tended to break bud first. Higher than average late-winter and early-spring temperatures were associated with earlier and shorter periods of leaf expansion. Spring frosts caused leaf damage every year, but the timing and magnitude of damage overall and among seed sources varied over time (Murakami et al. in preparation). In general, frost damage was greatest if leaves were only partially expanded at the time of frost exposure.

Presentations:

Schaberg, P.G. 2012. Update on the American chestnut progeny test at the Green Mountain National Forest in Leicester, Vermont. The American Chestnut Foundation 2012 New England Chapters Meeting, Beaver Brook Association, Hollis, NH, September 15, 2012.

Schaberg, P.G.; Saielli, T.M.; Gurney, K.M.; Hawley G.J.; Halman, J.M.; Murakami, P.F. 2012. Exploring the fit between genes and the environment relative to American chestnut restoration. Oral presentation at the 2012 American Chestnut Summit, Asheville, NC. October 20, 2012.

Schaberg, P.G.; Murakami, P.F.; Gurney, K.M.; Saielli, T.M.; Hawley G.J.; Halman, J.M.; Fitzsimmons, S.F. 2012. Exploring how genetics and silvicultural management influence the performance of American chestnut in the north. Poster presentation at the 2012 American Chestnut Summit, Asheville, NC. October 20, 2012.

Schaberg, P.G.; Saielli, T.M.; Hawley G.J.; Halman, J.M.; Gurney, K.M. 2012. Growth versus protection from the cold: a tradeoff for American chestnut grown at the species' northern range limit? Eastern CANUSA Forest Science Conference, The University of New Hampshire, Durham, NH, November 3, 2012.

Schaberg, P.; Murakami, P.; Gurney, K.; Hawley, G.; Saielli, T.; Halman, J.; Fitzsimmons, S. 2013. How genetics and silvicultural management influence the performance of American chestnut in the north. Poster presentation at the Vermont Monitoring Cooperative Annual Meeting, Burlington, VT, December 12, 2013.

Murakami, P.F.; Schaberg, P.G.; Gurney, K.M.; Halman, J.M.; Hawley, G.J.; Fitzsimmons, S.F. 2013. Spring phenology of American chestnut sources in a Vermont provenance test: implications for foliar frost injury. Poster presentation at the 30th Annual Meeting of The American Chestnut Foundation, Hemdon, VA, October 18-20, 2013.

Gurney, K.M; Murakami, P.F.; Schaberg, P.G.; Halman, J.M.; Hawley, G.J. 2013. Phenology assessments on the GMNF: implications of spring frost on chestnut health and restoration. Annual New England Regional Meeting of The American Chestnut Foundation, Portsmouth, NH, December 7, 2013.

Schaberg, P.G.; Hawley, G.J.; Gurney, K.M. 2014. Restoration of American chestnut at the northern extreme of its range. Northeastern States Research Cooperative Webinar, November 12, 2014, Burlington, VT and via web access.

Schaberg, P.G.; Murakami, P.F.; Hawley, G.J.; Halman, J.M.; Stern, R.L., Gurney, K.M. 2014. Exploring how silvicultural management and genetics influence the performance of American chestnut in Vermont. Vermont Monitoring Cooperative Annual Meeting, December 11, 2014, Burlington, VT. Page 41 in Pontius, J., J. Duncan, M. Pendleton, J. Rosovsky, and C. Waite (Eds.) 2015. Science to Policy: Benefitting from Actionable Science. Proceedings of the December 11, 2014 Vermont Monitoring Cooperative and Mt. Mansfield Science and Stewardship Conference: Burlington, VT, Vermont Monitoring Cooperative. Available online at http://www.uvm.edu/vmc/annualMeeting/2014/proceedings.

Publications:

Clark, S.C., Schlarbaum, C.C. Pinchot, S.L. Anagnostakis, M.R. Saunders, M. Thomas-Van Gundy, P.G. Schaberg and 16 additional authors. 2014. American chestnut restoration in the National Forest System. Journal of Forestry 112:502-512.

Saielli, T.M.; Schaberg, P.G.; Hawley, G.J.; Halman, J.M.; Gurney, K.M. 2014. Genetics and silvicultural treatment influence the growth and shoot winter injury of American and Chinese chestnut seedlings grown in Vermont, USA. Forest Science 60:1068-1076.

Murakami, P.F.; Gurney, K.M.; Schaberg, P.G.; Halman, J.M.; Hawley, G.J. In preparation. Spring phenology of American chestnut sources in a Vermont provenance test: implications for foliar frost injury. Restoration Ecology.

Press coverage: None known.

Figure 1. Phenological rating guide for American chestnut spring budbreak and leaf expansion. Adapted from: West, N.E and R.W. Wein. 1971. A plant phenological index technique. Bioscience 21:116-117.

CHESTNUT PHENOLOGICAL STAGES

The number to the left of the decimal denotes the most advanced phenological bud break that is occurring on the tree according to these categories:

0-Bud dormant, no sign of breaking
1-Bud displays silver/green tip
2-Bud green, but tight, no leaves unfolding
3-Bud expanding, leaves unfolding from bud
4-Internodes visible, leaves hanging but not enlarged
5-Internodes visible, leaves enlarged

3.5

Example: a seedling with terminal buds at stage 3 with 50% of the buds to this stage would receive ranking of 3.5. The phenological stage of the tree's leader bud should also be noted separately (or in the case of dieback or deer browse, the uppermost bud).

The number to the right of the decimal indicates the percentage of buds on the seedling (to the nearest 10%) that have developed to this stage.