

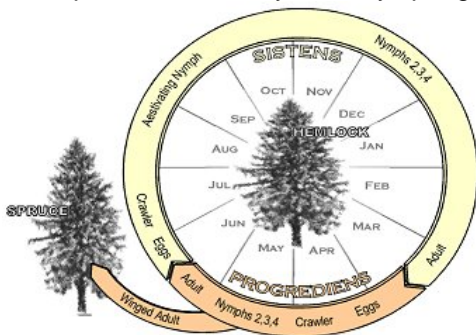
# Forest Health Fact Sheet

## Forest Tent Caterpillar

*Adelges tsugae*, the hemlock woolly adelgid, is a fluid-feeding insect that feeds on hemlock trees throughout eastern North America, including Pennsylvania. The egg sacs of these insects look like the tips of cotton swabs clinging to the undersides of hemlock branches.

Hemlock woolly adelgid was introduced from Asia into the Pacific Northwest in 1924. It was probably introduced into the northeastern US in the 1950's, and it was first discovered in Pennsylvania in 1967. This insect has been damaging hemlock ever since, and it is spreading. To date, 49 Counties in the eastern two-thirds of PA have been infested with this insect.

Hemlock woolly adelgid has two generations per year in Pennsylvania. All populations are made up of females that reproduce asexually. In early spring, overwintering females lay between 100 and 300 eggs in the woolly egg sacs beneath the branches. Mobile larvae, known as crawlers, emerge from the eggs in April or May to search for suitable feeding sites. Wind, birds and mammals often spread crawlers to nearby hemlocks. Once settled at the base of hemlock needles, crawlers become immobile nymphs which feed and mature into wingless or winged adult females by early summer. The winged form will die after searching for a suitable spruce tree that is not found in North America. The wingless form lays another 100 to 300 eggs on hemlock. Crawlers emerge from these eggs to search for suitable feeding sites. Once settled, the hemlock woolly adelgid becomes dormant until October or November, when it resumes development. Feeding continues throughout the winter and early spring.



Life Cycle, Courtesy of Vince D'Amico and Mike Montgomery

Eastern hemlock (Pennsylvania's state tree) and Carolina hemlocks (found further south in the Smokey Mountain sections of the Appalachians) are more susceptible to hemlock woolly adelgid damage than Asian and western hemlock trees due to feeding tolerance and predators that protect the latter species. Hemlock woolly adelgid sucks fluid from the base of hemlock needles. It may also inject toxins into the tree as it feeds, accelerating needle drop and branch dieback. Although some trees die within four years, trees often persist in a weakened state for many years. Hemlocks that have been affected by hemlock woolly adelgid often have a grayish-green appearance (hemlocks naturally have a shiny, dark green color).

Other factors can influence the impact of the hemlock woolly adelgid. Other insects, such as elongate hemlock scale, hemlock borer, and spittlebugs, which are also found on hemlock, can compound the impact of hemlock woolly adelgid. Drought and fungi, such as *Fabrella* or *Korfia tsugae* can weaken hemlock and cause it to become more susceptible to insect damage. Low winter temperatures, cold snaps (episodes of freezing and thawing), and heavy thunderstorms can reduce populations of the hemlock woolly adelgid. Particularly in the mountains, it is not uncommon to find hemlocks where the insect has been killed on the top third of the trees, where it's colder and windier, but survive on the bottom two-thirds. On the other hand, mild winters can result in sharp increases in hemlock woolly adelgid populations.

**PA DCNR uses integrated pest management (IPM)** principles to manage hemlock woolly adelgid. IPM relies on survey and monitoring of the insect and its hemlock host. It involves using a variety of management techniques, such as biological, chemical, cultural, and silvicultural control to reduce the populations to less damaging levels. The choice of control method will vary depending on the site and other circumstances of each situation. Unfortunately, eradication is not the objective, because hemlock woolly adelgid is already firmly established in our state.

**Survey and Monitoring** PA DCNR is currently attempting to map ecologically significant hemlock stands in our state, in order to detect new infestations, focus our control efforts and predict areas most vulnerable to hemlock woolly adelgid. We are using a variety of remote-sensing and ground-based techniques to accomplish this objective. Remote sensing technologies are also being evaluated for monitoring hemlock woolly adelgid. DCNR is cooperating with Rutgers to expand an algorithm developed for using Landsat imagery to detect changes in

hemlock health in NJ to PA. DCNR and USFS are working with cooperators to determine if hyperspectral images taken from helicopters can detect new infestations along the leading edge and in isolated patches.

**Biological control** is the release of natural enemies that attack the pest. Biological controls include predators, disease organisms (fungi, bacteria, and viruses), and parasitoids (predators eat their prey, and parasitoids reproduce in their victims). Unfortunately, there are no known parasitoids of the family Adelgidae, to which hemlock woolly adelgid belongs. Pennsylvania is a key participant in national efforts to use biological control towards the management of the hemlock woolly adelgid. Unlike chemical control, biological control is a long-term, permanent strategy to managing hemlock woolly adelgid throughout Pennsylvania. In spite of these benefits, biocontrol is NOT usually recommended for landowner use. In the case of beetles, the high cost (around \$3 each), large numbers of beetles required for control (thousands per site), the tendency of biocontrols to fly away from the initial release site, and the lengthy time (5-10 years) expected for noticeable results can make this method impractical. It is our hope that the biological control agents we release will, in time, protect hemlocks in ornamental situations as well as forests.

### Beetles to the Rescue

Biocontrol of hemlock woolly adelgid is used in forest situations, on vigorous trees with accessible lower branches that are infested with hemlock woolly adelgid. It is likely that PA DCNR will eventually establish several natural enemies that will work together to reduce the impact of hemlock woolly adelgid.



*Pseudoscymnus tsugae* (PT): PT is a pinhead-sized, specialized, black lady beetle discovered feeding on hemlock woolly adelgid in Japan in 1992. Having completed several years of successful tests in cooperation with the U. S. Forest Service, DCNR's Bureau of Forestry has embarked on a statewide PT release effort. PT only eats hemlock woolly adelgid, balsam woolly adelgid, and pine bark adelgid. Each larva eats about 500 eggs or 50 -100 immature adelgids, known as nymphs. PT females lay up to 300 eggs in March and April, during peak egg-laying of hemlock woolly adelgid. The beetles have a second generation in June around the same time as the second adelgid generation. Adult PT feed on dormant young adelgids during the summer. Releases of PT are focused on hemlocks along the leading edge of HWA infestation. 176,387 beetles have been

released at 50 sites in 23 counties. DCNR staff uses a plastic bat to beat branches over a white sheet to see if PT has established at sites in the years following release. This lady beetle should not be viewed as a cure-all, since its effectiveness is still in the testing stages. However, the data show some encouraging signs so far. To date, we have recovered 642 beetles. Adult recovery indicates overwintering success, and larval recovery indicates successful field reproduction.

The lady beetles are literally grown in lady beetle farms in Pennsylvania and New Jersey, and are used for testing in hemlock sites all over the eastern seaboard. In order to make the biocontrol program more affordable, Forest Pest Management has set up a cooperative agreement with New Jersey Department of Agriculture that involves sending tons of infested hemlock foliage a year to be used for rearing hemlock woolly adelgid. In return, NJDA provides us with a substantial percentage of their PT beetles each year.

An ironic problem with the lady beetles, unfortunately, is their voracious appetite for the hemlock woolly adelgid eggs. If they are not fed enough, they tend to not multiply as quickly and can fly off in search of better feeding grounds. However, the lady beetles have proven to be quite effective in the test sites at devouring the woolly adelgid, perhaps improving the future outlook for threatened hemlocks and reducing long-term pesticide use.

### More beetles



*Laricobius nigrinus* (LN): is a beetle that is native to the western North America where it preys on hemlock woolly adelgid on western hemlock. *Laricobius* beetles only feed on woolly adelgids. LN adults lay eggs in early spring on overwintering HWA nymphs. Larvae emerge and feed on HWA until they mature in spring, when they enter the soil to pupate. Adults remain dormant in the soil until fall. LN beetles prefer HWA to other adelgids, and it can only complete its development on this species. PA released 300 LN beetles at a site in Huntingdon County in December 2003, as part of a cooperative study with

Virginia Polytechnic Institute. More releases are planned in the eastern US over the next three years. Other lady beetles are also being tested for effectiveness against hemlock woolly adelgid in Connecticut and New Jersey. A leading candidate is the *Scymnus sinuanodulus* (SS) lady beetle from China. SS is yet another predator that feeds on woolly adelgid eggs. In addition to these, Connecticut is currently working with yet another type of Chinese lady beetle, *S. ningshangiensis*. Once laboratory testing is complete, DCNR's Bureau of Forestry may add one or more of these new beetles to the hemlock woolly adelgid arsenal.

### No, not that Lady beetle



Some folks who hear about DCNR's lady beetle releases are actually upset! They have had problems with another lady beetle, the **Asian Multicolored Lady Beetle**, which congregates on and in peoples' homes on sunny spring and fall days. Having the scientific name of *Harmonia axyridis* (HA), this Asian lady beetle is *huge* compared to the PT or *Scymnus* lady beetles-as big around as a pencil eraser-and is very colorful. Over one hundred PT beetles could hitch a ride on the back of one HA lady beetle! HA may be orange, brown, red, or yellow and could have black spots. It first was released by the U.S. Department of Agriculture in the 1920s to control aphids (another sucking insect) on agricultural crops. Once established, this beetle spread rapidly, until by the early '90s it could be found nearly everywhere. Attracted to warm, sheltered spots in the fall, HA prefers light-colored, sunlit houses as overwintering sites. Adults spend the

winter in attics, window wells, bedrooms, and between walls until spring, when they swarm out of the houses to breed and feed for the summer.

DCNR's Bureau of Forestry gets almost as many calls each year complaining about these big lady beetles as we do about gypsy moths and hemlock woolly adelgids. Our recommendation: vacuum them up and shake the bag outside. Also, seal up areas of your home that may allow them to get inside.

**Chemical control** Recent research has shown that an adelgid-killing chemical injected into tree boles or applied to the ground as a soil drench or soil injection may kill hemlock woolly adelgid, and prevent new established infestations for over a year. This has prompted PA DCNR to institute a chemical suppression program on public lands at 146 sites in the state. This type of control is restricted to large, high-value (ecological, historical, or aesthetic) trees. These trees may be too tall for biocontrol releases or for application of horticultural oils or soaps. Drawbacks of chemical control include high cost of treatment, temporary control, and secondary outbreaks of spider mites. It is our hope that chemical control can be used as a "stop gap" measure to stave the hemlock woolly adelgid off and give biological control time to take effect.

**Silvicultural control** The DCNR is attempting to restore areas that have been impacted by the hemlock woolly adelgid. This sometimes involves replanting with native species, such as eastern white pine, that are similar ecologically, but are not affected by hemlock woolly adelgid.

**Host Resistance** The DCNR hopes to increase our cooperation with researchers who are attempting to identify individual eastern hemlock trees that seem to be tolerant of hemlock woolly adelgid feeding. The seed source from these individuals could be used in regeneration programs. Other researchers are currently attempting to hybridize eastern hemlock with a more tolerant or resistant host. Unfortunately attempts to hybridize eastern hemlock with three Asian species have not been successful. Also, attempts to hybridize eastern hemlock with the morphologically similar western hemlock or mountain hemlock have been unsuccessful because these species are not well adapted to the east coast climate.

### What can landowners do about Hemlock Woolly Adelgid?

**Chemical Control Options:** What can be done depends on the value of the trees you wish to protect. Individual ornamental trees, small trees, or even several larger hemlocks in a landscape environment can be treated with insecticides. There are several spray materials registered for application to hemlocks by ground-spraying equipment and by injection techniques. Some sprays are relatively safe to the environment, such as horticultural oils and insecticidal soaps, and others are more toxic. Oils and soaps work by suffocating the adelgid. The best time to treat is either in spring and early summer when crawlers are present, or in fall when adults break dormancy. Sprays must completely drench the needles and twigs of the entire tree to be effective, therefore this method is only recommended for trees that are 30 feet in height or less. Applications of special insecticides can

be made to the tree trunk or to the soil around the tree roots. This way the tree actually moves the chemicals up to the twigs and needles where the adelgids are feeding.

Some insecticides registered for control of hemlock woolly adelgid are labeled for homeowner use. Other insecticides are restricted for use only by licensed certified pesticide applicators. Check with your county cooperative extension agent or local pest management specialist for more information, and always **read and follow the pesticide label directions**.

Both commercial spraying and injection are expensive and results with either method vary greatly depending on the quality of the equipment used, the experience of the applicator, and treatment timing (adelgid development, wind, rain, soil moisture, etc.). Call several reputable tree service companies for pricing, ask for references, and be sure to check with local clients they have served.

Forest landowners with dozens or hundreds of infested hemlocks have very few options: inject, harvest, or wait-and-see. Most Pennsylvania landowners are watching and hoping that their hemlocks survive. Some are selling their commercial hemlock timber, knowing that dead hemlock degrades very rapidly.

#### **Tips for maintaining hemlocks and avoiding or decreasing hemlock woolly adelgid infestations:**

- Do not disturb shallow roots with heavy equipment or by digging or tilling;
- Keep hemlocks well-watered (apply about 1 inch / week around drip line) during droughts;
- Do not place a bird feeder amongst your hemlock trees in infested areas of the state. Birds can transport hemlock woolly adelgid crawlers to your trees.
- Remove large, heavily infested trees that can act as reservoirs for uninfested trees.
- Clip and burn heavily infested hemlock branches. If you can catch the infestation early enough, this may significantly slow the insect's spread and build-up.
- Do not change the grade (slope of the land) near hemlocks, such as excavations or tree wells;
- Do not change water runoff patterns around hemlocks. Simply moving a downspout or installing a patio can stress these trees;
- Do NOT fertilize trees infested with hemlock woolly adelgid with nitrogen. Researchers have found five times as many hemlock woolly adelgids on nitrogen-fertilized trees, regardless of whether fertilization occurred at infestation or six months later. Once an infestation has been eradicated, fertilize hemlocks lightly with a balanced fertilizer, such as 5-10-5, late in the fall.
- When applying lime or weed killers to lawn areas, keep them at least 10 feet away from the drip line (tips of outermost branches) of hemlock trees.