

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

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 there. 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 seek 25% of the cost of a deer exclusion fence to reduce bud/shoot browse damage, and improve the speed and accuracy of phenological assessments. Knowledge of phenological differences could help identify sources that are well-adapted to the north now and as climates change.

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Duration of project: Spring 2012 through spring 2015.

Total amount requested: \$2,500 (25%) of a total \$10,000 needed for construction of a deer exclusion fence, necessary to remove herbivore pressure on buds/shoots that must be left intact in order to assess leaf/shoot phenology. The other 75% of the cost for the fence will be covered by a specific donation to TACF for cold tolerance research (\$2,500) and funding through the University of Vermont (\$5,000). Other (far greater) costs of this research associated with personnel time (scoring phenology in the field, entering and analyzing data, etc.), travel and other expenses will be covered by federal funding sources.

Short- and long-term goals: In the short-term, we will assess the spring and growing season phenology (timing of bud break, leaf and shoot expansion) for American chestnut saplings from 13 genetic sources (5 northern, 4 central and 4 southern sources). We will evaluate whether differences in phenology attributable to "source" (either alone or as grouped by "region" or "temperature zone"; Schaberg et al. in press, Saielli et al. in press, Saielli et al. submitted) help account for differences in growth or shoot freezing injury already identified (Schaberg et al. in press, Saielli et al. submitted). In the long-term, phenological data will also be compared to shoot sugar concentrations and cold tolerance levels (yet to be measured) to evaluate if differences in phenology may also influence these traits.

Narrative: For full restoration to occur, American chestnut (*Castanea dentata* (Marsh.) Borkh.) should be reintroduced to all parts of its former range – including high latitude and elevation limits where low temperatures may threaten seed viability, tree growth and survival. Indeed, a

series of studies from our laboratory group has shown that American chestnut nuts and woody shoots are both vulnerable to freezing injury during winter (e.g., Schaberg et al. 2009, Gurney et al. 2011). In 2009, our research group established a research planting on the Green Mountain National Forest (GMNF) that included American chestnut from five northern, four central, and four southern half-sib seed sources grown in common garden in three replicates of three silvicultural treatments: open, partial or closed overstory conditions. Preliminary results from this study indicate that genetic sources originating from colder locations experienced less shoot winter injury than other genetic sources, and that the protection of seedlings under partial or closed canopies reduced exposure to low temperature stress and winter injury (Schaberg et al. in press, Saielli et al. submitted). In general, there was an inverse relationship between winter injury and growth: genetic sources and silvicultural treatments that resulted in the greatest summer growth also experienced the most winter injury (Schaberg et al. in press, Saielli et al. submitted).

The primary focus of our research at the GMNF is to assess how genetics, silvicultural treatment and the interaction of the two, influence shoot cold tolerance and woody growth. However, another factor that is not currently being assessed could also influence the growth and cold tolerance of stock at the GMNF: differences in leaf/shoot phenology. Plant growth and sugar production (which is important to cold tolerance because some sugars act as cryoprotectants) can be modified by the timing and durations of leaf initiation, elongation and longevity. Although it is commonly reported that genetic sources from southern latitudes typically break bud earlier and experience greater shoot elongation than their northern counterparts when grown in common garden (e.g., Farmer 1993, Ghelardini et al. 2006), the opposite phenomenon (earlier bud break for northern sources) is also reported (e.g., Jensen and Hansen 2008). Because our GMNF planting has genetic sources ranging from Tennessee to Maine, this planting would be an ideal location to assess how source genetics influences the timing of bud break and the duration of shoot elongation of American chestnuts in the north. Early bud break and extended shoot elongation could increase tree growth (a potential adaptive benefit). However, early bud break and later shoot activity could also put sources at risk of early spring and late fall frost damage. Indeed, in May 2010 there were several killing frosts in the region that resulted in over 400,000 acres of foliar freezing injury in Vermont (<http://www.vtfrpr.org/protection/documents/Final2010ConditionReport.pdf>). Foliar frost injury in our GMNF chestnut plantation associated with this event was extensive, but it is unknown if differences in frost injury were related to differences in the timing of bud break and leaf expansion among genetic sources.

We propose to measure the timing of bud break, leaf and shoot expansion for the 13 genetic sources of American chestnut at the GMNF to see if differences in phenology help account for genetic differences in 1) growth, 2) vulnerability to spring and/or fall foliar freezing injury, and 3) possible differences in shoot cold tolerance. Currently all saplings in the GMNF planting are protected from deer herbivory by 1.2 m high by 0.75 m wide wire guards. However, saplings are outgrowing these guards - meaning deer can now browse off the buds/leaves that

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we seek to assess. In addition, existing guards can confine branches and obscure non-browsed buds/foilage from view - making visual assessment of phenology slow and inaccurate. To overcome these current limitations for measuring phenology, we hope to replace existing wire guards with a deer fence around two of the three replications of the “open canopy” silvicultural treatment the GMNF planting. We are seeking 25% of the funds necessary to construct an 8 ft tall deer enclosure (the other 75% of the cost of this fence will come other funding sources). We focus on the “open” treatment because 1) plants here are by far the largest (outgrowing existing deer protection and most likely to produce anomalous results due to a loss of buds/shoots to herbivory), and 2) plants here appear the most vulnerable to freezing injury (Schaberg et al. in press, Saielli et al. submitted) and spring foliar frost damage (data not shown), so understanding the contribution of phenology to these processes is particularly pertinent for this treatment.

Timeline: All requested funds will be used in spring 2012 to build the deer exclusion fence that will greatly facilitate the assessment of bud break, leaf expansion and shoot elongation (leaf and shoot phenology). Phenological assessments will be measured during the spring and summer of 2012, 2013, 2014 and 2015. Multiple years of data are needed to assess for possible year-to-year differences in the timing or duration of phenology based on interannual temperature and precipitation differences, including the possible influences of spring thaws, snow or frost events.

Results – measurements and reporting: Phenology data will be collected and analyzed yearly, and compared to growth and other data from the plantation that is also collected on a yearly basis. In addition to annual reports to TACF, journal articles and presentations to scientific organizations will be produced whenever pertinent results become available. Our group has a strong record of publication and outreach regarding American chestnut research (e.g., 3 manuscripts published, 2 in press, 1 submitted, 2 MS theses, 14 presentations at scientific conferences, and 3 field tours since 2007).

Funding breakdown and timeline: The \$2,500 that we seek will be combined with other funds to erect a deer exclusion fence at the GMNF American chestnut progeny planting in spring 2012. All TACF funding would be needed at that time. Funding from UVM and federal sources will pay for all other costs of this research, which will continue for three years.

References:

Farmer, R.E. 1993. Latitudinal variation in height and phenology of balsam poplar. *Silvae Genetica* 42:2-3.

Ghelardini L., M. Falusi, A. Santini. 2006. Variation in timing of bud-burst of *Ulmus minor* clones from different geographic origins. *Canadian Journal of Forest Resources* 36:1982-1991.

Gurney, K.M., P.G. Schaberg, G.J. Hawley, J.B. Shane. 2011. Inadequate cold tolerance as a possible limitation to American chestnut restoration in the Northeastern United States. *Restoration Ecology* 19:55-63.

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Jensen, J.S., J.K. Hansen. 2008. Geographical variation in phenology of *Quercus petraea* (Matt.) Liebl and *Quercus robur* L. oak grown in a greenhouse. *Scandinavian Journal of Forest Research* 23:179-188.

Saielli, T.M., P.G. Schaberg, G.J. Hawley, J.M. Halman, K.M. Gurney. In press. Nut cold hardiness as a factor influencing the restoration of American chestnut in the northeastern United States. *Canadian Journal of Forest Resources*.

Saielli, T.M., P.G. Schaberg, G.J. Hawley, J.M. Halman, K.M. Gurney. Submitted. Genetics and silvicultural treatment influence the growth and shoot winter injury of American and Chinese chestnut seedlings grown in Vermont, USA. *Forest Ecology and Management*.

Schaberg, P.G., K. M. Gurney, B.R. Janes, J.M. Halman, G.J. Hawley. 2009. Is nut cold tolerance a limitation to the restoration of American chestnut in the northeastern United States? *Ecological Restoration* 27:266-268.

Schaberg, P.G., T.M., Saielli, G.J. Hawley, J.M. Halman, K.M. Gurney. In press. Growth and shoot winter injury of American chestnut seedlings grown in common garden at the species' northern range limit. USDA Forest Service Northern Research Station General Technical Report, Newtown Square, PA.

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Education Ph.D. Botany, The University of Vermont (UVM), Burlington, VT. 1996.
Teaching certification. 1989. S. Connecticut State Univ., New Haven, CT.
M.S. Forestry. UVM. 1985.
B.S. Forestry and Environmental Studies. UVM. Graduated *cum laude* 1981.

Professional Experience

Research Plant Physiologist, USDA Forest Service, 1995-present.
Adjunct Associate Professor at UVM, 2005-Present.
Graduate Faculty, UVM, 1999-Present.
Fellow, *Gund Institute for Ecological Economics*, UVM. 2002-Present.
Acting Project Leader, NRS-4103, USDA Forest Service, 2005-2007.
Adjunct Assistant Professor, UVM, 1996-2005.
Research Associate, USDA Forest Service, 1989-1995.

Selected Cooperative Grants

Testing the value of high resolution LiDAR data for assessing the structure and integrity of forest canopies that influence tree health, insect populations, and bird habitats. Northeastern States Research Cooperative (NSRC) Grant program, 2011-2014, \$68,170. With A. Strong and G. Hawley (UVM).
Quantifying the influence of winter injury on carbon sequestration for red spruce trees within the Northern Forest: assessing forest health to inform policy and economics. NSRC Grant program, 2010-2013, \$52,606. With G.J. Hawley and A. Kosiba (UVM).
Calcium depletion as a limitation to tree growth and carbon sequestration within Northern Forests. NSRC Grant Program, 2009-2012, \$66,700. With G.J. Hawley (UVM).
Forest ecosystem health in a globalizing world: Building a diverse community of scholars. USDA CSREES, \$236,000. 2009-2013. Graduate student outreach and research grant with D. Wang, C. Ginger, J. Pontius, K. Wallin (UVM).
Restoring American chestnut and associated products to the Northern Forest. NSRC Grant Program, \$76,415. Research with G.J. Hawley (UVM) in collaboration with The American Chestnut Foundation (TACF) and the Green Mountain National Forest.
Preliminary research of the cause(s) of emerging tree declines within the Northern Forest: phase 1 – birch decline. Agency: USDA Forest Service Cooperative Research Program, 2007-2012, \$17,000. Research with G.J. Hawley (UVM).

Graduate Advisor - Major advisor for 16 graduated or ongoing M.S. or Ph.D. students, committee member on an equal number of other M.S. or Ph.D. committees.

Honors – USDA NRS Extra Effort Award 2011; USDA Performance Awards 2006, 2007, 2008; USDA Quality Step Increases 2003, 2005; NRS Multicultural Achievement Awards 2002, 2009; NE/NA Excellence in Customer Service Award 2001; NE/NA Civil Rights Award of Excellence 1998; USDA Certificates of Merit 1993, 1996, 1997; UVM-SNR Research Fellow 1982-1984; Community leaders in America 1983; International Youth in Achievement 1982-83; National Dean's List 1980-1981; UVM-SNR Dean's List 1979-1981; Xi Sigma Pi Honor Society 1980.

Professional Affiliations

International Association for Ecology, American Institute of Biological Sciences, Ecological Society of America, Society of American Foresters, Society for Conservation Biology, The American Chestnut Foundation

Selected Recent Peer-Reviewed Publications

- Schaberg, P.G., T.M., Saielli, G.J. Hawley, J.M. Halman, K.M. Gurney. In press. Growth and shoot winter injury of American chestnut seedlings grown in common garden at the species' northern range limit. Gen. Tech. Rep. Newtown Square, PA: USDA Forest Service, Northern Research Station.
- Saielli, T.M., P.G. Schaberg, G.J. Hawley, J.M. Halman, K.M. Gurney. In press. Nut cold hardiness as a factor influencing the restoration of American chestnut in the northeastern US. Can. J. For. Res.
- Hennon, P., D. D'Amore, P. Schaberg, D. Wittwer, C. Shanley. 2012. Shifting climate, altered niche, and a dynamic conservation strategy for yellow-cedar in the North Pacific rainforest. BioSci. 62:147-158.
- Schaberg, P.G., R. Minocha, S. Long, J.M. Halman, G.J. Hawley, C. Eagar. 2011. Calcium addition at the Hubbard Brook Experimental Forest increases the capacity for stress tolerance and carbon capture in red spruce trees during the cold season. Trees 25:1053-1061.
- Schaberg, P.G., P.E. Hennon, D.V. D'Amore, J.M. Halman, G.J. Hawley. 2011. Do limited cold tolerance and shallow depth of roots contribute to yellow-cedar decline? For. Ecol. Manage. 262:2142-2150.
- Schaberg, P.G., B.E. Lazarus, G.J. Hawley, J.M. Halman, C.E. Borer, C.F. Hansen. 2011. Examination of weather-associated causes of red spruce winter injury and consequences to aboveground carbon sequestration. Can. J. For. Res. 41:359-369.
- Halman, J.M., P.G. Schaberg, G.J. Hawley, C.F. Hansen. 2011. Potential role of soil calcium in recovery of paper birch following ice storm injury in Vermont, USA. For. Ecol. Manage. 261:1539-1545.
- Neufeld H.S., D.B. Poindexter, P.F. Murakami, P.G. Schaberg. 2011. Observations on the relationship between above- and below-ground anthocyanin production in *Galax urceolata* (Poir.) Brummitt growing in sun-exposed and shaded locations. Castanea 76:84-98.
- Gurney, K.M., P.G. Schaberg, G.J. Hawley, J.B. Shane. 2011. Inadequate cold tolerance as a possible limitation to American chestnut restoration in the Northeastern United States. Restor. Ecol. 19:55-63.
- Schaberg, P.G., G.J. Hawley. 2010. Disruption of calcium nutrition at Hubbard Brook Experimental Forest alters the health and productivity of red spruce and sugar maple trees and provides lessons pertinent to other sites and regions. Gen. Tech. Rep. NRS-P-64. Newtown Square, PA: USDA Forest Service, Northern Research Station, p. 190-200.
- Schaberg, P.G., E.K. Miller, C. Eagar. 2010. Assessing the threat that anthropogenic calcium depletion poses to forest health and productivity. Gen. Tech. Rep. PNW-GTR-802. Portland, OR: USDA Forest Service, Pacific Northwest and Southern Research Stations, p. 37-58.
- Strimbeck, G.R., P.G. Schaberg. 2009. Going to extremes: Low-temperature tolerance and acclimation in temperate and boreal conifers. In: Gusta, L.V.; Wisniewski, M.E.; Tanino, K.K.; eds. Plant Cold Hardiness: From Laboratory to the Field. CAB International Publishing, Wallingford, UK, p. 226-239.
- D'Amore, D.V., P.H. Hennon, P.G. Schaberg, G.J. Hawley. 2009. Adaptation to exploit nitrate in surface soils predisposes yellow-cedar to climate change-induced decline while enhancing the survival of western redcedar: A new hypothesis. For. Ecol. Manage. 258:2261-2268.
- Schaberg, P.G., K. M. Gurney, B.R. Janes, J.M. Halman, G.J. Hawley. 2009. Is nut cold tolerance a limitation to the restoration of American chestnut in the northeastern US? Ecol. Restor. 27:266-268.
- Strimbeck, G.R., T.D. Kjellsen, P.G. Schaberg, P.F. Murakami. 2008. Dynamics of low-temperature acclimation in temperate and boreal conifer foliage in a mild winter climate. Tree Physiol. 28:1365-1374.
- Murakami, P.F., P.G. Schaberg, J.B. Shane. 2008. Stem girdling manipulates leaf sugar concentrations and anthocyanin expression in sugar maple trees during autumn. Tree Physiol. 28:1467-1473.
- Schaberg, P.G., P.F. Murakami, M.R. Turner, H.K. Heitz, G.J. Hawley. 2008. Associations of red coloration with senescence of sugar maple leaves in autumn. Trees 22:573-578.
- Schaberg, P.G., P.E. Hennon, D.V. D'Amore, G.J. Hawley. 2008. Influence of simulated snow cover on the cold tolerance and freezing injury of yellow-cedar seedlings. Global Change Biol. 14:1-12.

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Education: Master of Science, 8/82 (UVM) Forest Genetics, Bachelor of Science, 6/78 (UVM)

Research Interests: Developmental cold tolerance and physiological mechanisms of winter injury in forest trees. Genetic diversity, evolutionary biology, and physiological adaptation of forest trees. Design, development and demonstration of high performance green buildings.

Selected Recent Grants

Restoring American chestnut and associated products to the northern forest. Northern States Research Cooperative (NSRC), Maine, 2008-2011, \$76,415. With P.G. Schaberg (USFS).

Soil calcium and reproduction of sugar maple in northeastern forest. USDA-NRI Grant Program, 2007-2010, \$400,000. With T. Fahey (Cornell University), J. Blum (U. Michigan), P.G. Schaberg (USFS), A. Richardson (UNH).

Science to assist the restoration of American chestnut to the Northern Forest. Agency: US Forest Service, 2006-2011, \$48,000. With P.G. Schaberg (USFS) and J.B. Shane (UVM)

Calcium depletion and shoot freezing injury as contributors to sugar maple decline in the Northern Forest. Northern States Research Cooperative (NSRC), New Hampshire, 2007-2010, \$80,000. With P.G. Schaberg (USFS).

A quantitative assessment of the influence of winter injury and calcium depletion on the productivity of red spruce trees in the Northern Forest. Agency: Northern States Research Cooperative (NSRC) New Hampshire, 2006-2010, \$41,563. With P.G. Schaberg (USFS).

The green renovation and expansion of the Aiken Center: A sustainable green building design, collaborative planning process and long-term demonstration and research project. US EPA, 2006-2010, \$867,800. With D.H. DeHayes (UVM) and A. McIntosh (UVM).

Quantitative assessment of the effect of winter injury on red spruce productivity. Agency: US Forest Service, 2005-2010, \$25,000. With D.H. DeHayes.

Evaluating the causes and consequences of red spruce winter injury resulting from acid rain-induced soil calcium depletion. US EPA, 2005-2010, \$198,400. With D.H. DeHayes (UVM) and P.G. Schaberg (USFS).

Preliminary research of the cause(s) of emerging tree declines within the Northern Forest: phase 1 – birch decline. Agency: USDA Forest Service Cooperative Research Program, 2007-2012, \$17,000. With D.H. DeHayes (UVM) and P.G. Schaberg (USFS).

The role of calcium depletion and winter injury on the productivity of red spruce in Vermont. Agency: McIntire-Stennis Forestry Research Program, 2006-2009, \$39,833. With D.H. DeHayes (UVM) and P.G. Schaberg (USFS).

Evaluating the impacts of atmospheric deposition on tree health and forest ecosystem sustainability in the Northeastern United States. Agency: US EPA, 2004-2007, \$248,500. With D.H. DeHayes (UVM) and P.G. Schaberg (USFS). Amendment to previous EPA grant.

Understanding the influence of Ca depletion on tree health and recovery from stress. Agency: Northeastern States Research Cooperative (NSRC) Grant Program, 2004-2008, \$40,000. With P.G. Schaberg (USFS) and C.H. Borer (UVM).

An evaluation of soil Ca:Al ratios, foliar CA and Al partitioning, and forest health. Agency: Northeastern States Research Cooperative (NSRC) Grant Program, 2003-2006, \$81,638. With P.G. Schaberg (USFS) and C.H. Borer (UVM).

Recent Publications

- Schaberg, P.G., T.M., Saielli, G.J. Hawley, J.M. Halman, K.M. Gurney. In press. Growth and shoot winter injury of American chestnut seedlings grown in common garden at the species' northern range limit. Gen. Tech. Rep. Newtown Square, PA: USDA Forest Service, Northern Research Station.
- Saielli, T.M., P.G. Schaberg, G.J. Hawley, J.M. Halman, K.M. Gurney. In press. Nut cold hardiness as a factor influencing the restoration of American chestnut in the northeastern United States. *Can. J. For. Res.*
- Schaberg, P.G., Minocha, R., Long, S., Halman, J.M., Hawley G.J., Eagar C. 2011. Calcium addition at the Hubbard Brook Experimental Forest increases the capacity for stress tolerance and carbon capture in red spruce trees during the cold season. *Trees* 25:1053-1061.
- Schaberg, P.G., Hennon, P.E., D'Amore, D.V., Halman, J.M., Hawley, G.J. 2011. Do limited cold tolerance and shallow depth of roots contribute to yellow-cedar decline? *For. Ecol. Manage.* 262:2142-2150.
- Halman, J.M., P.G. Schaberg, G.J. Hawley, C.F. Hansen. 2011. Potential role of soil calcium in recovery of paper birch (*Betula papyrifera*) following ice storm injury in Vermont, USA. *For. Ecol. Manage.* 261: 1539–1545.
- Schaberg, P.G., B.E. Lazarus, G.J. Hawley, J.M. Halman, C.E. Borer, C.F. Hansen. 2011. Assessment of weather-associated causes of red spruce winter injury and consequences to aboveground carbon sequestration. *Can. J. For. Res.* 41:359-369.
- Gurney, K.M., P.G. Schaberg, G.J. Hawley, J.B. Shane. 2011. Inadequate cold tolerance as a possible limitation to American chestnut restoration in the Northeastern United States. *Restor. Ecol.* 19:55-63.
- D'Amore, D.V., Hennon, P.H., Schaberg, P.G., and Hawley, G.J. 2009. Adaptation to exploit nitrate in surface soils predisposes yellow-cedar to climate change-induced decline while enhancing the survival of western redcedar: A new hypothesis. *Forest Ecology and Management.* 258:2261-2268.
- Schaberg, P.G., K. M. Gurney, B.R. Janes, J.M. Halman, G.J. Hawley. 2009. Is nut cold tolerance a limitation to the restoration of American chestnut in the northeastern United States? *Ecolog. Restor.* 27:266-268.
- Halman, J. M., P.G. Schaberg, G.J. Hawley, C. Eagar. 2008. Calcium addition at the Hubbard Brook Experimental Forest increases sugar storage, antioxidant activity, and cold tolerance in native red spruce (*Picea rubens* Sarg.). *Tree Physiol.* 28: 855-862.
- Schaberg. P.G., Hennon, P.E., D'Amore, D.V. and G.J. Hawley. 2008. Influence of simulated snow cover on the cold tolerance and freezing injury of yellow-cedar seedlings. *Global Change Biology* 14:1-12.
- Schaberg, P.G., D.H. DeHayes, G.J. Hawley, S.E. Nijensohn. 2008. Anthropogenic alterations of genetic diversity: Implications for forest ecosystem resilience. *For. Ecol. & Manage.* 256:855-862.
- Balogh-Brunstad, Z., Keller, C. K. , Bormann, R. B. T. , Wang, D., and Hawley, G.J. 2008, Chemical weathering and chemical denudation dynamics through ecosystem development and disturbance, *Global Biogeochem. Cycles*, 22, GB1007, doi:10.1029/2007GB002957.
- Schaberg, P.G. Murakami, P.F. Turner, M.R., Heitz, H.K., Hawley, G.J. 2008. Associations between the red coloration and senescence of sugar maple leaves in autumn. *Trees.* 22:573-578.
- Huggett, B.A., Schaberg, P.G., Hawley, G.J., Eagar, C. 2007. Long-term addition increases growth release, wound closure, and health of sugar maple (*Acer saccharum*) trees at Hubbard Brook Experimental Forest. *Can. J. For. Res.* 37:1692-1700.
- Hawley, G.J., Schaberg P.G., Eagar, C., and Borer, C.H. 2006. Calcium addition at the Hubbard Brook Experimental Forest reduced winter injury to red spruce in high-injury year. *Can. J. For. Res.* 36:2544-2549.
- Hennon, P., D'Amore, D., Wittwer, D., Johnson, Schaberg, P., Hawley, G., Beier, C., Sink, S., Juday, G. 2006. Climate warming, reduced snow, and freezing injury could explain the demise of yellow-cedar in Southeast Alaska, USA. *World Resource Review* 18(2):427-450.
- Hawley, G.J., Schaberg P.G., DeHayes, D.H., Brissette, J. 2005. Silviculture alters the genetic structure of an eastern hemlock forest in Maine, USA. *Can. J. For. Res.* 35:143-150.
- Schaberg, P.G., J.W. Tilley, G.J. Hawley, D.H. DeHayes, S.W. Bailey. 2006. Associations of calcium and aluminum with the growth and health of sugar maple trees in Vermont. *For. Ecol. Manage.* 223:159-169.
- Lazarus, B.E., P.G. Schaberg, G.J. Hawley, D.H. DeHayes. 2006. Landscape-scale spatial patterns of winter injury to red spruce foliage in a year of heavy region-wide injury. *Can. J. For. Res.* 36:142-152
- Nijensohn, S.E., Schaberg, P.G., Hawley, G.J., DeHayes, D.H. 2005. Genetic subpopulation structuring and its implications in a mature eastern white pine stand. *Can. J. For. Res.* 35:1041-1052.

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Summary: - **Current** Ph.D. student and research staff in Natural Resources at the University of Vermont
- Master's degree in Natural Resources – Forestry, from the University of Vermont

Education: University of Vermont, Burlington, VT
M.S. Natural Resources – Forestry 2007
B.S. Botany 2001
Arava Institute of Environmental Studies, Kibbutz Ketura, Israel
Junior year abroad 1999-2000

Employment: **2012- Present.** Lecturer in Forest Ecology. Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT.
2007- Present. Research and laboratory technician. Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT.
2004-2007. Graduate research fellow. Rubenstein School of Environment and Natural Resources, University of Vermont, Burlington, VT.
2001-2004. Laboratory technician. Department of Pharmacology, College of Medicine, University of Vermont, Burlington, VT.

Publications: Saielli, T.M., P.G. Schaberg, G.J. Hawley, **J.M. Halman** and K.M. Gurney. 2012. Nut cold hardiness as a factor influencing the restoration of American chestnut in northern latitudes and high elevations. *Canadian Journal of Forest Research. Accepted, in press.*
Schaberg, P.G., T.M. Saielli, G.J. Hawley, **J.M. Halman** and K.M. Gurney. 2012. Winter injury of American chestnut seedling grown in a common garden at the species' northern range limit. *Proceedings of 2012 Central Hardwood Conference. Accepted, in press.*
Schaberg, P.G., D.V. D'Amore, P.E. Hennon, **J.M. Halman** and G.J. Hawley. 2011. Do limited cold tolerance and shallow depth of roots contribute to yellow-cedar decline? *Forest Ecology and Management* 262: 2142-2150.
Schaberg, P.G., R. Minocha, S. Long, **J.M. Halman**, G.J. Hawley and C. Eagar. 2011. "Calcium fertilization at the Hubbard Brook Experimental Forest increases the capacity for stress tolerance and carbon capture in red spruce (*Picea rubens*) trees during the cold season." *Trees* 25: 1053-1061.
Halman, J.M., P.G. Schaberg, G.J. Hawley and C.F. Hansen. 2011. "Potential role of soil calcium in recovery of paper birch following ice storm injury in Vermont, USA." *Forest Ecology and Management* 261: 1539-1545.
Schaberg, P.G., B.E. Lazarus, G.J. Hawley, **J.M. Halman**, C.H. Borer and C.F. Hansen. 2011. "Assessment of weather-associated causes of red spruce winter injury and consequences to aboveground carbon sequestration." *Canadian Journal of Forest Research* 41(2): 359-369.

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Schaberg, P.G., K.M. Gurney, B.R. Janes, **J.M. Halman** and G.J. Hawley. 2009. "Is nut cold tolerance a limitation to the restoration of American chestnut in the northeastern United States?" *Ecological Restoration* 27(3): 266-268.

Halman, J.M., P.G. Schaberg, G.J. Hawley and C. Eagar. 2008. "Calcium addition at the Hubbard Brook Experimental Forest increases sugar storage, antioxidant activity and cold tolerance in native red spruce (*Picea rubens*)." *Tree Physiology* 28(6): 855-862.

Reports:

Halman, J.M., W Hackett and S.A. Rayback. 2009. "Reconstructing the history of the Preston Parcel (Richmond, VT) using dendrochronological techniques and orthophotos." *Report for The Nature Conservancy, Montpelier, VT.*

Presentations:

Halman, J.M., P.G. Schaberg, G.J. Hawley, C.F. Hansen, and T.J. Fahey. 2011. "Growth dynamics of American beech and sugar maple trees exposed to long-term calcium and aluminum additions." ESA Annual Meeting, Austin, Texas.

Halman, J.M., P.G. Schaberg, G.J. Hawley and C.F. Hansen. 2009. "Potential role of Ca in the response of paper birch (*Betula papyrifera*) to ice storm-induced decline in Vermont, USA." ESA Annual Meeting, Albuquerque, New Mexico.

Schaberg, P.G., G.J. Hawley, **J.M. Halman** and P.F. Murakami. 2009. Laboratory and field data indicate that acidic deposition-induced calcium depletion disrupts the nutrition and physiology of trees, predisposing them to decline. NADP Technical Committee Meeting, Saratoga Springs, NY.

Halman, J.M., P.G. Schaberg, G.J. Hawley and C. Eagar. 2007. "Calcium addition at the Hubbard Brook Experimental Forest increases sugar storage, antioxidant activity and cold tolerance in native red spruce (*Picea rubens*)." ESA/SER Joint Meeting, San Jose, California.

Halman, J.M. 2006. Determining the effects of calcium depletion on red spruce health and productivity. Hubbard Brook Experimental Forest Cooperators' Meeting, Thornton, NH.

Halman, J.M. 2005. Effects of calcium-depletion on red spruce health: A watershed based study at the Hubbard Brook Experimental Forest. University of Vermont Graduate Research Symposium, Burlington, VT.

Technical Expertise:

Antioxidant enzyme assays
Tissue digestion and nutrient analysis (ICP) – foliar, soil, stem
Tissue cold tolerance – foliar, stem, seed
Carbohydrate concentration assays – foliar, stem
C/N analysis
Northern, southern and western blotting
RT-PCR

