CHAPTER 3

Northeast Forest Insects

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The hemlock woolly adelgid (*Adelges tsugae*) (HWA) is a serious nonnative pest of eastern (*Tsuga canadensis*) and Carolina hemlocks (*T. caroliniana*). The insect is currently found in 17 eastern States from southern Maine to northeastern Georgia and west to eastern Kentucky and Tennessee. On average, HWA spreads about 12.5 km per year, HWA dispersing naturally by wind and birds, and artificially on hemlock nursery stock. Infested nursery stock has resulted in isolated infestations in Michigan, Ohio, Vermont, New Hampshire, and Maine. Such isolated infestations are eradicated when possible. HWA feeds on stored nutrients in the ray parenchyma cells of the xylem by inserting its stylet bundle through the leaf cushion where needles attach to the twig. Abundant adelgids soon deplete nutrients vital to shoot growth the next growing season. Damage occurs over 4 to 10 years, and includes stunted shoot growth or no growth at all, graying needles, branch dieback, and eventually tree mortality. All ages of hemlock are susceptible from seedlings to mature trees. Other biotic and abiotic stress agents like the elongate hemlock scale (*Fiorinia externa*) and drought hasten tree decline. Extensive tree mortality has been reported throughout the infested region of the Eastern United States.

The balsam woolly adelgid (*Adelges piceae)* (BWA) is a serious nonnative pest of true firs, (*Abies* spp.) including balsam (*A. balsamea*) in the Northeast, Fraser (*A. fraseri*) in the Southeast, and noble and shasta firs (*A. procera and A. shastensis*, respectively) in the Pacific Northwest. Native to central Europe, this insect was first discovered in North America in the early 1900s near Brunswick, ME, and in the Southern Appalachian Mountains in the 1950s. BWA has caused extensive damage to native fir stands throughout the eastern landscape in addition to serious economic losses to both Christmas tree and seed cone industries. This pest attacks all ages of fir trees but damage is often minimal until trees are about 30 years old. In the Northeast, BWA populations can build rapidly following consecutive years of mild winter temperatures. Susceptible fir trees often succumb to BWA infestations within 2 to 8 years depending on other insect or disease stressors or droughty conditions during the period of attack. Extensive decline and tree mortality have been reported throughout the coastal region in Maine in recent years and a series of off-frame plots—styled after plots by the Forest Inventory and Analysis (FIA) Program of the Forest Service, U.S. Department of Agriculture—was established to assess the relationship of recent weather patterns, climatic regions, and site conditions to BWA populations and impact trends.

Project NE-EM-03-01: Mapping Susceptibility and Spread Associated with Hemlock Woolly Adelgid

This project used GIS technology and available datasets to model the predicted spread of HWA over 25 years. Forest susceptibility was first assessed through interpolation of host species abundance estimated from more than 93,000 FIA plots throughout the Eastern United States. Host abundance was measured as basal area/ha of eastern hemlock. A geostatistical method called kriging was used to interpolate an unbiased estimate of hemlock basal area between plots to produce a surface basal area of eastern hemlock. Maps were then generated using the plot data and kriging estimates based on a grid of 1 km² cells.

This forest susceptibility map was then adjusted for forest density using National Land Cover Data acquired from the Multi-Resolution Land Characteristics Consortium as a raster matrix of 30 x 30 m cells coded for land use. These data were aggregated to 1 km² to estimate the forest cover for each cell. The forest susceptibility map layer could then be multiplied by the forest density map to generate the forest susceptibility map adjusted for percent forest cover.

The third dataset used in this analysis was the predicted spread of HWA, which was derived from county-level historical records that documented the year a county was first known to become infested. A GIS was used to calculate the minimum distance in the x and y direction from each county to the area first infested. A predicted spread map

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representing years of expected presence (between 2001 and 2025) was then generated using the estimated spread rate. The number of years of expected presence was then divided by the years of possible infestation (25 years) to produce a proportion of expected years of presence between 2001 and 2025. Areas with higher proportion of years infested are likely to see greater overall impact. The proportion map was then multiplied by the adjusted forest susceptibility map to create a map of HWA risk through 2025.

Utilization of project results—The conclusion of this analysis indicates that (1) HWA has only recently begun to move into areas with a large hemlock component; (2) the estimated risk of HWA was highest in a large proportion of New York and northern Pennsylvania; and (3) Vermont, New Hampshire, and New York are the highest risk areas that are currently uninfested.

The results of this analysis give land managers a planning tool to determine when HWA is first likely to appear in a specific geographical area where HWA is likely to have the greatest impact over a 25-year period, based on a measure of hemlock abundance.

Suggestions for further investigation—The risk model should be validated and updated periodically as HWA continues to spread to new areas. This approach may be used to examine the progression of hemlock decline and mortality following the introduction and build-up of HWA to improve the predictive value of risk map projections of significant mortality events associated with HWA. The model also could be improved if climatic information is used to weight regions with cold temperatures in addition to considering the number years infested.

Project NE-EM-03-02: The Impact of Balsam Woolly Adelgid (Adelges piceae) on Balsam Fir (Abies balsamea) Stands in New England

The objectives of this project were to (1) determine the magnitude of loss of the balsam fir resource in Maine; (2) analyze the associated BWA populations and damage patterns; and (3) develop a predictive risk model to map infestation susceptibility and vulnerability based on stand and site characteristics that could be applied regionally.

Maine Forest Service (MFS) crews developed a field assessment protocol to quantify BWA impacts on candidate stands. Vetted data fields and categories were adapted to FIA plot data protocols at a tree-level basis in the southeastern quadrant of the State to allow analysis for site and tree health conditions. Analysis by biophysical region of the data collected on the FIA plots revealed a distinct trend of decreasing damage levels moving inland from the coast. This gradient represents a gradient in climate as well, and increased levels of damage further inland can be expected with warming temperatures.

An analysis of tree ring chronology revealed that impacts caused by BWA began in the late 1980s and continued to about 2003 in the study area. An analysis of climate data indicates infrequent lethal temperatures for BWA have occurred since the 1940s and the drought of 2001 coincided with a spike of fir mortality. This correlation of BWA impact with warmer winters suggests that the footprint of BWA economic damage and the severity of damage in currently affected areas will increase with climate warming.

Utilization of project results—The MFS-developed field assessment protocol for quantifying BWA impacts continues to be the local standard for assessing current and future conditions on candidate stands. Consulting and industry foresters are using the hazard rating system to prioritize stands for treatment. MFS-Forest Policy and Management Division field staff use the protocol to approve harvest variance requests. Vetted data fields and categories adapted to FIA field plot protocols are being used to collect tree-level baseline and remeasurement data from 6.4 million acres of eastern and central Maine.

Suggestions for further investigation—Potential BWA range expansion and population/impact intensification should continue to be monitored using FIA plots. The developed risk model should now be validated for its utility elsewhere in the Northeast. Developing silvicultural prescriptions to mitigate impacts from BWA would be a useful tool for the forest management sector.