

2011 State Report for Pennsylvania to the NCERA-193

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A total of 46 invited lectures were given in three states; approximately 4,370 green industry stakeholders were in attendance at these lectures -- who knows the additive effect of these presentations on client groups. The total time spent lecturing to these green industry client groups was approximately 122.0 hours. Preparation and travel time is not included in this lecture time.

Update on Some Arthropod Pests of Woody Ornamental Plants in Pennsylvania

The impact of the diaspidid known as the **elongate hemlock scale**, *Fiorinia externa*, continues to cause mortality of hemlock in both the landscapes and forests in eastern and central Pennsylvania. Soil applications of dinotefuran are performing well against this key pest.

The **emerald ash borer**, *Agrilus planipennis* is now confirmed in 22 counties in Pennsylvania. The state order of quarantine was lifted in mid-April 2011. Releases of natural enemies of this pest have been made in Allegheny County in western Pennsylvania.

The **hemlock woolly adelgid**, *Adelges tsugae* is known from 52 of the 67 counties in Pennsylvania. Trees infested with this pest are being protected with soil applications of registered formulations of dinotefuran.

A relatively new pest called the **Japanese cedar longhorned beetle**, *Callidiellum rufipenne* has been detected both in ornamental nurseries and landscapes on arborvitae, cryptomeria, Chinese juniper, *Juniperus chinensis* (the cultivars 'Blue Hetz'; 'Sea Green'), eastern redcedar, *Juniperus virginiana*, Leyland cypress, *Cupressocyparis leylandii*, and Hinoki falsecypress in several southeastern and south central Pennsylvania counties. This species produces one generation each year. It overwinters as an adult in a gallery formed by the mature larva deep in the wood of the host plant. Treatment timing and products are being evaluated for this pest.

The armored scale insect called "**Japanese maple scale**", *Lopholeucaspis japonica*, has been frequently submitted for diagnosis the last several years. Most of these submissions are coming from southeastern and central Pennsylvania counties. I've seen this relatively new pest on the twigs and branches of Japanese maple, red maple, dogwood, Japanese zelkova, pyracantha, redbud, holly, and Bradford pear. This species produces two generations each year.

The **viburnum leaf beetle**, *Pyrrhalta viburni* has moved very quickly from northern Pennsylvania south to near the Maryland border during the past five years. There is a need to identify additional active ingredients that are effective against the adult stage of this leaf beetle.

Mortality of arrowwood, *Viburnum dentatum*, has been observed by PA Game Commission biologists who are concerned about the mortality caused by this insect and the potential impact it may have on ruffed grouse and songbird populations.

Short Courses and Inservice Training

Arborist Short Course: Integrated Management of Woody Ornamentals, Urban and Community Forestry Council, Pennsylvania State Cooperative, Chester County, Honey Brook, PA.

Arborist Short Course: Integrated Management of Woody Ornamentals, Urban and Community Forestry Council, Pennsylvania State Cooperative, Luzerne County, Forty Fort, PA.

Graduate Student Committees

I'm currently serving on five graduate student committees. One is a student in the Department of Entomology (Ph.D. candidate), a second is an (M. S. candidate) in the Department of Entomology. The third and fourth graduate student committees are in the School of Forest Resources (one is a M. S. candidate and the other a Ph.D. candidate). And the fifth graduate student committee is an (M. S. candidate) in the Department of Agricultural and Biological Engineering.

PUBLICATIONS

Article in Refereed Publication

Herath, P., Hoover, G. A., Angelini, E., and Moorman, G. W. 2010. Detection of elm yellows phytoplasma using real-time PCR. *Plant Disease* 94: 1355-1360.

Articles in Nonrefereed Publications

G. A. Hoover, G. W. Moorman, K. M. Richards, and S. I. Gripp. 2011. Insect, Mite, and Disease Management on Woody Ornamentals, Pennsylvania State University, College of Agricultural Sciences, 114 pp.

Most ornamental-related Entomological Notes are now formatted for use on the web. Color images continue to be associated with these fact sheets for use on the ornamentals entomology extension website. To date most have been translated into Spanish. These are being accessed frequently.

PDFs of nine EAB publications have also been placed on my ornamental extension entomology Web site. These publications are being used by ornamental horticulture and urban forester county extension educators and green industry professionals to educate their stakeholders regarding this pest in Pennsylvania. These color publications and poster are also included in the Pennsylvania EAB Resource Notebook. These notebooks have been distributed to state and federal governmental agencies.

SCHOLARSHIP

Grants Received

2010-2011 – USDA Forest Service, Urban/Community Forestry and Wildlife, \$372,640.00/yr. (with many collaborators at Pennsylvania State University).

2009-2011 - Elm yellows epidemiology, diagnosis, and management. (with Moorman, G. W.) The Pennsylvania State University. \$61,500/yr.

OTHER ACTIVITIES

Emerald Ash Borer (EAB)

I continued to distribute museum replicas of the adult and larval stages (20X the actual size) of the EAB and a 12” X 15” replica of ash bark with larval galleries and a D-shaped emergence hole were manufactured for use by ornamental horticulture county extension educators members in educating stakeholders regarding the EAB in Pennsylvania. These continue to be very well received and the stakeholders who have viewed them in public meetings and during TV programming.

Requests for educational programs on the EAB increased during 2010-2011 period. Images I’ve taken have proven effective in sharing my experiences and knowledge of this exotic flatheaded borer with green industry professionals and Penn State Extension educators in Pennsylvania and other states.

I’ve distributed more than 7,000 copies of the color, tri-fold publication titled, “What is the Emerald Ash Borer?” that targets the public and focuses on prevention of the movement of this pest via firewood. This publication is also being distributed statewide by Penn State’s College of Agricultural Sciences, Publications Distribution Center. I’ve also provided these publications at my ornamental entomology lectures and other entomology extension venues. The EAB is now found in 22 Pennsylvania counties. I’ll continue to assist with ground surveys for the EAB in eastern Pennsylvania.

I continued the development and updating of the Web site on the EAB in Pennsylvania during the period from 2010-2011. This Web site contains the Pennsylvania EAB Action Plan, images of the EAB and its symptoms and signs, native wood borers of ash, and EAB look alikes, US and Pennsylvania distribution maps, pdfs of publications on the EAB, and changes in the orders of quarantine are some examples of the sources of information on the EAB for stakeholders in Pennsylvania.

Website -- Ornamental Extension Entomology

This Web site continued to be updated in a timely manner [<http://ento.psu.edu/extension/trees-shrubs>]. The arthropod data regarding growing degree day and plant phenological information collected by the members of the Penn-Del IPM Research Group may soon be available online accessed at my Penn State Ornamental Extension Entomology web site for the green industry stakeholders in Pennsylvania as well as the US. Links at this Web site have been made to other

helpful sites for green industry stakeholder groups. This Web site also has Entomological Notes on woody ornamental arthropod pests with both line illustrations and color images.

Development of an Integrated Pest Management Program for the American Elms at University Park Campus – Dutch Elm Disease / Elm Yellows

I continued conducting an IPM program designed to protect the health of almost 270 American elms that are 80-130 years old on the University Park Campus of the Pennsylvania State University. The 2ee registration for Mavrik Aquaflow that I petitioned for several years ago continues to be used only by certified arborists in Pennsylvania and New Jersey. The switch to Astro Insecticide (permethrin) on the University Park Campus of Penn State has been a positive one. Protection of the health of the residual elms on main campus from Dutch elm disease continues to be realized. This pest management project is in cooperation with members from the Office of the Physical Plant (arborists). Monitoring of native elm bark beetles and smaller European elm bark beetle populations has been conducted for the past nineteen years. This unique plant health care program continues to receive both state and national interest.

Mortality of elms caused by elm yellows (a phytoplasma vectored by leafhoppers) continued to be significant around campus and in the Centre Region during the last three years. More American elms were removed from campus during this past winter. Most of these infested elms were removed from areas that had not received treatment for elm bark beetles for the past seven years. Funds have been provided to the Department of Plant Pathology from the University in order to conduct research on this insect-vectored pathogen. A real time PCR diagnostic test for this leafhopper-vectored pathogen has been developed. A research paper was written and published on this methodology.

Media Contacts

March 3, 2011 – Emerald Ash Borer State Quarantine Lifted 4/15/11 in Pennsylvania, Interview for radio, Pennsylvania State University, College of Agricultural Sciences, Agricultural Information Services, University Park, PA.

March 9, 2011 – Beneficial Arthropods in the Landscape and Garden, Pennsylvania Gardener Magazine, Mercer, PA.

Biocontrol / Natural Enemies of Pests in Nurseries and Landscapes - a DVD

The video titled, *Insects and Spiders and Mites, OH My! : Recognizing Beneficials in the Nursery and Landscape* that received first place recognition in the education category awarded by the Broadcast Education Association is now available in DVD format from San Luis Video Publishing, Los Osos, CA for \$49.95. This 39-minute video covers the identification of natural enemies of key arthropod pests that feed on trees and shrubs. The video project was the result of a cooperative effort between Pennsylvania Department of Agriculture entomologists, a nursery inspector, the grounds manager at Longwood Gardens, Ag Information Services, and myself.

SERVICE

Committee Assignments

University Tree Commission, Pennsylvania State University, Member, 1992 - present.

Pennsylvania Task Force on Asian Longhorned Beetle, Member, 1998-present.

Pennsylvania Task Force on Emerald Ash Borer, Member, 2004-present.

Penn State University Integrated Pest Management Technical Committee, 2001-present.

Consumer Horticulture Center, Penn State University, Department of Horticulture, member, 2002-present.

Regional Ornamental Research Committee, NCERA-193, Plant Health: Managing Insects and Diseases of Landscape Plants, member, 2005-present.

National Pest Detection Network (NPDN) Entomology Committee, member, 2006-present.

Forest and Shade Tree Disease Studies-2011

Colorado State University

Bill Jacobi, Professor

MS Graduate Students: Christy Cleaver, Meg Dudley, Anne Marie Casper, Rebecca Powel

PhD Candidates: Dan West, Javier Mercado

Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins CO 80523

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Shade Tree Research Impacts:

- We have a publication based on research related to camper movement of firewood in the west. Thirty nine percent of campers bring firewood to National Parks from out of state sources. The publication the risk of movement of insects in retail firewood is in draft format. We found >40% of retail firewood have live insects with 15 to 520 insects per bundle. Coleoptera insects accounted for 3,600 of the 4,000 insects collected with a mean of 3 to 60 per each of 24 families. Insects emerged up to 540 days after the wood was purchased.
- We found the exotic banded elm bark beetle can make feeding wounds on American elm branches and move the Dutch elm disease pathogen to the wounds.
- We are coordinating the National Elm Trial in 16 states.
- We have completed several studies on magnesium chloride ($MgCl_2$) use as a dust suppressant on non-paved roads and found the ions move up to 20 feet from the road, farther in roadside drainages, are detected in low concentrations in roadside streams and have determined foliar concentrations needed to cause mortality in the field and controlled conditions for several tree species. All publications are completed.

Shade Tree Disease Studies:

1. **MgCl₂ Studies:** Salt used for dust control on non-paved roads is common in the west. The salt ions move up to 20 feet away from roads on normal embankments. Roadside culverts and drainages allow salt to move away from roadway and stream sampling indicates low concentrations of salt are detectable in streams. Trees take up chloride and foliar concentrations are correlated with foliar damage. Four manuscripts on these issues are available..
2. **Banded Elm Bark Beetle:** The Dutch elm disease pathogen was successfully isolated from the banded elm bark beetle and a manuscript in Plant Disease is available. Inoculation/vector studies in 2006 and 2007 indicated artificially infested beetles can transport the fungus to feeding wounds. We submitted a manuscript this fall.
3. **National Elm Trial:** We have 16 states with 17 sites involved in a trial of 17-19 commercially available elm cultivars. NCR- 193 members and other cooperators are involved.
4. **Firewood and Exotics:** In cooperation with APHIS, we are completing a manuscript on insect infestation of retail firewood purchased in CO, NM, UT, and WY..

Forest Tree Insect/Disease Studies

1. White Pine Blister Rust:

- A hazard-rating model for WPBR will be submitted this year.
- Small-scale meteorological analysis of the risk of WPBR in the Rocky Mts is in final draft.
- We help coordinate white pine health work via the Central Rocky Mountains White Pine Health Working Group.
- A Research Note from the USDA For. Serv. Rocky Mt Research Station on the techniques and efficiency of pruning limber pine for WPBR management is published. A second paper reporting the effectiveness of pruning to keep trees alive after 5 years is in draft format.
- Anne Marie Casper, (MS candidate) will complete a study of regeneration issues related to natural regeneration and planting limber pine seedlings along the Front Range Mountains of Colorado
- White bark pine regeneration after wild fires in Wyoming. This research is in draft manuscript form and should be submitted this year.

2. **Ponderosa Pine Wood Borers:** Sheryl Costello's last paper from her research is in draft format and should be submitted soon.
3. **Fire, Dwarf mistletoe and Mt Pine Beetles in Front Range Colorado Ponderosa Pine:** Jennifer Klutsch and Russell Beam (MS graduates) have draft manuscripts on the interactions of these three disturbance agents.
4. **Bark Beetle mortality and future fire risk.** Dan West has a draft manuscript from his MS thesis that reports his research on occurrence of wildfires after beetle outbreaks in Colorado's lodgepole pine.
5. **Mountain pine beetle preference for Lodgepole and Ponderosa pine.** Dan West's new research for his PhD is on Mt Pine Beetle and host preferences. He has exciting preliminary results in choice trials and field data from plots along the Front Range Mountains in Colorado.
6. **Spatial relationships of Mountain pine beetle, phoretic mites and fungal associates in front range pine forests.** Javier Mercado (PhD candidate) is making collections of fungi this summer.
7. **Aspen dieback in Colorado:** Meg Dudley (MS candidate) will complete her manuscript on the health of aspen in Colorado shortly
8. **Aspen insect and disease occurrence Rapid Threat Assessment with WWETEC:** Betsy Goodrich has completed research and report on an analysis if different insect and disease survey types can be combined to look at large-scale – western U.S. -relationships between aspen health, site and environmental conditions.
9. **Limber pine status and regeneration potential.** Christy Cleaver (MS) has just started a survey of limber pine in CO, WY and MT to determine the impact of Mountain pine beetle and white pine blister rust on adults and if there is regeneration in these areas.

Publications:

1. Jacobi, W.R., B.A. Goodrich, R. D. Koski. 2009. Environmental effects of magnesium chloride based dust suppression products on roadside soils, vegetation and stream water chemistry. Colorado State University, Agricultural Experiment Station, Technical Report, TR09-04, 185pp.
2. Goodrich, B. A., Koski, R.D. and W.R. Jacobi. 2009. Monitoring surface water chemistry near magnesium chloride dust suppressant treated roads in Colorado. J. Environ. Qual. 38(6):2373-81.

3. MacDonald, J., Allen, C., Gadoury, D., Jacobi, W., Kelemu, S., Moyer, J., Murray, T., Ong, K., Pearson, C., Sherwood, J., and Vidaver, A. 2009. Education in Plant Pathology, Present Status and Future Challenges. *Plant Disease* 93: 1238-1251.
4. Egan, J.M., Jacobi W.R., Negron J.F., Smith, S.L. and Cluck, D. R. 2010. Forest thinning and subsequent bark beetle-caused mortality in Northeastern California. *Forest Ecol. Management.* doi:10.1016/j.foreco.2010.08.030
5. Costello, S.L., Negron, J.F and Jacobi, W.R. 2011. Wood-boring insect abundance in fire-injured ponderosa pine. *Agriculture and Forest Entomology.* DOI: 10.1111/j/1461-9563.2011.00531.x
6. Crump, A. Jacobi, W.R. Lundquist, J. E. 2011. Dissemination of forest health research information in the Rocky Mountains. *Journal of Forestry.* 43-49.
7. Jacobi, W. R., Goodrich, B.A. and Cleaver, C. M. 2011. Firewood transport by National and State Park campers: A risk for native and exotic tree pest movement. *Arboriculture and Urban Forestry.* 37: 126-138
8. **Klutsch, J. G., Kallas-Ricklefs, M. A., Reich R. M. Harris, J. L. and. Jacobi W. R. 2011. Relationship of site and stand characteristics to Armillaria root disease incidence on ponderosa pine in the Black Hills. *Forest Pathology- Accepted.***
9. **Crump, A., Jacobi, W. R., Burns, K. S., and Howell, B. S. 2011. Pruning to manage white pine blister rust in the southern Rocky Mountains. USDA Forest Service, Rocky Mountain Res Station. Res. Note RMRS-RN-44. 10 p.**

New Disease Issues:

- ◇ Pine wilt nematode killed 4 scotch pines this year.
- ◇ Death of all walnuts by 1000 cankers is a major concern in Colorado. *Pityophthorus julandis* and *Geosmithia sp.* canker involvement. Drs Tisserat and Cranshaw are heading up this research. New findings in Tennessee, PA, MD.
- ◇ Foliar diseases were common this year on oak (anthracnose and blister), aspen, and poplars since we had a wet spring.
- ◇ Oaks in Boulder CO parks with scale and wood borers and drippy nut disease (bacterial

New Insect Issues:

- ◇ Mountain pine bark beetles populations are severe now on the northern Front Range forests after attacking limber pine, lodgepole pine in dramatic proportions on the west slope of the continental divide.
- ◇ Leaf mining on elms by European elm leaf weevil was down this year.
- ◇ *Pityophthorus julandis* on walnuts.

NCERA -193: Arthropod Pests & Diseases of Ornamentals: Delaware & SE PA

University of Delaware Co-operative Extension:

Bob Mulrooney, Nancy Gregory, Brian Kunkel

Longwood Gardens:

Casey Sclar & Mike Leventry

Regional Weather:

Winter 2010-2011 returned to normal amounts of precipitation and temperatures compared to winter of 2009 – 2010. Spring was wet in SE PA, whereas DE received relatively normal amounts of precipitation. Summer was hot with temperatures occasionally exceeding 100°F with heat indexes greater than 110°F for a few days in mid-late July. Precipitation during the summer was at or slightly below average until August.

August and September 2011 experienced above average precipitation – much was due to Hurricane Irene. Precipitation in DE and nearby MD or PA was slightly below average amounts of rainfall for the year until August. Southern DE received less precipitation for the year and as of mid-November was slightly below normal to average. The remainder of DE was about seven (Kent County) to 16 inches (New Castle County) above normal for the year.

Insect and Disease Highlights:

Insects

Caterpillar pests frequently encountered this year included *Trichoplusia ni* (**Cabbage looper**), *Podosesia syringae* (**Lilac/Ash borer**), *Coleotechnites atripunctella* (**Baldcypress webworm**) and *Homadaula anisocentra* (**Mimosa webworm**). **Eastern tent caterpillars, bagworms, fall webworms, and larch casebears** were also reported this year but were not as common as recent years.

Soft scales such as *Ceroplastes ceriferus* (**Indian wax scale**), *Toumeyella liriodendri* (**Tuliptree scale**), *Eulecanium cerasorum* (**Calico scale**) and *Pulvinaria* scales (**Cottony Taxus/Camellia Scale, Cottony Maple Scale**) were sent to the lab for identification this year. Many armored scale samples were diagnosed this summer including *Chionaspis pinifoliae* (**pine needle**), *Fiorinia externa* (**elongate hemlock**), *Aspidiotus cryptomeriae* (**cryptomeria**), *Diaspidiotus ancyclus* (**Putnam**), *Pseudaulacaspis prunicola* (**white prunicola**), *Unaspis euonymi* (**euonymus**), *Lepidosaphes pallida* (**Maskell**), *Pseudaulacaspis pentagona* (**white peach**), *Carulaspis juniperi* (**juniper**), *Lepidosaphes ulmi* (**oystershell**) and *Lopholeucaspis japonica* (**Japanese maple**) scales. Reports of Euonymus and white prunicola scale were more common this year than previous couple of years and Japanese maple scale infestations are still problematic for landscape maintenance companies.

Other sucking insect pests such as **whiteflies**, **hawthorn lace bugs**, **aphids** and **mealy bugs** were minor problems reported during the year. During the spring, one of the local public gardens had a minor outbreak of **apple mealybug** on native azaleas, *Kalmia* and *Fothergilla*. Thrips and **eriophyid mites** heavily infested roses in business landscapes in Kent County this year.

Cool and warm season spider mites were occasionally reported this summer and fall, but their populations were not as high as last year. Christmas tree farms reported small populations of **Cooley spruce galls** and **Douglas fir needle midge**. Nurseries in the mid-Atlantic continue to struggle with **redheaded flea beetle** control and also reported another chrysomelid feeding on azaleas (species being determined). **Hawthorn**, **Hibiscus**, **roseslug** and **dogwood sawflies** were prevalent in landscapes this year causing considerable damage. Other minor pests encountered this year include, various **ant species** invading homes, **thrips** invading homes, **boxwood psyllid**, **boxwood leafminer**, **Yucca plant bug** and **cypress twig gall midges**. **Japanese beetle** populations are still low compared to populations in the recent past (ca. 2006). **Cicada killers** and **Scoliid** wasp populations were less this year than the previous couple of years.

Select Invasive species

Scouting for **emerald ash borer** continues in Delaware and none have been found to date. **Brown Marmorated Stink Bug** (*Halyomorpha halys*) populations are drastically less than last year but continue to be the most common fall household invader. Common ornamental plants this pest was reported to be found on this summer include: **elms**, **redbud**, **crabapple**, **cherry**, **Hydrangea**, **hackberry**, **Pawlonia**, **tree lilac**, **ash** and **maples**. I have heard reports that their feeding is through the bark of trees or on the fruits. I (Brian) did not observe BMSB feeding on these plants, although I did observe them on many of the previously mentioned plants.

Diseases

Evergreen ornamentals suffered tip and twig dieback, following two seasons of fluctuating temperatures and drought. This was often difficult to accurately diagnose, but **Phomopsis** and **Pestalotiopsis** were among the pathogens found. **Seiridium canker** continues to affect Leyland cypress, as over-crowded trees mature. **Phytophthora root rot** was diagnosed on juniper, arborvitae, Canaan fir, Fraser fir, Douglas fir, and rhododendron that were situated in areas with poor drainage. **Rhizosphaera needle cast** was diagnosed on blue spruce and Norway spruce. Douglas fir was affected by **Rhabdocline** and late season drought and spider mite damage. **Fire blight** was prevalent on flowering pear, and continued to show up as brown terminals late into the fall. **Sycamore anthracnose** was very prevalent on susceptible London planetree and American sycamore. Most trees were defoliated early but had pushed out a new set of leaves by mid-June. **Monilinia blight** on Japanese quince caused dieback of twigs and caused blossom and twig blight on Kwanzan cherry. The blight was very prevalent in New Castle County, and the pathogen was identified as **Monilinia laxa** by Dr. Guido Schnabel at Clemson. **Dutch elm disease** was confirmed on 'Princeton' American elm, a cultivar that has been reported to have some resistance to DED.

Late season **Septoria leaf spots** were common on numerous hosts including pear, *Prunus*, sunflower and *Rudbeckia*. **Bacterial leaf scorch** was noticeable in the landscape; most commonly affected were northern red oak and pin oak. **Hypoxyton canker** was confirmed on several hardwood species of oak, maple, and sycamore, and appears to be increasing in incidence in the area. **Pythium** and **Fusarium** crown rots were diagnosed in numerous perennials (*Vinca*, *Veronica*, *Cimicifuga*, shasta daisy) under drought stress late in the season. Other diseases reported during the year included **Peony blotch**, **Frog-eye leaf spot**, **black spot**, **cedar quince rust**, **powdery mildew**, **azalea petal blight**, **cedar apple rust** and **iris leaf spot**. Common diseases found on turf were **red thread** and **brown patch**.

2010-2011 Publications & Notables

Kunkel, Mulrooney, and Sclar contributed weekly columns on insects and diseases to *Ornamentals Hotline*, a grower newsletter published and distributed by University Delaware Cooperative Extension to over 150 subscribers. We changed the blog site for the pictures corresponding to Hotline this year.

The Ornamentals Task Force at the University of Delaware continues to offer training sessions for green industry professionals at their business. The disease training is conducted by Mulrooney or Gregory and Kunkel provided entomology training. Kunkel provided 'hands-on' workshops this spring aimed at landscape maintenance personnel in addition to typical workshops and pest walks. The 'hands-on' workshop provided green industry professionals the opportunity to closely examine samples under the microscope and to ask questions regarding these pests. Most of the samples provided by Kunkel were armored scale, borers, or leaf miners. Participants had an opportunity to examine samples they brought to the workshop too. Kunkel and Gregory are working with Christmas tree growers of Delaware on a project evaluating new varieties of Christmas tree susceptibility to insects and diseases of the area. Master Gardener training was also conducted by Mulrooney, Kunkel, and Gregory.

2010 Impact statements

Research: The research projects conducted at the University of Delaware continue to provide the ornamental industry in SE Pennsylvania and Delaware information regarding pesticide efficacy of new products in the market for controlling diseases, scale insects, and flea beetles. Future projects are being developed to investigate feeding preferences and adult emergence of the redheaded flea beetle. Additional projects are being developed to examine BMSB feeding on herbaceous plants in greenhouses and pesticide efficacy of various insecticides.

Outreach: The Ornamentals Task Force in Delaware offers many opportunities for professional and volunteer staff to keep informed about various emerging pests in the mid-Atlantic region. Newly emerging pests of our region are frequently discussed and include pests such as: Thousand Cankers Disease, emerald ash borer, Asian longhorn beetle, granulate ambrosia beetle, and others. Professionals and others educated about new concerns and the products or techniques needed to manage these pests will be better prepared to handle them when the need arises.

2010 Research Highlights:

Control of Euonymus Scale (*Unaspis euonymi* (Comstock))

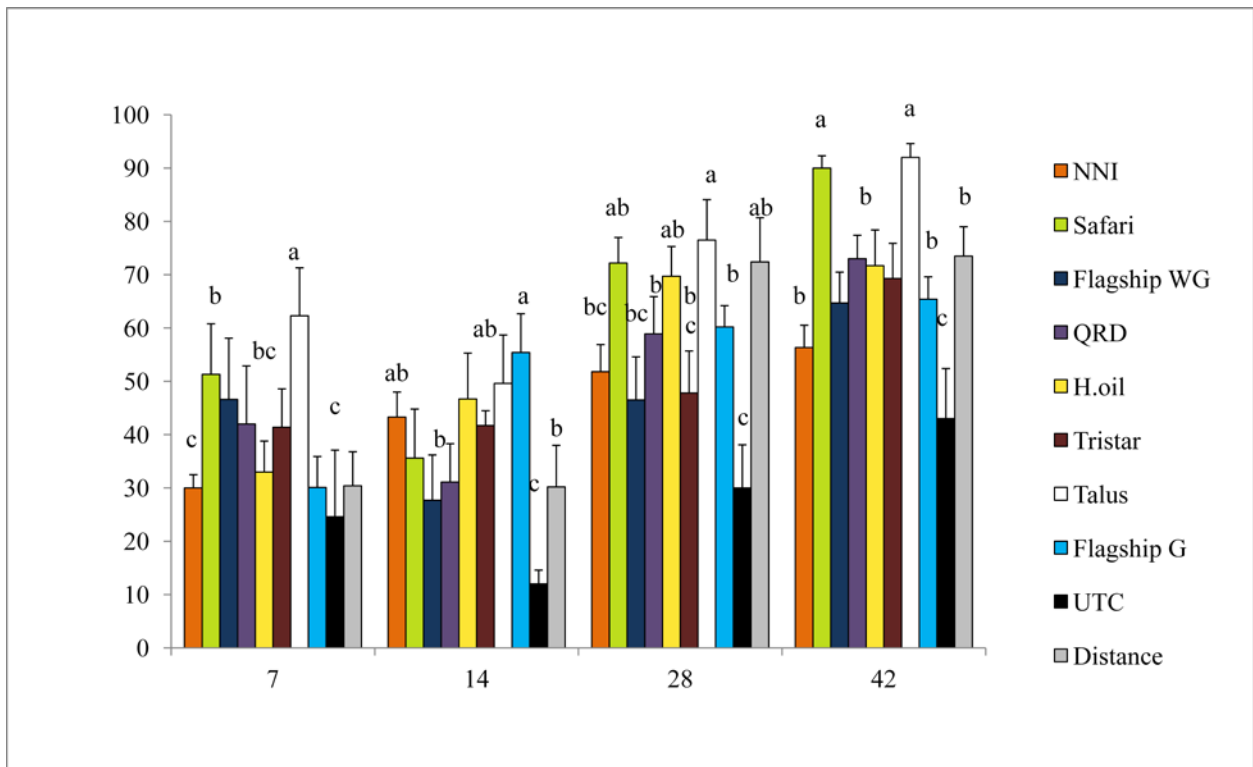
Brian Kunkel, Ornamentals IPM Extension Specialist
University of Delaware
Newark, DE

A local nursery provided *Euonymus fortunei* in one gallon pots with severe scale infestations. The pots were brought into the greenhouse and maintained throughout the experiment at 70°F and about 45% relative humidity. The second generation of crawlers began activity around the middle of July with peak crawler emergence the end of July. Applications were made using a CO₂ sprayer at 35 psi in the evening until leaf drip. There were six replicates of the treatments in the table below. The boom was moved around and into the plant to ensure adequate coverage of the plant with the insecticide used. Mortality readings were taken at 0 (pre-treatment), 7, 14, 28, and 42 days after treatment (DAT). Two six inch sections of *Euonymus* containing visible infestations of scale were removed with pruners and kept in a cooler until examined under a dissecting scope in the laboratory. The first 50 scale insects encountered were probed to determine if they were dead or alive. Means separation procedure used was Tukey's and letters designate significance at $\alpha=0.05$.

Table 1. Products used to treat crawler stage of euonymus scale on 27 July 2011

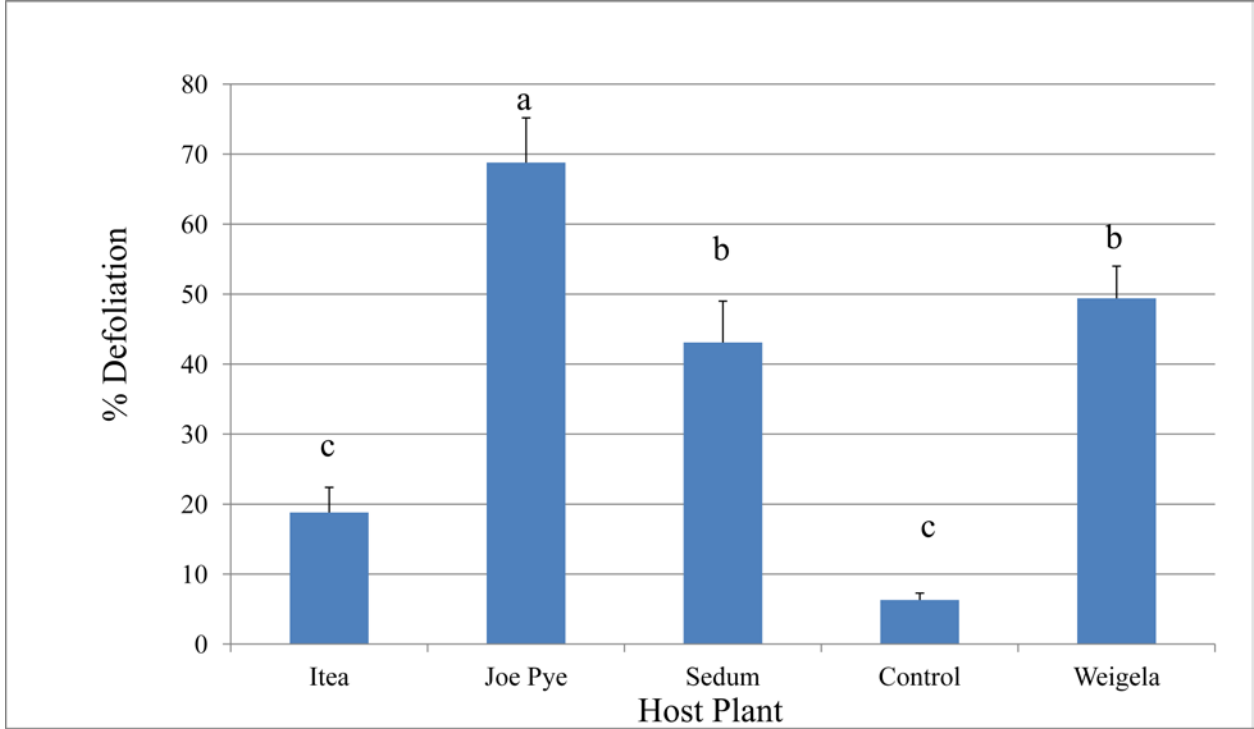
Product	Rate
NNI-0101	18 fl oz/100 gal
Safari 20SG	24 oz/100 gal
Flagship WG	8oz/100 gal + Capsil
QRD 416	128 oz/100 gal
Horticultural oil	1% solution
Tristar 30SG	8oz/100 gal + Capsil
Talus	21.5 oz/100 gal
Flagship G	20 g/1 gal container
Untreated Control	water
Distance	12 fl oz/100 gal

Results:



Feeding trials of redheaded flea beetle, *Systema frontalis*, adults

The redheaded flea beetles were collected at a local nursery and stored in a cooler with ice packs until used in the experiment. Foliage used in the trial was collected from the University of Delaware Botanical Gardens. A single leaf from each host plant was placed in the corner of the bioassay arenas and 15 – 20 adult flea beetles were added to the container. The bioassay arenas were plastic sandwich boxes with 1.3 cm of wax in the bottom. Foliage was held above the wax bottom on pins with acetate squares underneath and above the foliage. Beetles were permitted to feed on the foliage for about 60 h at 25°C, 12:12 L:D. The trial consisted of eight replicates and means separation procedure used was Tukey's with letters designating significance at $\alpha=0.05$.



NCERA-193 State Report

Landscape Arthropods of Concern in Texas, 2011

Prepared by Bastiaan M. Drees, Professor and Extension Entomologist

Texas AgriLife Extension Service and Texas AgriLife Research

The Texas A&M University System, College Station, Texas

The summer of 2011 was the hottest summer on record for any state, ever! Much time was devoted to revising and updating the outreach education web site, <http://LandscapeIPM.tamu.edu>. One efficacy trial for bagworm control was initiated in Plano, TX using Safari® (dinotefuran) as a soil treatment, but was abandoned when Kim Schofield resigned from her position as Extension Program Specialist in Dallas. Dr. Jim Reinert also retired from his research position in June. Landscape arthropod pests (insects and mites) were minimal throughout the year. Grasshopper outbreaks were reported from central Texas during the summer months (August). There was one report of an outbreak of leafhoppers on Bermuda grass in east Texas, but this was not identified as the new exotic leafhopper pest reported in the state:

Leafhoppers in Texas Turfgrass: Although not a common or widespread problem, leafhoppers occasionally become locally abundant and can be quite damaging to various species of turfgrass, especially Bermudagrass. Leafhoppers are small sucking insects in the order Hemiptera and family Cicadellidae. Leafhoppers are similar in shape to tiny cicadas and have sucking mouthparts held between the first pair of legs underneath the body when at rest. There are many species of leafhoppers in Texas and some are known to damage crops like alfalfa, where damage they cause is called “hopper burn”. Most leafhoppers are small (about 1/4 inch long) and are very active; walking, hopping and flying. Winged adults are strongly attracted to lights at night.

A sample of leafhopper specimens preserved in alcohol containing both nymphal and adult stages is characteristic of a breeding population as opposed to that of feeding or dispersing adults migrating to night lights (**Fig. 1**). Leafhoppers are difficult to identify and are best collected and sent to a specialist for accurate identification. The Illinois Natural History Museum has a whole web site devoted to leafhoppers: <http://www.inhs.uiuc.edu/~dietrich/Leafhome.html>.

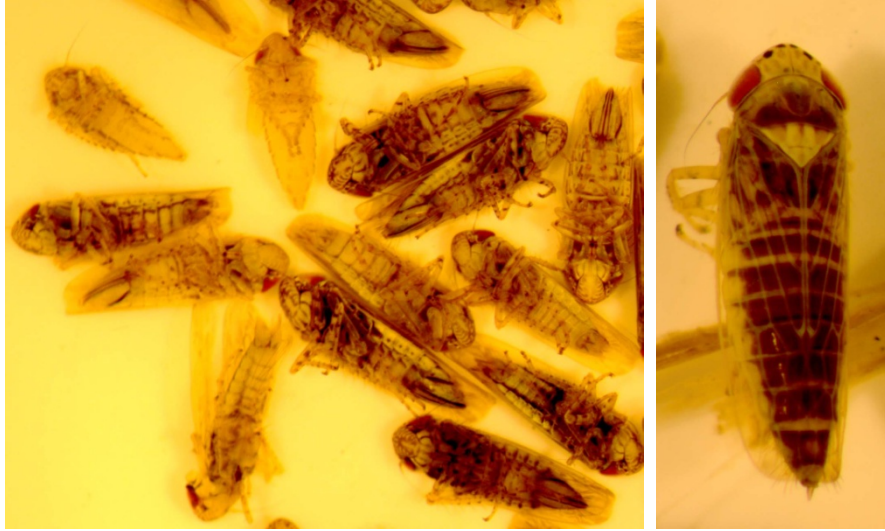


Fig. 1. Leafhoppers (nymphal stages top left, winged adult right image) collected from Bermudagrass, Jefferson Co., TX, July 2011 (photos by B. M. Drees).

Since 2006, a new species of leafhopper, the “invasive red-streaked leafhopper,” *Blaclutha rubrostriata* (Melichar), has been reported in Texas from Bandera, Bexar, Hays, Harris, Kerr, Kleberg, and Travis Counties (pers. Com. M. Quinn, <http://bugguide.net/node/view/87190>). It is native to the old world and in the US, it was previously reported only in Florida (Zahniser 2011). Adults of this species are about 4.2 mm long and most abundant in July and early August. They typically feed on grasses.

The incidence of leafhopper problems in turfgrass has historically been low. However, with severe drought and a new invasive species, leafhoppers could become a more important problem in the near future.

Damage. In infested lawns, most leafhoppers will hop when disturbed, making their presence noticeable. Leafhoppers feed by inserting their mouthparts into the leaf blades. While they feed, they inject toxic salivary secretions causing yellow, bleached-out spots. Feeding by developing nymphs and adults can cause yellowing of the entire turfgrass in the area of infestation.

Management. Large leafhopper infestations in turfgrass may be a symptom of frequent and intensive nitrogen fertilizer applications. Often, simply reducing the use rate of nitrogen fertilizer will minimize the problem. Insecticides targeting other turf pests such as chinch bugs may also be effective against leafhoppers. A list of insecticides for leafhopper control in turfgrass can be found at <http://www.entomology.umn.edu/cues/Web/244Leafhoppers.pdf> (University of Minnesota Extension) <http://www.ext.colostate.edu/pubs/insect/05608.html> (Colorado State University Extension).

Acknowledgements

Thanks to Dr. Jim Reinert and Mike Quinn for supplying information used to develop this page, and Ed Riley for helping identify the leafhoppers from Jefferson Co. as not being the “invasive red-streaked leafhopper.”

Citation

Zahniser, J. N., S. J. Taylor and J. K. Krejca. 2011. First reports of the invasive grass-feeding leafhopper, *Blaclutha rubrostriata* (Melichar)(Hemiptera: Cicadellidae) in the United States. *Entomological News* 121(2):132-138.

Pest ants: The **red imported fire ant**, *Solenopsis invicta*, were negatively affected by hot dry summer conditions. Populations in untreated control plots in trials conducted in Brazos and Jefferson Counties declined dramatically from May through August. **Raspberry crazy ants** (*Nylanderia* species near *pubens*) were moderate in number but populations grew substantially during the summer months. This ant was reported from Matagorda Co., TX, bringing the number of counties with spot infestations to 18 (see <http://UrbanEntomology.tamu.edu>). **Argentine ant**, *Linepithema humile*, outbreaks are becoming problematic across large acreage in a number of sites across the state. Efforts are being made to develop and assess granular bait formulations for attractiveness to these ants and control provided due to the large areas of infestation which make use of liquid bait stations unfeasible.

Impact: Program efforts, including the web site, in-person presentation, applied research and result demonstration efforts strive to increase the cost-effectiveness of current Integrated Pest Management recommendations and develop new technology. Management guidelines and education are designed to reduce over-reliance on insecticide and miticide use in the urban landscape by emphasizing cultural (good horticultural and agronomic practices) and use of least toxic methods for arthropod suppression.

Publications

Refereed Scientific Journal Articles

Schofield, K., B. M. Drees, and B. Summerlin. 2010. Worker ant foraging response on and near mounds of the red imported fire ant, *Solenopsis invicta* Buren. *Southwestern Entomologist* 35(4):533-538.

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- Calixto, A., M. Harris, B. Drees, and J. Johnson. 2011. Impact of toxic baits on field populations of the two social forms of the fire ant and other ecological implications *in* Proceedings of the Imported Fire Ant Conference (P. Nester, ed.), Galveston, Texas, April 4-7, 2011. Pages 95-98.
- Schofield, K., W. Brown and B. Drees. 2011. University based research on the effectiveness of home remedies to control red imported fire ants, *Solenopsis invicta* (Hymenoptera: Formicidae) *in* Proceedings of the Imported Fire Ant Conference (P. Nester, ed.), Galveston, Texas, April 4-7, 2011. Page 99.
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**2011 Ohio Report
NCERA-193**

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Project: NCERA193: NCR-193: IPM Strategies for Arthropod Pests and Diseases in Nurseries and Landscapes

Ohio Report for the Period: 10/1/10 – 9/30/2011

OUTPUTS / ACCOMPLISHMENTS:

Obj. 3: Pesticide alternatives: Develop management strategies for key pests based on classical biological control (i.e., predators and parasitoids), host plant resistance, and cultural control.

A. Systemic induced resistance in the Austrian pine / *Diplodia pinea* / European pine sawfly system. Collaborators: Patrick Sherwood (Ph.D. student), Dan Herms (Dept. of Entomology), Don Cipollini (Dept. of Biological Sciences, Wright State University).

This work is in transition at the moment. Following previous work now published (Barto et al. 2008; Eyles et al. 2007a; Wallis et al. 2011; Wallis et al. 2008), we continue to examine cross induction of systemic resistance to the European pine sawfly (EPS) in Austrian pine induced by infection with *D. pinea*, over a fertility gradient imposed in a computer controlled fertigator, as well as in a field trial. More specifically, we are conducting experiments to test the validity of the systemic induced resistance (SIR) hypothesis (Bonello et al. 2006).

Work on the biochemical mechanisms underlying SIR in pine is also continuing, in the studies described above as well as others. For example, using a metabolomics approach, we are in the process of attempting to identify the signaling molecules at the basis of SIR. We are also conducting lab experiments to verify if the compounds identified as likely mechanisms of systemic resistance in previous work (Wallis et al. 2011; Wallis et al. 2008) have antimicrobial activity against *D. pinea in vitro*.

B. Chemistry of coast live oak defense response to *P. ramorum*. Collaborators: Anna Conrad (Ph.D. student), Brice McPherson and David Wood (Dept. of Environmental Science, Policy, and Management, UC Berkeley).

In coastal California, wildland populations of coast live oaks, *Quercus agrifolia*, continue to suffer large losses from sudden oak death, caused by *Phytophthora ramorum*. The pathogen causes bleeding cankers on the lower trunk. Despite a high infection rate, asymptomatic coast live oaks have persisted for 15 years in heavily affected stands. We modeled survival to 2009 of coast live oaks that were experimentally inoculated in 2002, as a function of canker length 9 months after inoculation. Trees with cankers < 21.2 cm in length had $\geq 80\%$ probability of survival to 2009; cankers < 6.6 cm had $\geq 90\%$ probability of survival. The distribution of canker

lengths is consistent with quantitative, multi-gene resistance to *P. ramorum*. The concentration of soluble phenolic compounds in phloem was found to discriminate between trees that were classified by their 2009 disease status as susceptible or resistant. Threshold concentrations that predicted a tree's response to inoculation with *P. ramorum* were determined for ellagic acid, a tyrosol pentoside-hexoside, and for total phenolics. The identification of low molecular weight compounds (biomarkers) associated with resistance may lead to minimally invasive assays for assessing the response of individual coast live oaks or populations to *P. ramorum*.

C. Molecular biology of ash resistance to EAB. Collaborators: Justin Whitehill (former PhD student), Sourav Chakraborty (post-doc), Amy Hill (technician), Dan Herms and Om Mittapalli (Dept. of Entomology), Don Cipollini (Dept. of Biological Sciences, Wright State University), Jennifer Koch (US Forest Service, Delaware, Ohio).

We used Difference Gel Electrophoresis (DIGE) to compare the phloem proteomes of resistant Manchurian to susceptible black, green, and white ash. Differentially expressed proteins associated with the resistant Manchurian ash when compared to the susceptible ash species were identified using nano-LC-MS/MS and putative identities assigned. Proteomic differences were strongly associated with the phylogenetic relationships among the four species. Proteins identified in Manchurian ash potentially associated with its resistance to emerald ash borer include a PR-10 protein, an aspartic protease, a phenylcoumaran benzylic ether reductase (PCBER), and a thylakoid-bound ascorbate peroxidase.

We also characterized the constitutive phenolic profiles and lignin levels of the phloem tissue of green, white, black, blue, European, and Manchurian ash. Phloem was sampled twice during the growing season, coinciding with phenology of early and late instar EAB, respectively. We identified 66 unique metabolites over the two sampling dates and across the six ash species. The interspecific pattern of variation in the phenolic profiles among the six ash species strongly corresponded with their molecular phylogeny. Previously identified lignans and lignan derivatives were confirmed to be unique to Manchurian ash, and may contribute to its high level of resistance to EAB. Other compounds that had been considered unique to Manchurian ash, including hydroxycoumarins and the phenylethanoids calceolarioside A and B, were detected in susceptible species, and are unlikely to contribute to EAB resistance of Manchurian ash, as previously hypothesized (Eyles et al. 2007b). Discovery of resistance-related proteins and phenolics in Asian species will inform approaches in which resistance genes can be introgressed into North American ash species.

D. Validation and development of a methyl jasmonate delivery system for insecticide-free control of the emerald ash borer. Collaborators: Justin Whitehill (former PhD student), Vanessa Muilenburg (post-doc), Dan Herms (Dept. of Entomology), Don Cipollini (Dept. of Biological Sciences, Wright State University)

We have recently conducted field experiments providing strong evidence that application of methyl jasmonate (MeJA), a natural plant hormone associated with plant resistance mechanisms to pests and pathogens, induces endogenous defenses in ash that lead to resistance to EAB in several susceptible North American species of ash. This result provides the foundation for this proposal, in which we hypothesize that MeJA can be developed into a practical control tool for EAB. Being a natural product, MeJA would obviate the introduction of currently recommended, broad spectrum pesticides (e.g. emamectin benzoate, bifenthrin), into the environment. This would have clear benefits for society and, more directly, pesticide applicators.

OUTCOMES / IMPACTS:

Obj. 3: Pesticide alternatives: Develop management strategies for key pests based on classical biological control (i.e., predators and parasitoids), host plant resistance, and cultural control. The PR-10 protein, the aspartic protease, the phenylcoumaran benzylic ether reductase (PCBER), the thylakoid-bound ascorbate peroxidase, lignans, and lignan derivatives will be the target of functional studies for their role in resistance of Manchurian ash to EAB.

Ellagic acid and tyrosol-like compounds in coast live oak phloem can be used as biomarkers of coast live oak resistance to *P. ramorum*.

Treatment with MeJA protects small ash trees against the emerald ash borer at the same level as that conferred by treatment with a commercial topical insecticide.

A PhD degree in Plant Pathology was conferred to Justin Whitehill.

PUBLICATIONS RELATED TO WORK DESCRIBED ABOVE: (10)

- Whitehill JGA, Popova-Butler A, Green-Church KB, Koch JL, Herms DA and Bonello P (2011) Interspecific proteomic comparisons reveal ash phloem genes potentially involved in constitutive resistance to the emerald ash borer. PLoS ONE 6(9): e24863. doi:10.1371/journal.pone.0024863.
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NEW FUNDING IN CALENDAR YEAR 2011:

OARDC SEEDS. 2011-2013. \$50,000. Validation and development of a methyl jasmonate delivery system for insecticide-free control of the emerald ash borer. P. Bonello and D.A. Herms. 2 yrs.

USDA Forest Service. 2011-2012. \$28,000. Natural Resistance of Coast Live Oak to *Phytophthora ramorum*: Implications for the Management of Sudden Oak Death. P. Bonello, D.L. Wood, S. Mori. 1 yr.

GRADUATE STUDENTS SUPERVISED:

Graduated: Justin Whitehill, PhD Plant Pathology, June 2011.

Current: Anna Conrad, Patrick Sherwood, David Showalter, all PhD.

ABSTRACTS: (30)

- Bonello P. 2010. What do ambrosia beetles have to do with resistance of coast live oak to *Phytophthora ramorum*? Another Dave Wood tale. Annual Meeting of the Entomological Society of America. San Diego, CA.
- Burgos-Hernandez, T., Hill, A., Bonello, P., Whitehill, J. 2010. Relationship between phloem nutritional composition in ash trees (*Fraxinus* spp.) and resistance to the emerald ash borer. AGMUS 2010 Research Symposium, September 10-11. San Juan, PR, USA.
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Michigan Entomology Report for NCERA-193
October 4, 2011
Dave Smitley, Michigan State University

Summary

Results from research tests on emerald ash borer conducted from 2003 to 2009 at six different test sites in Michigan indicate that several insecticide products provide ash trees a high level of protection against emerald ash borer. Imidacloprid applied as a soil drench in May of each year at the labeled rate for Merit or Bayer Advanced Tree and Shrub Insect Control consistently gave > 90% control of EAB on trees with a dbh of “8 or less. This level of control kept trees healthy while control trees declined or died rapidly. Results were not consistent for larger ash trees treated in this way at the same rate, and the level of success declined as the dbh increased from 12 to 20”, suggesting that higher rates of imidacloprid are necessary to protect larger trees. Dinotefuran applied as a basal soil drench also protected small ash trees (< 15” dbh) when applied in May of each year.

Trunk injection of emamectin benzoate (TREE-äge) at a rate of 0.1 mg ai per inch dbh gave a very high level of protection for 1 or 2 years after a single treatment, while trunk injection at a rate of 0.4 mg ai per inch dbh protected the same moderate-sized (13 – 17” dbh) test trees for 2 or 3 years. During this time all of the control trees rapidly declined and died. Because this treatment appears to provide 2 – 3 years of protection, depending on the size of the tree and pressure from EAB, it reduces the cost of trunk injections to a level that many homeowners, cities, and golf courses can afford. It is likely that after the initial wave of EAB has killed nearly all of the ash trees in a given area, it will be easier to protect trees with insecticide treatments. The initial wave usually lasts 4 – 5 years after the first trees in a town succumb to EAB.

Although trunk injections with TREE-äge may cost less than tree removal, even when all costs are considered over a 20 or 30-year period, some arborists and city foresters still hesitate to make trunk injections because of the perceived dangers of trunk injection to the tree due to the wounds made during the injection. In a study in East Lansing, Michigan we felled 60 ash trees 1 to 4 years after receiving trunk injection treatments in order to section the trunks and observe the ash tree response to injection wounds. In all cases, if the insecticide product gave a high level of protection against emerald ash borer, the trees grew rapidly and encapsulated wounds from trunk injection. Although some vascular discoloration was observed in the first year after trunk injection, no signs of oozing, spreading infection or structural damage were observed.

Following a survey of pathogens and parasites of Japanese beetle in Michigan in 1999 and 2000, *Ovavesicula popilliae* was collected in Connecticut and introduced into Michigan. Five years after *O. popilliae* was introduced into small plots (100 m²) at 3 golf courses, it spread to surrounding fairways and roughs at epizootic levels (> 20% infection). Survival of Japanese beetle larvae from October to May in two winter seasons between 2006 and 2008 was highly correlated with the incidence of *O. popilliae* infection of larvae. At golf courses where > 35% of the Japanese beetle larvae were infected with *O. popilliae* mortality of larvae from October to April was 50%, compared with 25% at golf courses where *O. popilliae* was absent or at very low levels. In addition egg production by females infected with *O. popilliae* was reduced 66% when compared with healthy females.

Publications

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NCERA-193 Report – Iowa - 2011

Compiled by:

- Mark Gleason – Extension Plant Pathologist
- Donald Lewis – Extension Entomologist
- Laura Jesse and Erika Saalau-Rojas – Extension Associates, ISU Plant and Insect Diagnostic Clinic

Weather-related damage to trees. Based on weather records, photos, symptoms, and growing location descriptions, it appears that many conifers (especially Colorado blue spruce) and some broadleaf trees (especially hard maples) displaying foliage yellowing, leaf scorching, premature defoliation, dieback, and death suffered from delayed effects of root damage caused by excessive soil moisture. During 2009 and 2010, we had extremely wet weather throughout Iowa. This period was capped by an extraordinary episode in late July and early August of 2010 in which 2 to 3 weeks of persistent saturated soils were accompanied by unusually high temperatures. As a result, many trees in saturated soils suffered from root damage due to low soil oxygen levels. Aboveground symptoms of this damage began to appear in late 2010, but mainly during the summer of 2011, following periods of very warm and dry weather, as water and nutrient needs of foliage could not be met by compromised root systems.

Arthropod pests. Japanese beetle (JB) continues to expand its territory within Iowa. The Japanese beetle was first reported in Iowa in 1994. As of today, specimens have been confirmed from 56 counties. Beetles continue to move to new locations within counties where JB has been reported, keeping alive the beetle's status as a "new" pest (that is, new to some folks, at least). Areas where JB have been observed for many years are experiencing the expected "moderation" in infestation levels with widely variable numbers from season to season. There is considerable interest among homeowners and tree care companies about systemic insecticides, especially non-target effects and application timing.

The magnolia scale has traditionally been an incidental pest in Iowa, with known infestations reported only from a limited area in northern Des Moines. More recently, magnolia scale has been reported in other areas of the state including eastern Iowa and Ames. Treatments have been effective, although plants are frequently heavily infested and stressed by the time the sooty mold and the scales are noticed.

Iowa has an interesting relationship with bagworms on spruce, arborvitae and other host trees. We are at the northern edge of its range meaning the central region of the state has a lot in some years, and none in other years. Historically, bagworm was present only in the southern two tiers of counties. Then in 2008, after 5 consecutive, relatively-mild winters bagworms defoliated trees as far north as Ames, Iowa City, Cedar Rapids and Clinton. A prolonged period of below-zero temperatures in winter 2008-2009 eliminated bagworms from the middle of the state in 2009 and 2010. Bagworms were noticed in central Iowa again this year, but in limited numbers. Treatments are effective when applied against early instar caterpillars, though most homeowners don't find the pest in time for effective treatment.

On May 6, 2010, four emerald ash borer larvae were collected from one ash tree on an island in the Mississippi River, 2 miles south of the IA/MN border (Allamakee County, IA). In

two seasons of trapping, sentinel tree in sections, and public reporting, NO additional EAB have been found in Iowa. As a result of EAB challenges, the Iowa Department of Agriculture and Land Stewardship, on January 1, 2011, implemented firewood regulations requiring anyone who sells or distributes firewood in the state (defined as any length cut and intended for burning) to label firewood bundles and bulk deliveries with the county and state of origin. The label must include the identity of the wood (one species or mixed), the net quantity in cubic feet or cubic meters (not just “cord,” “face cord,” “pickup-load” or other ambiguous terms), the name and address of the dealer, the unit price, and the county and state where the wood was harvested.

To date, Iowa has recorded FIVE (5) specimens of the brown marmorated stink bug, 1 from Linn County and 4 from Johnson County. All specimens are believed to be accidental introductions and not from an established reproducing population in the state. As of this writing, no additional BMSBs have been found or reported through public reports and a minimal trapping program using 10, DEAD-INN Stink Bug Traps spread around the state. Our BMSB efforts have included publication of a pocket guide for recognition of common Midwest stink bugs and related insects. <https://store.extension.iastate.edu/ItemDetail.aspx?ProductID=13641>

Diseases. Most of the ornamental samples seen in the Plant and Insect Diagnostic Clinic this year consisted of broadleaf or coniferous urban trees. However, relatively few diseases were diagnosed on these trees. Some broadleaf trees showed anthracnose leaf spots during the early part of the season. Only one oak was confirmed with oak wilt and only one maple and one lilac were confirmed with *Verticillium* wilt. Conifers were received throughout the entire season and most of the samples consisted of blue spruces severely affected with needle cast. Approximately half of the blue spruces were diagnosed with *Rhizosphaera* needle cast and the rest were diagnosed with *Stigmina*.

Very few annual and perennials were submitted to the clinic this year. During the early part of the season we diagnosed Botrytis blight on peony and impatiens, iris leaf spot, and hosta virus X. In July we saw anthracnose on peony and a couple of samples with hosta petiole rot. On potted indoor or greenhouse plants, the most common problem seen was root rot by *Pythium* sp.

Springtime turf diseases in 2011 included Septoria leaf spot, anthracnose, and Ascochyta leaf blight. During very warm and humid weather conditions in July, we saw several cases of Pythium blight and brown patch. During late July and August, most lawn samples submitted were diagnosed with summer patch. There were also scattered reports of gray leaf spot on golf course fairways in early September, with damage ranging from slight to moderate.

Bur oak blight. This disease discovered in Iowa several years ago, remains a focus of research by Dr. Tom Harrington at ISU. From an article published on the PIDC website in February 2011:

It's beginning to look like bur oak blight, or BOB for short, is a long-time resident of Iowa, and he's here to stay. Bur oak blight has been recognized in Iowa for only the last 6 or 7 years, but the fungus that causes it has probably been here much longer. A shift in climate to more frequent rain events appears to be increasing the severity of BOB throughout much of the western two-thirds of the state. The same phenomenon that contributes to Iowa's now all-too-common floods may be helping BOB kill our state tree.

A common leafspot fungus, *Tubakia dryina*, was initially thought to be the cause of the blight on bur oak, but closer examination showed that the cause was a new species of *Tubakia*. With funding provided by the US Forest Service, Harrington was able to show that there are five

species of *Tubakia* that can infect bur oak, but only one species can cause dramatic leaf symptoms and tree mortality.

The disease tends to intensify year-to-year in individual trees, and if only a portion of the crown is affected, it usually starts in the lower branches and then later progresses up the tree. The fungus overwinters on the petioles of dead leaves that remain attached to branches. Spores are produced in May from black pustules on the petioles of these old leaves, and the spores infect the newly emerging shoots and leaves during rainy weather. Dramatic leaf symptoms do not become evident until July, however, and the severity of symptoms increases in August and September if weather conditions are right. Leaf symptoms include necrosis (death) of the tissue along the veins and wedge-shaped areas of browning at the tips or sides of the leaves. Severely affected trees may die after several years of severe defoliation.

Not all stands of bur oak are seriously affected by the disease, and not all trees are equally susceptible in even the most severely affected stands. Thus far, Harrington and his team have seen severe BOB only on naturally established bur oak, especially on mature trees on upland sites that appear to be remnants of savannah forests. Bur oak in dense forests and bottomland sites are less seriously affected. Harrington has confirmed the pathogen in 55 of Iowa's 99 counties, but most of the severely affected stands have been in the western half of the state. He has also confirmed BOB in eastern Nebraska and southern Minnesota.

Harrington is experimenting with fungicide injections for control of BOB in high-value trees. Injections of propiconazole (Alamo) into bur oak in late May or early June, before symptoms appear, have been effective. However, propiconazole at the rate recommended for oak wilt can be phytotoxic to bur oak, and the treatment is costly.

As long as the rains keep coming, BOB will probably continue to intensify on upland sites across much of Iowa, and we could lose a number of stately bur oak. Hopefully our next generation of bur oak should be better adapted to a wetter climate and have the resistance necessary to withstand our long-time resident, BOB.

An [18-minute video](#) on the symptoms and other characteristics of BOB is available on the ISU Extension website (<http://fms.extension.iastate.edu/vod/video/2010BobPresentCIC.html>).

2011 North Dakota Report - Woody Plant Disease Research - Jim Walla, NDSU Plant Pathology

NCERA-193; IPM strategies for arthropod pests and diseases in nurseries and landscapes, Austin, TX, October 3-4, 2011.

1. *Stigmina* on spruce needles

Stigmina lautii was identified on spruce in ND in 2006, apparently causing a needlecast similar to that caused by *Rhizosphaera kalkhoffii*. It has been found in many states and provinces of eastern and central USA and Canada. **Koch's postulates have not been proven, so there is still no proof that *S. lautii* causes a disease.**

In a spruce planting in which disease severity (if *S. lautii* causes a disease) has been observed periodically each year from 2006, condition of the trees has progressively deteriorated each year since 2006, passing the point of severe *Rhizosphaera* needlecast in similar conditions in 2009. *R. kalkhoffii* fruiting bodies were observed on only one group of four needles out of thousands of needles observed microscopically in that planting in 2007, and was not seen there in 2008 and 2009. In 2010, *Rhizosphaera* fruiting bodies could readily be found on brown needles, but *S. lautii* still predominated. In 2011, in one of two field plots, *Rhizosphaera* pycnidia were more common on brown needles than were sporodochia of *S. lautii*. Some brown needles had *S. lautii* sporodochia on one portion and *R. kalkhoffii* pycnidia on another portion. Only *S. lautii* produced spores on green needles.

Information continues to be collected and processed from observations made during a 2007-2008 fungicide trial. It was suggested during our 2010 meeting (J. Hartman) that there was adequate information available to propose a disease cycle. In this trial, there were six treatments at various times over two years. It appears likely that differences in presence of symptoms and signs among treatments are due to differences in when the needles were protected by a fungicide. Compilation of such observations provides indications of first infection period, major infection periods, age when needles can be infected, and so on. Using such information, a putative *Stigmina* needlecast disease cycle was developed. It is a work in progress, and is being modified as additional information is obtained.

Development of the disease cycle allows development of fungicide management recommendations. Two options appear to be available. Option 1) Allow infection, but keep the tree green. This will require needle protection for two months after bud break and continuing indefinitely. Option 2) Prevent infection until inoculum source is gone. This will require needle protection every year during the entire sporulation period (about 5 months in ND) until the youngest infected needles are cast, likely 4 or 5 years.

Differential infection among needle age classes had not been observed among trees in prior year. Symptoms had developed on some needles of all observed trees under severe infection pressure during their second growing season. In 2011, one tree was present in the fungicide trial plots on which the first symptoms did not develop on needles until their third growing season. This is the first indication that host resistance may be an option for disease management.

Fungicide trials were made in 2010 to 2011 to more closely assess when infection occurs.

2. National elm trial (a national project led by W. Jacobi, Colorado State Univ.)

No elms were planted in 2011.

A numerical value was assigned to the tree condition ratings, and the ratings were totaled for each clone to provide a relative ranking of tree condition in September, 2011. At the Bismarck site, Commendation (repeat), Danada Charm (repeat), New Horizon (repeat), and Triumph (repeat) were in the best condition, while Accolade was the only 2010 cultivar that dropped out. Three cultivars (Commendation, New Horizon, and Pioneer) improved in condition by at least a full ranking level from 2010. At the Fargo site, Danada Charm (repeat), Patriot, and Valley Forge were in the best condition, while Princeton was the only 2010 cultivar that dropped out. The same three cultivars (Danada Charm, Patriot, and Valley Forge) improved in condition by at least a full ranking level from 2010.

3. Dothistroma needle blight projects(cooperative with Irene Barnes, Univ. of Pretoria, South Africa)

Dothistroma needle blight (DNB) was discovered in ND in 2010, the first time it had been found there after I had looked for it for 30+ years. Diagnosis currently require molecular work, and the authority is Irene Barnes in South Africa. Contact with Dr. Barnes led to discussions of how the disease seems to be exploding in the northern hemisphere, that there is much research worldwide except in the USA. That discussion led to involvement in two projects.

One project is a national collection of DNB samples from as many hosts in as many types of sites in as many states as possible. Dr. Barnes had previously been largely unsuccessful in obtaining DNB samples from the USA. Hopefully, with coordination occurring in the USA, a good sample could be obtained. A sampling protocol was developed, but not until mid-2011. With that, emphasis will be placed on coordination of a collection effort in 2012.

The second project is a population genetics study in several north central states. Sampling was done in three of about 10 that we hope to get (ND to KS to IN to MI). Some sites in the additional states have been identified, and additional contacts are yet to be made.

Recent publications

Zeleznik, J, and Walla, J. 2011. Diseases of apple trees - black rot. North Dakota State University Crop & Pest Report 2011 (12):. Online at:
<http://www.ag.ndsu.edu/cpr/forestry/diseases-of-apple-trees-black-rot>

Zeleznik, J., and Walla, J.A. 2011. Storm damaged trees. North Dakota State University Crop and Pest Report 2011 (2):11-12. Online at: <<http://www.ag.ndsu.edu/cpr/pdf-reports/12May11%20Diane2.pdf/view>>.

2011 Ohio Report: NCERA-193

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Analysis of constitutive and induced resistance mechanisms of ash to emerald ash borer

Vanessa Muilenburg, Post-doctoral Research Scientist

Previous work by Eyles et al (2007), Whitehill (2011), and Rivera (2011) identified potential constitutive metabolic and transcriptomic resistance mechanisms of ash to emerald ash borer (EAB). However, the role of induced defenses to EAB is unknown, largely due to the lack of an experimental method to successfully inoculate EAB eggs to ash trees. This past spring we worked out a method to artificially apply eggs to ash trees in order to study the natural, localized induced response to EAB larval feeding. Building off the aforementioned work, the overarching goal of this experiment is to analyze the induced and constitutive resistance mechanisms of mature resistant (*Fraxinus mandshurica*) and susceptible (*F. pennsylvanica*, *F. americana*) ash trees to emerald ash borer (EAB).

Girdling has been identified as an effective tool for studying tree resistance to wood-boring insects. After a tree is girdled, current photosynthate accumulates above the girdle, fueling defensive responses, but tissues below the girdle become depleted of photosynthate because the flow is cut-off to tissues below the girdle. This results in phloem tissues that are resistant above the girdle and susceptible below the girdle. Therefore, ash species were girdled on May 5th, 2011 in a common garden in Novi, MI.

Natural induced responses of ash were elicited by inoculating girdled and ungirdled trees with EAB eggs above and below the girdle on July 7th, 2011. Phloem around larval galleries resulting from EAB egg inoculation was excised to study the localized, induced resistance mechanisms. Phloem without galleries was also sampled to analyze constitutive resistance mechanisms. Phloem samples will be analyzed to compare phenolic and mRNA transcript profiles among/between (1) species, (2) above and below the girdle, and (3) ungirdled and girdled trees in order to characterize putative metabolic and gene-level resistance mechanisms. Additionally, both girdled and ungirdled trees were harvested and dissected to reveal EAB larval galleries in order to relate colonization levels with potential resistance mechanisms.

Biochemistry, physiology, and ecology of paper birch defenses to bronze birch borer and their responses to anthropogenic greenhouse gases

Vanessa L. Muilenburg, Ph.D. 2010

Periodic outbreaks by bronze birch borer (*Agrilus anxius*) have caused widespread birch (*Betula*) mortality in the boreal forests of North America. Mechanisms by which deciduous trees resist wood-borers are not understood but have been hypothesized to result from integrated physical and biochemical phloem defenses. Historically, wood-borer outbreaks have been

associated with environmental stress, which is thought to weaken tree defenses. Therefore, the overarching goals of this dissertation research were to characterize birch defenses to bronze birch borer, their relationship to whole plant physiology, and how their expression is affected by environmental stress.

Objectives of this research were to use a metabolomics approach to compare the constitutive and induced biochemical profiles of paper birch (*B. papyrifera*) phloem, which is resistant to bronze birch borer by nature of its coevolutionary history, with that of European white birch (*B. pendula*), which is much more susceptible. Then, to investigate the relationship of these putative defenses to whole plant physiology, paper birch stems were girdled to disrupt transport of current photosynthate and alter within-tree resistance to bronze birch borer (*Chapter 4*). Finally, to determine how environmental factors modify expression of resistance, the effects of elevated CO₂ and ozone (O₃) on paper birch resistance and bronze birch borer colonization were analyzed.

Rate of wound periderm (callus) formation did not differ between paper birch and European white birch, but may contribute to resistance if it interacts with defensive chemicals or nutritional factors that slow feeding, allowing wound periderm to encapsulate larvae. Constitutive and induced phenolic profiles of paper birch and European white birch differed. Paper birch had two phenolics that were not detected in European white birch, and concentrations of six were higher in paper birch than European white birch, which may contribute to higher resistance of paper birch to bronze birch borer.

Trunk girdling decreased phloem resistance to bronze birch borer below the girdle, confirming that stress compromises resistance and supporting the hypothesis that the flux of current photosynthate from leaves to trunk provides the energy to drive defensive responses. Total phenolic concentration and rate of wound periderm formation were higher above the girdle, corresponding with higher resistance in that portion of the tree.

Elevated atmospheric CO₂ and O₃ decreased paper birch resistance to bronze birch borer in a four-year study at the Aspen FACE facility in Rhinelander, WI. In combination, however, elevated CO₂ and O₃ had no effect on paper birch resistance, which is consistent with previous studies showing elevated CO₂ to ameliorate effects of elevated O₃ on tree physiology. Elevated CO₂ and O₃ altered phloem chemistry but not in ways that could explain patterns of bronze birch borer colonization. The results suggest that on-going changes in atmospheric composition could facilitate bronze birch borer outbreaks, possibly altering the distribution of paper birch in North America.

Effects of nursery production practices on resource allocation patterns, and carbon sequestration trajectories of hybrid elm and river birch in urban environments

Alejandro Chiriboga, Ph.D. Candidate

Global climate change concerns have increased the need to create multiple mitigation scenarios to reduce carbon dioxide (CO₂) emissions. Strategic management of urban forests at different times and levels (e.g. nursery and landscape) can contribute to reduce CO₂ rates over time. Preliminary results, showing the analysis of the structure and functions of street trees in Wooster, OH, have suggested that the economic value of environmental services can increase substantially with strategic management. Nursery management practices such as fertilization and irrigation can play a crucial role on the establishment and the future of trees in the landscape. In urban ecosystems, tree establishment can become more challenging because of the wide variety

of stressful environmental conditions. Thus, the goal of this research is to investigate how nursery management practices can enhance stress tolerance and environmental services (particularly carbon sequestration) provided by urban trees. We will test a theoretical framework that postulates that alteration of nutrient availability at the nursery level will affect (1) resource allocation patterns and stress tolerance of fast growing tree species during their establishment period in the landscape and (2) consequently will impact carbon sequestration rates over time. Results of this study will contribute to identify management strategies that can alter (increase/decrease) rates of carbon sequestration of urban trees over time and can also enhance the economic value other environmental services. In addition, this research will increase our understanding of the physiological responses of trees and their stress tolerance in urban environments.

Indirect effects of emerald ash borer (*Agrilus planipennis*) induced ash mortality on the forest floor invertebrate community

Kayla I. Perry, M.S. Candidate

I am interested in surveying the forest floor invertebrate community to determine if the species abundance and composition differs in response to the widespread simultaneous removal of ash and the creation of forest canopy light gaps from emerald ash borer infestation. An increase in ash coarse woody debris may increase the diversity and abundance of these invertebrate species by increasing habitat heterogeneity, and thus available resources. The invertebrate community associated with existing canopy gaps and decaying ash woody debris will be sampled in Michigan to observe any natural patterns. A manipulation experiment will be used to explain these patterns, and deconstruct the effects of light gaps, woody debris, and the interaction between both on the forest floor invertebrates. Experimental plots were created to test this interaction, and these include light gap present with woody debris (+/+), light gap present without woody debris (+/-), light gap absent with woody debris (-/+), light gap absent without woody debris (-/-). Additionally, litter decomposition rates will be assessed as well as abiotic characteristics, such as temperature and moisture, to determine the effects of EAB altered forest floor microenvironments on invertebrate decomposition activity. A forest floor invertebrate food web will be constructed based on the feeding guilds represented in the collected samples.

Cascading ecological impacts of emerald ash borer: tritrophic interactions between prickly ash, giant swallowtail butterfly larvae, and larval predators

Kevin B. Rice, Ph.D. Candidate

Since its accidental introduction from Asia, the emerald ash borer, *Agrilus planipennis*, (EAB) has killed millions of ash trees, *Fraxinus spp.*, in Midwestern forests. Extensive tree mortality has generated widespread canopy gaps, resulting in increased light penetration to the understory. Foliage of the native shrub prickly ash (*Zanthoxylum americanum*) contains furanocoumarins, which are secondary metabolites that deter most herbivores, especially as they become more toxic when photoactivated by UV light. Furthermore, furanocoumarin biosynthesis is energy intensive, and their concentration increases when photosynthesis is enhanced by increased light availability. Female plants typically invest more resources towards defensive compounds while males allocate more resources towards growth. Therefore, male and

female prickly ash located in canopy gaps created by EAB-induced ash mortality may differ in their furanocoumarin concentrations, relative growth rates, and reproductive investments.

In the larval stage, the giant swallowtail butterfly, *Papilio cresphontes*, is a specialist herbivore on prickly ash that is capable of detoxifying furanocoumarins with cytochrome P450's. Previous studies have documented a fitness cost (delayed development) associated with furanocoumarin detoxification in caterpillars. Delays in larval development increase exposure to natural enemies. Therefore, *P. cresphontes* larvae feeding on prickly ash in canopy gaps may experience increased predation pressure.

In a series of field experiments, we examined the effects of EAB-induced canopy gaps on prickly ash specific leaf area (SLA) and new growth. Prickly ash located under canopy gaps had lower SLA compared to shaded plants. A significant sex by light interaction was observed in new growth. Male prickly ash grew more in sun compared to males in shade. However females located in sun grew less than females in shade. We hypothesize females in sun allocate more resources towards reproduction (fruit) and defense (furanocoumarins) resulting in reduced growth.

In addition, we examined the effects of prickly ash foliage collected from understory and canopy gaps on *P. cresphontes* development. Larvae consuming foliage from plants located in sun had lower relative growth rates compared to larvae feeding on foliage from shaded plants. Our results suggest *P. cresphontes* larvae development is negatively affected by widespread canopy gap formation. Future studies will examine interactions between canopy gaps and swallowtail larvae predation pressure. We hypothesize caterpillars located in canopy gaps will experience higher predation rates compared to caterpillars in the understory.

Characterization of adult emergence patterns, induction and termination of prepupal diapause of emerald ash borer (*Agrilus planiplennis* Fairmaire)

Samuel A. Discua, M.S. Candidate

Emerald Ash Borer (*Agrilus planiplennis* Fairmaire), EAB, is an exotic beetle native to Asia that threatens North American ash with devastating economic and ecological impacts in forests and urban landscapes. Understanding the seasonal biology of EAB is required to timely forecast the emergence of the adults and inform regulatory decisions. This research will focus on some aspects of the phenology of EAB by characterizing the adult emergence patterns across a latitudinal gradient, as well as determining the effects of temperature and photoperiod in the induction and termination of prepupal diapause. Results from this study will provide useful information to improve the accuracy of phenological and spread models as well as well as increasing our understanding about the environmental factors that regulate diapause in EAB.

The Cascading Impact of Emerald Ash Borer: Effects of Ash Mortality on Breeding Bird Communities in Fragmented Midwestern Forests

Lawrence C. Long, M.S. Candidate

It is my aim to assess the potential shift in breeding bird community resulting from EAB-induced ash mortality. The focal hypothesis is that infestation by EAB will result in a substantial enough shift in insect community and forest structure to influence the foraging behavior of woodpeckers and other bark foragers as well as the abundance of other insectivorous bird species

guilds. One such guild of insectivores; woodpeckers; have already begun to exhibit a strong winter feeding response in areas of high EAB infestation. So strong is this response in fact that I was able to show with preliminary data, that woodpeckers in heavily infested sites preferentially forage on ash, almost to the exclusion of other tree species.

Insectivorous birds known to make their living as bark foragers or weak excavators such as the white-breasted nuthatch (*Sitta carolinensis*) or downy woodpecker (*Picoides pubescens*) may be primed to benefit during the late spring and summer emergence of the adult beetle, particularly in the early to mid stages of a forest's infestation. The contribution of this particular resource pulse to bark foraging specialists and the extent to which it is utilized has never been studied, nor has been the impact of the bark foraging guild on the progression of infestation in any given region.

Furthermore, there has been no investigation of the bark foraging guild's utilization of ash in "aftermath" forests. Utilizing transect observation of foraging behavior I wish to answer such questions as: How does foraging preference differ post EAB infestation compared to during and before the beetle's arrival? Also, what sort of insects are infesting the ash snags and deadfall? And, are these food items abundant enough to support an EAB-induced increase in the bark foraging community if this is shown to occur? Finally, with data gleaned from early season point counts, I hope to show that in areas of appropriate ash density, the bird community can be altered. For example, perhaps there emerges a shift toward species known to rely on successional type forest structure, whose release was caused by EAB-induced ash mortality.

Patterns of Ash Mortality and Regeneration in the Huron River Watershed in Southeast Michigan in Response to the Emerald Ash Borer Invasion

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We have monitored progression of ash (*Fraxinus* spp.) decline and mortality due to emerald ash borer (EAB, *Agrilus planipennis*) in 38 forest stands in the Upper Huron River watershed of southeastern Michigan since 2003. Black (*F. nigra*), green (*F. pennsylvanica*), and white (*F. americana*) ash were most common in hydric, mesic, and xeric stands, respectively. A transect was established within each stand consisting of three 0.1 ha circular plots (114 plots total). Within each plot, all ash trees were identified to species and assigned a crown dieback rating on a scale of 1-5, with '1' indicating no decline and '5' being a dead tree.

Ash decline significantly increased over time from a mean rating of 3.5 in 2004-2005 to

4.8 in 2007, to 4.9 in 2008. Although black ash initially experienced greater decline and mortality than white or green ash in 2004-2005, this trend was absent in 2007, indicating that all species are now declining at equal rates. Overall ash mortality is now 99.7% in all plots, with the vast majority of surviving trees clustered in the 1-2 inch DBH size class. A significant negative relationship was detected between percent ash tree mortality and distance from the epicenter of the infestation in township of Canton, Michigan from 2004 to 2006, with mortality decreasing 2% with each km away from the epicenter. On average, percent mortality of ash increased 30% over the three years, but the slope of line describing this relationship (2% decrease in mortality per km away from the epicenter) remained unchanged. However, this relationship was no longer significant as of 2007, as mortality of ash in stands farther away from the epicenter now exceeds 99%. The location of all surviving trees has been mapped and reported to Dr. Jennifer Koch at the Delaware lab, whom has collected scion material to evaluate them for resistance as part of her "Lingering Ash" research project.

We have also quantified (1) ash regeneration by sampling the ash seed bank from 2005-2008, (2) ash seedling and sapling dynamics in 2008-2010, and (3) EAB populations in relation to ash density through annual sampling with purple panel traps in 2008 and 2009. Our previous results have shown that ash are the most common woody species in the seedling and sapling layers of these forests, which has led us to pose these questions: (1) will this regeneration restore ash if EAB is locally extirpated due to depletion of its food resource, or (2) can ash regeneration maintain an EAB population indefinitely as the supply of susceptible saplings is continually replenished? We measured densities of four demographic classes of ash: newly germinated seedlings (cotyledons present), established seedlings (at least one-year-old but less than 25 cm tall), saplings (25 cm tall to DBH of 2.5 cm), and trees large enough to support EAB (DBH > 2.5 cm).

Four years of intensive soil sampling (432 samples / yr) suggests that the ash seed bank in these stands is rapidly depleted as overstory trees die. Small numbers of seeds were found in 2005 and 2006; however, no ash seeds were found in the soil or on the soil surface in 2007 or 2008. Our observations also indicate, contrary to some earlier speculation, that ash trees do not increase seed production as they become stressed by EAB. Patterns of ash demography were consistent with conclusions reached from seed bank sampling. Density of new ash seedlings was 0.5 and 0.1 plant / ha in the Michigan plots in 2008 and 2009, respectively. No new ash seedlings were observed in 2010 inside or outside the monitoring plots. In contrast, density of new ash seedlings routinely exceeded 800 plants / ha in Ohio plots where EAB mortality was still low or nonexistent, and exceeded 20,000 plants / ha in some plots in 2009 following mast seed production on a regional scale in 2008. Established ash seedlings (no cotyledons but less than 25 cm tall) were far more abundant than new seedlings in the Michigan plots, averaging 76 and 191 plants / ha in 2008 and 2009, respectively. However, this pattern was reversed in Ohio plots, where new seedlings greatly exceeded established seedlings, except in stands where mortality of mature ash approached 100%.

Density of ash saplings was much lower (6.1 plants / ha in 2009) than that of established seedlings, possibly due to self-thinning. Density of trees large enough to be colonized by EAB (> 2.5 cm DBH) was less than 1.0 plant / ha in both 2008 and 2009. Numbers of EAB captured on purple panel traps were correlated with percent survival of mature ash, and declined from 2008 to 2009 as ash mortality increased. However, EAB continued to persist at low levels in all plots, suggesting that ash saplings may be sustaining low density populations.

In summary, EAB-induced mortality of trees with DBH > 2.5 cm now exceeds 99% in

the Huron River Watershed in southeast Michigan. Our evidence suggests the ash seed bank does not persist after overstory trees succumb. Ash regeneration has ceased in these plots, as new seedlings were virtually nonexistent in 2008 and 2009, averaging less than one plant / ha. Established seedlings and saplings with DBH < 2.5 cm are the only demographic classes of ash remaining in these plots. EAB continues to persist at low levels even in plots where ash mortality exceeds 99%, suggesting that an EAB population might be sustained, at least in the short-term, as established seedlings and saplings become large enough to be colonized. Ultimately, in the absence of ash regeneration, EAB may be locally extirpated as this orphaned cohort of juvenile ash is gradually depleted via EAB mortality.

Recent Publications

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