CHAPTER 7

North Central Forest Diseases

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This chapter describes eight projects covering a wide range of disease issues in the region. Three of the projects involved investigations pertaining to decline syndromes or physiological problems in hardwoods (white oak, white ash and black ash), two were related to nonnative or organisms of unknown origin (*Diplodia pinea* and the organisms involved in the beech bark disease complex), and the others involved interactions of disease and prescribed fire, dwarf mistletoe in black spruce stands, and the native pinewood nematode.

Project NC-EM-02-02: Rapid Detection of Two Exotics in Michigan: Beech Bark Disease and Hemlock Woolly Adelgid

This project was proposed to determine the distribution of hemlock woolly adelgid and beech bark disease in the State of Michigan, and to lay the groundwork for risk modeling efforts that will be addressed in a future project.

This 3-year project ended in 2004. Results for the first 2 years were presented in a poster at the 2004 Working Group meeting held by the national Forest Health Monitoring (FHM) Program of the Forest Service, U.S. Department of Agriculture. Final results of the project were presented at the same forum in 2005. Hemlock woolly adelgid was introduced on landscape nursery stock into two nurseries in Michigan in 2001. Detection and eradication efforts were undertaken by the Michigan Department of Agriculture, and it was assumed that the insect was eradicated in the vicinity of the infested nurseries. During the current project, in 2002-03, the Michigan Department of Natural Resources (DNR) surveyed 34 forested stands or recreation areas in the Upper Peninsula and 25 in the Lower Peninsula, and detected no hemlock woolly adelgid infestations in the State.

Beech bark disease was recognized in Michigan in 2000, and scale infestations were found in both the Upper and Lower Peninsulas. During the current project in 2002-03, no beech scale adelgids were detected outside the core area of previously documented beech scale infestations in either the Upper or Lower Peninsula.

Utilization of project results—Data from this project will be used to help generate risk criteria for inclusion in GIS-based risk models for hemlock woolly adelgid and beech bark disease. In addition, the methods developed for the surveys will be used in future surveys for exotic forest pests. The methods developed include a stratified, repeatable, fixed-plot system that uses host distribution and density information—based on data from the Forest Inventory and Analysis (FIA) Program of the Forest Service—to stratify sample plots. The survey methodology incorporates FHM crown indicators to assess tree vigor, and is organized and conducted relatively quickly with minimal training.

Suggestions for further investigation—None identified.

Project NC-F-03-03; NC-F-04-01: Interactions of Prescribed Fire and Insect and Disease Pests in Red Pine

The objectives of this project were to (1) determine the effects of fire and mechanical treatments, alone and in combination, on incidence and impact of forest insect pests and pathogens in mature red pine stands in the Lake States, and (2) document the effects of these treatments on forest vegetation and litter parameters, and relate these effects to the biology of forest pests. The site-intensive project was conducted in a single 17 ha stand in Luce County, in Michigan's Upper Peninsula.

Preliminary results of this project were presented in poster format at the 2006 FHM working group meeting. At the time of reporting, mechanical treatments had been completed, but the prescribed fire component had not been initiated (scheduled for 2006). Results comprised an evaluation of the species composition of the site, and spore trap data for the *Diplodia pinea* (syn. *Sphaeropsis sapinea*) and *Sirococcus conigenus* shoot blight pathogens. In the study area, 54.2 percent of trees were red pine, 16 percent were white pine,

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11.3 percent were jack pine, and 8.9 percent were red oak. Both *Diplodia pinea* and *Sirococcus conigenus* spores were trapped on the site in the summer months, but larger numbers of *S. conigenus* spores were found.

Utilization of project results—Final results of this project are not yet available. The efficacy of prescribed fire or mechanical treatments to control these diseases has not yet been determined, and recommendations for implementation have not been offered.

Suggestions for further investigation—Final results for this project are not yet available, and the development of final conclusions will likely require data collection and monitoring over several years to determine the ultimate effects of mechanical and prescribed fire on insect and disease incidence in this stand. If this project is successful, it may lead to additional experiments with these site-altering treatments and their effects on insects and pathogens in northern forests.

Project NC-EM-03-04: Evaluating Distribution and Structure of Epidemic Populations of *Sphaeropsis sapinea*

It has been proposed that the name of this pathogen should be changed back to *Diplodia pinea*, because it had been incorrectly changed to *Sphaeropsis sapinea*. Because most researchers working with this organism appear to support the change, it will subsequently be referred to as *Diplodia pinea*. The study had three goals: (1) to characterize *D. pinea* populations in epidemic situations, (2) to characterize *D. pinea* populations in non-epidemic situations, especially those beyond the range of historical reports of significant damage, and (3) to determine the potential for virulent populations to persist with asymptomatic hosts in Federal, State, and private conifer nurseries.

Results of this project were documented in a journal article in 2005 (Stanosz and others 2005) and in a poster presented at the 2006 FHM working group meeting. Results presented to date involve the third objective, determining "latency" in non-symptomatic hosts in tree nurseries. Incidence of symptomatic seedlings varied widely within and between the seven nurseries included in the study. Symptomatic seedlings were more frequent in beds near windbreaks including diseased trees. Symptomatic seedlings were infrequent in the three nurseries where red pines were not present (or were rare) or appeared healthy in windbreaks.

Frequency of identification of *D. pinea* from asymptomatic seedlings varied widely within and between nurseries. The pathogen was found more frequently from asymptomatic seedlings in nurseries with windbreaks that included diseased pines, and more frequently near the infected windbreaks than from seedlings more distant from the windbreaks. Overall, in five of the seven nurseries in the study, the pathogen was recovered from asymptomatic seedlings at frequencies ranging from 0 to 88 percent. The pathogen was not recovered from asymptomatic seedlings from two Michigan nurseries, where red pines were not present or were rare in windbreaks.

Utilization of project results—Forest tree nurseries throughout the north central region have taken steps to eliminate red pine windbreaks from nurseries, to reduce the level of inoculum present.

Suggestions for further investigation—The authors do not propose any next steps or further research in their poster or paper, but the first two objectives of this study deserve examination. Latency in *Diplodia* species and the recent discovery that there is an additional *Diplodia* sp. present in the Lake States (*D. scrobiculata*) make it difficult to assess the risks posed by members of this genus. Because most red pine in the Lake States is in plantations, the disease has been spread from infected nurseries on asymptomatic, infected seedlings. The extent of distribution of *D. pinea* and *D. scrobiculata* has not been fully investigated, and there is increasing discussion that *D. pinea* may be a pathogen introduced into the United States in the last century.

Project NC-EM-04-02: Developing a Damage Threshold for Dwarf Mistletoe Infested Black Spruce Stands

Partial results of this project were presented at the 2005 FHM working group meeting, the 2005 Western International Forest Disease Work Conference, 2009 North Central Forest Pest Workshop, the 2009 Joint Statistical Meetings, and the 2009 International Association of Landscape Ecology. Results were recently published in the journal *Ecological Applications* (Hanks and others 2010), and another paper is in press in the *Northern Journal of Applied Forestry* (Baker and others, in press).

The authors proposed to use FIA and FHM plot information as a starting point, and to implement GPS-based surveys, using consumer-grade GPS units, in stands infested with black spruce dwarf mistletoe (*Arceuthobium pusillum*). The data were then to be used with a spatial model to project future disease losses. Projection results would be provided to forest managers and policymakers to help make informed decisions about management in infested stands.

Stated objectives of the project were (1) to develop field procedures for using GPS in surveys, (2) to evaluate the reliability of FIA dwarf mistletoe incidence, and (3) to identify infestation levels on FIA plots that indicate extensive stand damage.

The investigators surveyed parts of 202 stands, establishing plots that determined that 112, or 55 percent, had dwarf mistletoe. The plots were located near FIA plots, which could not be directly located because of privacy concerns. Of the 144 stands within 0.5 miles [0.8 km] of a plot which FIA considered infested, 67 percent were actually infested. Conversely, of the 58 stands examined within 0.5 miles of an uninfested FIA plot, only 26 percent were infested. Of all the stands surveyed, the mistletoe status of 79 percent of stands agreed with that of the nearby FIA plot. Thus, the FIA plot probably does a good job of indicating the presence of dwarf mistletoe, but tends to underestimate the presence of dwarf mistletoe in surrounding stands. This might in part explain the reportedly low incidence of dwarf mistletoe based on FIA plots.

The Minnesota DNR inventory also records the presence of pests such as dwarf mistletoe. Analysis of those data showed that Minnesota DNR inventory crews recorded dwarf mistletoe in just 23 percent of 112 infested stands. This low level of detection is not likely due to miscoding the pests, as most of the incorrectly assessed stands were coded as "0" or no pest.

The investigators initially planned to project losses in infested stands, and then relate the magnitude of the losses to FIA plot infestation level. Given the difficulty of even categorizing dwarf mistletoe presence, they abandoned this approach. However, the data collected during the surveys permitted an analysis of the spatial autocorrelation of dwarf mistletoe occurrence on the landscape. The spatial autocorrelation model was used in a Bayesian Hierarchichal model to improve the accuracy of dwarf mistletoe incidence based on the Minnesota DNR dataset, resulting in the prediction that 35 to 59 percent of black spruce stands in northern Minnesota are infested with dwarf mistletoe.

The investigators have developed a multi-stand, spatially explicit simulation model, written in Python, which projects dwarf mistletoe impact in infested stands. The model was designed to allow users to change spread rates and volume equations. This design was employed to allow using the model for any aggregated forest loss situation, such as that caused by root disease. The model will be shared with State, Federal, and international cooperators.

Another unique aspect of this model is that it will run backwards to help examine the importance of bird vectors in initiating dwarf mistletoe infestations. They plan to take existing infestations and shrink them over time ("un-spread the parasite"). Some centers will remain at the time of stand initiation, others will disappear. Disease centers that disappear at some critical time, say 30 years, after stand initiation, clearly did not originate with the stand, and were probably started by birds.

The conclusions derived from this project include:

- Consumer grade GPS units can be used to record information for dwarf mistletoe surveys.
- Transect lines 200 m apart were adequate for detecting dwarf mistletoe in black spruce stands.
- FIA plots underestimate the incidence of dwarf mistletoe. The Minnesota DNR inventory, which has the primary goal of recording timber volumes, is even less effective at identifying dwarf mistletoe.
- FIA crews are not likely to code dwarf mistletoe (or witches' brooms) each time they visit the plot, so information from all observations will give the best indication of the presence of dwarf mistletoe.
- Eleven percent of FIA plots are infested, but the proportion of infested plots observed in any year was usually less, ranging from 0 to 16 percent.
- In Koochiching County, MN, the relative proportion of black spruce represented in FIA plots is much less than in other surrounding counties.

Utilization of project results—The model derived from this project was still in preparation as of 2009. Eventually, the model will be made available to land managers to help predict dwarf mistletoe incidence and impacts in black spruce stands.

Suggestions for further investigation—The Bayesian Heirarchichal model provides a unique tool to merge broad scale relatively inaccurate datasets with highly focused but accurate surveys and make inferences not possible from either dataset. These inferences (e.g., that between 35 and 59 percent of black spruce stands are infested) need to be evaluated. In addition, a larger sample of FIA plots needs to be examined, to demonstrate the utility of this technique for FIA. Finally, these observations were made only in stands older than 60 years where dwarf mistletoe is very obvious. Surveys of younger stands are needed to determine if the disease incidence is as great as it is in mature stands.

Project NC-EM-04-05: White Oak Decline

Partial results of this study were presented at the Iowa chapter of Society of American Foresters meeting in 2006. Forest health professionals have been observing tatters on leaves of declining oak trees in eastern Iowa and other Midwestern States since the 1990s. Beginning in 2004, initial work on this issue in Iowa examined relations to temperature (late frost) and the possibility of oak wilt fungus with no conclusive

results. In 2006, work was planned in cooperation with the University of Iowa Hygienic Laboratory looking at the presence of low levels of ambient herbicide in air, rainwater and tree tissue samples as a possible explanation of the tatters phenomena. Oak wilt sampling was performed by the Forest Service in the fall of 2006 at White Pine Hollow with the results coming back from the Iowa State University (ISU) Plant Disease Clinic as negative for oak wilt. White oak seedlings were tested at ISU greenhouse for their reaction to volatile levels of acetochlor, atrazine, 2-4D and chlorine.

In cooperation with ISU field testing oak and hackberry seedlings with farm chemicals were ongoing in a volatilization experiment (Spring 2008). The findings of that initial study showed the acetochlor caused tatters on white oak at a rate 1/10 and 1/100th of the labeled application rate. This initial study, in conjunction with field findings, suggests that acetochlor is causing tattering on oak leaves.

Utilization of project results—No information is currently available regarding utilization of results derived from this project.

Suggestions for further investigation—Further investigation regarding levels of acetochlor sufficient to cause tatters on oak and hackberry are warranted. Timing of the physiological effects of acetochlor on leaf development also should be examined.

Project NC-EM-06-01: Assessment of Decline and Contributing Diseases in White Ash Stands in Michigan

Ash decline was a notable issue in white ash stands before the arrival of the emerald ash borer. The intent of this project was to assess the roles of various factors potentially involved in the ash decline syndrome in stands not yet affected by emerald ash borer. The project was designed to assess the role of various factors in the expression of decline symptoms in white ash. The primary biotic factors involved were ash yellows and several root and butt rot organisms that were identified during a preliminary study. Other risk factors in the analysis included abiotic influences, including stand dynamics, climatic, physiographic and edaphic site factors, and stand management history. Particular attention was given to ash yellows, including quantification of the relationships between ash decline, ash yellows, and various field symptoms, including deliquescent branching, witches' brooms, basal bark cracks, and epicormic sprouts.

Preliminary results from this project were presented in poster format at the 2008 FHM working group meeting. The study found that distribution of the ash yellows phytoplasma (AshY) is statewide in Michigan. The frequency of AshY in woodlands with white ash varied from 0 to 40 percent. Crown decline was not correlated with the presence of AshY in forests. Mean radial growth (mean diameter at breast height) was identical for white ash trees whether they were positive or negative for AshY, in a 65-year-old stand. Preliminary observations suggest that white ash decline in Michigan forests may be due, in part, to several root and butt rots.

Final results from this project are not yet available. Plans for field work in 2008 included collecting tree-ring data from 80 white ash that were to be evaluated to determine whether ash decline appeared following successive years of drought. Tree-ring data were to be used to try to determine whether AshY affects white ash recovery from drought. White ash with basal cracks (a common phenomenon) were to be assayed to determine whether the cracks are correlated with the presence of AshY. Real-time polymerase chain reaction and transmission electron microscopy assays were to be compared to DAPI fluorescence microscopy to determine the efficiency of these techniques in identifying AshY infected trees.

Utilization of project results—None identified. When completed, the project may inform silvicultural prescriptions for dealing with AshY-infected ash in forest stands.

Suggestions for further investigation—None noted. This project was incomplete at the time this document was prepared.

Project NC-EM-07-02: Relating Black Ash (*Fraxinus nigra*) Decline and Regeneration to Tree Age and Site Hydrology

Black ash decline is a widespread phenomenon throughout the upper Midwest and Northeast. Several factors have been implicated in the onset of black ash decline, including drought, disease, soil, and hydrologic factors. The goals of this 2-year project were to develop an assessment of decline and mortality severity within black ash ecosystems in Minnesota that appear to be heavily impacted based on FIA data, and to prepare a quantitative assessment of the relationships between site hydrology and soil moisture, tree age, and decline.

Preliminary results of this project were reported in a poster at the 2008 FHM working group meeting. The study found that, across the 21 sites examined in Minnesota, black ash stands showed marked differences in frequency of declining trees (from less than 20 percent to more than 60 percent). The investigators were able to group the stands into heavily impacted ("susceptible") stands with substantial decline, and generally "healthy" stands. Decline of overstory trees in

susceptible stands may be related to tree age, since healthy trees in these stands averaged 20 years younger than declining trees in the same stands. Tree age was unrelated to decline in healthy stands. Both declining and healthy stands contained seemingly healthy regeneration cohorts, but densities were higher in healthy stands. The authors observed no obvious causal insect or disease organisms on declining trees. Decline appears to be positively correlated with wetter conditions and deeper depth to a mineral layer, indicating that the site is more prone to anoxic, saturated conditions.

Final results are not yet available for this project, which was completed in 2008. The investigators sampled an additional 31 stands in Lake, St. Louis, Carlton, Aitkin, and Itasca counties in Minnesota, but results have not yet been made available. The investigators are also examining successional trends in declining stands.

Utilization of project results—None noted. Recommendations for improving ash silviculture may be forthcoming when the project analysis is completed.

Suggestions for further investigation—None noted. This project was incomplete at the time this document was prepared.

Project INT-EM-04-06: Pine Wilt in the Central Great Plains: Differences in Pinewood Nematode Populations and Identification of Insect Vectors

Pine wilt caused by the nematode *Bursaphelenchus xylophilus* is a severe problem throughout the Midwest primarily on Scot Pine (*Pinus sylvestris*) though it can be found in other pine species. The pine wilt disease was identified for the first time in the United States in Columbia, MO, in 1979 (Powers 2004). Since that first report, *Bursaphelenchus xylophilus* has been found in 36 states, including all the Great Plains states except for North Dakota. The widespread distribution of the pinewood nematode suggests that it is native to the United States. In North America, investigators have confirmed the disease on 27 species of *Pinus* (pine), one each of *Abies* (balsam) and *Pseudotsuya* (fir), and two each of *Cedrus* (cedar), *Larix* (larch), and *Picea* (spruce). The disease is unique in its complexity, since it involves a plant-parasitic nematode, one or more insect vectors (primarily pine sawyers), wood-staining fungi, and possible other organisms (Gleason and others 2000). Incidence of the disease appears to be greater during periods of drought impacting aesthetics, high-value windbreaks, and Christmas tree plantations. An EM project funded in 2004 was set up to compare nematode populations found in Scot and Ponderosa pine. In addition, the project was designed to look at the pine sawyer beetle (*Monochamus* spp.) and other potential insect vectors involved in the spread of pine wilt.

Virulence of populations of *Bursaphelenchus* spp. associated with conifers varies throughout the range of this nematode in the United States. Pathogenicity of Pine Wilt Nematode (PWN) in the United States depends on the interaction of the pine species with different PWN populations, the physiological status of the infected pine, and environmental conditions. Mating and reproductive potential, virulence, DNA sequence differences determined by restriction fragment length polymorphisms, and isozyme differences are useful criteria for studying population biology and genetics of PWN. When used together, these factors can elucidate speciation of *Bursaphelenchus* associated with conifers (Kiyohara and Bolla 1990).

Utilization of project results—Results of this EM project were utilized and incorporated into the Plant and Insect Parasitic Nematode website: http://nematode.unl.edu.

Suggestions for further investigation—

- Host specificity within *Bursaphelenchus xylophilus* in the Midwest needs further investigation.
- More information is needed about how other insect carriers of PWN influence spread of the disease.

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