Hickory Decline and Mortality

UPDATE ON HICKORY DECLINE RESEARCH

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Dead and dying bitternut hickory in Carley State Park, Minnesota, August 2006.

Research continued through the 2010 field season on the etiology of hickory decline that is characterized by thinning crowns with small, yellow leaves and hickory bark beetle attack on the upper main stem. This research is part of a larger project initiated in 2006 to assess the distribution and determine the cause(s) of Forest Health Monitoring reported decline and death of hickories in the north central and northeastern regions of the USA. A cumulative list of previous reports and presentations can be obtained from the first author (jjuzwik@fs.fed.us); a list of the most recent ones is provided at the end of this report.

Six monitoring plots were established in 2009 to document the rapidity of crown decline or dieback in each of five to eight bitternut hickories per plot. Monitored trees in the four Shawano Co., WI, plots changed from "healthy" crown condition (26 of 28 trees) to severely affected (80 to 99%) between late June 2009 and early September 2010 (see Table 1). Changes in crown conditions of 14 trees in two Menominee Co., WI, plots were less for the same time period.

Pathogenicity trials were conducted in Minnesota and Wisconsin with *Fusarium solani* and *Ceratocystis smalleyi* obtained from actively declining bitternut hickory in those states. The overall goal is to determine the role of selected fungi in the decline and death of hickory. *C.smalleyi* was shown to be a virulent pathogen based on large, elongate cankers found within 14 months of artificial inoculation on poletimber sized bitternut hickory. *F. solani* proved to be a weak pathogen with small cankers produced within 12 months of inoculation.

The interaction between hickory bark beetles (*Scolytus quadrispinosus*) and *C. smalleyi* was investigated. Three actively declining bitternut hickories from two Wisconsin locations were felled and bark stripped from the entire main stem of each. Hundreds of inner bark and sapwood lesions were found on the stems. Over 90% of these were associated with hickory bark beetle attack. The bark beetles emerged from infested trees between late June and late July. *C. smalleyi* was commonly isolated from beetles collected during their construction of entry holes. In contrast, the fungus was seldom (3 of 41) isolated from adults manually

collected from bark beetle galleries on declining trees just prior to beetle emergence. Furthermore, the fungus was not isolated from 40 beetles emerged from logs in rearing tubes. Thus, hickory bark beetles are likely involved in initiation of cankers on beetle colonized stems. It is not clear, however, whether bark beetles only provide the entry hole (i.e. infection court) for the fungus or whether they are vectors as well.

Field studies also were conducted to more precisely determine the role *C. smalleyi* plays in causing hickory decline. The fungus colonizes the sapwood as well as the bark in naturally and artificially inoculated trees. The effect of multiple inoculations (50 per tree between 6 and 12 ft. on main stem) on within tree water transport was evaluated by monitoring sap flow rate and documenting tylose production in the sapwood of trees that had been inoculated 14 months before in two locations. Only one of eight inoculated trees showed any symptoms of decline in the crown when sap flow was monitored; however, extensive, elongate cankers were evident. Bitternut hickory with numerous cankers showed significantly reduced mean sap flow rates compared to non-infected trees ($P = 0.005$) in the 2009 evaluation conducted in southeastern Minnesota (Figure 1). Sap flow rates were inversely related to the extent of inner bark tissue death associated with *C. smalleyi* inoculations ($P < 0.01$) (Figure 2). Lastly, sap flow rates were inversely related to the numbers of tyloses found in xylem vessels of the study trees (Figure 3). A prior anatomical study found that tyloses are produced in response to *C. smalleyi* infection. These preliminary results suggest that multiple stem infections of *C. smalleyi* impair water transport in bitternut hickory. These preliminary findings also support the overall hypothesis that the synergistic interaction of hickory bark beetles and *C. smalleyi* lead to tree decline and mortality.

Conclusions to Date and Future Work

Hickory decline is a complex of diseases rather than a disease complex. The most widespread of the diseases is the one causing rapid crown decline and tree death. Stress events or stand conditions (e.g. drought, flooding, over-topping) predispose trees to hundreds to thousands of hickory bark beetle attacks. Hundreds of main stem cankers result after the pathogen, *C. smalleyi*, is either introduced with the beetle or infects through beetle entry holes. Coalescing cankers and additional attacks by bark beetles coupled with invasion by secondary invaders (e.g flat-headed wood borers) lead to crown decline. Control of hickory bark beetles is the key to managing this disease. Guidelines include management of stand density to reduce stress on trees, management of bitternut hickory abundance in mixed stands to reduce susceptibility to beetle attacks, and appropriately timed removal (sanitation) of beetle attacked trees. Data analyses and final report preparation are currently underway. Publication of these findings will mark the completion of this Forest Health Monitoring (U.S. Forest Service) funded project.

Table 1. Crown conditions of bitternut hickory over time in stands with active hickory decline associated with hickory bark beetles and Ceratocystis cankers.

Location	Plot	June 2009		Early Sept. 2010		Ave. rating
	no.	No. trees	Ave. rating	No. trees	Ave. rating	change
Shawano Co.	1	6	1.0	6	5.0	+ 4.0
WI	2	8	1.6	8	5.4	+ 3.8
	3	7	1.0	7	5.1	+ 4.1
	4	7	1.0	7	4.9	+ 3.9
Menominee Co.	1	6	1.0	5	2.4	+ 1.4
WI	2	8	1.0	8	3.8	+ 2.8

Crown rating system: 1 = dieback or decline < 20%; 2 = 20 to 39%; 3 = 40 to 59%; 4 = 60 to 79%; 5 = 80 to 99%; and 6 = dead crown.

Figure 1. Diurnal patterns of mean sap flow rate (m/hr) over time in *Ceratocystis smalleyi* inoculated and non-inoculated (control) bitternut hickory trees.

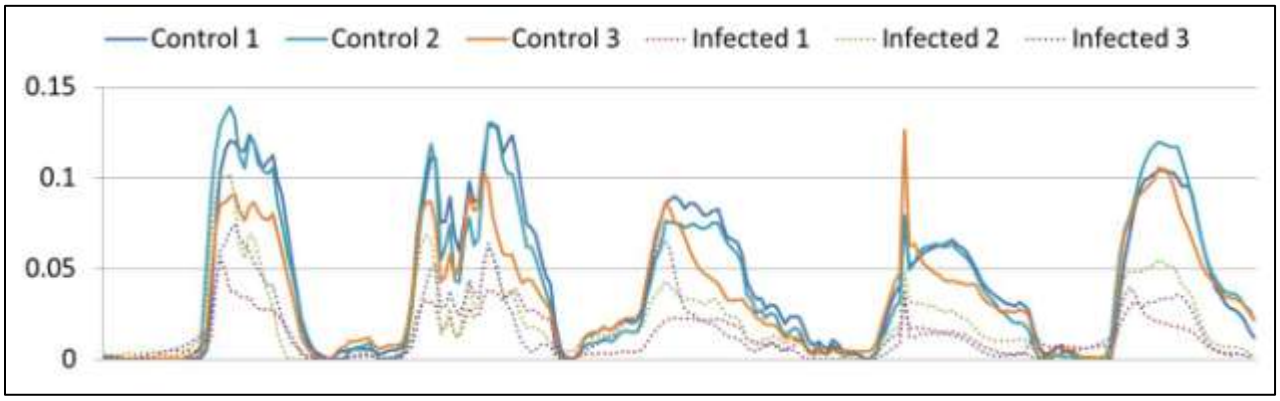


Figure 2. Mean sap flow rate (m/hr) versus proportion of tree stem surface area (between 6 and 12 feet) with necrotic inner bark tissue for both control and *Ceratocystis smalleyi* inoculated bitternut hickories.

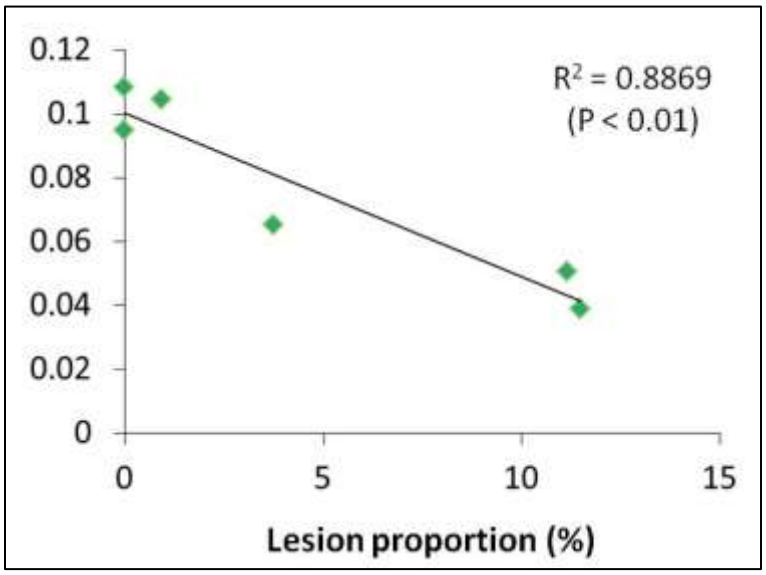
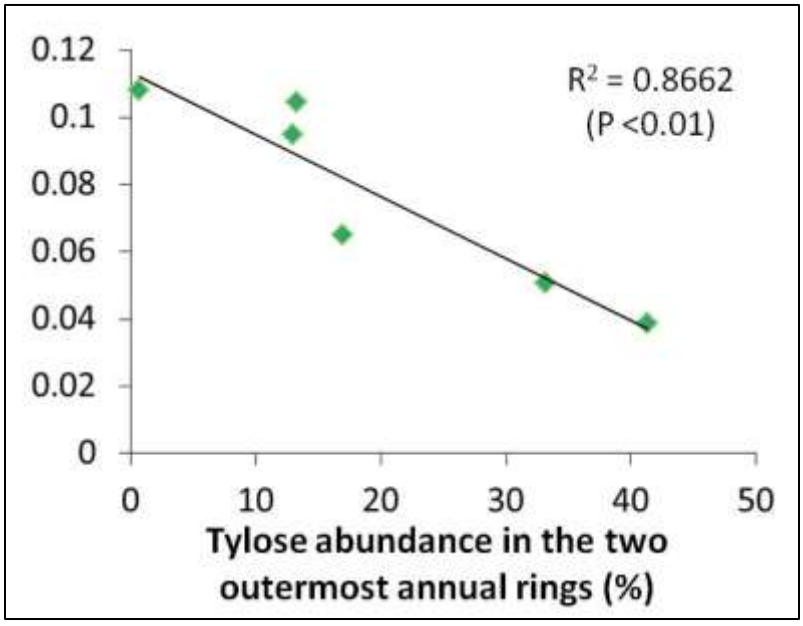


Figure 3. Mean sap flow rate (m/hr) versus numbers of tyloses present in outer sapwood vessels for both *Ceratocystis smalleyi* inoculated and non-inoculated (control) bitternut hickories.



Bark and sapwood lesions were commonly associated with hickory bark beetle attacks.

Hickory bark beetles attacking bitternut hickory in late August and early September 2009 were collected and assayed for presence of *Ceratocystis smalleyi*.

Dutch Elm Disease

Dutch Elm Disease was introduced to North America in the 1930's and began killing millions of native elm trees. Dutch Elm Disease has been identified in all of Iowa's counties, and it's estimated that just over 95 percent of the urban elm trees have succumb to this disease.

Unfortunately, Dutch Elm Disease became famous after devastating our native elm populations. The fungus is native to Asia and was introduced to Europe shortly after World War I. From Europe, it traveled to North America in the 1930's in crates made from infected elm logs. The disease quickly infected elms across the United States since our native elms did not have natural resistance to the introduce pathogen.

It's during this time of year that we are reminded that the disease is still out there; as numerous elms are currently dying in the landscape. This year, Dutch Elm Disease has been very prevalent in the urban landscapes and in our woodlands.