

**TITLE:** Assessment and etiology of hickory (*Carya* spp.) decline in the mid-west and northeastern regions

**LOCATION:** IA, IN, MN, OH, NY, WI

**DURATION:** Year 3 of 3-year project    **FUNDING SOURCE:** Base EM

**PROJECT LEADER:** Jennifer Juzwik, USDA Forest Service, Northern Research Station, (651) 649-5114, [jjuzwik@fs.fed.us](mailto:jjuzwik@fs.fed.us); and Linda Haugen, USDA Forest Service, Northeastern Area State and Private Forestry – St. Paul Field Office, (651) 649-5029, [lhaugen@fs.fed.us](mailto:lhaugen@fs.fed.us)

**COOPERATORS:** Steve Katovich, USDA Forest Service, NA S&PF – St. Paul Field Office; Tom Harrington, Iowa State University; Tivon Feeley, Iowa Dept. of Natural Resources; Phil Marshall, Indiana Dept. of Natural Resources; Jane Cummings-Carlson, Wisconsin Department of Natural Resources; John Graham, New York Department of Environment and Conservation.

**FHP SPONSOR/CONTACT:** Manfred Mielke, NA S&PF – St. Paul Field Office

**PROJECT OBJECTIVES:** 1. Conduct field evaluations to: a) determine frequencies of decline and mortality of *Carya cordiformis*, *C. ovata* and other species in appropriate forest cover types where deviations from expected levels of mortality have been observed, b) quantify relationships between decline incidence and pathogen and/or insect pest presence, and c) quantify relationships between decline incidence and prior land use, fire history, soil fertility and/or drought. 2. Determine the role of two newly described *Ceratocystis* spp. (*C. smalleyi* and *C. caryae*) in decline and mortality of *Carya* spp. in trees from which these fungi can be isolated.

**JUSTIFICATION:** Our proposed project addresses the selection criteria as follows.

1. The project is directly linked to FHM detection monitoring, where recent widespread hickory decline is indicated by off-plot survey data in parts of the two regions which is an unexpected deviation from earlier published FHM grid plot reports for the species.
2. Geographic scale: Bitternut hickory is the most abundant and uniformly distributed *Carya* spp. in the two regions; however, shagbark hickory and other species are also common. Deviations from expected levels of decline have been reported in Iowa, Minnesota, New York, Ohio, and Wisconsin.
3. Biological impact and/or political importance: Hickories are an important component of many forest associations in the eastern United States, particularly various oak-hickory cover types. Hickories are important sources of hard mast for wildlife and have the potential to produce valuable timber. They are also important in the biological diversity of stands threatened by numerous other stressors and damage agents. Sites impacted by hickory decline and mortality have been reported to lose a high proportion of the hickory over a very short period of time (3 to 5 years), causing a significant adverse impact to wildlife, timber value and diversity on the sites.
4. Feasibility/probability of success: Early success has been achieved in preliminary work conducted with state cooperators on a very limited scale in WI and MN in 2006. This work has included determination of presence of *Ceratocystis* spp., several insect pests/damage agents, and other pathogens associated with affected trees. Thus, a high probability of success is likely.

**DESCRIPTION:**

**a. Background:**

Hickory decline, particularly of bitternut hickory and shagbark to a lesser extent, has recently been noted in Iowa (Johnson et al. 2005), in Missouri, Maryland, New York, Pennsylvania and West Virginia by FHM (USDA Forest Service 2003 and 2004), and Wisconsin (Wisconsin DNR, 2005). Widespread mortality of

hickory has historically been attributed to outbreaks of the hickory bark beetle (*Scolytus quadrispinosus*) during extended periods of drought (USDA Forest Service 1985). The insect is considered the most important pest of the species group (Solomon and Payne, 1986). In 1994, a newly discovered fungus was reported in discolored wood and sunken bark cankers associated with beetle attacks (USDA Forest Service, 1994). This fungus, *Ceratocystis smalleyi*, and a new sister species (*C. caryae*) were recently described (Johnson et al. 2005). Both species were pathogenic on 2-y-old *Carya* spp. in greenhouse studies. The researchers suggested that *C. smalleyi* might play a significant role in hickory mortality. Past land use and soil fertility were shown to indirectly determine outbreaks of the bark beetle (Dale, et al. 1990). Phomopsis galls, *Armillaria* root rot and a flatheaded woodborer (*A. otiosus*) have also been associated with declining trees (Wisc. DNR 2005). A re-examination of affected ecosystems is needed to determine and/or clarify the importance of hickory decline and mortality in relation to these damaging agents as well as climatic, edaphic and cultural factors.

**b. Methods:** Field Evaluation – Multiple decline-affected stands in at least six states will be identified by state cooperators for evaluation. Information on site history, stand and site conditions, and recent episodes of drought or other stresses will be recorded. Standard tree and stand information such as tree size class, area of stand, species present, will be recorded for each site. Transect survey methodology will be used to obtain estimates of decline and mortality frequencies. One to two trees in several decline foci will be closely examined for evidence of insect pest and/or damage presence, and for disease damage and/or pathogen presence. Samples will be collected and forwarded to the processing lab for insect pest identification or rearing plus identification and for pathogen isolation and identification. Relationships between i) insect pest and/or pathogen presence; ii) historical site and climate information; and iii) soils and stand condition information and decline and mortality frequencies will be investigated.

Role of *Ceratocystis* species – A) Field and laboratory studies will be conducted in selected stands with active hickory decline to determine the role of *Ceratocystis* spp. in tree decline and mortality. i) Isolations will be attempted from hickories with and without a) hickory bark beetle colonization, b) *Agrilus* spp. colonization, and c) open wounds, to determine the frequencies of *C. smalleyi* and *C. caryae* associated with each. B) Field inoculations of apparently healthy pole-sized trees of the predominant hickory species will be inoculated with isolates of both *Ceratocystis* species to confirm pathogenicity suggested by seedling tests (Johnson et al. 2005) and to investigate whether systemic spread of the organisms occur within infected trees. C) The contamination frequency of hickory bark beetles with *C. smalleyi* dispersing in the stand and/or emerging from colonized trees will be determined.

**c. Products:** This project will produce 1) maps of states showing locations of evaluated stands and key findings, 2) quantitative summaries and predictive understanding of the relationships between decline and mortality probabilities and the factors investigated, 3) qualitative and quantitative summaries relating to the role of two *Ceratocystis* species in the decline process. One manuscript summarizing the findings of the 2006 preliminary survey have been published (Proceedings of the 2008 Central Hardwoods Conference).

**d. Schedule of Activities:** Year 2 (activities remaining) – i) purify and identify fungal isolates obtained from cankered stems of logs sampled during 2008 survey, ii) finish identification of collected insects and record numbers of each species obtained, iii) summarize and analyze results of 2008 field surveys, and iv) conduct preliminary statistical analyses on relationship between hickory condition and stand site factors. Year 3 (planned) – i) conduct several additional field evaluations in Indiana (2), Iowa (2) and Ohio (1) if suitable sites are located, ii) set up replication of field experiment attempting to reproduce decline symptoms in tree crowns of healthy bitternut hickory, iii) set up replication of field experiment investigating relationship between presence of diffuse canker fungus and associated sapwood colonization with disrupted xylem functioning, and iv) determine frequency of *C. smalleyi* and diffuse canker presence with hickory bark beetle attacks for two additional trees, and v) determine the frequencies of hickory bark beetles emerging from declining hickory and carrying viable *Ceratocystis* spp. propagules.

**e. Progress/Accomplishments for Year 2 (FY08):**

Field Evaluations and Processing of Collected Samples (Objective 1) Accomplishments -Site, tree, insect and pathogen data were collected for 11 sites with reported hickory decline and mortality in Indiana, New York, Ohio and Wisconsin between 27 May and 25 June 2008. Stem sections collected from three trees felled in each site were processed in the laboratory and greenhouse. Insects emerging from log sections in emergence tubes were collected weekly over a 50 day time period. Attempts to isolate causal fungi from observed stem galls or cankers were completed. Counts of collected insect species are underway. Purification and identification of fungal isolates are also underway. *Preliminary Findings* – 1) Bitternut hickory dying in 1 to 2 years is attributed to hickory bark beetle attack and colonization and, potentially, xylem functioning impairment caused by *Ceratocystis smalleyi*, 2) Hickory dieback, where a major fork or top main stem is killed, is often due to very numerous annual cankers often caused by *Fusarium solani*, 3) Hickory bark beetles accounted for 91% of emerged insects from 2008 survey samples and hickory timber beetles accounted for 8%, 4) Diffuse cankers, sometimes with bleeding, and discolored sapwood were commonly found, and 5) Perithecia of *Ceratocystis* sp. were obtained from diffuse cankers on trees in five stands in New York, two stand in Ohio, and one stand in Indiana. If the isolates obtained from the perithecia are confirmed as *C. smalleyi*, the results will greatly expand the known range of the pathogen.

Role of *Ceratocystis* spp. in Hickory Decline (Objective 2) Accomplishments – The second and final evaluation of the preliminary study on the relative ability of putative hickory stem canker fungi to contribute to decline of bitternut hickory was completed. Collected datasets were summarized and analyzed as appropriate. *Ceratocystis smalleyi* was identified as the species most likely to contribute to hickory decline. A scientific poster presentation of these results was delivered at the 2008 annual meeting of the American Phytopathological Society. Three additional field experiments were initiated in summer 2008. The studies are designed to further evaluate the role of this fungus in disrupting normal tree functioning and its ability to cause crown decline. *Preliminary Finding* – In a field trial involving inoculation of pole-size bitternut hickory, cankers and sapwood discoloration associated with two *C. smalleyi* isolates were at least two times larger than bark necrosis associated with isolates of *C. caryae* and *F. solani* as well as the sterile agar control. Thus, *C. smalleyi* is the species most likely to contribute to bitternut hickory decline and death.

**COSTS: YEAR 3**

	<b>Item</b>	<b>Requested FHM EM Funding</b>	<b>Other-Source Funding</b>	<b>Source</b>
<b>YEAR 3</b>				
<b>Administration</b>	Salary	\$26,528	\$46,250	NRS RWU
	Overhead (8 %)	2,742		
	Travel	2,000	1,500	NRS RWU
<b>Procurements</b>	Contracting	1,000		
	Equipment			
	Supplies	2,000	2,200	NRS RWU
<b>Total</b>		\$34,270	\$49,950	