

TITLE: Assessment of Beech Bark Disease in Michigan: Rate of Spread and Impacts on Stand Composition and Down Woody Material. Progress Report - September 2010

LOCATION: Michigan

DURATION: 3 years; current request is for Yr 3 funds.

PROJECT LEADER: Deborah G. McCullough, Professor, Dept. of Entomology and Dept. of Forestry, 243 Natural Science, Michigan State University, 517-355-7445; mccullo6@msu.edu

COOPERATORS: Roger Mech & Robert Heyd, Michigan Dept. of Natural Resources & Environment; Daniel Hayes, Dept. of Fisheries and Wildlife, Michigan State University

FHP SPONSOR/CONTACTS: Manfred Mielke & Joseph O'Brien, St. Paul, MN

PROJECT OBJECTIVES: We expect to (1) monitor and delineate advancing and killing fronts of beech bark disease (BBD) in MI; (2) re-visit BBD plots established in 2002-2003 to record changes in beech scale density, tree mortality and crown condition, species composition (overstory and regeneration) and down woody material; (3) validate and refine our previous model of spread rate of the advancing fronts in upper and lower MI and (4) assess changes in within-stand beech scale density and distribution over time.

JUSTIFICATION AND BACKGROUND: Beech bark disease, an etiological complex consisting of the nonindigenous, sap-feeding beech scale (*Cryptococcus fagisuga* Lind.) and cambium-killing *Neonectria* and *Nectria* spp. fungi (1,7,8), was first identified in MI in 2000 (13), then in WI in 2008. Most previous BBD studies have occurred in eastern forests and relatively little is known about BBD effects and spread in the Great Lakes/North Central region. Progression of BBD and subsequent regeneration could profoundly alter species composition and productivity (2,4,5,18), biodiversity and overall forest health. In MI, the maple-beech-birch cover type comprises roughly 33% of forested land and includes more than 1.4 million board feet of beech timber (6). Beech is a particularly important resource for wildlife in northern hardwood forests (10,17), providing hard mast, perching branches and cavities for a wide array of mammals and birds. Windthrow and hazard trees have become a concern in several campgrounds and recreation areas with mature, vulnerable beech trees (14).

Our objectives are well in line with EM guidelines, address 4 of the 9 subject areas identified in the FY11 EM proposal guidelines, and build upon our previous BBD projects. Results will supplement information collected in FIA and FHM monitoring plots and address important information gaps regarding DWM, beech scale dynamics and spread of the advancing front in this region. We will re-survey 62 sites originally sampled in 2002-2003, when BBD impacts remained largely undetectable. These sites effectively serve as pre-BBD controls, enabling us to quantify the extent, progression and rate of change in beech canopy condition and mortality, stand composition and structure, and DWM, as BBD advances. The absence of such pre-BBD data has largely precluded any detailed assessment of BBD impact in the northeastern US. We will document tree mortality and canopy decline attributable to BBD, and assess regeneration and potential species composition in affected stands. Abundance and distribution of down woody material (DWM), an important component of wildlife habitat and carbon budgets, will be quantified. Forest health specialists have estimated that 7.5 million large beech trees (DBH \geq 10 inches) representing 800 million board feet of sawtimber will likely die as the killing front of BBD moves through MI (10). This mortality represents a potentially major, synchronous pulse of DWM (11) that merits documentation and study. Up-to-date information on BBD distribution, spread and impacts will enable foresters in MI and this region to assess stand susceptibility and vulnerability, regulate timber and firewood harvest, and prioritize risk management operations such as pre-salvage, salvage or regeneration activities.

METHODS INCLUDING PROGRESS TO DATE: To delineate the advancing front of BBD, areas likely to contain beech trees are located using a basal area map developed from FIA data (12) and ground surveys. A plot center and variable radius plot (10 BAF prism) are established where we first encounter at least three large beech trees (≥ 12 cm dbh). GPS coordinates are recorded and beech trees within the plot are carefully examined to determine if any beech scale is present. Two additional plots are established in randomly chosen directions 100 m from the first plot. Previously uninfested sites within 5 km of infested sites along the advancing front are revisited each summer. If beech scale has colonized trees at the revisited site, the next closest, previously uninfested site is visited. This process continues until a buffer of uninfested sites is established. Between 2005 and 2009, a total of 803 sites were examined and 254 sites were revisited across 73 of the 83 counties in MI (21). We expect to continue this survey in 2011, particularly in lower MI, where spread rates could increase if satellite populations coalesce (15). An inverse, iterative modeling process was applied to assess spread of the advancing front in MI from 2004-2006 (16). Estimated spread rates varied considerably between the two years, ranging from 0.9 to 2.5 miles per year. Additional distribution data collected as part of this project will be used to refine this model.

We began re-surveying the 62 sites established in 2002-2003 by a crew from the University of MI and A. Kearney (MSU) in July 2010. These sites originally represented three levels of beech basal area (low, moderate and high) and three categories of beech scale (absent, low, heavy) (9). Each site must be re-located using hand-drawn maps, site descriptions and a metal detector to identify metal stakes that were buried in most (but not all) of the sites. Once we locate a site, we record GPS coordinates of the center subplot. A combination of fixed radius plots, transects and individual tree sampling are employed to assess overstory and understory species composition, diameter and canopy condition (transparency, dieback) of overstory trees, and beech scale density (see methods in 20). Number and species of seedlings (<30 cm tall), saplings (30 cm tall but <2.5 cm diam) and recruits (2.5 to 15 cm DBH) are recorded in subplots with 2.4, 3.5, 7.3 m radii, respectively. Tree size, species and canopy condition (dieback, transparency) are measured in the original five subplots (7.3 m radius) and in two belt transects (each 51 x 10 m). While beech condition is of primary interest, all overstory species are examined to distinguish effects of BBD from other stresses. Frequency, size and decay class of DWM are recorded along three transects (51 x 1 m) within each site. Additional variables related to wildlife habitat (snags, cavity size and abundance) are also recorded when overstory trees are evaluated. To date, we have been able to re-locate the 28 original sites and subplots established in lower MI; our efforts will expand to the Upper MI sites in 2011. Measurements of variables related to beech scale density, vegetation and DWM have been completed in seven sites. Beech scale is present at varying densities in all seven sites; three were not infested in 2003. Sampling will continue in 2011 and if needed, in 2012.

Relatively little is known about the within-tree and within-stand dynamics of beech scale, largely because of the difficulty of counting individual scales under the wax (3,19). Questions of interest include effects of severe winter weather on scale survival and the rate at which scale populations build from a trace to a heavy infestation. We developed a method to monitor scale density over time using digital photos and imaging software (20). Individual beech trees with varying beech scale density were selected and tagged in 14 sites with varying levels of infestation in lower MI in 2008. Using a stratified random sampling design, we periodically take photos at three heights (0.9, 1.2, 1.5 m) and aspects, 30 cm from the tree, using a tripod-mounted camera (with built-in stabilizer). Photos are scanned and the area of scale wax is used to estimate scale density (per cm^2) (20). Trees in all 14 sites were photographed in 2009 and 2010. They will continue to be monitored in spring (winter mortality) and mid summer (peak wax production; pre-reproduction).

PRODUCTS: Data from our previous and current projects have enabled us to identify nine satellite populations of beech scale. We developed a model to predict beech scale numbers using wax abundance. We have also delineated the advancing fronts in Upper and Lower MI. A current map of the advancing front was distributed to state forest specialists (August 2010) and presented at the North Central Forest Pest Workshop (October 2010). Beech scale distribution and progression of the advancing front will continue to be surveyed and mapped. Data (from re-visited sites) related to beech canopy condition and mortality, regeneration, DWM and estimated spread rates will be summarized in 2011 and 2012. Maps and data summaries will be provided to forest health specialists, resource managers and extension educators in annual progress reports and at state, regional and national meetings. Data will be employed to revise BBD models used for the National Forest Risk Map project. Final results will be published in scientific journals.

Schedule of Activities: *Fall-winter 2010:* Continue data collection in lower MI plots; Enter and summarize data; Scan photos to quantify beech scale density. *Winter-spring 2011:* Request permits for work on state and national forests; Acquire and scan photos of beech scale to assess winter mortality; *Summer-fall 2011:* Complete measurements in lower MI sites; Survey advancing fronts in lower and upper MI; Re-locate sites in Upper MI and begin data collection and surveys; Acquire photos to assess peak beech scale density; *Fall-winter 2011:* Complete fieldwork in lower MI sites; Scan photos; Begin data analysis, including spread model validation; Prepare map of advancing front and progress report; *Spring-winter 2012:* Complete fieldwork, data analysis and model revisions; Prepare maps, progress reports and manuscripts.

PROGRESS TO DATE: Transfer of Year 1 funds to MSU was delayed by several months. Funds did not become available until spring 2010. A graduate student, James Wieferich, who has previously conducted BBD-related field work, was recruited and began his M.S. (Forestry) project in summer 2010. See “*Methods Including Progress To Date*” above for more information.

REQUEST FOR YEAR 3 FUNDING

	Item	Requested FHM EM funding	Other source funding ²	Source ²
Year 3				
Administration	Salary	40,700 ¹	8,540	5% PI effort; fringe at 29.47%
	Overhead			
	Travel	4,000 ³		
Procurements	Contracting			
	Equipment			
	Supplies	2,500		
Indirect			28,985	Total Direct MSU & USDA FS x 52%
Total Year 3		47,200	37,525	

¹Expected costs include stipend and health benefits for a graduate student (1/2-time, M.S. level) and 1-2 undergraduate student assistants (\$10/hr). ²PI assumes 5% annual time commitment; fringe benefit rates of 28.54-29.47%. MSU indirect costs waived. ³A leased MSU Motor Pool vehicle (3-4 months) will be needed to access field sites. Funds are needed to cover student travel costs (e.g. camping fees) and attendance at a regional or national meeting to present results.

Literature Cited

1. Ehrlich, J. 1934. The beech bark disease: a *Nectria* disease of *Fagus*, following *Cryptococcus fagi* (Baer.). *Can. J. For. Res.* 10: 593-692.
2. Forrester, J.A., G.G. McGee and M.J. Mitchell. 2003. Effects of beech bark disease on aboveground biomass and species composition in a mature northern hardwood forest, 1985-2000. *J. Torrey Bot. Soc.* 130:70-78.
3. Gardner, G. 2005. Population and large-scale dispersal dynamics in the beech scale insect *Cryptococcus fagisuga*. p.121–123, In: *Beech Bark Disease: Proc. of the Beech Bark Disease Symposium*. June 16-18, 2004. Evans, C. A., Lucas, J.A. and Twery, M.J., eds. Gen. Tech. Rep. NE-331. Newton Square PA, USDA Forest Service, Nor. Res. Sta.
4. Gaven, D.G., and D.R. Peart. 1993. Effects of beech bark disease on the growth of American beech (*Fagus grandifolia*). *Can. J. For. Res.* 23: 1566-1575.
5. Hane, E.N. 2003 Indirect effects of beech bark disease on sugar maple seedling survival. *Can. J. For. Res.* 33: 807-813.
6. Hanson, M.H. and G.J. Brand. 2006. Michigan's forest resources. USDA Forest Service, North Central Res. Sta. Res. Bull. NC-255. 41 p.
7. Houston, D.R. 1994. Major new tree disease epidemics – beech bark disease. *Annu. Rev. Phytopathol.* 32:75-87.
8. Houston, D.R., E.J. Parker, and D. Lonsdale. 1979. Beech bark disease: patterns of spread and development of the initiating agent *Cryptococcus fagisuga*. *Can. J. For. Res.* 9:336-344.
9. Kearney, A.M. Impacts of beech bark disease on stand composition and wildlife resources in Michigan. M.S. Thesis. Dept. of Entomology, Michigan State University. 118 p.
10. McCullough, D.G., R.L. Heyd and J.G. O'Brien. 2001. Biology and management of beech bark disease: Michigan's newest exotic forest pest. MSU-Extension bulletin E-2746. 12 pp.
11. McGee G.G. 2000. The contribution of beech bark disease-induced mortality to down woody material loads in northern hardwood stands of Adirondack Park, New York, U.S.A. *Can J. For. Res.* 30: 1453-1462.
12. Morin, R., A. Liebhold, P. Tobin, K. Gottschalk, and E. Luzader. 2007. Spread of beech bark disease in the eastern United States and its relationship to regional forest composition. *Can. J. For. Res.* 37: 726-736.
13. O'Brien, J.G., M.E. Ostry, and M.E. Mielke. 2001. First report of beech bark disease in Michigan. *Plant Disease* 69: 905.
14. Papaik, J.J., C.D. Canham, E.F. Latty and K.D. Woods. 2005. Effects of an introduced pathogen on resistance to natural disturbance: beech bark disease and windthrow. *Can. J. For. Res.* 35:1832-1843.
15. Shigesada, N. and K. Kawasaki. 1997. *Biological Invasions: Theory and Practice*. Oxford University Press. 205 pp.
16. Schwalm, N.J. 2009. The beech scale (*Cryptococcus fagisuga* Lind) in Michigan: distribution, models of spread and relation to forest and wildlife resources. M.S. Thesis. Dept. of Fisheries and Wildlife, Michigan State University. 147 p.
17. Tubbs, C.H. and D.R. Houston. 1990. *Fagus grandifolia* Ehrh., American beech. p. 325-332, In: *Silvics of North America*. Vol. 2 Hardwoods. USDA Forest Service Agric. Handbook 654.
18. Wagner, S., C. Collet, P. Madsen, T. Nakashizuka, R.D. Nyland, K. Sagheb-Talebi. 2010. Beech regeneration research: from ecological to silvicultural aspects. *For. Ecol. Manag.* 259:2172-2182.
19. Wainhouse, D. 1980. Dispersal of first instar larvae of the felted beech scale, *Cryptococcus fagisuga*. *J. Appl. Ecol.* 17(3): 523–532.

20. Wieferich, D., D.G. McCullough and D. Hayes. 201Xa. Evaluation of techniques to estimate density of beech scale (*Cryptococcus fagisuga* Lind). *In prep.*
21. Wieferich, D., D. Hayes, D.G. McCullough and N. Schwalm. 201Xb. Distribution of Beech scale (*Cryptococcus fagisuga* Lind.) in Michigan from 2004 to 2009. *Northern Journal of Applied Forestry. Accepted.*