BIOLOGICAL CONTROL OF HWA

Japanese Natural Enemy: Mark McClure's team at the CT Ag Experiment Station are excited about a Japanese coccinellid (*Pseudoscymnus tsugae*). Their studies show it possesses important attributes of a successful biocontrol agent:

- its life cycle is well synchronized with HWA;
- beetles move from release trees to adjacent trees indicating they will spread in infested forests;
- beetles survived one of Connecticut's most severe winters;
- it is developing, reproducing and increasing its numbers in hemlock forests;

The result so far: HWA was far less numerous on branches exposed to these beetles compared to branches where the beetles were excluded suggesting that it significantly reduced HWA abundance. These findings are encouraging but more studies are needed to ensure that *P. tsugae* will merit the resources needed to mass rear them for release throughout the infested area.

Mark McClure (860) 688-3647

Biological Control Workshop: Two grants will support biological control against exotic forest pests in the Southern Appalachian Man and the Biosphere (SAMAB) region. Cooperating agencies include National Biological Service, SAMAB, The Nature Conservancy and the University of Tennessee. The workshop goals are: identify exotic pests affecting forests in the SAMAB region; rank them according to their threat to the resource and the potential utility of biological control; and choose highest priority pests for further action. The workshop will take place in Asheville, NC on September 26-27, 1996.

Charles Parker (423) 436-1704.

Chinese Natural Enemies - A shipment of coccinellids and chamaemyids received in June are in culture at the USDA Forest Service Quarantine Laboratory at Ansonia, CT. The most promising species are *Scymnus camptodromus* and *S. sinnaunodulus*. They are four times larger than *Pseudoscymnus tsugae* and are the most abundant HWA predators in China. Observations in quarantine indicate that adults feed on all HWA life stages. Another shipment of HWA natural enemies from China is expected this fall. Mike Montgomery (203) 230-4331.

Taiwanese Natural Enemies: A May 1996 trip to Taiwan by Mike Montgomery had two objectives: 1) to investigate *Lymantria xylina* and other Lymantriidae that could become pests in the USA; and 2) to collect HWA natural enemies. (A previous visit had obtained a new *Laricobius* species, a derodontid beetle.) Unfortunately a typhoon, five days of torrential rain and an earthquake limited his success. Mike did find a few coccinellid predators including a *Pseudoscymnus* species (not tsugae) and chrysopid and
syrphid larvae. Hopefully, colleagues in Taiwan will collect more specimens to ship next spring. **Mike Montgomery** (203) 230-4331.

**Cold Hardiness:** Scientists at the Entomology Research Laboratory, University of VT, in cooperation with state forest health specialists in ME, MA, VT and State & Private Forestry in Durham NH have completed the first year of a two year study to see if overwintering populations of hemlock woolly adelgid (HWA) can survive in colder regions of New England. Field collected HWA were subjected to below freezing temperatures for different periods of time. This carefully controlled series of experiments should help answer basic questions such as "Will low winter temperatures limit the spread of HWA?" Bruce Parker (802) 656-5440.

**Predator Feeding Preferences:** The feeding behavior of *Scymnus suturalis*, *Harmonia axyridis*, *Laricobius rubidus* and *L. nigrihus* was investigated in the laboratory. Feeding rates and choice tests were conducted with several prey items. *H. axyridis* fed on adelgids, aphids, mirids, predatory diptera, and larvae of S. suturalis and preferred aphids over adelgids. The three other predators preferred adelgids and fed minimally on other prey items. *S. suturalis* seems to prefer pine foliage to hemlock foliage. **Mike Montgomery** (203) 230-4331.

**Call for Proposals:** From 1993 to 1995, the National Center of Forest Health Management provided technical and financial support to various state, university and federal organizations involved in research, development, and application efforts for HWA (Table 1). In May 1995, the Forest Health Technology Enterprise Team (FHTET) was created with field offices in Davis, CA; Fort Collins, CO; and Morgantown, WV (National Center of Forest Health Management). The FHTET- Morgantown is focusing efforts on the development of biological controls for HWA. The FHTET-Morgantown has requested proposals dealing with biological control of HWA and will fund several in addition to the efforts ongoing with Dr. Mark McClure at the Connecticut Agricultural Experiment Station. **Dick Reardon** (304) 285-1566.

**Finch Pruyn & Co.:** This pulp and paper company is located in Glens Falls, NewYork and is a major user of eastern hemlock in their species mix. Although, HWA has had little impact within their procurement area, they have been a leader in finding practical management alternatives. Their commitment has supported biological control and tree resistance research. **Roger Dziengeleski** (518) 793-2541 ext 5353.

**ECOSYSTEM IMPACTS**

A frequently asked question is "How will uninfected forests change after HWA arrives?" A new study is examining the community and ecosystem-level consequences of HWA invasion in New England's hemlock forests by relating changes in ecosystem-level variables such as soil pH and nitrogen mineralization to changes in community-level variables such as hemlock mortality and regeneration of different species. This study will test a theoretical classification scheme designed to predict the impacts of introduced species on community
and ecosystem dynamics in their new habitats. The six study sites range in HWA induced mortality from 0% to nearly 100%. The sites are located in CT and MA. Jen Jenkins (603) 862-2264 or via email at jen.jenkins@unh.edu

**NJ Impacts:** In 1988 the NJ Dept of Agriculture established 11 study plots hemlock stands to evaluate the impact and biology of HWA. At that time, some plots were uninfested while others were lightly to heavily infested. Crown ratings were added in 1994. Conclusions: 1) no beneficial insects were found impacting HWA during a two year search; 2) tree mortality became evident in 1992; and 3) plots that were heavily infested at the beginning of the study are now declining rapidly and tree mortality is averaging 58%. Bob Chianese (609) 530-4192.

**Forest Impacts:** In 1995, David Orwig and David Foster of Harvard Forest in Petersham Massachusetts began a study to evaluate HWA's impact at the stand, landscape and regional scale in south-central Connecticut. Permanent plots established in eight hemlock stands already exhibit a wide range of hemlock damage and mortality (up to 95% hemlock mortality). The initial vegetation response to hemlock canopy gaps has been a dramatic increase in black birch seedlings. They are currently examining tree cores to determine age-structure and developmental history of these forests. At the landscape level, they are mapping the pre-HWA hemlock distribution throughout the central core of CT from Long Island, NY to the MA border. This information combined with physiographic features will help determine the factors controlling HWA distribution and spread. Dave Orwig (508) 724-3302 ext. 250 or via email at Orwig@fas.harvard.edu

**Impact Plots:** In 1993 the Delaware Water Gap, West Virginia Dept. of Agriculture, Pennsylvania Dept. of Environmental Resources and FHP Morgantown Field Office established a network of plots to monitor changes in hemlock health using FHM Crown Rating methods. Baseline "profiles" of crown conditions are currently being analyzed and correlated to site conditions. Monitoring will continue to follow HWA infestations to evaluate differences in tree response and if recovery is possible. Brad Onken (304) 285-1546 or via email at bonken@mserv.fsl.wvnet.edu

**Ecosystem Biodiversity:** The National Park Service and National Biological Service have begun landscape level studies of hemlock ecosystem biodiversity at the Delaware Water Gap National Recreation Area and Shenandoah National Park. Previous ecological studies were limited to two or three hemlock stands in each park and did not include stream ecology. In contrast, the new initiative will include as many as 40 stream study sites at the Water Gap. The initiative's goals are: 1) determine the contribution of hemlock dominated forests to landscape level diversity; 2) identify environmental correlates of hemlock occurrence and mortality; and 3) predict and measure the effects of hemlock decline and mortality on ecosystem structure, function and diversity. Carolyn Mahan (814) 863-1904 or via email at cgm2@psuvm.psu.edu
SATELLITE IMAGERY

This project developed a method to classify hemlock health at the landscape level using satellite imagery. Comparing 1985 (prior to HWA infestation) and 1995 images using various vegetation indices allowed us to classify each transformed image into four hemlock health levels. A field crew used the USFS Crown Condition Rating Guide to ground truth the images. Initial results indicate an overall classification accuracy above 80%. Next we will apply the best vegetation index to earlier images to detect change in health over space and time. These patterns will be correlated with landscape/environmental features. Plots are being established within the four classes to look at biotic and abiotic factors that contribute to hemlock decline and HWA distribution and abundance.

Kathleen Shields (203) 230-4320.

Landsat: Rutgers University and the NJ Bureau of Forest Management are using Landsat TM satellite imagery to detect, quantify and map hemlock forest health in New Jersey. Using change detection techniques (Vegetative Index Difference) and methods developed in a pilot test, they are mapping hemlock decline throughout the state. George Koeck is collecting field data and conducting aerial surveys to improve base maps and verify accuracy. This work has helped quantify the extent and condition of hemlock in New Jersey and these methods are applicable elsewhere with minor adjustments.

Denise Royle (908) 932-1582 or via email at royle@ocean.rutgers.edu

PUBLICATIONS AND MEETINGS

Review Proceedings: The first HWA review was held in Charlottesville, VA on October 12, 1995. The newly available proceedings were edited by Scott Salom, Tim Tigner and Dick Reardon and published by the Forest Health Technology Enterprise Team located in Morgantown, WV. It includes summaries of fourteen presentations given at the review and is an excellent reference for managers, researchers and forest health specialists. Lisa Cress (304) 285-1563.

Hemlock at Risk Video: Forest Health Unit, Southern Region, in cooperation with the Northeastern Area's Forest Health Protection, recently released a 13 minute video on hemlock and the HWA. Designed to raise awareness about HWA and hemlock's importance in eastern forest ecosystems, initial reviews have been excellent. It is equally useful to land managers, forest health specialists and natural resources educators. If you would like a copy, contact James Rhea (704) 2574314 or Brad Onken (304) 285-1546.

New Publication: Scott Salom and Mark McClure will prepare a color brochure that will be published with support from the Forest Health Technology Enterprise Team (FHTET). A draft copy is anticipated this December. The content and format will be similar to the USDA Forest Insect and Disease Leaflets (FIDL). Dick Reardon (304) 285-1546.

Best Management Practices (BMP): Three publications in progress describe BMPs to address desired fixture condition (expectations, interests and values) for landowners and
forest managers. *Hemlock: A Special Resource* describes the social values of a hemlock forest. It's intended to raise landowner awareness and commitment to a management plan. *Hemlock Ecosystem Restoration Practices* describes ways to restore function and value to declining hemlock ecosystems. It includes methods to restore and enhance habitat values associated with people, wildlife, fisheries, and flora/fauna of special concern. *Ecosystem Management in the Lower Connecticut River Valley: Impact of HWA on Associated Ecosystem,* revises Beth Lapin's original White Paper and includes a best management practices matrix. **Tom ODell (860) 399-7912.**

**OTHER ACTIVITIES OF INTEREST**

**Chemical Control:** Although the use of chemical insecticides is often limited to ornamental settings, it remains the most effective way to protect hemlock trees. Insecticidal soaps and horticultural oils are effective and remain the most commonly used materials. Hemlocks can remain in good condition if treatment begins early in the infestation process. Many applicators are treating trees twice a year in the early spring and early fall. Systemic insecticides, such as Imidacloprid, are a newer alternative. These systemics cost more to use and their labels may restrict more locations where they can be applied but preliminary results indicate that protection may last up to two years. **Rusty Rhea (704) 257-4314 or Mark McClure (860) 688-3647.**

**Hemlock Resistance:** The search for hemlock resistance continues at a slow pace because of the lack of funding support. The University of Tennessee Tree Improvement Program has formed a group of cooperators including states and federal land managers throughout the eastern seaboard to collect hemlock seed for genetic conservation. This seed will be a source for outplantings that can be easily protected and used as a future breeding population. The National Arboretum has recently hired a geneticist to identify the various hemlock hybrids that exist. **Scott Schlarbaum (615) 974-7993 or via e-mail at tenntip@utk.edu**

**Estimating Abundance:** A method to estimate HWA abundance was developed based on binomial sampling where twigs are classified as either having a minimum threshold number of HWA or not. The efficiency and precision of binomial estimates were compared to traditional counting methods for several seasons and HWA generations in Virginia and Pennsylvania. The binomial method was much more efficient when using a threshold of three or more HWA. A paper describing this study (by D. Gray, R. Evans and S. Salom) has been submitted to the Journal of Economic Entomology. This study was supported by the USDA Forest Service, the Pennsylvania Bureau of Forestry and the National Park Service. **Richard Evans (717) 296-6952 or via e-mail at Richard Evans@nps.gov**

**Southern Model:** Scott Salom and David Grey completed their cooperative agreement with FHTET that developed a population dynamics model for the southern range of HWA. The model will predict: duration and mortality for each developmental stage; and temperature's impact on development. **Scott Salom (703) 231-6341 or via email at salom@vt.edu**
Host Quality: Hemlock trees were sampled for HWA density and fecundity, density of a scale insect, foliar %N, shoot length, needle size and density, and bud abortion. Samples were taken from terminal and lateral branches throughout the crown. Data will be analyzed this fall for relationships between the variables. Mike Montgomery (203) 230-4331.

Feeding at the Cellular Level: The spring generation does not feed on the sap, or phloem but on xylem ray parenchyma cells, a type of cell that stores and transports nutrients within the plant. The overwintering generation also feeds on xylem ray parenchyma cells, but some individuals feed on trace parenchyma or cortical parenchyma. All parenchyma cells store food reserves in the form of starch or fat for growth, and thus it is likely that HWA feeding depletes the tree's reserves. Studies of drought-stressed trees suggest that HWA infestation increases the tree's stress levels based on chlorophyll fluorescence. Kathleen Shields (203) 230-4320.
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<th>Coop. #</th>
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| 42-778  | North Carolina State University USDA Forest Service Northeastern Center for Forest Health Research | $30,000  | 9/93-7/94  | Survey and Augmentation of Natural Enemies of HWA | (1) Determine the distribution of HWA and hemlock stands that are priority for protection.  
(2) Survey for the presence of HWA natural enemies in order to locate donor populations and establish need for augmentation of natural enemies.  
(3) Augment biological control by collecting and transferring natural enemies (e.g. *Scymnus suturalis*) from localized "nursery" populations to high value stands newly invaded by HWA. |
| 42-787  | Virginia Polytechnic Institute & State University | $45,950  | 1/94-12/94 | Life History and Population Dynamics of HWA in the Southern Appalachians | (1) an intensive life history and population dynamics evaluation of HWA under varied site conditions, within the southern Appalachian region of Virginia. Develop a life history model for HWA.  
(2) Conduct laboratory rearing and bioassay procedures for investigating the physiological responses of hemlock trees to HWA feeding. |
| 42-794  | Connecticut Agricultural Experiment Station | $92,000  | 5/94-12/96 | Establishing Natural Enemies of HWA in North America | (1) To determine the biological and ecological requirements of *Diapterobates humeralis* and *Pseudoscymnus* sp.  
(2) To develop methods to rear predators of HWA for release.  
(3) To design standard protocols to sample HWA and predator populations.  
(4) To release, to determine the effectiveness of, and to establish natural enemies of HWA.  
(5) To develop an effective biological control program for the HWA. |
|         | USDA Agricultural Research Service  | $7,500*  | 10/93-12/94| Potential Use of *Harmonia axyridis* in Biocontrol of HWA | Release beetles in 44 sites (DE, MD, PA) and estimate impact.                                                                                                                                                                                                                                                                                                   |
| 42-655  | University of Massachusetts USDA Forest Service Northeastern Center for Forest Health Research A.#6 | $4,000   | 9/95-4/96  | Augmentation of Natural Enemies of HWA | Complete analysis of data concerning *S. suturalis* and prepare publication                                                                                                                                                                                                                                                                                    |

* GRAND TOTAL $335,690  

*Matching funds provided by ARS