

WINTER MORTALITY IN *ADELGES TSUGAE* POPULATIONS IN 2003 AND 2004

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The hemlock woolly adelgid (HWA), *Adelges tsugae* Annand, an exotic pest native to Asia, is a major threat to hemlock as a forest resource in eastern North America. The entire range of eastern hemlock is at risk, however cold winter temperatures might limit its continued northward spread. We assessed the mortality of HWA populations after the winters of 2002-2003 and 2003-2004, the coldest winters recorded in the Northeast in the past decade.

Between March and April 2003, we sampled HWA populations at 36 sites in NH, MA, CT, NY, PA, and NC. During a similar period in 2004 we sampled populations at 35 sites in ME, NH, MA, CT, NY, NJ, PA, MD, WV, and NC. Where possible, at least 100 HWA sistens, nymphal stage 2 or older, were examined from each of 10 trees at a site, totaling at least 1,000 HWA per site. Latitude, longitude, and elevation were recorded at each site. Highest and lowest daily temperatures for the period November 2002 through March 2003 were obtained from the National Climate Data Center for the weather station closest to each site. (Verified weather data for 2004 were not yet available.). Data were analyzed using the Spearman rank correlation test and multiple regression. Values of $P < 0.05$ were considered significant.

In 2003, HWA winter mortality averaged 86.0% at 29 sites in NY and New England, 73.8% at six PA sites,

and 11.2% at a NC site; highest mortality was 99.4% at a NH site. In 2004, HWA winter mortality averaged 93.6% at 17 NY and New England sites, 78.4% at seven PA sites, and 21.1% at the NC site; highest mortality was 100% at a NY site. Analysis of data from the winter of 2002-2003 indicates that mortality was positively correlated with degrees of latitude ($r=0.422$, $P=0.010$), even when the outlying NC site was excluded ($r=.371$, $P=0.028$), and negatively correlated with mean daily low temperature ($r=-0.626$, $P=0.03$). There was a slight negative correlation between percent mortality and the minimum temperature recorded at each site ($r=0.333$, $P=0.047$). The 35 sites sampled in 2004 extended over a greater part of the adelgid's current range and there was a stronger positive correlation between adelgid mortality and degrees of latitude ($r=0.590$, $P=0.0002$). Mortality was negatively correlated with degrees of longitude ($r=-0.624$, $P=<0.0001$) and elevation ($r=-0.395$, $P=0.0190$), but only latitude accounted for a significant amount of the variance in percent mortality ($P=0.0321$).

Although HWA populations are established in the eastern U.S. as far north as the Catskills in NY and southeastern NH and ME, existing populations are restricted to plant hardiness zone 5A (min. low of -26.5° to -28.8° C), or warmer. Based on the high winter mortality that occurred in northern HWA populations in 2003 and 2004, we speculate that cold winter temperatures will limit the rate and extent of its northward spread.