Update

FOREST HEALTH TECHNOLOGY
ENTERPRISE TEAM UPDATE

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Biocontrols in Hemlock Forests:

Need and Response

Beetles and mites from Japan, China, and the U.S. are chomping up this non-native pest.

Since the 1920s, a small Asian insect, the hemlock woolly adelgid (HWA), has been marching east and south across the United States, inflicting increasing damage to wild and ornamental hemlock along the way. Several control methods have been used to arrest the pest's advance and minimize the damage it causes. The results have been mixed, but one of the most promising methods is biocontrol.

Biocontrol focuses on the development of small-scale agents—pathogens, parasites, and predators—which can be cultivated and released *en masse* against the pests. There are many factors to consider when searching for such agents, but a few generalities apply. The agents must be relatively easy to culture or reproduce, target-specific, and self-sustaining. Plus, their effects must be confined to small geographic areas and prey bases.

Moving from the general to the specific: Candidates for HWA biocontrol must meet some strict criteria. Foremost, they must prefer HWA to other food sources. As a practical limitation, the agent species should be relatively easy to raise in a laboratory environment so populations can be produced for release into HWA-infested areas. Finally, to assure populations are self-renewing, they must be active during HWA emergence, and must thrive in the Eastern United States.

Some native North American insects and pathogens meet all these criteria and attack HWA. (A beetle from the American West that feeds on HWA is being studied.) However, tests have shown they do not attack HWA aggressively enough to control populations. In the absence of suitable, native biocontrol agents, HWA predators from the pest's Asian host countries have been identified and now form a "pool" of biocontrol candidates. That pool includes a predatory mite and beetle from Japan, and three species of beetles from China. All the Asian beetles in the pool (coccinellid or lady beetles) feed on HWA eggs; the Japanese mite feeds on the sac surrounding the eggs, leaving other insects to feed on the eggs.

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Facts:

- *Biocontrol focuses on small scale pathogens, parasites and predators*
- *Adults and larvae of the Japanese beetles (Pseudo-scymnus tsugae) feed readily on all stages of HWA*
- *Short-term HWA suppression ranges from 47% to 87%*
- *Contact--**Dick Reardon** (FHTET-Morgantown) (304) 285-1566*
  rreardon@fs.fed.us

What's in the Update. . .

Hemlock Woolly Adelgid:
A Primer

The key to successful biocontol of this pest lies in understanding how it moves, multiplies, and feeds. It sucks the life out of its hemlock host and can tolerate extreme changes in climate.

Facts:

- *Eastern hemlocks are at very high risk.*
- *Traditional control methods are not effective on a large scale.*
- *Multiple HWA generations within a year place extra pressure on host populations.*
- *Contact:* ***Dick Reardon*** *(FHTET, Morgantown) (304) 285-1566* rreardon@fs.fed.us

Hemlock woolly adelgid (*Adelges tsugae* Annand) originated in Asia and was inadvertently introduced into Western North America in the 1920s. (Adult HWA lay their eggs in a protective "woolly" egg sac on hemlock trees–hence the name.) Fortunately, the western hemlock species has a high natural resistance to the pest, so damage has been minimal.

Beginning in the 1950s, HWA began to spread into the Eastern United States, and unfortunately, the eastern and ornamental hemlocks proved less resistant to the pest than the western hemlock. In effect, eastern hemlocks are at very high risk to HWA attack. Dieback among this plant species threatens to change the ecological makeup of forests throughout the Northeast and mid-Atlantic states.

Eastern hemlock and other less-common hemlock species are important components for wildlife, plants, fish, and recreation in eastern forests. They extend from Georgia and Alabama to the Maritime provinces of Canada, and from the Eastern Seaboard to Western Michigan and Wisconsin. Ten states within this range have been infested by HWA, and hemlock in these states show little or no resistance to HWA. Furthermore, because the pest can tolerate extreme temperatures and conditions, there is little prospect that geographic features or conditions will provide a natural barrier against its continued spread.

Adult HWA lay eggs on the tree needles. Hatching HWA crawlers and nymphs attack the trees by sucking food reserves from the vascular system at the base of those needles, causing them to dry. This leads to defoliation, tree stress, and eventually death. Defoliation begins in the lower branches and moves up the tree. Trees can die within four years. Multiple HWA generations within a year place extra pressure on host populations. Wind and contact with birds and mammals (including humans) can help spread HWA between infection points.

Traditional control methods, such as spraying individual trees, injecting or otherwise introducing systemic insecticides, pruning dead and dying branches to prevent spread, and watering to prevent susceptibility due to stress, work well against HWA on a small scale--meaning in residential, recreation, and accessible park areas. Unfortunately, these methods are not practical on a large scale--meaning in forested or on inaccessible sites.

Furthermore, because of their impacts on aquatic life, it is difficult to justify the use of pesticides in riparian zones, where hemlock are an important component species. Hence, biocontrol is the preferred, large-scale management option.

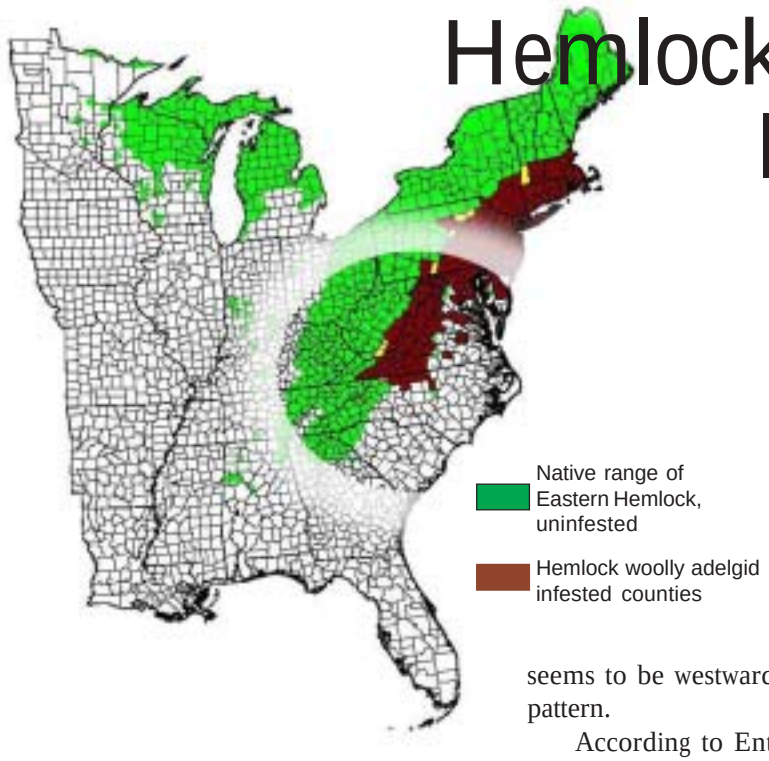
Japanese beetles (Pseudoscymnus tsugae) *feeding on Hemlock woolly adelgid larvae in egg sacs. Note the comparative size between the beetle and the hemlock needles.*

More about Hemlock Woolly Adelgid, pages 1, 3, 4, 7

Hemlock Woolly Adelgid In The Southeast

Spotlight on Virginia and North Carolina

This non-native, invasive pest, now common to the Northeast, is hitchhiking south in a hurry



Hemlock woolly adelgid is concentrated in, but not confined to, the Northeast, but has spread south as far as North Carolina.

North Carolina

Heading into 2001, HWA infestations were present in eleven of North Carolina's 100 counties, with new infestations having been added at a rate of one to two counties per year. Notably, the infested counties had been geographically removed from the main, native hemlock populations in the mountains, and the hemlock being attacked was primarily ornamental, not wild.

However, that situation changed dramatically beginning in early spring, 2001. Since then, HWA outbreaks have been detected in seven previously HWA-free counties, and all of those infestations are within the main hemlock range. Furthermore, the movement seems to be westward in a patchwork pattern.

According to Entomologist **Rusty Rhea (FHP-Southern Region 8)** the patchwork pattern of infestations most likely resulted from infested hemlock material that had been carried into an area, rather than through the natural migration of the pest.

"It is alarming to note that HWA has moved over 100 miles from its previously known area to an area just ten miles outside the Great Smoky Mountains National Park and the Joyce Kilmer Wilderness Area," says **Rhea**.

Rhea says it would be very difficult to develop an accurate assessment for actual acreage infested by HWA. However, he's certain HWA has infested less than 2% of North Carolina's hemlock forests.

Three of the seven newly infested counties have HWA populations of a size that indicates the pest has been in place for at least four years. The remaining four counties have smaller HWA populations, indicating they are just gaining a foothold.

Since 1999, the Forest Service has released the HWA biocontrol agent *Pseudoscymnus tsugae* in three areas: A state park (1999), the Nantahala National Forest (2001), and the Blue Ridge Parkway National Park (2001). Results show promise, and more releases are planned.

As well, chemical controls have been used on several smaller, newer infestations, and results have been good.

Virginia

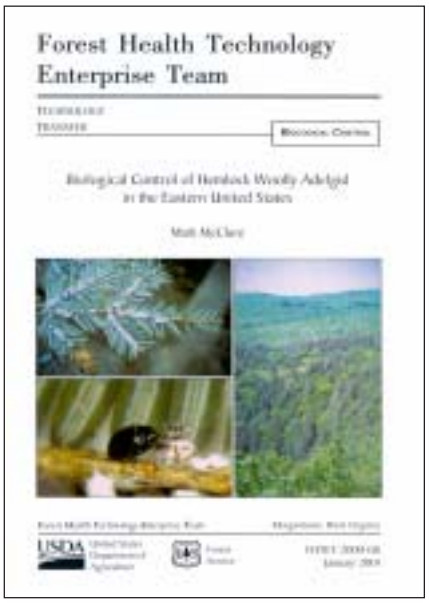
Drought and HWA seemed to have teamed up against hemlock in Virginia. Mortality has been quite high.

Both chemical and biocontrol agents have been applied. Chemicals have been used on many ornamental hemlocks with positive results. The Forest Service released the HWA biontrol agent *P. tsugae* in three locations: Two in the Jefferson National Forest, and one on private land.

Rhea says that, while it is too early to assess efficacy for biocontrol in these areas, the beetle has established itself well and more beetles will be released as they become available.

More about Hemlock Woolly Adelgid, pages 1, 2, 4, 7

Hemlock Woolly Adelgid Publications



The FHTET-Morgantown office has released two new publications dealing with the eastern hemlock pest, hemlock woolly adelgid (HWA): FHTET 2001-03, *Hemlock Woolly Adelgid,* (**Mark S. McClure, Scott M. Salom**, and **Kathleen S. Shields**), and FHTET 2000-08, *Hemlock Woolly Adelgid in the Eastern United States* (**Mark McClure**).

Together, these publications give a thorough overview of the nature and effect of this invasive species, and the damage-control efforts being used against it.

Hemlock Woolly Adelgid
Damage and Death in the Hemlock Forests

Hemlock Woolly Adelgid is a publication in the *Technologoy Transfer: Non-native Pest* series published by the Forest Health Technology Enterprise Team. This ten-page pamphlet is well illustrated and is quick and easy to read. It presents HWA biology, extent, and damage sustained by hemlocks in the Eastern United States, plus an overview of the life cycle of HWA and the damage it inflicts on hemlock trees. It provides details, techniques, and options for suppressing the pest and protecting individual trees.

Biological Control of Hemlock Woolly Adelgid in The Eastern United States
Testing Biocontrol Agents

This 14-page booklet deals with biocontrol research into combating the spread and intensity of HWA populations, and focuses on the use of biological agents to curb HWA populations in areas where they have spread. It details the process for identifying and selecting HWA biocontrol agents, their release into hemlock forests, and means for monitoring and evaluating their impact, thereafter.

(For more details on this publication, see FHTET Update, Spring/Summer 2001, page 10.)

Biocontrols in Hemlock Forests: Need and Response

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The Japanese beetle (*Pseudoscymnus tsugae*) is the most promising of all candidates and has become the focus for testing, release, and evaluation. Although its long-term effects in the U.S. have not been definitively established, in its native Japan, *P. tsugae* accounts for between 86% and 99% HWA mortality in infested stands. The high mortality is due primarily to the fact that both the beetle's adult and larval stages feed readily on all stages of HWA development.

In addition to its appetite for HWA, *P. tsugae* is adapted to a wide range of climatic conditions, and because it can produce at least three generations per year, it is well-suited to laboratory reproduction.

The Forest Service released *P. tsugae* for the first time in 1995 in forests in Connecticut, New Jersey, and Virginia. Release results have been good: Short-term suppression on known HWA populations ranges between 47% and 87%. In addition, *P. tsugae* has reached population levels at the release sites that make it practicable to capture individual beetles for dispersal on other HWA-infested stands.

Although preliminary results are promising, long-term monitoring and evaluation are necessary to determine the Japanese beetle's ultimate role in curbing HWA populations. It's likely that a combination of predators will be needed to minimize HWA damage and control its spread.

More about Hemlock Woolly Adelgid, pages 1 - 4, 7

The Red Turpentine Beetle Meets Scratch-and-Sniff:
Pheromone applications from the perfume industry

Madison Avenue marketing technology is helping to confound and control pine pests.

A spin-off of the scratch-and-sniff technology used by perfume manufacturers to scent advertising inserts ("blow-ins") in glossy magazines and *attract* customers, is being evaluated as a possible delivery system for verbenone, a pheromone used as a *repellant* against pine pests such as moths and beetles.

The technology, called Micro-encapsulation (MEC), is a sprayable water suspension of 25-micron-diameter polymer beads containing verbenone, which repels or inhibits pine beetles, such as the southern pine beetle and red turpentine beetle (RTB). Verbenone is the first semiochemical identified for RTB.

Field trials show promise: Results indicate MEC reduced by 89% the number of RTB (*Dendroctonus valens*) caught in a late-season trap-catch test in California.

RTB attacks all species of pines in North America and recently was found to have caused significant mortality in a thinned ponderosa pine plantation near Pondosa, in Northern California.

The application of MEC is an attractive alternative to conventional control methods. Although conventional insecticide applications to the basal portions of tree boles are known to reduce RTB damage, MEC is a more environmentally benign method of control.

MEC tests were conducted on a California plantation, and were part of an on-going, cooperative project with **Nancy G. Rappaport**, (Pacific Southwest Research Station, Berkeley CA), **Donald R. Owen** (California Department of Forestry, Redding, CA), and **John D. Stein** (FHTET, Morgantown). The tests' intent was to measure the response rates of red turpentine beetle to MEC, and another proven-effective verbenone delivery system, called the bubblecap.

Thirty surrogate trees made from cardboard cylinders were placed on a grid, 20 meters apart. Surrogates, rather than live trees, were used in order to:

- Minimize variance.
- Avoid tree mortality.
- Provide a consistent physical release of the microencapsulated formulations. (The cardboard cylinders were superior in this respect to real trees.)
- Avoid bias in beetle response to visual stimuli.

The cylinders were used in all treatments. Each cylinder was randomly assigned either no treatment (control), or a treatment of either MEC or the bubblecap. Each treated cylinder received ten replicates of the treatment. For MEC treatments, a hand-held garden sprayer was used to spray the full length of each cylinder to run-off.

(A preliminary mid-season test of the verbenone bubblecap treatment was conducted before the MEC formulation was available. That test used the experimental design described above, except that treatments destined to receive MEC applications were used as an extra set of controls.)

To challenge the repellency of the two verbenone release systems, an 8-funnel Lindgren trap baited with a *D. valens* kairomone lure was suspended just above the ground next to each cylinder. To avoid confounding beetle responses to tree-shaped visual cues, untreated cylinders were placed adjacent to the Lindgren traps for both the controls and the verbenone-baited treatments.

Analysis

Analysis of the results indicate verbenone did interrupt the RTB response to the host kairomone lure in both the MEC and bubblecap tests.

In the mid-season test using just the bubblecap treatment, verbenone reduced trap catch by 97.4%, from a mean of 3.8 beetles/trap to 0.1 beetles/

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Facts:

- *Microencapsulated verbenone offers promise on sites where Bubblecaps cannot be used.*
- *Verbenone appears benign toward non-target insects.*
- *Evidence suggests verbenone would not trigger outbreaks by secondary borers.*
- *Contact--**Nancy G. Rappaport** (PSW Research Station - Berkeley CA)* (510)-559-6474 nrappaport@fs.fed.us

Scratch-and-Sniff, continued from page 5

trap.

In the late season test, both the MEC and bubblecap release systems trapped significantly fewer RTB than did the control, suggesting that either system might protect plantation trees against RTB attack. Using both formulations, trap catch was reduced 82.1% by the bubblecap and 89.3% by the MEC. These findings are important because there is a growing interest in, and need for, alternative, environmentally friendlier, yet effective new methods of control—especially biocontrol with EPA-registered biopesticides.

Each technology--bubblecap and MEC--has unique advantages for pest management, which depend on land allocation, human exposure, and management objectives. For example, the bubblecap is likely to be especially valuable in situations wherein transporting liquids poses problems, whereas MEC shows promise for aerial application on plantations and spot treatments in campgrounds and parks.

For non-target insects, verbenone functioned mostly as a repellent. In the mid-season test, verbenone reduced trap catch of cerambycids, buprestids, elaterids, and clerids. In the late-season test using both bubblecaps and MEC, there were no significant differences in the numbers of trapped, non-target insects.

It is noteworthy that verbenone repelled all of the beetle taxa tallied in this evaluation, including representatives from five Coleopteran families, and the secondary buprestid, cerambycid borers, and clerids.

Clerids are among the most important natural enemies of *Dendroctonus* bark beetles, but they are generalist predators that prey on many other bark beetle species. That verbenone repels clerids might indicate that operationally deployed verbenone could help conserve this natural enemy.

EVENTS

First International Symposium on Biological Control of Arthropods, Jan 13-18, Honolulu, HI. Contact: Roy Vandriesche (413) 545-1061, vandries@fnr.umass.edu2

Thirteenth Annual USDA Interagency Research Forum, January 15-18, Annapolis, MD. Contact: Michael McManus (203) 230-4321; mlmcmanus@fs.fed.us; http://www.fs.fed.us/ne/morganotown/4557/forum2002

Third Annual Forest Vegetation Management Conference: Recommending Success, January 22 - 24 January, Redding, CA. Program contact: Keith Greenwood (530) 873-0530; kgreenwood@spi-ind.com. Registration contact: Sherry Cooper (530) 224-4902; fax (530) 224-4904; shcooper@ucdavis.edu.

Second Hemlock Woolly Adelgid Symposium, Feb 5-7, New Brunswick, NJ. Contact: Jim Lashomb (732) 932-9795; lashomb@rci.rutgers.edu

Second Forest Vegetation Simulator (FVS) User's Conference, Feb. 12 – 14, Fort Collins, CO. Call for papers is out. http://www.fs.fed.us/fmsc/fvs/fvs_conference2.htm

Ninth Biennial Remote Sensing Applications Conference (RS 2002), April 8 – 13, San Diego, CA. Call for papers is out. http://www.fs.fed.us/eng/rsac/rs2002/

Western Forest Insect Work Conference, April 23 – 25, Whitefish, MT. Contact Ken Gibson (406) 329-3278, kgibson@fs.fed.us or Sandy Kegley (208) 765-7355, skegley@fs.fed.us.

Fourth International Conference on Forest Vegetation Management: Technical, Environmental and Economic Challenges of Forest Vegetation Management, June 17 - 21. Nancy, France. Contact: Henri Frochot, fax (33) 3 83 39 40 34; ifvmc4@nancy.inra.fr; http://www.ifvmc.org.

Methodology of Forest Insect and Disease Survey in Central Europe, August 2002 (dates TBA), Krakow, Poland. Contact: Michael McManus (203) 230-4321; mlmcmanus@fs.fed.us.

Fiftieth Annual Meeting of the Western International Forest Disease Work Conference, September 2002 (dates TBA), Victoria, BC, Canada. Contact John Muir, fax 250-387-2136; john.muir@gems1.gov.bc.ca.

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The Web Corner

Forestryimages.org

http://www.forestryimages.org

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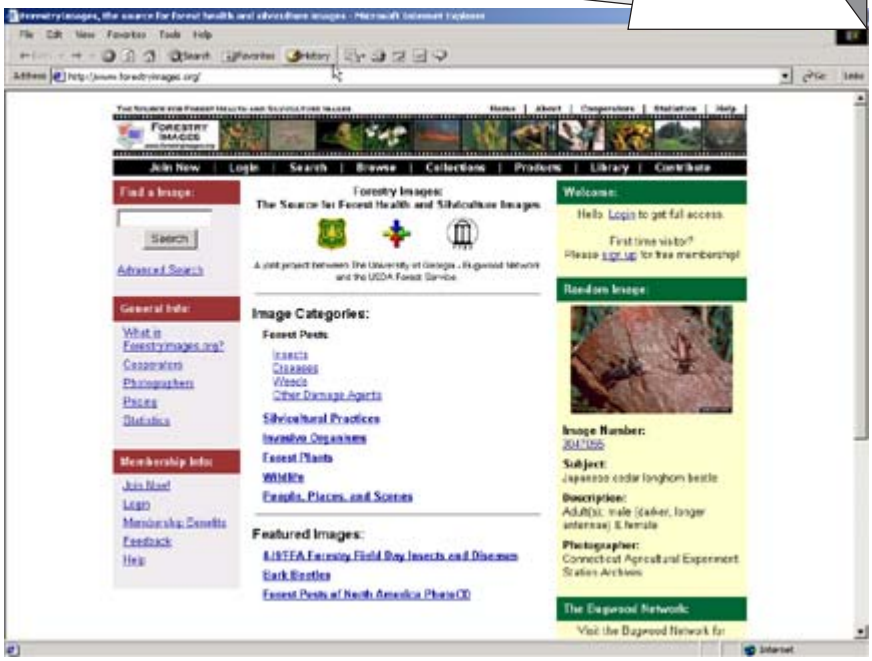
There are thousands of *jpeg* images; each one can be displayed at three separate pixel resolutions, from 128x192 to 512x768. Members can access two additional, higher resolutions of each image and can create custom image libraries. Membership is free and registration takes about 30 seconds.



Hemlock Woolly Adelgid Websites

http://ael.er.usgs.gov/groups/gis/hemlock/index.html Research on decline of eastern hemlock (*Tsuga canadensis*) conducted by the Aquatic Ecology Laboratory, Kearneysville, WV. Pages describe research conducted by the USGS, Biological Resources Division, Leetown Science Center on potential biodiversity losses to stream communities of Delaware Water Gap National Recreation Area (DEWA) due to hemlock woolly adelgid (*Adelges tsugae*). This project concluded in 1998.

http://www.invasivespecies.gov/profiles/hemlockwa.shtml Excellent resource. Very comprehensive collection of links to internet sites with research, papers, presentations, and illustrations on HWA. Maintained by the National Biological Information Infrastructure.

http://www.state.nj.us/agriculture/plant/hwa%202000.PDF PDF presentation of 2000 Annual Report, New Jersey Department of Agriculture: The Effect of HWA in Natural Hemlock Stands (requires Adobe Acrobat Reader.)

http://www2.champaign.isa-arbor.com/PHC-PM/adelgid.html Managing Hemlock Woolly Adelgid in Ornamental Landscapes, Mark S. McClure, Connecticut Agricultural Experiment Station.

http://www.cce.cornell.edu/suffolk/grownet/tree-insect/hemwool.html Comprehensive Website on HWA maintained by Cornell Cooperative Extension, Cornell University, Ithaca, NY.

More about Hemlock Woolly Adelgid, pages 1 - 4