



*The Connecticut Agricultural Experiment Station
Valley Laboratory
153 Cook Hill Rd., P. O. Box 248
Windsor, CT 06095*

*Phone: (860) 683-4977
Fax: (860) 683-4987*

*Founded in 1875
Putting science to work for society*

*Email: Carole.Cheah@ct.gov
Website: www.ct.gov/caes*

Hemlock Woolly Adelgid, *Adelges tsugae* (Annand)

Mark S. McClure, Retired,
Revised by Carole A. Cheah, Richard S. Cowles, and Rose Hiskes, Valley Laboratory
The Connecticut Agricultural Experiment Station

Valley Laboratory Plant & Insect Information Office: 860-683-4977

What It Is and How to Stop It

Hemlock woolly adelgid is a small aphid-like insect from Japan that has become a serious pest of eastern hemlock, *Tsuga canadensis*, in the eastern United States. Even though the adelgid is smaller than a period at the end of this sentence, it is easily recognized on the new growth by the presence of a dry, white woolly substance that covers its body and egg masses. Hemlocks are injured when the insects feed on the stem parenchyma cells and may inject toxic saliva into the tree. This dries out the needles turning them a yellowish or grayish-green color, and needles may drop from the tree within a few months. Many buds may also be killed, so little if any new growth is produced on infested branches. Death of major limbs may occur within two years and progresses from the bottom of the tree upwards, even though the infestation may be evenly distributed throughout the tree. Trees can die within four years in New England, but some survive longer in a severely weakened condition with only a sparse amount of foliage at the very top of the crown. These weakened trees are unsightly and have variable chance for recovery, depending on favorable environmental conditions. They often fall victim to wood-boring insects or diseases and are easily damaged by the wind.



Hemlock woolly adelgid can be managed in forests, nurseries and ornamental landscapes. Trees can be saved by carefully monitoring for the presence of the adelgid and by implementing various cultural practices to enhance tree vigor, to discourage pest invasion, and by using mechanical and chemical measures as needed to bring the adelgid under control.

Biology



(image by Rose Hiskes)

← nymphs, eggs



(image by Rose Hiskes)



Adelgid nymph (C. Cheah)

The hemlock woolly adelgid is parthenogenetic. That means all individuals are female. It completes two generations of development each year. During March and April, adults of the overwintering generation lay about 100 eggs each in a cottony mass on the young twigs. Nymphs (called crawlers) hatch from these eggs during a period of several weeks from April to May. Within a few days, they either disperse from the tree or settle on the twigs near the base of the needles where they insert their piercing and sucking mouth parts. There they feed and remain throughout their development. The spring generation matures by mid-June. Some of the adults produced at this time have wings and are unable to reproduce on hemlocks. They leave the hemlock tree in search of spruce. There is no suitable spruce host in the eastern United States, so they soon die. Other adults produced at this same time are wingless and are able to reproduce on hemlock. In the middle of June these wingless adults lay about 100 eggs each in a cottony mass on the twigs. Crawlers, which hatch in early July settle on the new growth and soon become dormant until the middle of October when feeding resumes. Nymphs feed and develop during the winter and mature in the spring.

How to Monitor for the Pest

It is important to detect infestations early, because the hemlock woolly adelgid can damage trees so quickly. Frequent visual inspection is the most effective means of determining whether or not a hemlock is infested. For most of the year the dry, white "wool" produced by the adelgid on the twigs is quite conspicuous. For year-to-year comparisons, evaluating adelgid populations from November to March is most efficient, because wool is readily seen from adelgids overwintering on the newest growth. Counting only these adelgids simplifies the assessment process, as it avoids having to identify the newest from previous generations. A standardized and fast method is to count the number of wool tufts from ten inches of new growth, and from ten samples from each tree. Count only up to ten tufts per sample, and then add these counts to provide a 0 – 100 rating. Further evidence of hemlock woolly adelgid infestation is the thinning or grayish-green (not red or yellow) color of the needles on some branches. Usually, by the time these symptoms appear, the tattered "wool" of a previous adelgid generation is also present on the branches. During severe winters, hemlock woolly adelgid populations may be drastically reduced, depending on the winter temperature minimums experienced and the location of hemlocks within the three regional climatic zones in Connecticut (NOAA). Information on yearly winter mortality of HWA can be obtained by contacting carole.cheah@ct.gov and can help reduce the need for chemical control in the landscape in the subsequent growing seasons.

Cultural Control Methods

Reducing invasion by adelgids: Birds, squirrels and deer are important dispersal agents. Thus any effort to discourage these animals from visiting hemlocks will reduce the risk of trees becoming infested. Care should be taken when moving plants, logs, firewood, or bark chips from infested areas into non-infested areas, especially from March to June when adelgid eggs and crawlers are present. Cleaning vehicles, clothing, etc. after visiting forests, recreational areas, parks or other properties with infested hemlocks is also advisable during this period. Hemlock woolly adelgid infestations often start in large mature hemlocks that intercept the wind or are especially attractive to birds and other wildlife. These trees serve as reservoirs for the adelgid and selective treatment or removal of them can retard the establishment of new infestations.

Improving tree health: The hemlock woolly adelgid infests and kills hemlocks of all sizes and ages, even in habitats with seemingly excellent growing conditions. Trees that grow in poor sites or experience stress from drought and other agents succumb to adelgid attack more quickly. Maintaining good growing conditions can play an important role in the survival of hemlock. The hemlock is a shallow rooted tree and is particularly prone to stress when there is little rain. Therefore, during periods of drought, trees should be watered as often as needed. Ensure that they receive 1 inch of water per week (including rainfall) over the area beneath the drip line of the crown. Water should be applied slowly so that the roots are well watered. Pruning may also be of some value in improving the health of hemlock. Remove dead and dying branches and limbs from hemlock will promote new growth by allowing more light to reach the foliage. It will reduce the likelihood of attack by insect pests and diseases. Hemlocks are a low-nutrient adapted tree, and fertilizing infested hemlocks with nitrogen enhances adelgid survival and reproduction. As a result, a fertilized hemlock becomes more heavily infested and more severely injured than an unfertilized one. Fertilizing a tree after adelgids have been controlled is not necessary to

stimulate growth. The potential risks and benefits of applying fertilizers which do not contain nitrogen to adelgid-infested hemlocks are unknown.

Mechanically removing adelgids: Eggs and crawlers are easily dislodged from trees by the wind and rain. Most of these individuals are unable to find their way back onto the tree and die. Therefore, intentionally dislodging eggs and crawlers by directing a strong stream of water at infested branches periodically during April through June may be of some value in reducing adelgid numbers. Clipping the more heavily-infested twigs from hemlock branches will also reduce adelgid density on a given tree. However, extensive clipping may have undesirable effects on the general appearance and health of the tree.

Planting resistant hemlock species: Chinese hemlock, *Tsuga chinensis*, is immune to attack from the strain of hemlock woolly adelgid found in the eastern United States. This species, and its hybrids with the Carolina hemlock, can be considered for replacing eastern hemlocks in landscape plantings and have similar aesthetic value. Other species of hemlocks, northern Japanese hemlock, *Tsuga diversifolia*, southern Japanese hemlock, *Tsuga sieboldii*, western hemlock, *Tsuga heterophylla*, and mountain hemlock, *Tsuga mertensiana*, are currently being evaluated at the Lockwood Farm.

Chemical Control Methods

Deciding whether or not to use pesticides: The use of chemical pesticides is an important component of any control program for hemlock woolly adelgid. Even though cultural control measures can significantly reduce adelgid numbers on hemlock, infested trees are usually unable to survive for more than a few years without the help of chemical pesticides. It is important to understand that hemlocks need to be protected from the adelgid as often as necessary until the danger has passed. This may be for a period of several years until all the unprotected hemlocks in the vicinity have died and can no longer serve as a source for re-infestation. Therefore, the initial decision on whether or not to use chemical control measures should take into account the value of the trees relative to the anticipated cost of protecting them over the long term. It may be advisable to identify individual trees or groups of trees that have special value or significance on the property and to concentrate control efforts on those trees. This may be more successful than the overly ambitious approach of trying to save everything at first, only to lose it all when resources have been depleted a few years hence.

What you need to know about pesticides: Several pesticides are registered for control. Some can be used by homeowners, while others are only available to licensed commercial arborists. These pesticides vary from having a relatively short life in the environment, to being sufficiently persistent to provide about 5 years of protection from adelgids. Treating a non-infested tree with pesticide offers little or no protection from invasion by the insect. Hemlocks should be treated only when an adelgid infestation is known to be present. Before applying any pesticide, read the product label carefully. It will provide important information on safety, toxicity, methods, and rates of application.

Applying pesticide sprays: Non-systemic control of adelgids can also be achieved with horticultural oil, insecticidal soap, or any one of several insecticides specifically labeled for this use. Oil is used most often because it is highly effective in killing adelgids, mites, and scales, and yet is relatively safe to the applicator, beneficial insects, and the environment. Unlike other insecticides which kill by contact or ingestion, the oil kills soft-bodied insects, such as adelgids, by suffocation. *It is essential that all parts of the infested hemlock be drenched thoroughly with insecticide.* This precludes control on very large trees (usually those greater than about 80 feet tall) and those in forest settings. A backpack or garden hose sprayer may be sufficient to drench trees less than 30 feet tall, but taller trees may require the services of a professional arborist using a hydraulic sprayer. Fortunately, it is unnecessary to target a particular life stage of the adelgid for control; all are equally susceptible. Therefore, pesticide sprays can be applied any time during the year, weather permitting. One thorough application each year may be enough, if there are no other infested hemlocks within 100 yards from which adelgids could readily disperse. However, two spray treatments each year are usually necessary for most situations. If two applications each year are needed, an effective strategy is to spray in early April and again during the first half of June. Another option is to substitute a spray during the last half of September for the April treatment. Either of these schedules will target both adelgid generations and minimize the impact of immigration. It is advisable to spray as soon as a new infestation is detected because the hemlock woolly adelgid propagates and injures hemlocks so quickly. Then, if necessary, adopt one of the maintenance schedules described above.

Applying pesticides to the soil or bark: The most common and effective method for control of adelgids on ornamental hemlocks is to wet the bark at the base of the tree or thoroughly drench the soil surrounding the trunk with a solution of a systemic insecticide, either imidacloprid or dinotefuran. These products are absorbed efficiently by roots or through the bark, and can provide two (dinotefuran) or five (imidacloprid) years of protection from hemlock woolly adelgids. One advantage of dinotefuran is that it can also suppress armored scale populations, which may be as injurious to hemlock trees as adelgids. Homeowners can obtain either granular or liquid formulations of imidacloprid to use in home landscapes. Do not apply soil injections or drenches when the ground is frozen or waterlogged. Systemic insecticides work best when there is efficient sap flow, meaning that they perform best in relatively healthy trees. Imidacloprid can take 6 – 12 months to move into foliage and suppress adelgids, and so this product is not suitable for trees showing severe stress. Dinotefuran is much more mobile in the tree than imidacloprid, and can save trees that are already showing significant damage. Unlike stem injection and implantation, these soil treatments do not wound the tree. However, trees located close to bodies of water may best be treated through trunk injection with a systemic insecticide.

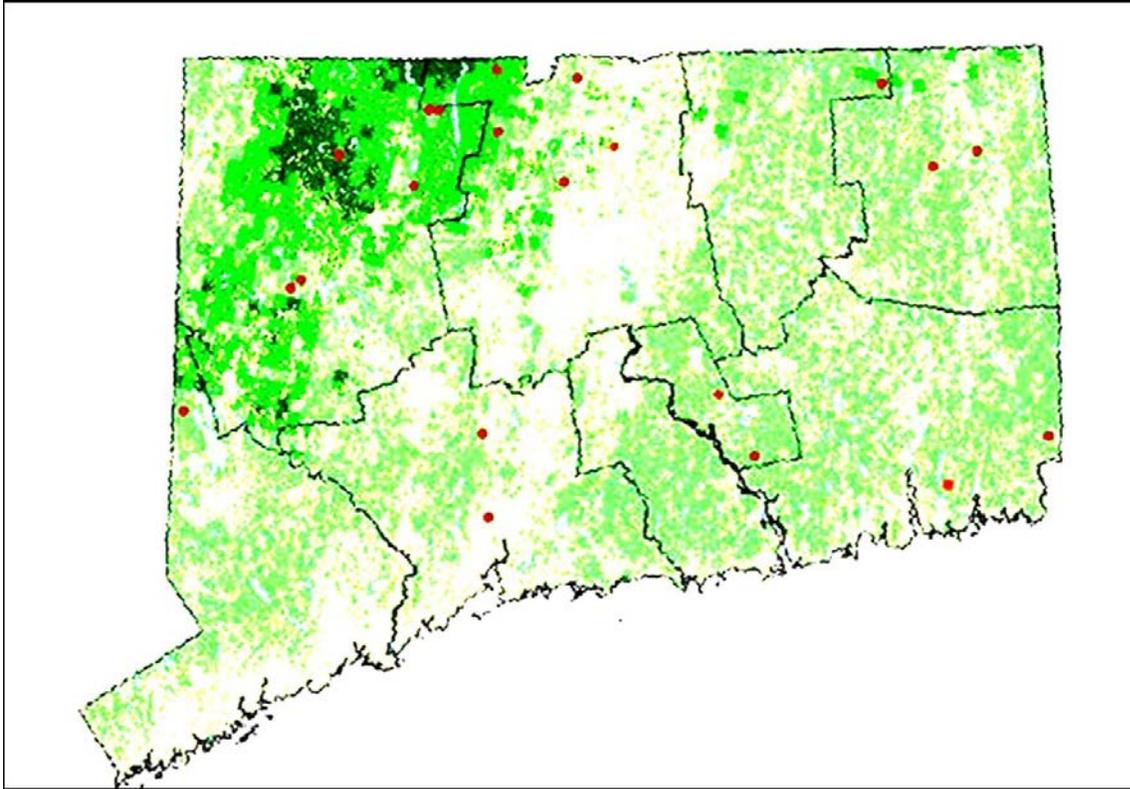
Evaluating the effectiveness of chemical controls: Unfortunately, the "wool" can persist on the twigs for several months after the adelgid has been killed. Furthermore, imidacloprid can take many months to show its full effects. Be patient following an imidacloprid application, but continue to evaluate wool routinely on an annual basis between November and March (see "How to Monitor the Pest" above). Reconsider applying systemic insecticides only once adelgid numbers begin to increase.

Biological Control Methods



Sasajiscymnus tsugae Sasaji and McClure. Photo by C. Cheah

Hope on the horizon: Several native insects, including beetles, flies, and lacewings, are occasional predators of the hemlock woolly adelgid in North America. Unfortunately, none of these has had a significant impact on adelgid populations or has shown much potential for biological control. Several predators from the native range of hemlock woolly adelgid in Asia and in the Northwest have been introduced to provide biological control. Among these, several small lady beetles (*Sasajiscymnus tsugae* and *Scymnus* spp.) and another predatory beetle *Laricobius nigrinus* have been introduced into the eastern United States. Both *S. tsugae* and *L. nigrinus* have established and are reproducing well, and may in time be able to keep adelgid populations low enough to make further insecticide applications unnecessary. The main predator introduced in Connecticut is the native predator of HWA in Japan, *Sasajiscymnus tsugae*, (= *Pseudoscymnus tsugae*), discovered by Hiroyuki Sasaji and Mark McClure in 1997. The first release in the USA occurred in Windsor, Connecticut in 1995. Over 176,000 of this species were reared at the Valley Laboratory, CAES, and released throughout Connecticut hemlock forests from 1995-2007. Annual hemlock recovery has been documented in 70% of hemlock forested sites in Connecticut 2005-2009 but concurrent infestations of another exotic pest, elongate hemlock scale, compromise full recovery.



S. tsugae release sites in Connecticut 1995-2007 (C. Cheah)