Efforts to Improve the Detection and Management of Ambrosia Beetles in Ornamental Nurseries

Chris Ranger
USDA-ARS
Wooster, OH

Michael Reding
USDA-ARS
Wooster, OH

Jason Oliver
Tennessee State Univ.
McMinnville, TN

Peter Schultz
Virginia Tech.
Virginia Beach, VA

John Vandenberg
USDA-ARS
Ithaca, NY

Louela Castrillo
Cornell Univ.
Ithaca, NY

Heping Zhu
USDA-ARS
Wooster, OH

Charles Krause
USDA-ARS
Wooster, OH

USDA ARS

VirginiaTech Invent the Future

Tennessee State University

Cornell University

An Emerging Pest Management Challenge Facing the Industry

- Ambrosia beetles
  - Order: Coleoptera
  - Family: Curculionidae
  - Subfamily: Scolytinae
  - Tribe: Xyleborini
  - Genus: Xylosandrus

- Extensive economic loss, but not well defined

- Wood-boring behavior, thus difficult to detect and control

Black Stem Borer
Xylosandrus germanus

- Introduced from Japan or east Asia
  - -First reported in NY (1932)
- Northeastern, Southeastern, Midwestern, Southern, and Northwestern US

Granulate Ambrosia Beetle
Xylosandrus crassiusculus

- Introduced from southern Asia
  - -First reported in SC (1974)
- Northeastern, Southeastern, Midwestern, Southern, and Northwestern US, plus Hawaii

Hosts for *X. germanus* and *X. crassiusculus*

- >200 hosts worldwide; deciduous trees preferred
  - Apple, Cherry, Chestnut, Dogwood, Hydrangea, Golden Raintree, Lilac, Magnolia, Maple, Peach, Pear, Redbud, Styrax, Weeping Mulberry, Yellowwood
- Typically pests of stressed or dying trees
- But, examples of attacks on “apparently healthy” trees too
  - “Apparently healthy” to whom?

Cryptic Tunneling Behavior of Ambrosia Beetles

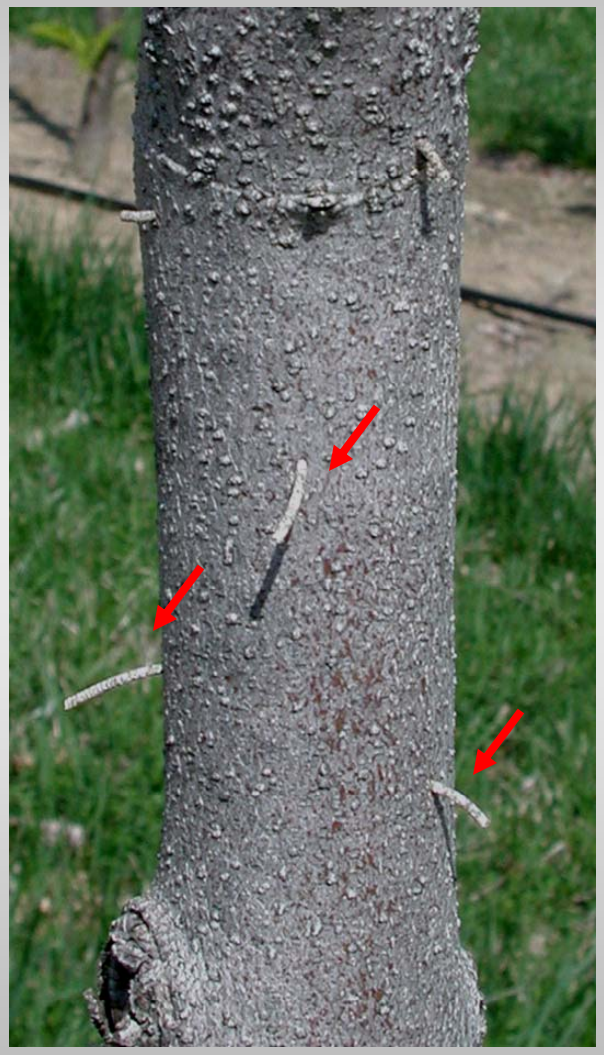
~1 mm diam.

X. germanus

~2 mm diam.

X. crassiusculus

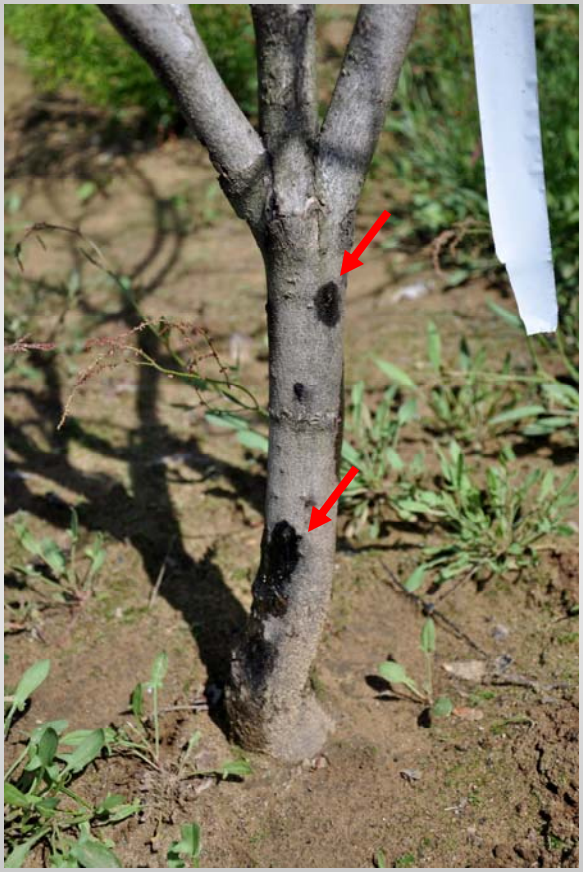
Frass Toothpicks = Symptom of an Infestation



Cornus

Magnolia virginiana

Sap Production = Symptom of an Infestation



Cornus

Styrax

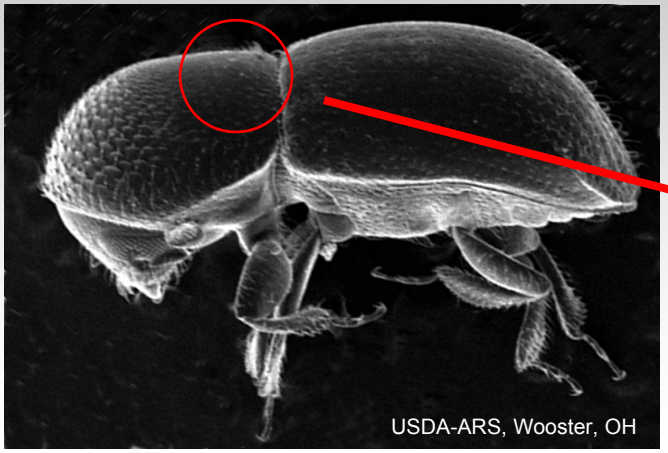
Styrax

Gallery Formation

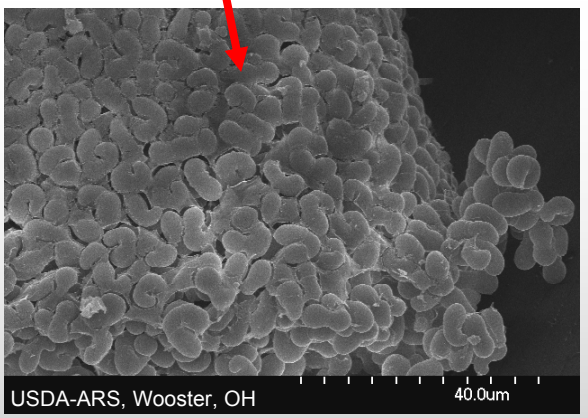
X. germanus gallery in *Magnolia virginiana*

X. germanus larvae and pupae

Ambrosia Beetle Fungal Symbionts



X. germanus



- Symbiotic fungi maintained in pouch (i.e., mycangia)
- Larvae and adults feed on fungi, not host tree
- *Ambrosiella* species associated with *X. germanus*

Terminal dieback, basal sprouts = symptoms of an infestation

Magnolia virginiana

Team Members

Project: "Improving the Monitoring, Trapping, and Management Tactics of Ambrosia Beetles in the Nursery Agroecosystem"

Michael Reding, Ph.D.
Research Entomologist
Application Technology
Research Unit
USDA-ARS
Wooster, OH

Jason Oliver, Ph.D.
Research Associate Prof.
Otis L. Floyd Nursery
Research Center
Tennessee State Univ.
McMinnville, TN

Peter Schultz, Ph.D.
Prof. and Director
Hampton Roads Ag. Res.
and Ext. Center
Virginia Tech Univ.
Virginia Beach, VA

Charles Krause, Ph.D.
Research Leader/
Plant Pathologist
ATRU
USDA-ARS
Wooster, OH

Roles:

(1) Optimize trapping and monitoring tactics
(2) Characterize seasonal flight activity
(3) Screen the efficacy of conventional insecticides and botanical formulations
(4) Determine the effects of stress factors on tree attractiveness
(5) Characterize pathogenicity of fungal symbionts

Chris Ranger, Ph.D.
Research Entomologist
ATRU
USDA-ARS
Wooster, OH

Team Members

Project: "Microbial Control of Ambrosia Beetles *Xylosandrus crassiusculus* and *X. germanus* and their Symbiotic Fungi *Ambrosiella* spp."

John D. Vandenberg, Ph.D.
Research Entomologist
USDA ARS Bio-IPM Research Unit
Robert W. Holley Center for Agriculture and Health
Ithaca NY

Louela Castrillo, Ph.D.
Research Associate
Department of Entomology
Cornell University
Ithaca, NY

Roles:

(1) Isolate and identify symbiotic fungi

(2) Determine genetic diversity and pathogenicity among populations of symbiotic fungi

(3) Assess microbial control agents against beetles and their symbiotic fungi

Team Member

Project: "Biological, Microclimate, and Transport Processing Affecting Pest Control Application Technology"

Heping Zhu, Ph.D.
Agricultural Engineer
Application Technology Research Unit
USDA-ARS
Wooster, OH

Roles:

(1) Improve insecticide application technology by developing sensor-based delivery system

(2) Evaluate chemigation tactics for controlling ambrosia beetles

Results Related to Ambrosia Beetle Detection and Monitoring

"Improving the Monitoring, Trapping, and Management Tactics of Ambrosia Beetles in the Nursery Agroecosystem"

Team Members

Ranger (USDA-ARS), Reding (USDA-ARS), Oliver (TSU), Schultz (VT), Krause (USDA-ARS)

Detecting and Monitoring Ambrosia Beetles

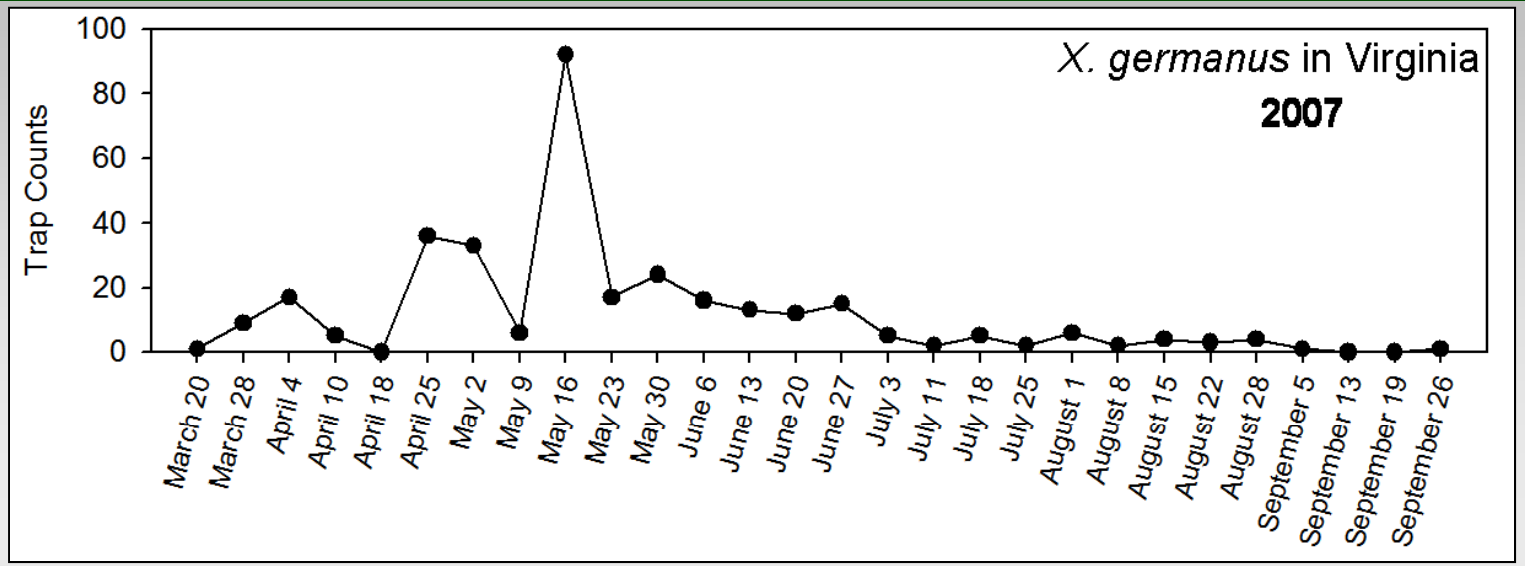
- Ethanol-baited traps are used for monitoring seasonal activity
  - Traps best placed along edge of a woodlot

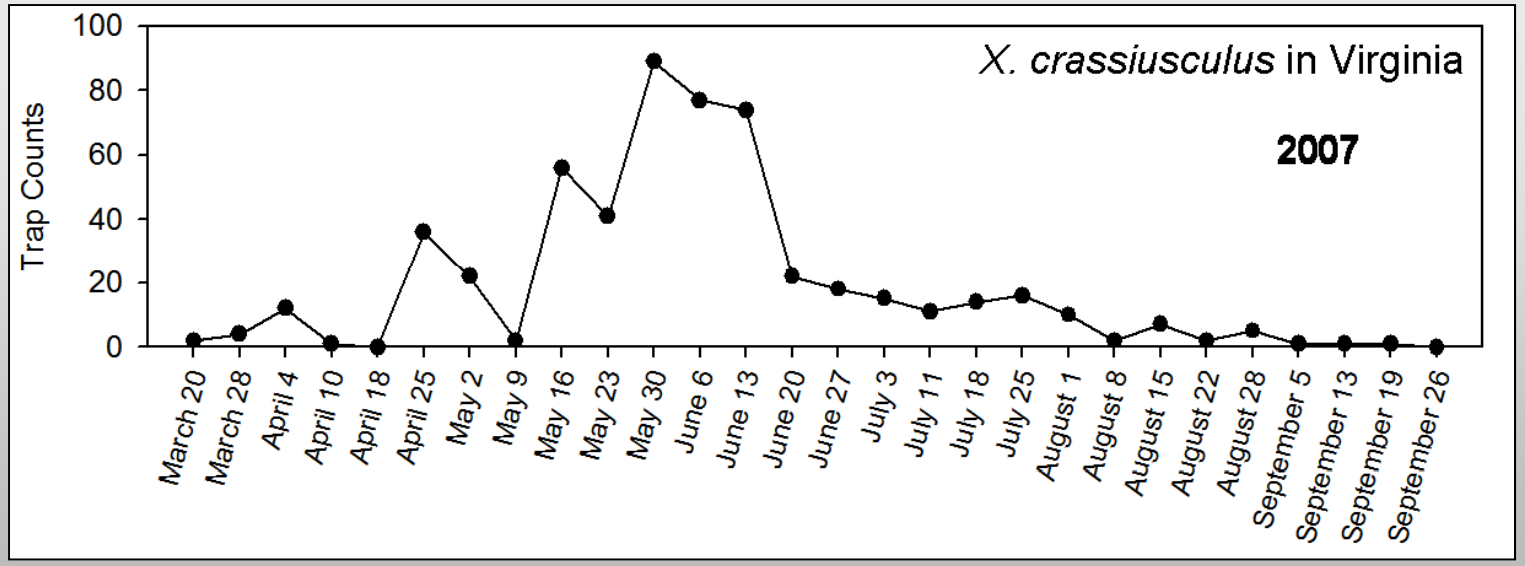
EtOH lure

Bottle trap

Lindgren trap

Monitoring Seasonal Activity

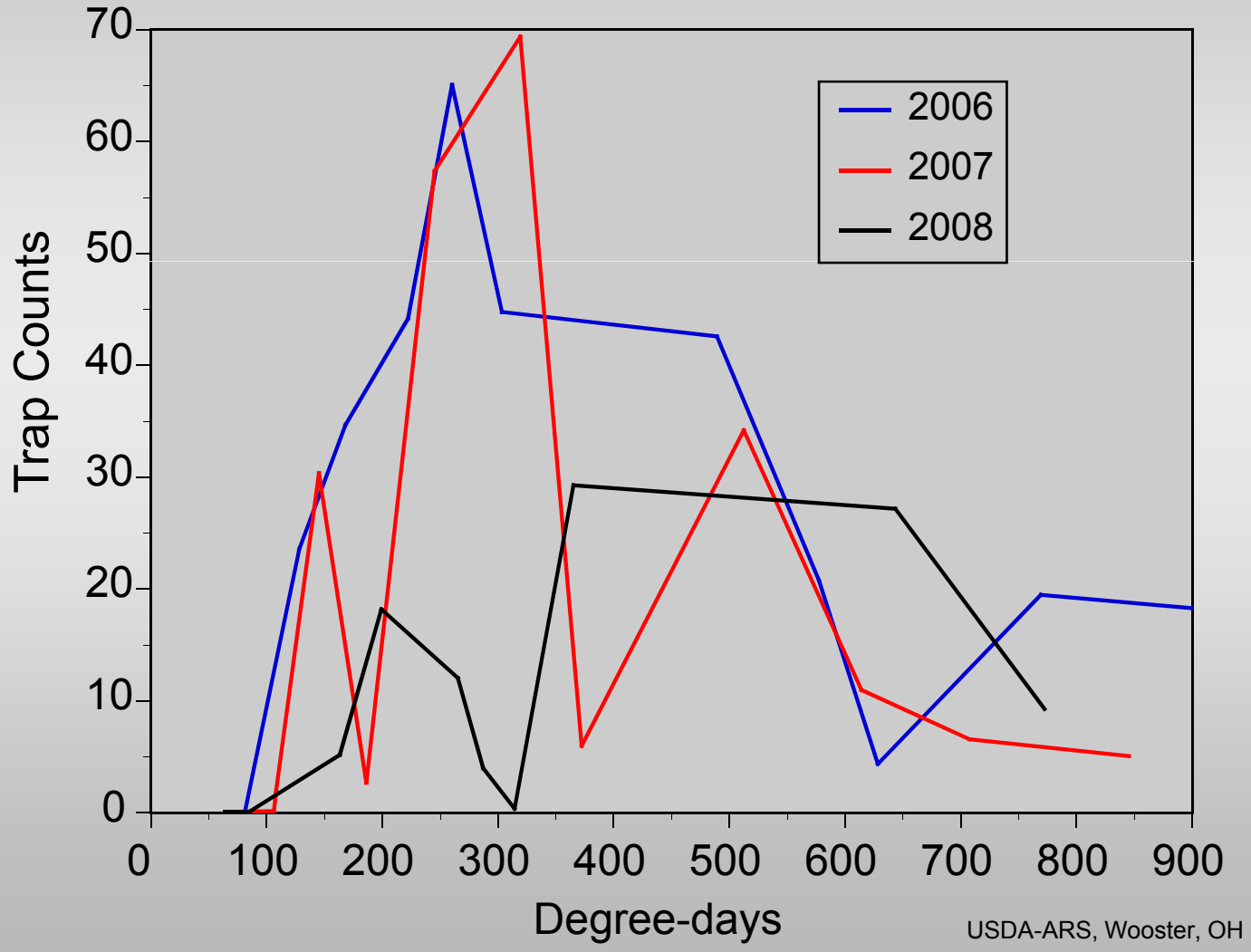




VT, Virginia Beach, VA

Correlating Seasonal Activity with Degree Days

~ 100 DD associated with initial collection of *X. germanus* in Ohio



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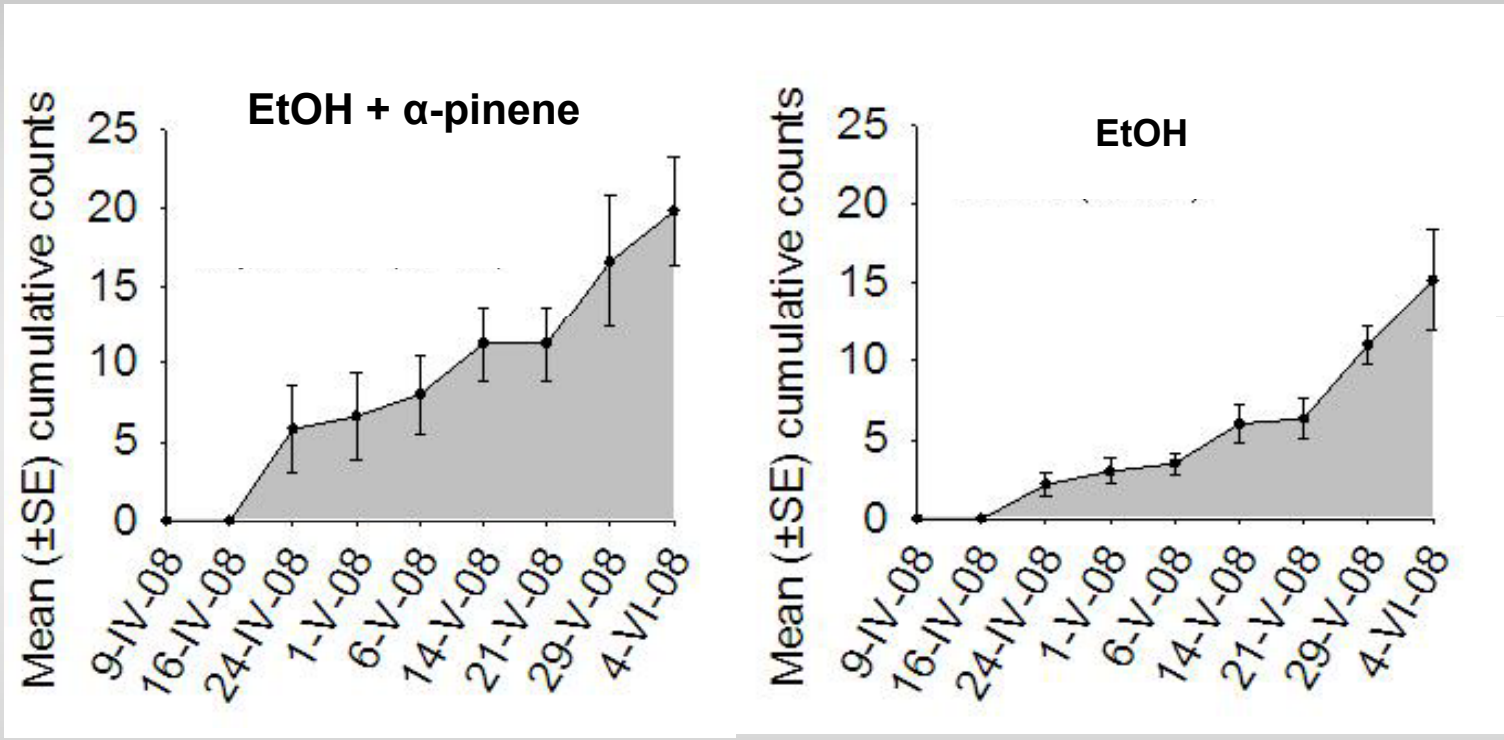
Attempts to Improve Lure Attractiveness

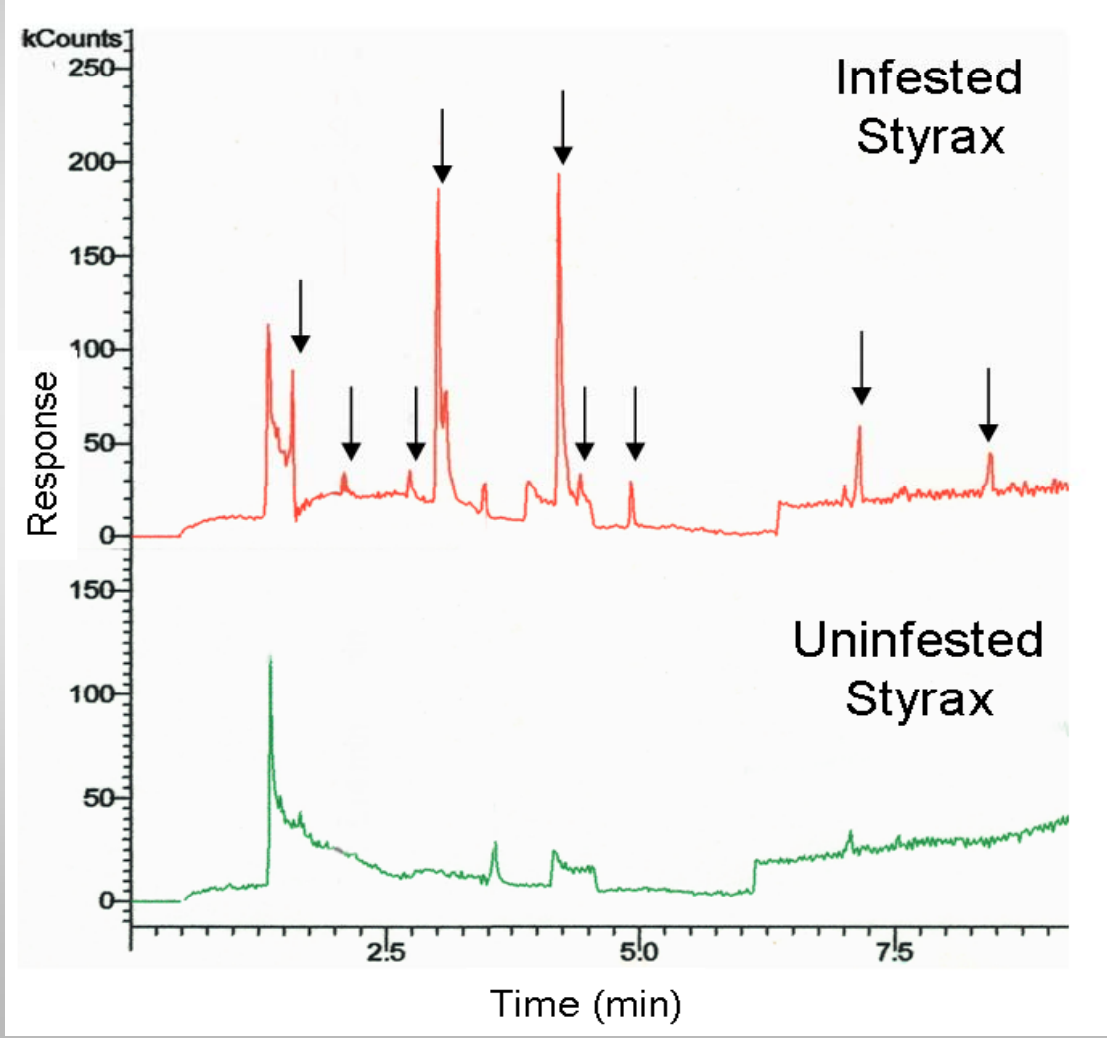
- EtOH + α-pinene slightly more attractive to *X. germanus* than EtOH alone



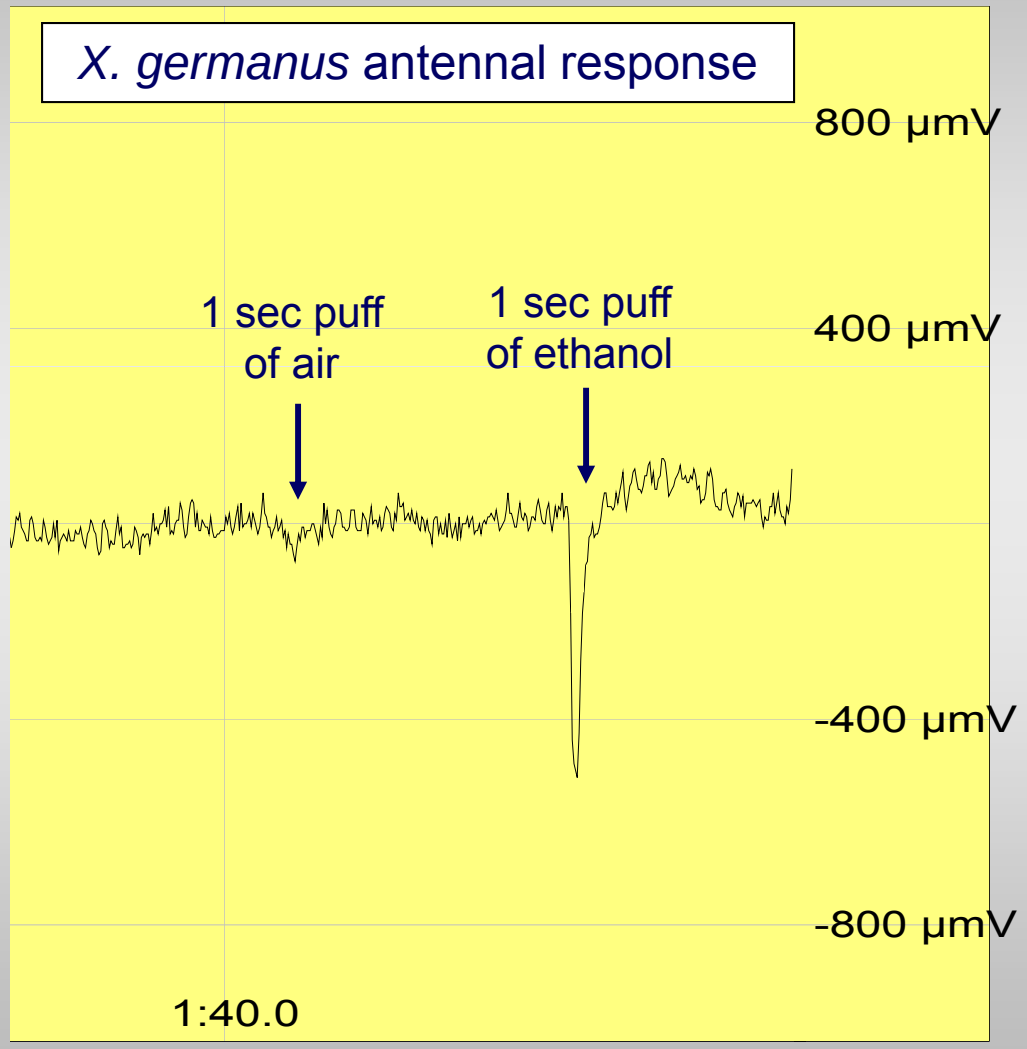
- Other stress-related volatiles tested to date haven't exhibited synergism with EtOH
  - Acetaldehyde, acetone, ethyl acetate, methanol, and propanol

Attempts to Improve Lure Attractiveness

- More volatiles (odors) released from infested vs uninfested trees

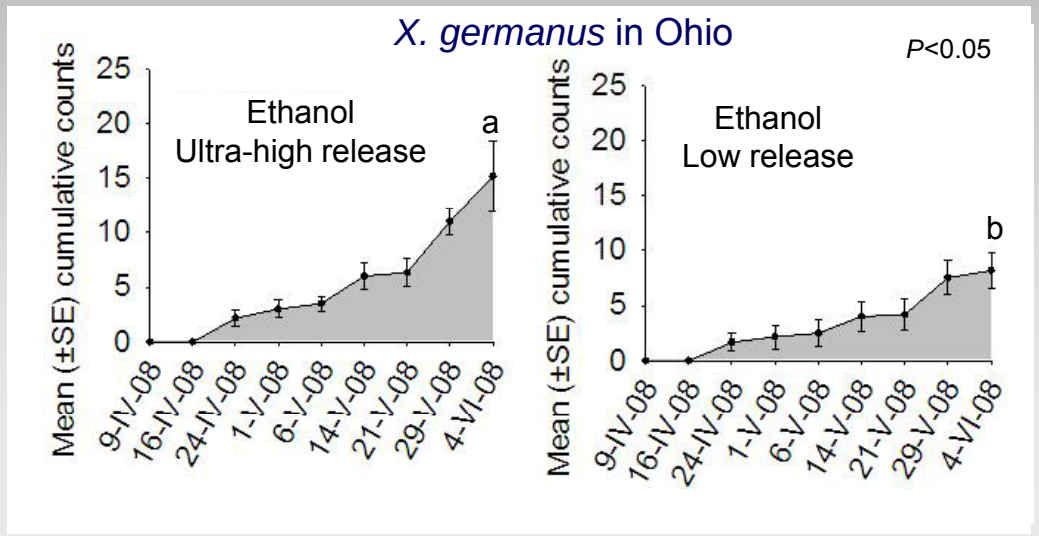


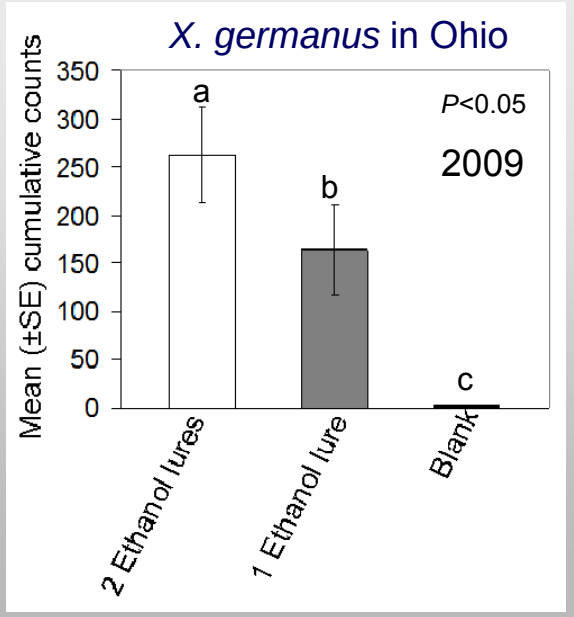
Identifying Attractants using Electrophysiology

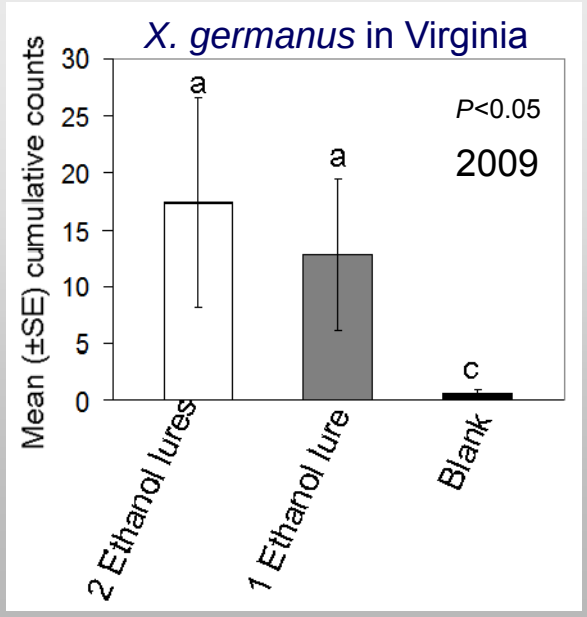


Importance of Ethanol Release Rate

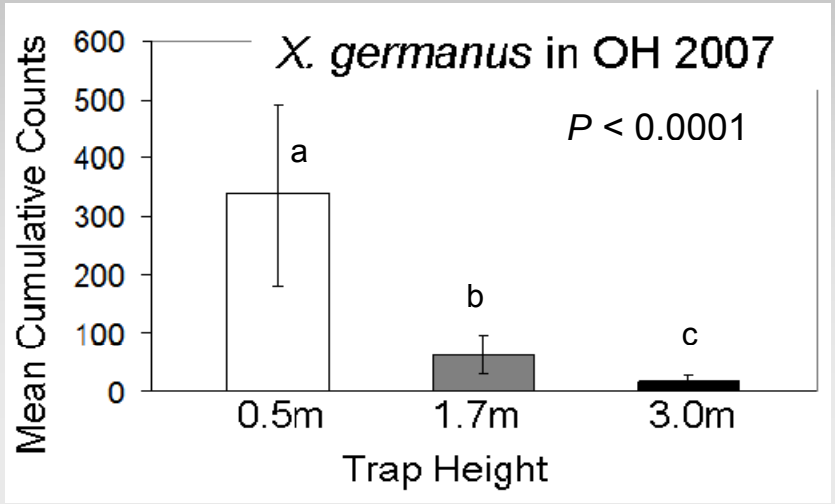
Trap counts of *X. germanus* increase with ethanol release rate

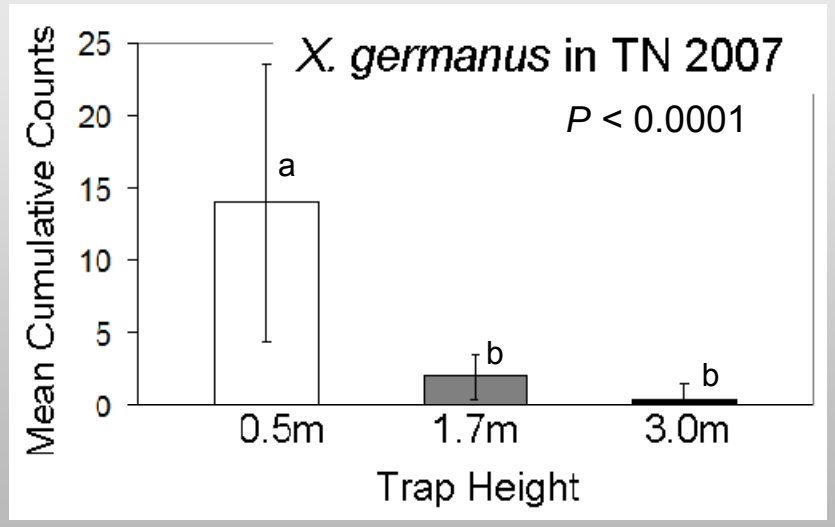


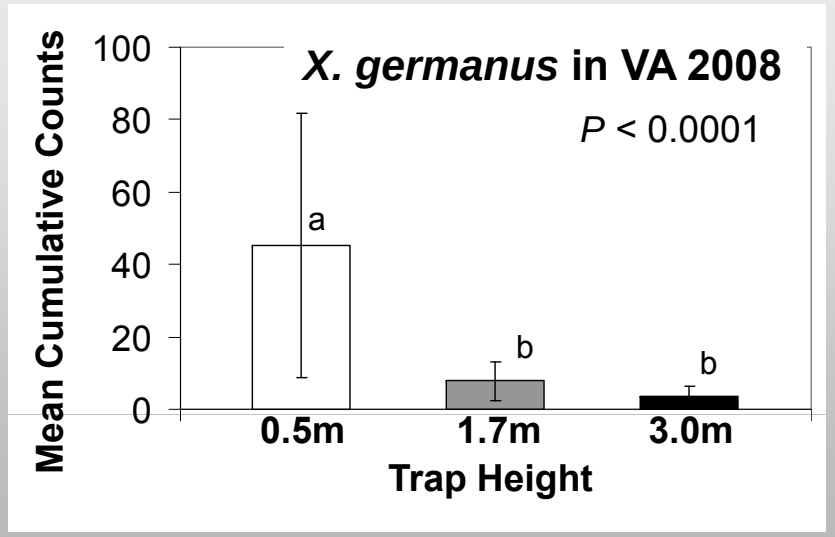




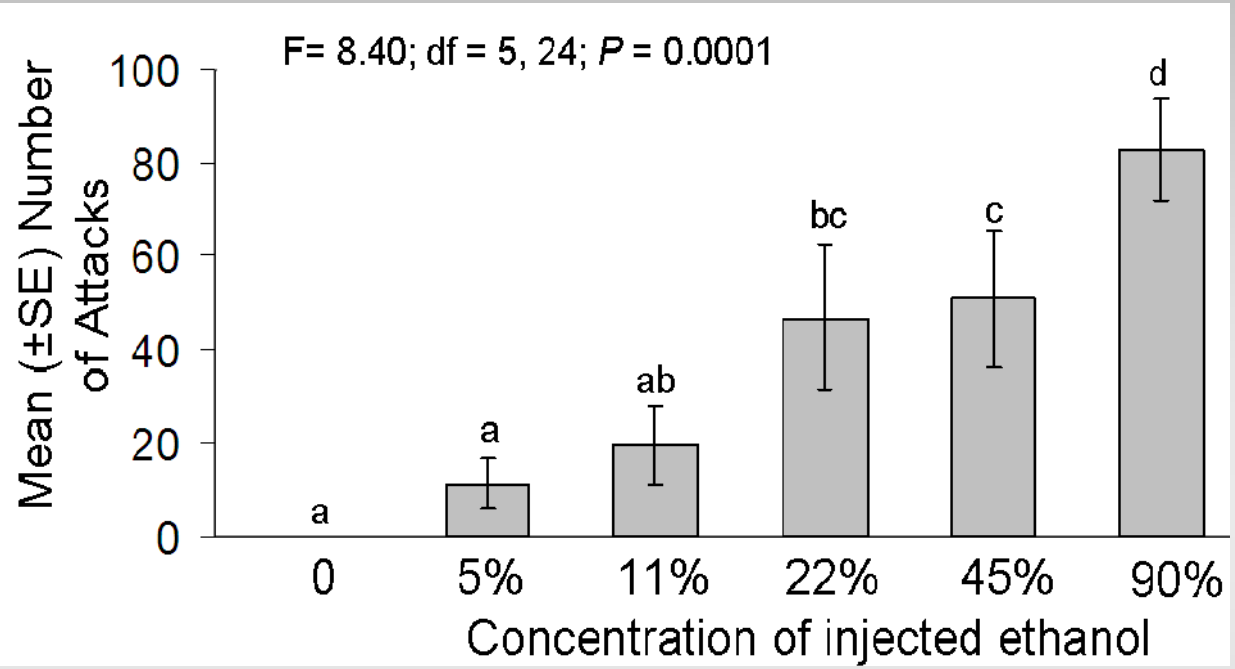
Optimizing Trap Design: Importance of Trap Height







Inducing Ambrosia Beetle Attacks on Specific Trees



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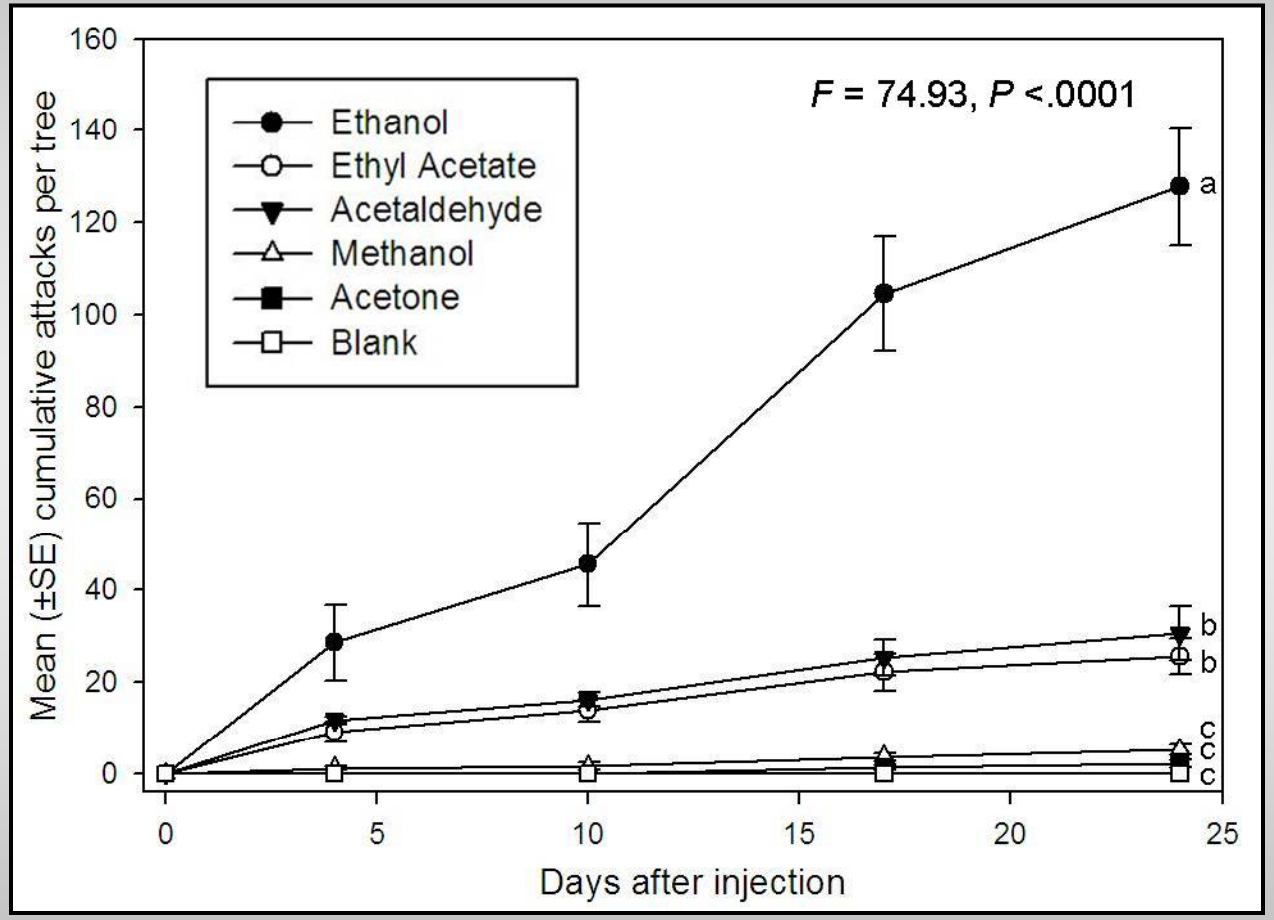
Why?

- ✓ Monitoring beetle activity
- ✓Trap trees
- ✓ Insecticide trials

Variability of Stress-Related Volatiles to Induce Attacks



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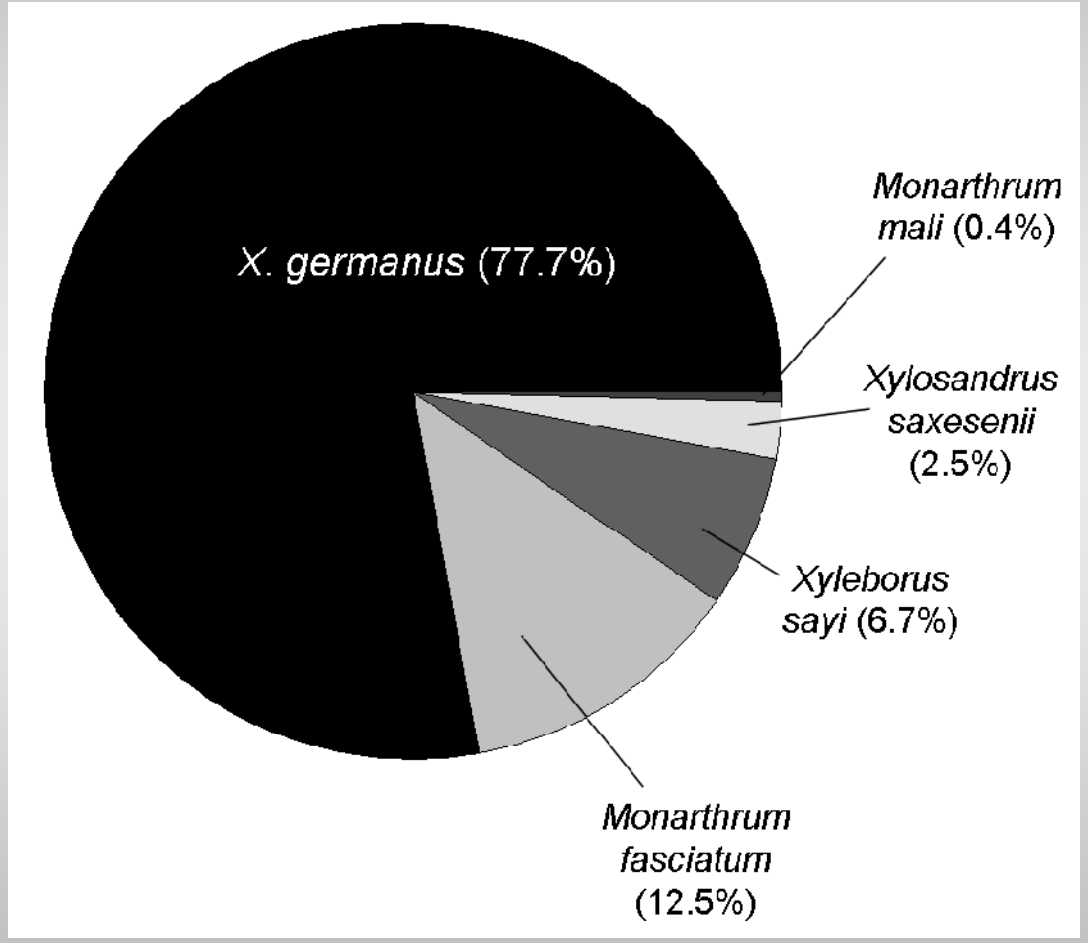
Species Emerging from Ethanol-Injected Trees in Ohio



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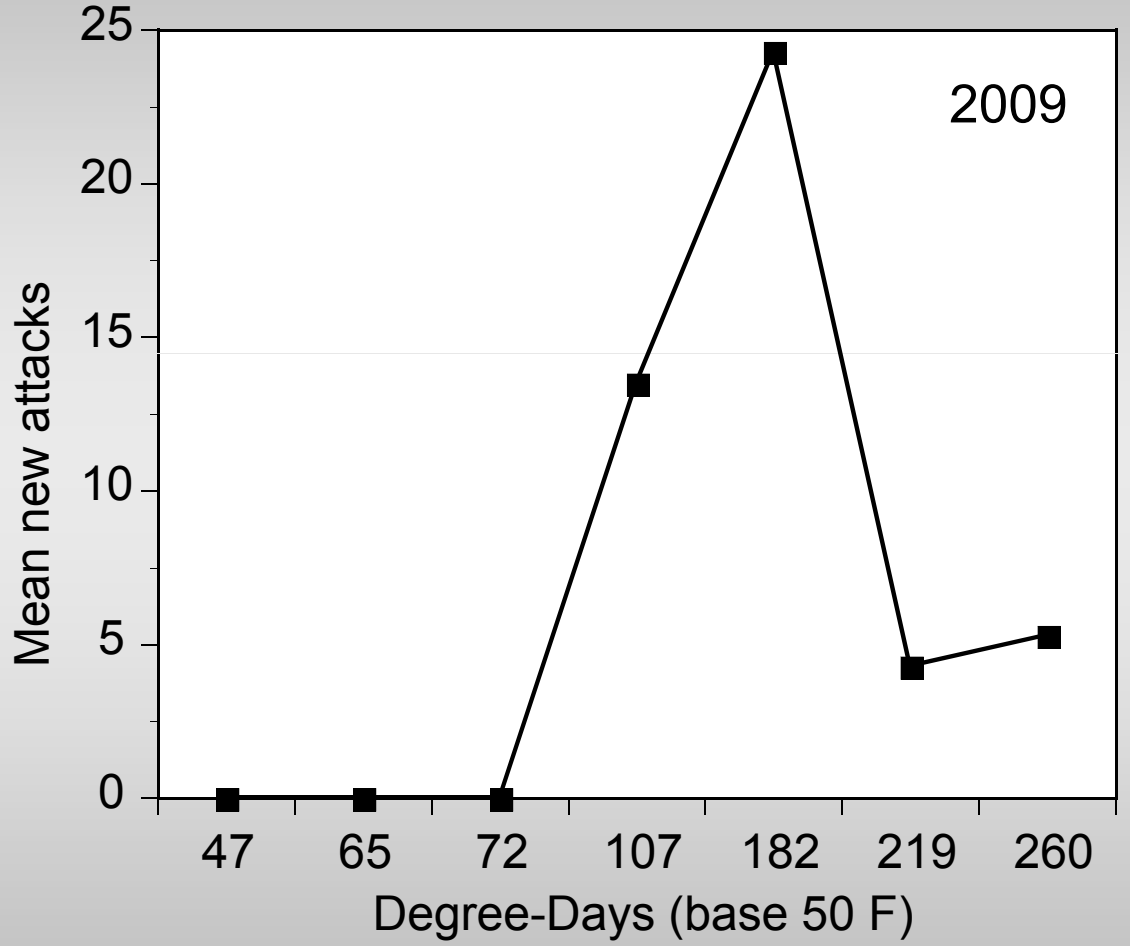
X. crassiusculus also attracted to ethanol-injected trees in TN and VA

Attacks on EtOH-Injected Trees in Relation to Degree-Days



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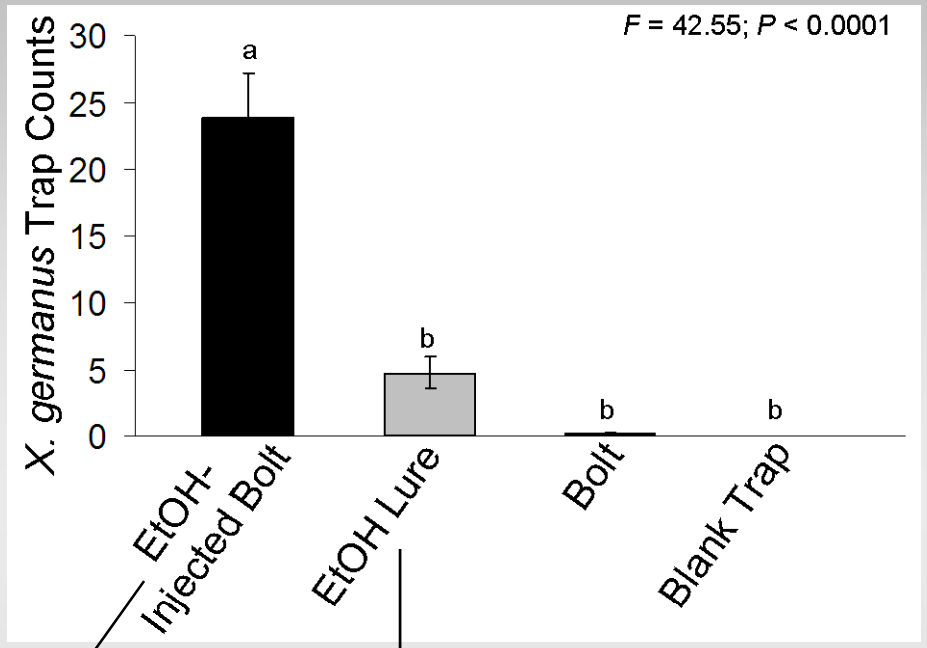
EtOH-Injected Bolt Superior to EtOH Lure



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Results Related to Ambrosia Beetle Management

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Vandenberg (USDA-ARS) and Castrillo (Cornell Univ.)

"Biological, Microclimate, and Transport Processing Affecting Pest Control Application Technology"

Zhu (USDA-ARS)

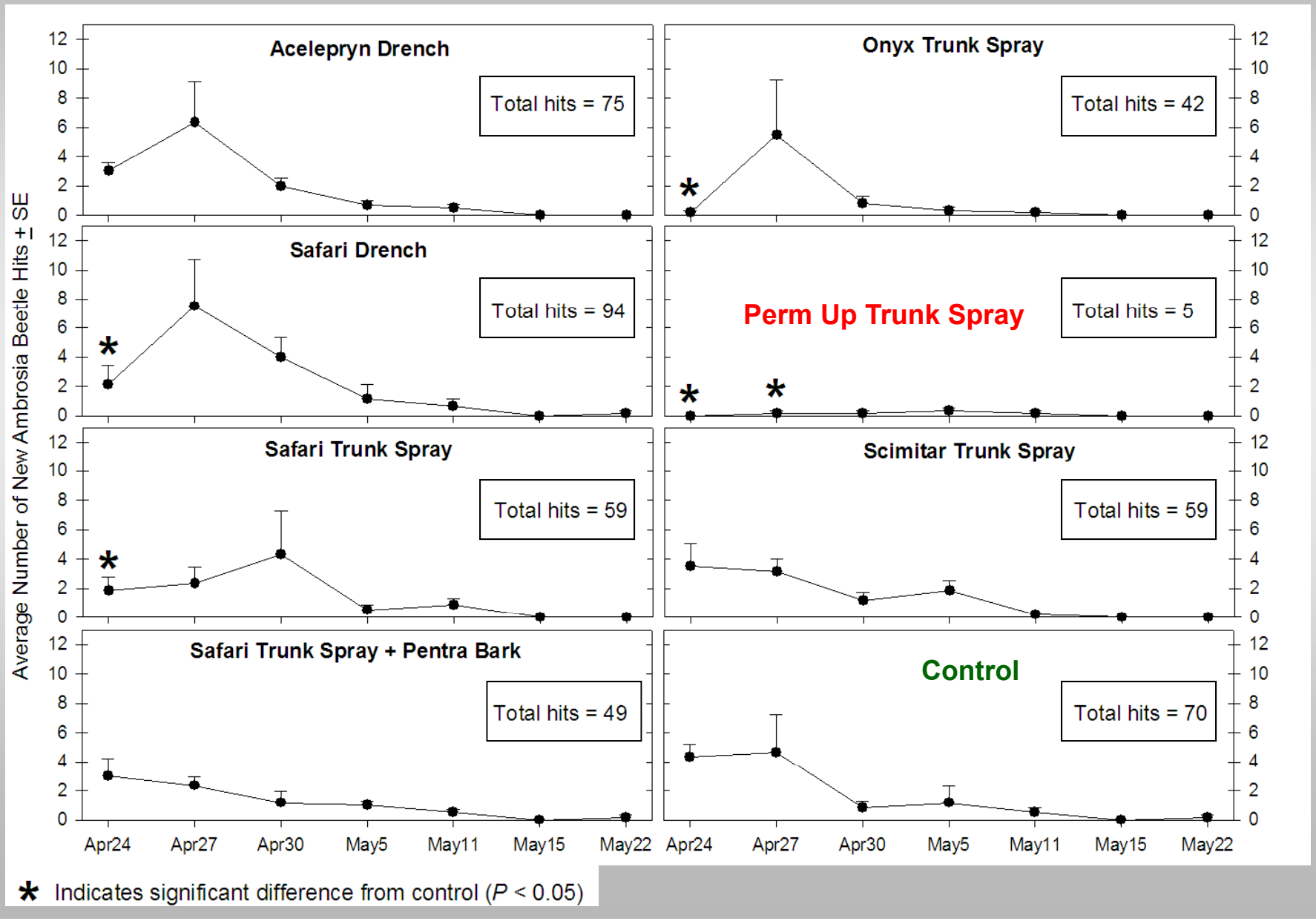
Insecticide Efficacy Trials

Inject trees with ethanol to ensure ambrosia beetle attacks on untreated and treated trees

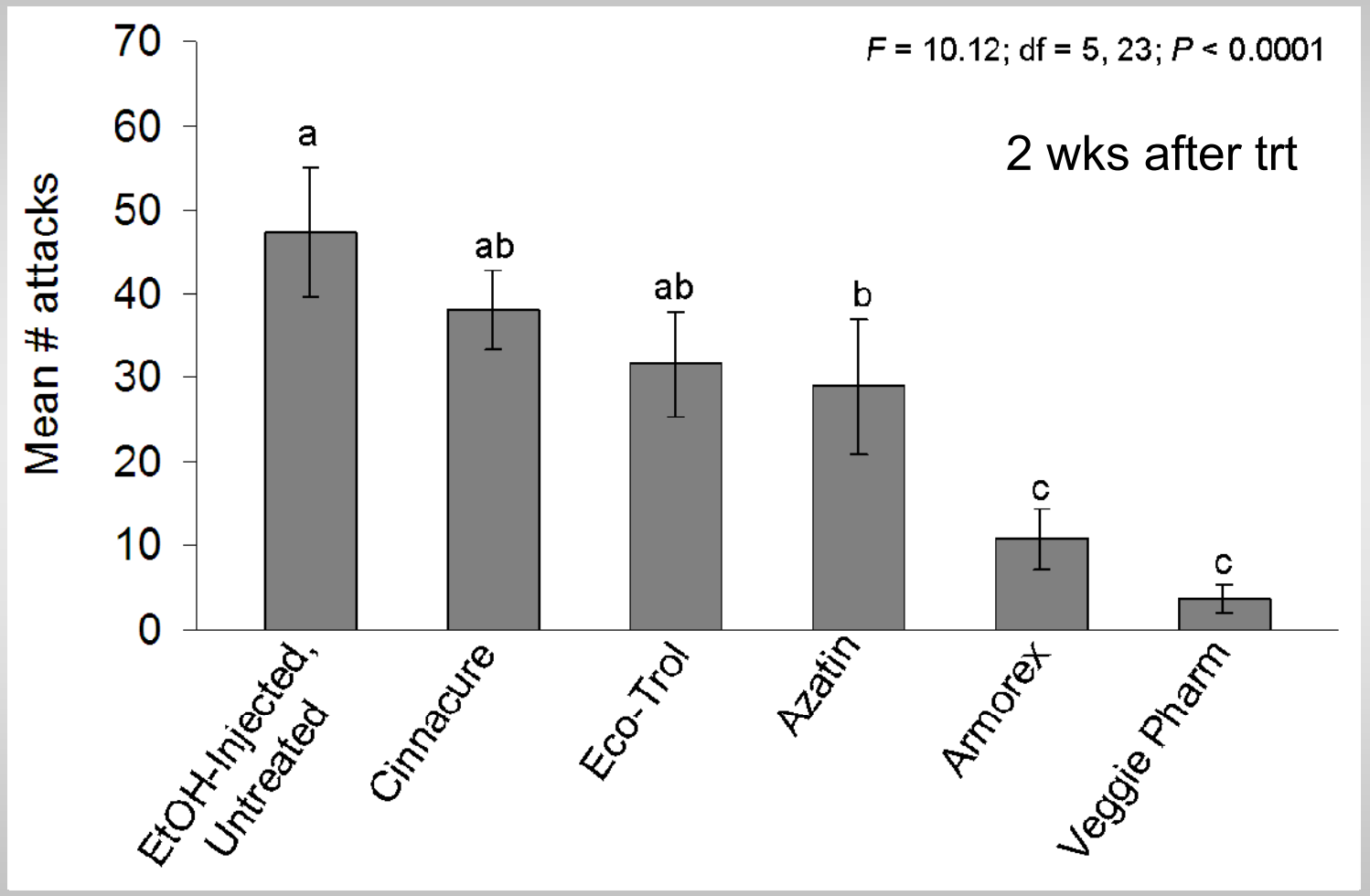
Apply product

Count Attacks

Conventional Insecticide Efficacy Trials in Tennessee



Efficacy of Botanical Formulations in Ohio



Count Attacks

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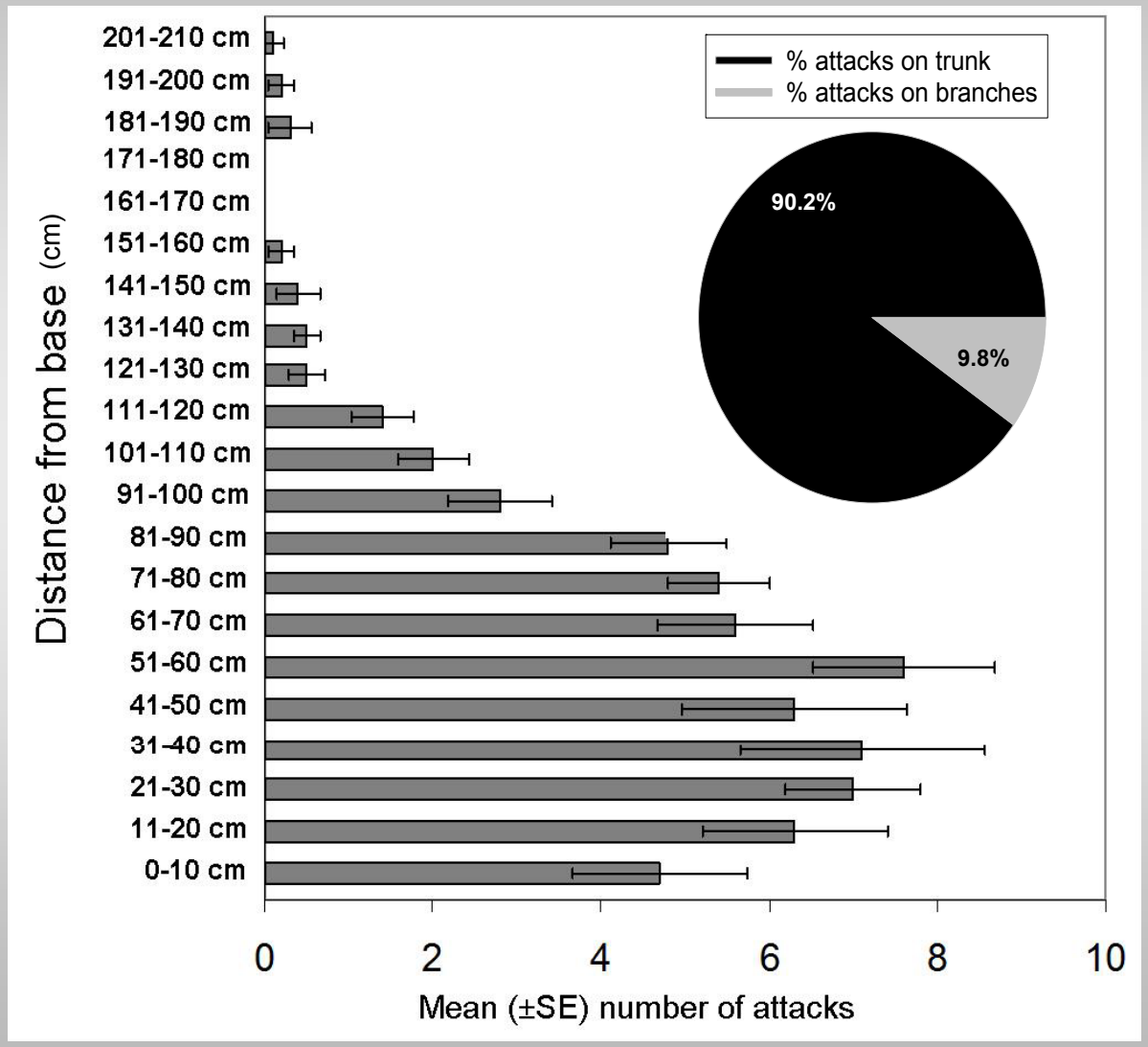
SMART Sprayer Application Technology

- **Sensor-Based Spray System**
  - Matches crop structure with insecticide delivery
  - Ensures thorough coverage
  - Minimizes non-target waste

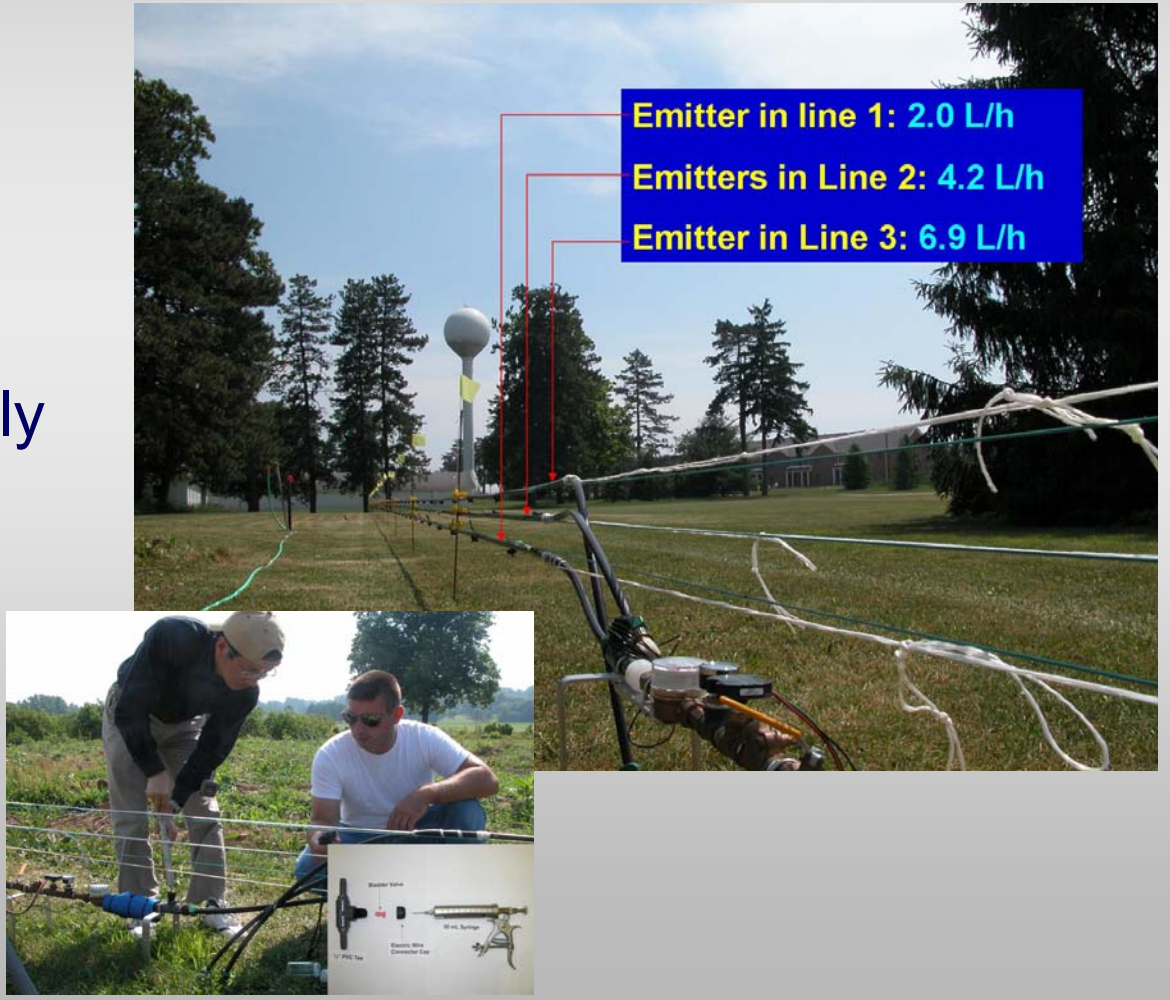
Distribution of Attacks by *X. germanus*



Efficacy of Chemigation for Ambrosia Beetles?

- Drip irrigation system developed to test efficacy of systemic insecticides for controlling ambrosia beetles

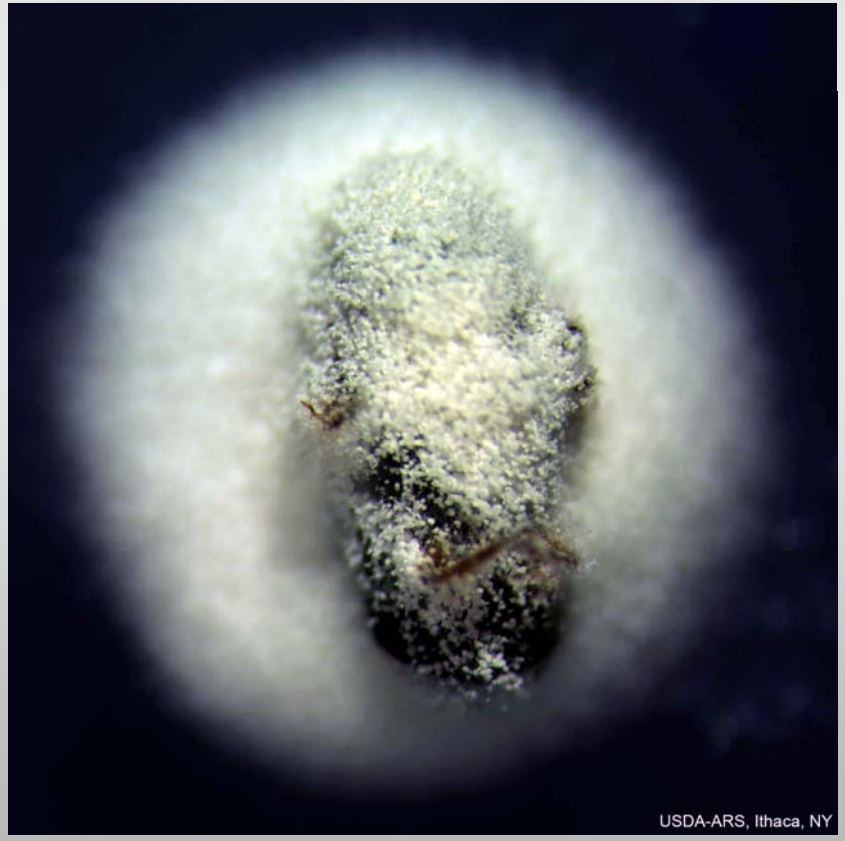
- Emitter flow, amount of injected materials, and injection time individually controlled



Biological Control of Ambrosia Beetles

• *X. germanus* successfully infected with commercially-available entomopathogenic fungi

Beauveria bassiana
White muscardine disease



Metarhizium anisopliae
Green muscardine disease

Rearing *X. germanus* in the Laboratory

Rearing chambers

Larvae and pupae in artificial diet

Isolation of Fungal Symbionts from *X. germanus*

- 77 isolates of symbiotic fungi have been isolated from *X. germanus*
- DNA extracted from each isolate is being sequenced to compare geographical variability

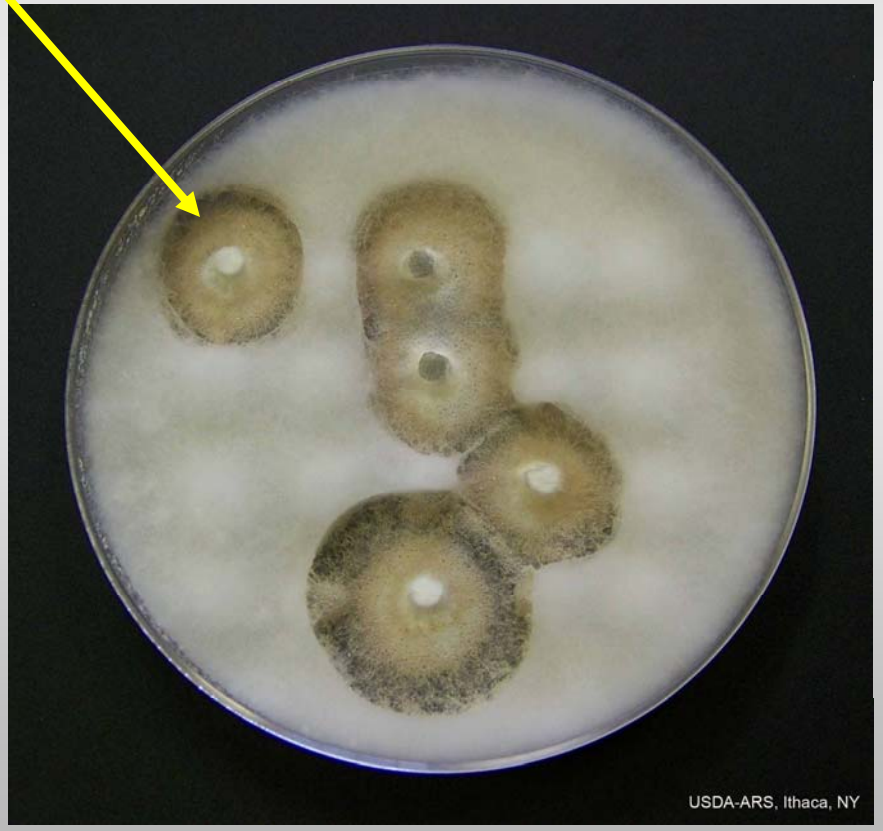
NY Isolates

OH Isolates

VA Isolates

Biocontrol of Ambrosia Beetle Fungal Symbionts

Mycelial growth of *Ambrosiella* fungus collapsing as *B. bassiana* spreads outwardly

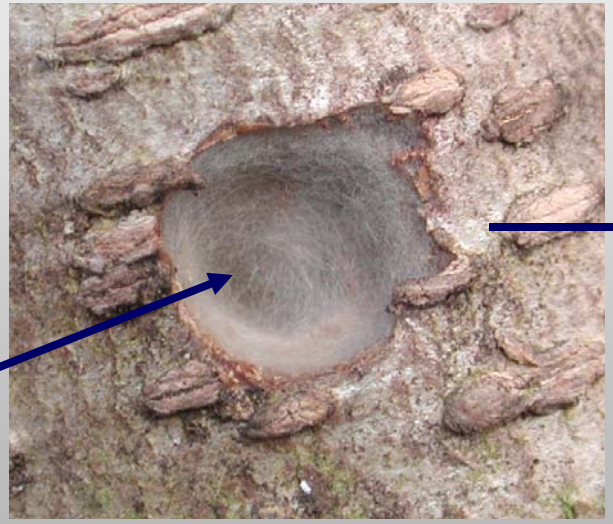


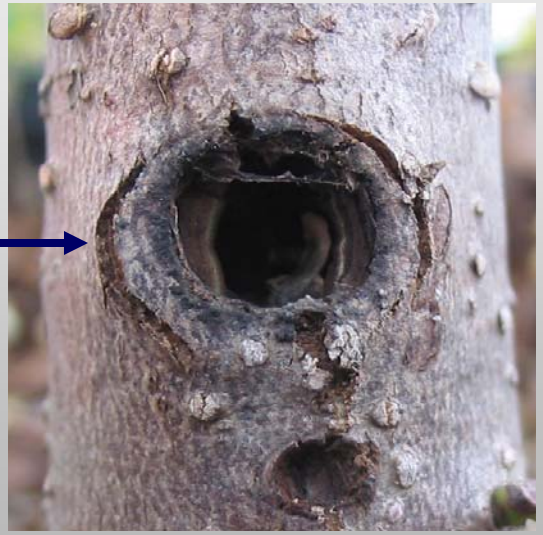
Pathogenicity of Symbiotic Fungi to Trees?

- Pathogenicity of *Ambrosiella* species usually moderate, but varies among isolates

- Tree death usually related to highly pathogenic *Fusarium*

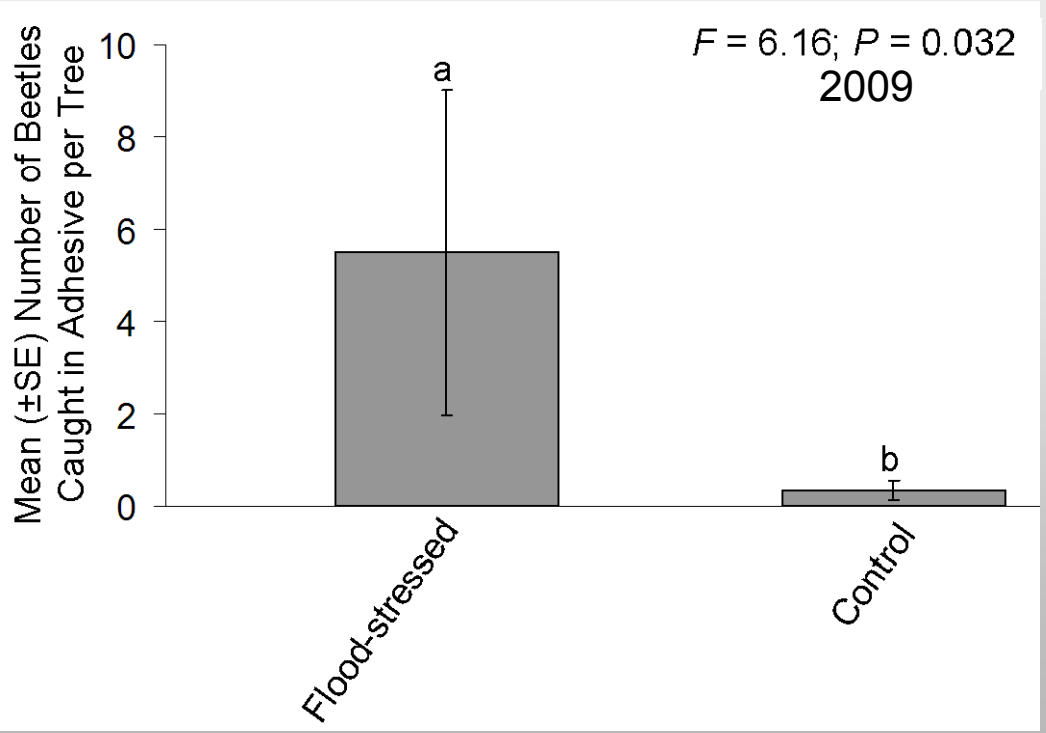
Magnolia virginiana inoculated with *Ambrosiella hartigii*





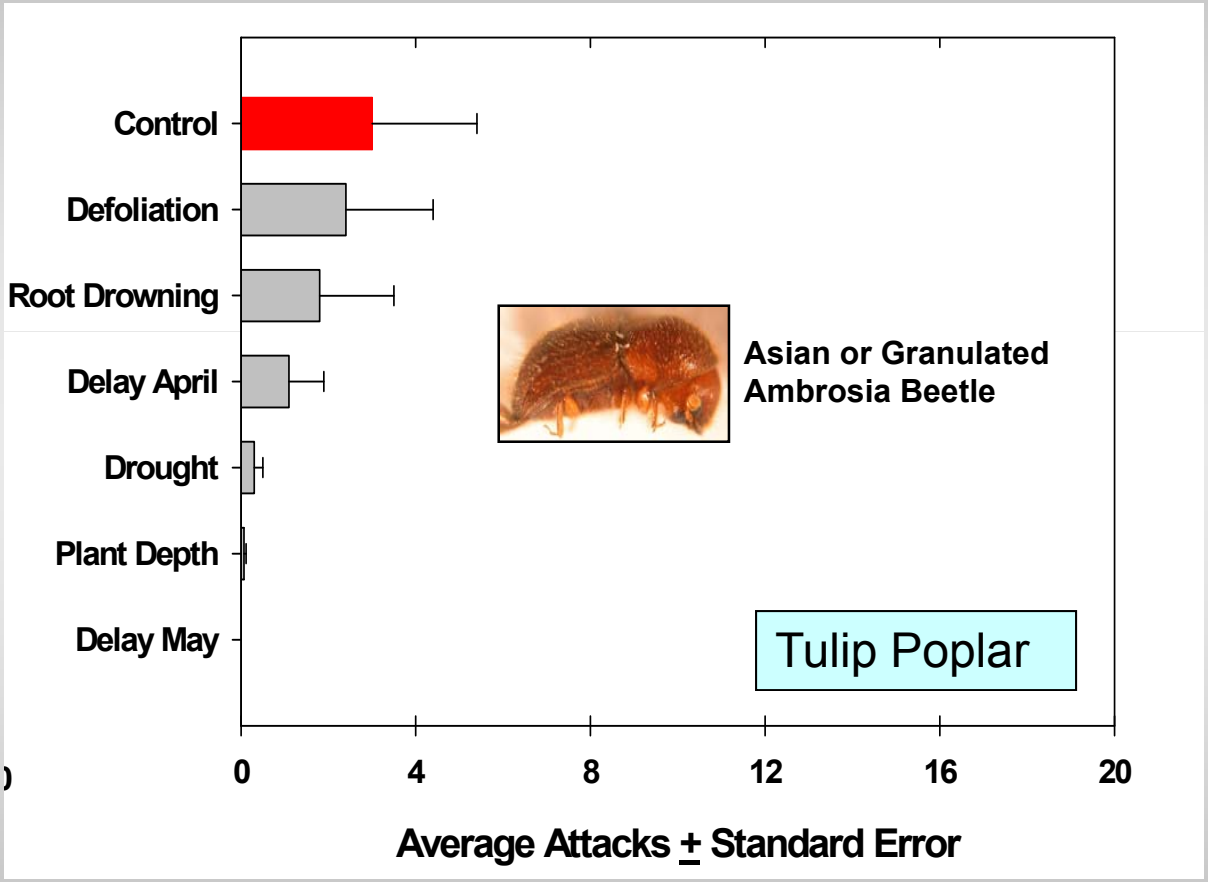
Impact of Stress on Beetle Preference: 2009 Flood Stress Test in OH

- Significantly more *X. germanus* stuck in adhesive on flood-stressed dogwoods
- Only 2 out of 6 flood-stressed trees were attacked, but multiple times



Evaluation of Stress Treatments in TN

- No significant differences in # of attacks across treatments



- Flood-stressed white oak significantly more attractive than control to *X. crassiusculus* in Louisiana (Ott, 2007)

Summary Points of FNRI-Funded Ambrosia Beetle Research

- Ethanol lures useful for timing insecticide applications
  - -Trap height and release rate are important

- Attacks on specific trees induced by ethanol injection
  - - Push-Pull Strategy

- Pyrethroids most effective conventional insecticide
  - -Systemics not promising

- Botanical formulations (repellents) show promise

- SMART sprayer technology

Summary Points Con't

- Biocontrol fungi capable of controlling beetles and fungi in lab assays

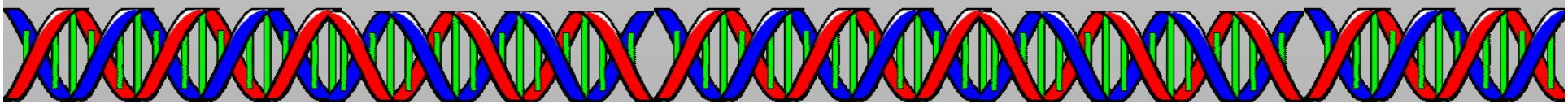
- Genetics and pathogenicity of ambrosia beetle fungal isolates being characterized

- Stressed trees attractive to *X. germanus*
  - *X. crassiusculus* appears more aggressive in host-selection

Advantages of Industry-Driven Research

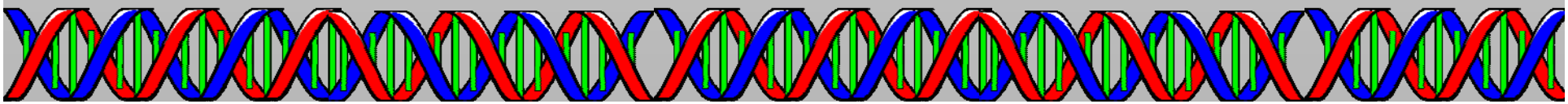
- Stakeholders help identify “real world problems” and priorities
  - Better perspective on industry needs

- Alliances are important to address problems
  - Public and private sector can work together to plan, implement and interpret results of research programs
  - Collaborative research creates opportunities to gain knowledge



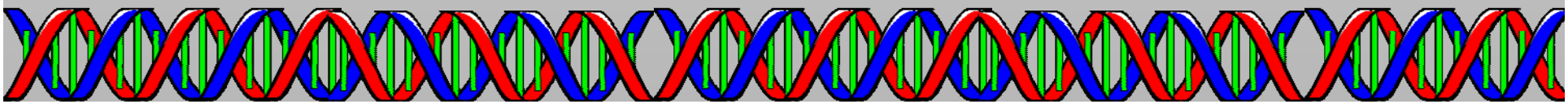
Challenges of Industry-Driven Research

- High expectations
  - Short-term solutions *may* take precedence over sustainable approaches
  - Longer-term research *may* be less attractive
- Problem may take longer and cost more than funding sources are willing to commit
- Synthesizing information from multi-disciplinary teams into a management strategy



Addressing Challenges of Industry-Driven Research

- ✓ Assemble complementary team interested in group research
  - Collaboration by laboratory and field researchers is a synergism that cannot be achieved by either component alone
  - Optimizes equipment and expertise
  - Economics of ambrosia beetles?
- ✓ Communication among team members
- ✓ Mixture of short-term and long-term research
- ✓ Thoroughly explain implications and applications of work to industry personnel
- ✓ Consider feedback and input from industry



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Barbara Faulk
Marie Dills

Tennessee State University

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