The Effect of the Hemlock Woolly Adelgid, *Adelges tsugae* (Homoptera: Adelgidae) In New Jersey Hemlock Stands

Annual Report 2009

Prepared by:

Mark Mayer
Robert Chianese

Hemlock Woolly Adelgid
photo: S. Geloski-Kimmel, Philadelphia Inquirer

Division of Plant Industry
Phillip Alampi Beneficial Insect Laboratory
Trenton, NJ 08625

Abstract

Peak populations of the HWA occurred every nine years since 1989 with the lowest populations occurring midway between the peaks. There was a slight increase in tree mortality to 60.7% in the monitored plots.

INTRODUCTION

This report is the result of the Permanent Hemlock Study Plot monitoring program partially funded by the United States Department of Agriculture-Forest Service. The objective of this work is to show the impact of the HWA and associated factors in natural hemlock stands over an extended period. Data collected include stand mortality, HWA population level, and crown ratings.

MATERIALS AND METHODS

Study Plots

Eleven study plots were set up in 1988. These plots were chosen as representative of natural hemlock stands and adelgid populations. Of the 11 plots selected, nine were infested with adelgid and two were uninfested. The same 11 plots were monitored in 1989. Two of the plots were abandoned in 1990 because they were continually being treated with chemicals and/or fertilized and field personnel were unable to get an accurate record of the treatments. Subsequently, in 1990 two new plots were added to replace the plots that were dropped. These eleven plots had been continuously monitored since 1990. Data are occasionally not available from certain plots because permission to enter the property could not be obtained from the new property owners**.** In 2003, the last remaining trees in the Shades of Death study plot died, leaving only ten plots now being monitored. During 2008, the plot at Schooley's Mountain was dropped from the study as access to the plot became questionable as well as potentially dangerous leaving nine plots.

After a plot was chosen as representative of a noninfested, lightly infested, or heavily infested hemlock stand, three subplots were established within each plot to ensure that an undisturbed group of trees could be observed from year to year. Subplots were set up using the following criteria: 1) location in the densest parts of the hemlock stands; 2) good accessibility to branches; 3) open areas were avoided because they were not representative of a plot as a whole.

A #10 prism was used to delineate the sample hemlock trees within the subplot. One tree was designated as the center tree and any tree that was observed within the 360^{o} radius of the prism was included in the subplot. The tree lying closest to magnetic North with respect to the center tree was designated tree number 1. All hemlock trees within the prism, moving in a clockwise direction, were numbered sequentially.

HWA Population Levels

Previous work (Ward 1991) indicated that the percent new growth in hemlocks declines precipitously when a population of 25-30 HWA at the base of 100 needles is reached. There was no appreciable effect on the percentage of new growth when populations of HWA were less than

25-30 HWA per 100 needles. The HWA population categories were then assigned as follows with H = heavy, > 30 adelgids per 100 needles; L = light, < 30 adelgids per 100 needles; N = none, no adelgids per 100 needles.

Population levels were determined by sampling HWA infested trees just outside of the subplots. Cuttings were made from six different trees within the site (2 cuttings each in the proximity of each subplot. These cuttings were brought back to the laboratory and ten -100-needle sections were randomly selected from each of the six cuttings; 6,000 needles were examined in each plot. All adelgids present in the sections were counted and then an average was obtained for each of the plots. Not all population data was collected at some of the plots in 1991 and in 1992 due to insufficient personnel.

Crown Rating

The crown ratings of ratio and transparency for all the plots were implemented as in Millers *et. al*. 1992. Dieback was not included in the crown ratings because the project had been ongoing for some time and it would be difficult to evaluate that measurement. Crown diameter was felt to be highly variable and thus was not included in the data. Crown density is the amount of foliage, branches *etc.* that blocks light visibility through the crown and is expressed as a percentage. Since this measurement did not appear to be useful as crown transparency it was not included beginning with the 2007 survey. Crown ratio is the percentage of total tree height that supports living foliage. Crown transparency is the amount of visible light going through the live portion of the crown and is also expressed as a percentage. A high percentage means that more light is visible through the crown, which indicates a distressed crown/tree. Crown transparency is akin to percent defoliation. Figure 1 shows a hemlock with a thin crown, which would have a high transparency percentage rating. Figure 2 shows a healthier crown, which would have a much lower transparency rating than the tree in Figure 1.

Figure 1. Hemlock with a thin crown

Figure 2. Hemlock with a healthy crown

Mortality

Mortality was defined as no cambial activity and no needles on the tree. Trees with any needles at

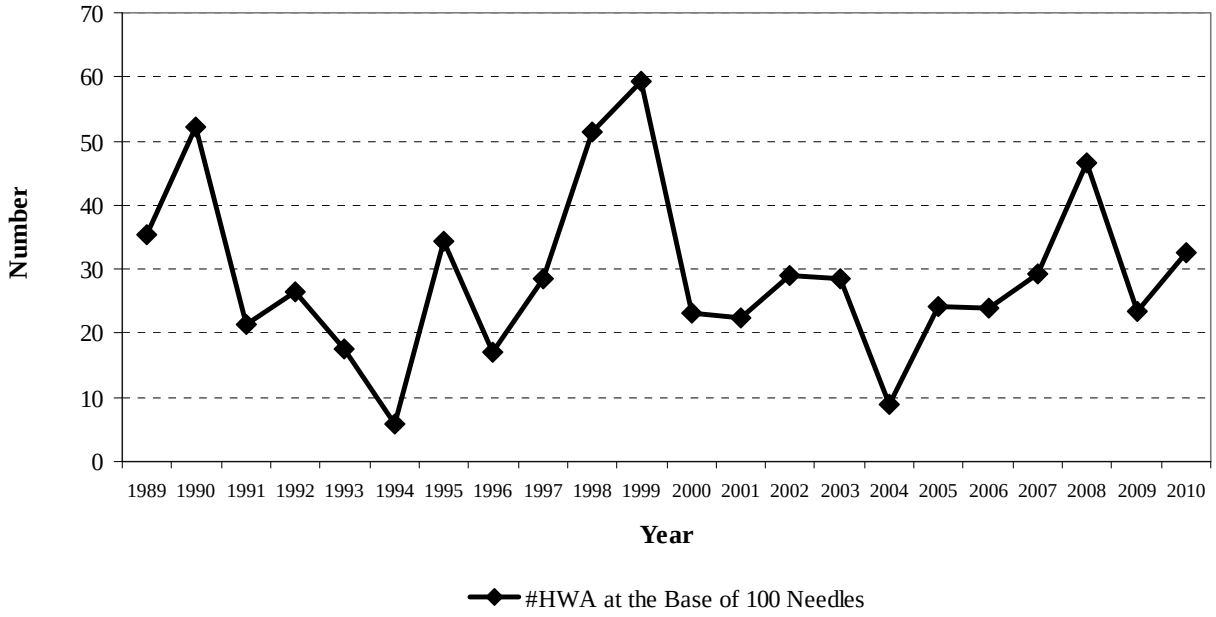
all were considered to be living even though they may have been ecologically dead. Plot mortality was calculated by counting the number of dead trees observed during the crown rating survey and dividing that number by the total number of trees in the plot to determine the percentage.

RESULTS AND DISCUSSION

HWA Population

Figure 3 shows the average HWA population levels for the permanent study plots from 1988-2010. Interestingly, there is a peak population level for the hemlock woolly adelgid every nine years, in 1990, 1999, and in 2008. There are subsequent smaller peaks but it seems that once the amount of new growth and tree health decline, the HWA population crashes four to five years after the peak population.

Figure 3. HWA Population From 1989-2010



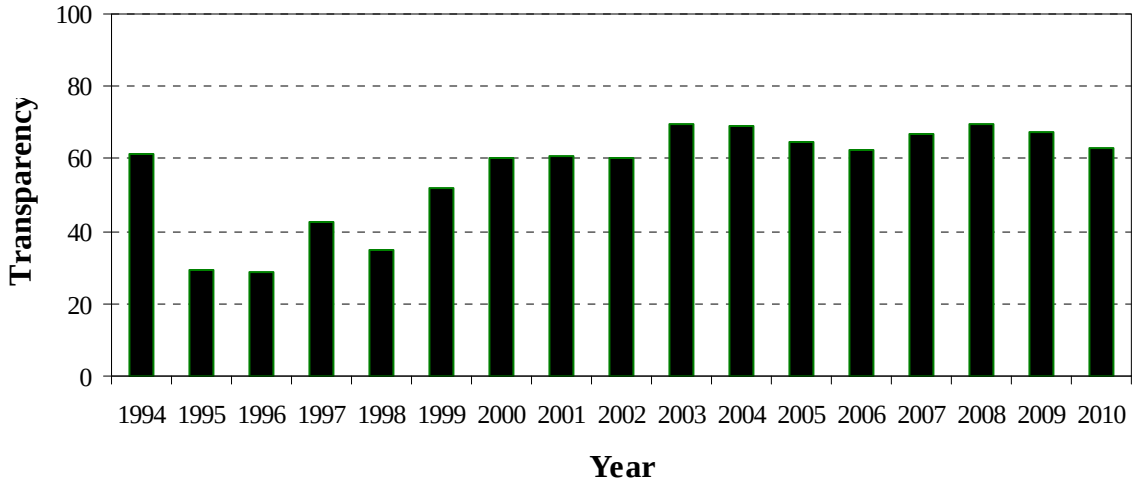
The 2010 data indicate that NJ is at the beginning of a cyclical downward trend in the HWA population in the next four to five years.

Crown Ratings

The plots that have a series of years where the HWA population was heavy are the plots that have the lowest crown ratios and the highest transparencies. Taken all together, the relative health of the hemlock in those plots is poor when compared to stands where the trees have not been infested as long. In NJ, all of the Permanent Study Plots have at least some unhealthy trees. The lower the transparency value, the healthier the stand or tree. The stands that have been attacked earliest by the HWA are the stands that are in the poorest health in New Jersey. Figure 4 shows the average combined crown transparency ratings of the living trees for all of the plots. The lower ratings

from 1995 to 1998 included were primarily due the increase in the amount of new growth on the trees during that time period.

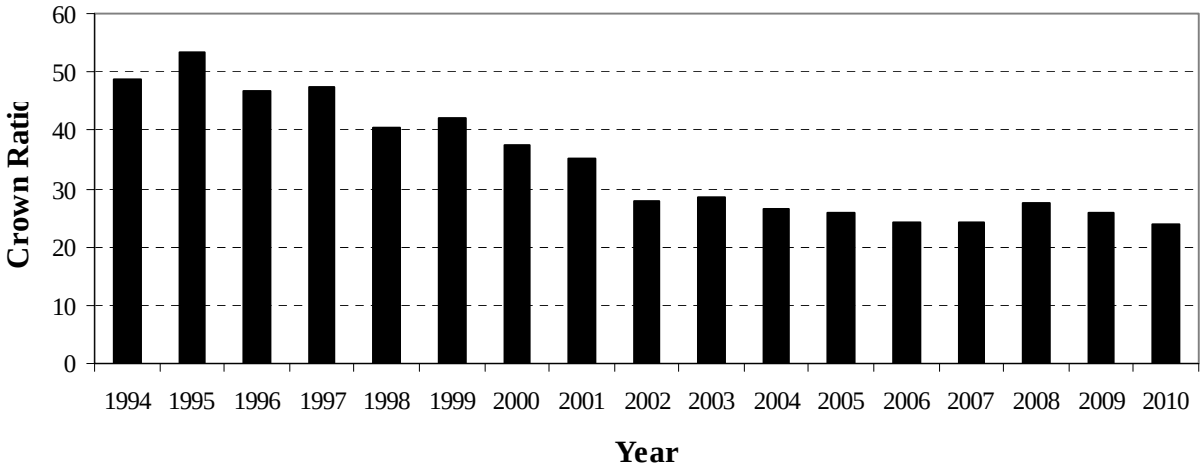
Figure 4. Crown Transparency of Living Trees in NJ 1994-2010



Overall, the plots with the most stress have high crown ratings for transparency. The more often a stand is heavily infested, the higher transparency in the stand and the poorer tree health. This effect is not seen for a few years after the initial infestation, but when the earliest data from each stand is compared to the data from some years later, the effect is readily apparent. Figure 4 shows a stable pattern of transparency since 2000.

Figure 5 shows the average crown ratios for all plots since 1994 with the ratios having declined since that time. This decline makes it difficult to sample for the hemlock woolly adelgid predators with the majority of the foliage up in the crown where it is unreachable by field crews.

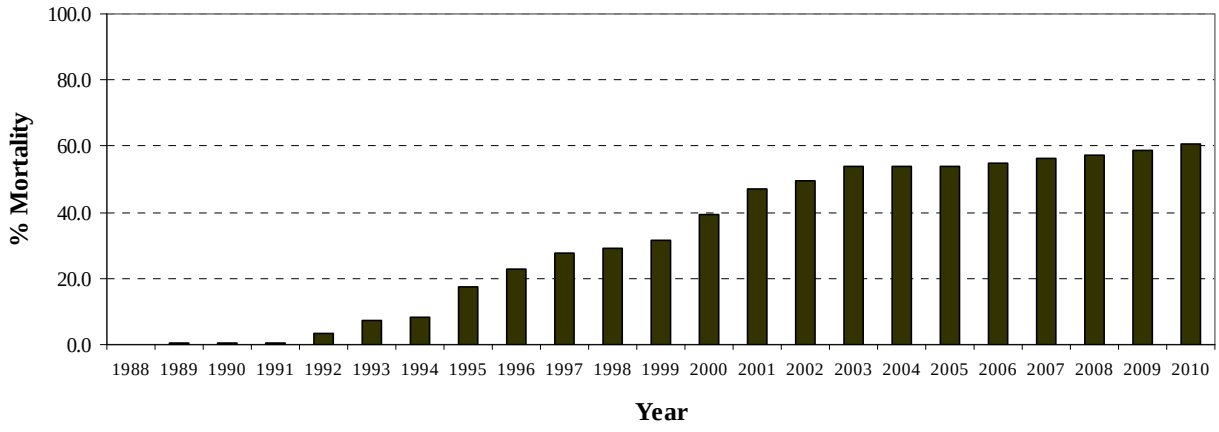
Figure 5. Average Crown Ratio of Hemlock Trees in NJ 1994-2010



Tree Mortality Considerations

Obviously the HWA is putting stress on the trees in the forest. Figure 7 shows the combined overall average mortality in all of the monitored sites. The tree mortality has been increasing over time but has been relatively stable since 2003 although there was a slight increase this year to 60.7%. As a measure of the state as a whole then, 60% of the hemlock trees have died in New Jersey since the beginning of the hemlock woolly adelgid infestation. There are other factors that contribute to the death of the trees such as drought, elongate hemlock scale and in one plot, beavers, but the one factor that stands out consistently is the presence of a heavy HWA population. The sites that were marginal for hemlock are the sites that showed the most mortality. Hemlock mortality does seem to be affected by the amount of water available to the trees and the amount of water available is related to the percent new growth. From observation in the heavily infested stands monitored in NJ, the closer a tree is to a water source, the healthier it appears. At Walnridge, Lake Valhalla and Johnson Lake PSP's, the trees that are still alive and the healthiest are either at the bottom of a slope, near a stream, or by a roadside, which is at the bottom of a slope. Shades of Death, Schooley's Mountain, Lake Valhalla and Johnson Lake are the plots with the highest mortality and they are all plots where the majority of the hemlocks are on a ridge or a site that is somewhat xeric. They were also the plots that have had numerous high HWA populations in the past. It seems that if a site has been heavily infested, the surviving trees are the ones that have the best access to a water supply.

Figure 7. Average % Mortality of Hemlocks in NJ 1988-2010



It must be emphasized that even the trees close to water in heavily infested stands are still stressed by the HWA. Abundant water negatively affects sucking insect populations and it seems reasonable to infer that it negatively impacts the HWA as well. Figure 8 shows a healthy hemlock stand with no adelgid. This stand is well shaded, with an understory of young hemlock.

Figure 8. Healthy dark hemlock stand

Figure 9 shows initial mortality as it first appears while Figure 10 illustrates the hemlock stand after mortality has been present for a few years. There is little understory and many branches have fallen onto the ground increasing the slash. The increase in slash also increases the fuel inventory making the stands more susceptible to forest fire. Widowmakers (trees leaning on other trees) are a common sight and many of the trees have split and fallen.

Figure 9. Initial mortality at Newark Watershed

Figure 10. Stand mortality at High Point SP

On windy days, it is hazardous to go into some of the stands due to the number of dead trees and falling branches. There was no concurrent mortality of other tree species in any of the stands. Mortality can show up about 3-4 years after the first heavy HWA infestation and does increase in succeeding years, but there is no gradual increase in mortality from year to year. The HWA population declines as the trees become a poor food source; followed by more new growth as the HWA population declines and the trees recover, but as the amount of new growth increases, the HWA population increases once again and the trees decline further.

CONCLUSION

From the 2010 survey results presented here, it appears that the HWA continues to negatively impact hemlock stands in New Jersey. The percentage of highly stressed trees and mortality in the most heavily infested stands has slightly increased but overall mortality has been fairly stable since 2002. Extrapolating the data from the PSP's, approximately 60% of the hemlock trees in NJ have died since the beginning of the hemlock woolly adelgid infestation in the mid 1980's. The HWA shows a nine year cycle in NJ where there are peak populations and then periods where the population has collapsed. The longer and more times that a stand has been heavily infested, the greater the stress and mortality. Other factors such as water supply, elongate hemlock scale populations, and drought, are also probably contributing to the decline in hemlock health. However, the one factor that is consistent, where the mortality and transparency ratings are the greatest, is a series of years of heavy populations of the HWA.

Photo credits:

Figure 8 – Jason Zhang and James Lashomb, Department of Entomology, Rutgers University, Cook College

REFERENCES

McClure, M. S., S. M. Salom, and K.S. Shields. 1996. Hemlock Woolly Adelgid. Forest Health Technology Enterprise Team, USDA-FS, Morgantown, WV. FHTET-96-35.

Millers, I., R. Anderson, W. Burkman, W. Hoffard. 1992. Crown Condition Rating Guide. USDA-FS Technical Report.

Onken, B.P. 1994. A summary of impacts from HWA and drought on eastern hemlocks in New Jersey. USDA-FS, Morgantown, WV. Unpublished, from data provided by the New Jersey Department of Agriculture, Division of Plant Industry, Phillip Alampi Beneficial Insect Laboratory.

Ward, R. 1991. The effect of the hemlock woolly adelgid *Adelges tsugae* (Homoptera: Adelgidae) in New Jersey forests. Unpublished Annual Report, Phillip Alampi Beneficial Insect Laboratory, Division of Plant Industry, New Jersey Department of Agriculture.