Biology, Impact, and Management of Hemlock Woolly Adelgid in Ornamental Landscapes

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Hemlock trees have always been important plants of ornamental landscapes. A vigorous nursery industry in North Carolina supplied hemlocks for installation here and throughout the eastern United States. However, the sustainability of using hemlocks in ornamental landscapes became questionable as hemlock woolly adelgid (HWA), *Adelges tsugae* spread throughout the northeast. In 1998, HWA was discovered in North Carolina threatening the nursery industry and ornamental plantings that used hemlocks as hedges and shade trees. In addition to obvious effects on forested land, arrival of HWA has had serious economic implications because trees and shade cover contribute to residential property values. Moreover, production, installation, and maintenance of trees contributes enormous value and jobs to the economy of North Carolina.

Although sales are down since HWA arrival hemlocks are still produced and sold in North Carolina because they have many qualities desirable in ornamental landscapes. Outside of areas with natural hemlock stands and HWA infestations hemlocks are relatively pest free. However, as the recent infestation of Hemlock Bluffs Nature Preserve in Wake County made clear, hemlocks require vigilant monitoring to detect pests early and prevent infestation of natural areas. This park, outside Raleigh, contains a remnant hemlock population that until now has never had HWA because there was no local source. This demonstrates that trees hundreds of miles from a natural infestation can become infested via movement by humans.

Hemlock trees are susceptible to several native and exotic pests that must be managed to sustain tree health in landscapes. The greatest threat to hemlocks in ornamental or natural settings is HWA. Elongate hemlock scale (EHS), *Fiorinia externa*, is the other major threat. This is because both pests will attack healthy trees and can interact to hasten tree decline and death. To effectively manage these and other pests it is important to understand their biology and impact on tree health.

Fluffy white ovisacs produced by Hemlock Woolly Adelgid in early spring and summer. Photo: S.D. Frank

HWA has two generations per year. Eggs are laid in spring in woolly, round ovisacs. This is the most woolly stage of the insect and the easiest to see. Crawlers hatch from eggs and foray out to find a place to feed. Crawlers settle at the base of needles and insert their mouth parts to feed. After settling the insects do not move again. The first generation matures in early summer when females produce woolly ovisacs and die. Crawlers hatch and move to new foliage to settle. This second generation goes into aestivation, or dormancy, during the hot summer months in which they stop feeding and growing. Activity resumes for a few months in fall before going dormant again for winter.

HWA feed in the xylem ray parenchyma cells on twigs at the base of needles. Carbohydrates and other nutrients are removed by the insect which reduces energy available to support tree growth, metabolism, and defense. Since adelgids produce dozens of crawlers per female two times per year and have no effective natural enemies, populations increase rapidly. This has cascading consequences on tree health. Twig length becomes shorter so fewer needles are produced. This limits the tree's photosynthetic capacity further limiting carbohydrate production. Over a short period of years twig growth ceases altogether and existing twigs begin to shed needles and die.

It is important to remember that HWA thrive on healthy trees that provide plentiful carbohydrates to support insect growth. Thus, the highest HWA populations are found on trees before a drastic decline in health. HWA populations become very small when photosynthesis is minimal and there are no new needles to colonize. A misleading symptom common in HWA infestations is a flush of new growth after a year or two of no growth. However, this "recovery" is short-lived as HWA rapidly recolonize the nutritious new foliage and further deplete tree carbohydrate reserves.

Elongate hemlock scale is an invasive species from Japan that was first detected in the U.S. in 1908. Elongate hemlock scale is and armored scale that settles on the underside of hemlock needles. In North Carolina, it has two generations per year and attacks eastern hemlock and Carolina hemlock. Scale draw out needle fluids with thread-like mouth parts reducing resources available to sustain needles and plant growth. Several scales feeding on the same needle can cause needle death. As needles die and drop, photosynthesis is further compromised. Therefore, EHS infestation can exacerbate hemlock decline initiated by HWA by increasing needle loss.

Trees under stress are more susceptible to secondary pest infestation. Stress can result from environmental factors, particularly drought, and from insect feeding. Greater abundance and damage by secondary pests is common during insect outbreaks when tree resources are diminished by repeated defoliation or feeding. For example, during severe gypsy moth defoliation considerable oak mortality is caused by secondary pests such as twolined chestnut borer (*Agrilus bilineatus*). This pest is not normally a significant source of oak mortality but attacks weakened trees and thus becomes very abundant during gypsy moth outbreaks. Likewise, HWA and EHS infestations can be associated with secondary pests such as hemlock borer (*Melanophila fulvogatta*).

Hemlock borer is a native flat-headed borer that occurs throughout the native range of hemlocks. It can become very abundant when weakened trees are abundant such as after severe wind throws or drought (MacAloney 1967). As larvae form galleries beneath the bark, infested branches will lose needles and die. Presence of borers will also be indicated by woodpeckers that search the trunk for larvae.

Hemlocks in natural and managed landscapes are susceptible to many other pests including spruce spider mite *(Oligonychus ununguis)* and hemlock rust mite *(Nalepella tsugifolia)*. Mites are of particular importance on hemlocks in ornamental landscapes because they can be difficult to control and exacerbated by other management practices.

Although the number and severity of pests seems daunting, hemlocks can be successfully managed in ornamental landscapes. (Management of nursery stock is the subject of current research and will be addressed in a future article). The most important aspects of management is maintaining optimal tree

See **Management of Hemlock Woolly Adelgid** – continued on page 44

Management of Hemlock Woolly Adelgid – continued from page 43

health through proper planting, irrigation, and maintenance. In addition, since HWA and EHS populations can infest and overwhelm hemlocks in a few years monitoring is essential. HWA and EHS can be detected throughout the year by inspecting twigs and needles. In addition, pay attention to the overall appearance of trees to detect changes in color or needle drop. This will be especially important in large trees of which the crown is less accessible.

To manage pest infestations successfully it is important to understand the different management options available and when to use them. Biological control of HWA is the subject of extensive research by universities and government agencies. Significant progress has been made in identifying, rearing, and releasing natural enemies from the native range of HWA in Asia. However, at this time there is no biological control option for HWA that is reliable and economical enough for use in landscapes. Likewise EHS, although subject to some mortality by native natural enemies, is not manageable by augmentation biological control.

For such a voracious and lethal pest HWA is not difficult to kill with insecticides. Insecticidal soap and horticultural oil have been shown to provide excellent control of HWA in landscapes. Applications of oil or soap made in summer or fall caused 100% mortality of HWA on small forest trees (McClure 1987). Oil applied to adults and eggs in spring was slightly less effective (95% mortality) due to eggs or adults escaping coverage amidst woolly masses (McClure 1987). These contact insecticides provide a control method with minimal non-target effects or risk of environmental contamination. However, since they rely on contact with the insect they can only be used when thorough coverage is possible. In areas where HWA is prevalent, oil or soap treatments typically have to be repeated yearly.

Systemic insecticides are an excellent control option for HWA. Neonicotinoids can be used to kill existing adelgids and prevent reinfestation. On small, accessible trees and hedges imidacloprid (Merit) or dinotefuran (Safari) can be applied as a foliar spray. My research has also found foliar applications of TriStar to be very effective. Foliar applications provide quick results because translaminar movement of the chemicals into needles and twigs makes the plant toxic to HWA. Foliar applications will provide long residual control though not as long as soil and trunk application methods. Foliar applications also are not suitable for large trees or trees near water or sensitive areas.

Soil applications by drench or soil injection and trunk injection can be used to treat larger trees. These also provide longer control because the trees take up the chemical over time. Imidacloprid applied to the soil can prevent reinfestation for 3 or more years but may take up to a year to achieve full efficacy (Webb et al. 2003; Cowles et al. 2006). Dinotefuran is more water soluble which means it works faster but protects trees for up to two years. Efficacy of soil-applied chemicals is dependent on maintaining adequate soil moisture so chemicals are actively taken up by the tree. However, excessive water can dilute the chemicals, wash them away from the root zone, and transport them to non-target areas.

A recent development in HWA control is trunk applications of Safari permitted by a supplemental label. Safari applied to tree trunks is absorbed through the bark and into the vascular system and transported throughout the tree. This provides an alternative to soil applications in sensitive areas and is less labor intensive that trunk injections.

An important difference between imidacloprid and dinotefuran is their efficacy on scale. Imidacloprid is not effective on armored scales and thus does not control EHS (Doccola et al. 2008). Safari is very effective against armored scales and would be expected to control EHS although some research on this species is equivocal (Raupp et al. 2008). Armored scales, such as EHS, can be killed by horticultural oil and other chemicals such as acetamiprid (Tristar) and pyriproxyfen (Distance) (Heller & Kline 2007; Raupp et al. 2008).

Broad spectrum contact insecticides such as pyrethroids can be used to target crawlers of HWA and EHS but can increase scale abundance (McClure 1977; Raupp et al. 2001). This is because scales are concealed under wax covers and thus not easily killed by pyrethroids but natural enemies, especially parasitoids, are killed for many weeks by pyrethroid residual (McClure 1977; Raupp et al. 2001). Another potential secondary pest is spider mites. Broad spectrum contact insecticides kill natural enemies such as predatory mites, lacewing larvae, and minute pirate bugs that suppress mite populations. In addition,

See **Management of Hemlock Woolly Adelgid** – continued on page 47

Management of Hemlock Woolly Adelgid – continued from page 45

research indicates that imidacloprid can mite abundance and damage though the mechanism is not fully understood (Raupp et al. 2004). Due to the impact on non-target organisms and potential for secondary pest outbreaks broad spectrum insecticides such as Talstar should be used cautiously. However, mites such as spruce spider mite and hemlock rust mites should be monitored as part of a management program.

Hemlock borer does not require insecticide control because it is targeting trees already in decline. Treating trees for hemlock borer is just protecting sick trees without addressing the real problem. Imidacloprid and other chemicals can improve the health of trees even if they are heavily infested and damaged by HWA (Webb et al. 2003). Trees that had been infested for several years and had no new growth recovered after imidacloprid therapy reduced HWA feeding.

As with all pest management programs, monitoring and follow-up assessments are essential. The easiest time to see HWA is early spring and early summer when adults and woolly ovisacs are present. However, the black and white nymphs can be seen any time of year on new foliage. In western parts of the state where natural areas are fully infested landscape trees will require routine assessment and treatment as they are subject to constant reinfestation. Thus the cost of long-term management versus removal should be considered before hemlocks are treated. In other parts of the state where hemlocks are not prevalent landscape trees may never need treatment because sources of infestation are few and far between. However, as we have seen in Hemlock Bluffs Nature Preserve, HWA is always a possibility due to human movement of plant material and early detection will pay dividends.

References:

Cowles, R.S., M.E. Montgomery, and C.A.S.-J. Cheah. 2006. Activity and residues of imidacloprid applied to soil and tree trunks to control hemlock woolly adelgid (Hemiptera: Adelgidae) in forests. *Journal of Economic Entomology* 99:1258-1267.

Doccola, J.J., Cruz, B.I., Wild, P.M., Aiken, J.J., Royalty, R.N., Hascher, W. 2008. A new strategy to control Hemlock Woolly Adelgid using imidacloprid and an arboricultural method to gauge hemlock health. *In* B. Onken and R. Reardon, compilers. *Fourth symposium on Hemlock Woolly Adelgid in the Eastern United States*. FHTET-2008-01.

Heller, P.R., Kline, D. 2007. Management study to suppress elongate hemlock scale with multiple applications of two translaminar formulations on fraser fir christmas trees. Arthropod Management Tests, 32, G40.

MacAloney, H.J. 1967. The hemlock borer. USDA Forest Pest Leaflet 109.

McClure, M.S. 1987. Biology and control of hemlock woolly adelgid. Bulletin of the Connecticut Agricultural Experiment Station 851. New Haven, CN. 8 p.

McClure, M.S. 1977. Resurgence of the scale, *Fiorinia externa* (Homoptera:

Diaspididae) on hemlock following insecticide application. *Environmental Entomology* 6:480–484.

Raupp, M.J., J.J. Holmes, C. Sadoff, P. Shrewsbury, and J.A. Davidson. 2001. Effects of cover sprays and residual pesticides on scale insects and natural enemies in urban forests. *Journal of Arboriculture* 27(4):203-214.

Raupp, M.J., Webb, R.E., Szczepaniec, A., Booth, D., Ahern, R. 2004. Incidence, abundance, and severity of mites on hemlocks following applications of imidacloprid. *Journal of Arboriculture* 30(2):108-113.

Raupp, M., Ahern, R., Onken, B., Reardon, R., Bealmear, S., Doccola, J., Wolfe, P., Becker, P. 2008. Efficacy of foliar applications, trunk injections, and soil drenches in reducing populations of elongate hemlock scale on eastern hemlock. *Arboriculture and Urban Forestry* 34, 325-329.

Webb, R., R. Frank, and Michael J. Raupp. 2003. Eastern hemlock recovery from attack by hemlock woolly adelgid following imidacloprid therapy. *Journal of Arboriculture* 29:298–302.

Elongate Hemlock scale and Hemlock Woolly Adelgids on hemlock. Photo: S.D. Frank