Hemlock Woolly Adelgid: *Adelges tsugae* Annand

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Introduction/Overview

The hemlock woolly adelgid (HWA), *Adelges tsugae* Annand, is an insect pest native to Japan. HWA is parthenogenic (all adults are female) and each adult can produce between 50-300 eggs within her lifetime. Populations can explode because HWA has numerous offspring, two generations per year and lacks natural enemies in North America.

On eastern hemlock (*Tsuga canadensis* (L.) Carr.), HWA causes severe needle drop, bud mortality, branch die-back and tree death. Young twigs are the preferred feeding sites and sap feeding causes needle discoloration and branch desiccation (McClure, 1992; Orwig & Foster, 1998). Infestations on eastern hemlock and Carolina hemlock (*T. caroliniana* Engelmann) are generally fatal, and tree death occurs usually within four to six years of infestation (McClure, 1995; Cheah & McClure, 1998). The rapid decline in tree health suggests that a toxin within the saliva may be responsible for the rapid desiccation of foliage and branches (McClure, 1992), but this must be investigated further.

The first report of HWA in the USA was on western hemlock in the Pacific Northwest in 1924. In 1954, the first east coast report was in Maymont Park, Virginia. Hemlock woolly adelgid is now active in twelve states from North Carolina to Massachusetts. Approximately 25% of 1.3 million hectares of eastern and Carolina hemlock have been infested, and Rhea (1995) states that the rest of the population is at risk within 20 to 30 years. HWA defoliates all sizes of trees, from seedlings to mature individuals, and can eliminate entire hemlock stands within a few years. Hemlock seed banks are short-lived and rapidly become depleted (Orwig & Foster, 1998).

Hemlock trees are ecologically important and provide a unique environment. *Tsuga canadensis* is a long-lived conifer, and its stands form a cool, damp habitat with low light levels in the understory. These dense stands possess a very different microclimate and unique species composition from the surrounding, more open forests. These forests are normally stable and resistant to plant invasions. The loss of *T. canadensis* from such forests will greatly affect the microclimate and soil conditions. Large-scale hemlock die-off will affect species diversity, vegetation structure, stand environmental conditions, and ecosystem processes. For example, lepidopterans such as *Semiothisa fissinotata* that feed solely on hemlocks will be affected (Schweitzer, 2000). Orwig & Foster (1998) discovered that light reaching the forest floor through canopy breaks resulted in increased density and average heights of *Betula lenta* (black birch), *Acer rubrum* (red maple), *Prunus serotina* (black cherry), and several *Quercus* species. Canopy breaks also facilitated the establishment of invasive species such as *Berberis thunbergii* (Japanese barberry), *Celastrus orbiculatus* (Asiatic bittersweet), *Ailanthus altissima* (tree of heaven), and *Microstegium vimineum* (Japanese stilt grass).

HWA can disperse easily by wind, birds, mammals, and logging activities (McClure, 1990). The rate of HWA spread is estimated at 30 km/yr (Orwig & Foster, 1998).

Control

Currently, there are no methods to control HWA in a forest environment although a HWA biological control agent was recently introduced to the eastern US and may have some impact. In urban settings, trees are sprayed with horticultural oils or insecticidal soaps. However, good coverage is necessary for successful control, and this is extremely difficult and expensive in forest environments (McClure, 1992). Although oils and soaps are less environmentally harmful than many other pesticides, they are still non-selective contact insecticides that will kill non-target arthropods.

Injected or implanted pesticides can provide some control. However, this method is time intensive and works best only in recently infested and relatively healthy trees. A toxin present in the saliva of the HWA may impair water conduction. This effectively shuts off the mechanism for movement of injected or implanted pesticides and renders these pesticides ineffective in heavily infested trees (McClure, 1992).

USA-native natural enemies have not been found that effectively reduce HWA densities (Cheah & McClure, 1998). In 1992, a predatory ladybeetle (*Pseudoscymnus tsugae*) that feeds exclusively on HWA in Japan was discovered. Laboratory and field tests evaluated it's potential as a biological control agent against HWA in the USA. Releases of *P. tsugae* were made in Connecticut and Virginia during 1995-1997. Its effectiveness has yet to be determined.

Non-target effects of *P. tsugae* include larval and adult feeding on other adelgids such as the pine bark adelgid (*Pineus strobi*), Cooley spruce gall adelgid (*Adelges cooleyi*), and the balsam woolly adelgid (*A. piceae*). Of these, only *Adelges cooleyi* is native to the northern USA and Canada. It is found on spruce and douglas fir, and is considered a pest by foresters. *P. tsugae* may also feed on aphids, but does not feed on the native aphid commonly known as the "green bug", or on the alder aphid. Feeding on the later was a concern of managers at the Quabbin Reservoir in Massachusetts working to preserve the harvester butterfly. The butterfly's carnivorous caterpillar feeds on the alder aphid. The total impact on other hemlock arthropod fauna should be minor because adult *P. tsugae* are extremely tiny (1.5-2 mm in length) and thus far it has not been found feeding on or otherwise harming any other hemlock arthropods.

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