# Impacts of Hemlock Woolly Adelgid—The Effects on Tree Health and Mortality Probability

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The hemlock woolly adelgid (*Adelges tsugae* Annand) (HWA) was first found on the eastern hemlock (*Tsuga canadensis* (L.) Carriere) in the early 1950s and has been recognized as a significant pest of eastern hemlock since the mid-1980s. In September 1994, the study *Monitoring the impacts of hemlock woolly adelgid on hemlock*, was initiated by the Northeastern Area, Forest Health Protection in Morgantown. The purpose of the study was to evaluate HWA impacts on trees and stands; identify site and stand characteristics that make hemlock more susceptible to attack or vulnerable to mortality; identify other pests that may be compounding observed impacts; determine rates of tree mortality; and determine if hemlock are able to survive or recover from a HWA infestation. Here, we report the current status and describe the future direction of this study. Data have been collected each year since 1993; the database now contains 6,935 observations from 145 10-tree plots in 29 sites over the 4 study areas. At each plot, the average slope, aspect, soil type (4 categories), moisture regime (3 categories), elevation, stand density (3 categories), and stand composition (one 10-BAF prism plot) have been recorded. Ten trees per plot were permanently tagged for revisiting annually; DBH and crown position was recorded. Five variables were used to decide the health of plot tree crowns each year: diameter (widest and at right angles to widest), ratio, density, dieback, and foliage transparency. Defoliation, tree vigor, and any other damage and causal agent notations also were recorded. The plot system does an excellent job of capturing the variation among these measures across hemlock in the eastern United States. A plot-wide assessment of HWA was made using non-destructive sampling of ten 12-inch branch tips per plot, each from a different tree. Samples consisted of (1) the number of terminals present before new growth, (2) the number of terminals producing new growth, and (3) the proportion of terminals infested with HWA. From a regression of the proportion of terminals infested with adelgid against the proportion of terminals that produce new growth, we found a highly significant and rational relationship, but this relationship only explained 1.64% of the total variation. Very few plots have become infested with HWA. We have established a revised sampling plan using variance estimates derived from our area-site-plot system to optimize our chances to capture the impacts of HWA. Initial results from these revised data collection procedures were presented.

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