Update on
hemlock woolly adelgid
and the management of hemlock decline at Delaware Water Gap

Past studies at Delaware Water Gap National Recreation Area (Pennsylvania and New Jersey) have shown that an alien insect, hemlock woolly adelgid (HWA, *Adelges tsugae*), has been causing decline of eastern hemlock forests, leading to the loss of native biodiversity, and opening the way for invasions of alien plants. New and ongoing studies continue to expand our understanding and documentation of these changes. In addition, we are making progress in developing strategies and techniques to address important management issues associated with these changes.

Monitoring—Annual monitoring of hemlock forest plots has documented the spread of HWA infestations throughout hemlock stands, and consequent declines in stand health. Initial HWA infestations only occur on a few branches of a few trees in a stand, and have little or no effect on overall hemlock stand health. As infestations increase and spread to more trees, they reduce the annual production of new twigs in the stand, eventually nearly eliminating it (fig. 1).

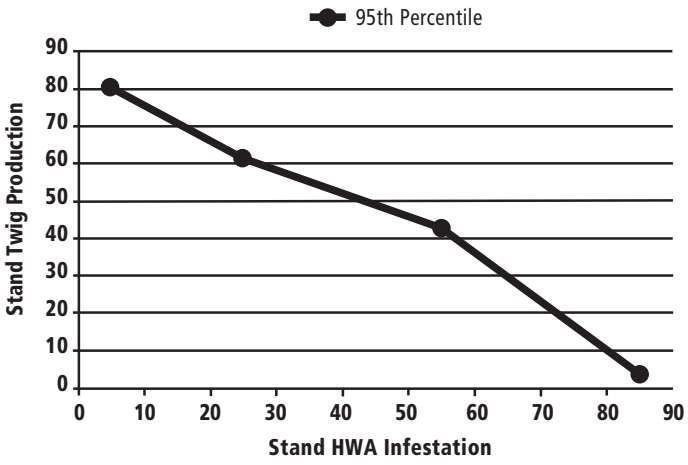

Figure 1. The graph documents decline in hemlock stand twig production with increasing levels of HWA infestation at Delaware Water Gap National Recreation Area during the 10-year period from 1995 to 2004. Data collected from monitoring plots in seven hemlock stands.

Research—Dr. Denise Royle, USDA Forest Service, used Landsat Thematic Mapper satellite imagery to quantify and analyze hemlock forest decline on a pixel-by-pixel (30-m x 30-m) basis throughout the national recreation area. This analysis has provided useful information about the spatial distribution, rate, and extent of hemlock decline and indicated that, as of 2002, approximately half of the hemlocks in the recreation area were dead or in severe decline, and half were healthy or in moderate decline (fig. 2). Forest plot data, collected "on the ground," indicate similar levels of hemlock decline.

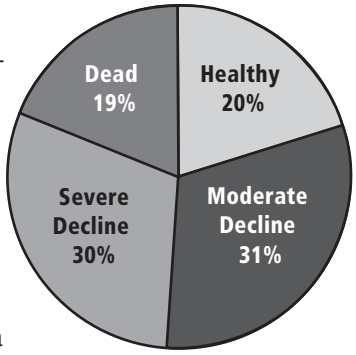

Figure 2. The pie chart shows health of hemlock forests in Delaware Water Gap National Recreation Area in 2002, as indicated by satellite (Landsat) image analysis.

In 2003, Anne Eschtruth, a doctoral student at the University of California–Berkeley, initiated research in the park to determine if and how alien plant invasions are facilitated by hemlock decline, browsing by white-tailed deer, and surrounding alien plant populations. Results indicate that invasive alien plants are much more common and abundant in hardwood stands than healthy hemlock stands, but become more common and abundant in declining hemlock stands.

Management—In 2003 the national recreation area hosted an interdisciplinary workshop to gain expertise in developing strategies and techniques to manage declining hemlock forests. The workshop focused on developing (1) management plans for several important visitor use areas already experiencing severe hemlock decline and mortality, and (2) strategic goals and priorities for all of the 140 hemlock stands covering some 2,800 acres (1,134 ha) in the park. The NPS restoration ecologist assisted with the workshop, and representatives from the USDA Forest Service, the states of Pennsylvania and Connecticut, Rutgers University, and The Nature Conservancy contributed expertise in silviculture, plant ecology, landscape management, forest pest management, GIS, and remote sensing. A summary of the workshop, available from the author, was completed, and detailed site management plans are in preparation.

—Richard A. Evans, ecologist, Delaware Water Gap National Recreation Area, Pennsylvania; richard_evans@nps.gov.

Editor's Note: Readers may find the USDA Forest Service publication "Eastern hemlock forests: Guidelines to minimize the impacts of hemlock woolly adelgid" of interest; it is available at www.fs.fed.us/na/morgantown/fhp/hwa/ pub/guidelines_to_minimize_hwa_impacts_pub.pdf.