Impact of Invasive Insects and Plants on our Ecosystems

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Feb. 13, 2015

Threats to the Sustainability

1. Lack of plant and animal biodiversity

2. Importation of exotic, invasive species to US

3. Substitution of exotic plants for native plants

4. Climate change – the warming of our cities

5. Impervious surfaces – water infiltration, compaction, stress

6. Anthropogenic inputs of nutrients and pesticides
Terminology I will use

- Native = indigenous
- Non-native = alien = exotic = introduced
- Non-native ≠ invasive
- Invasives can be native (e.g. poison ivy) or non-native (e.g. Norway maple)

What is native and alien?

It all depends on time and space.
Is honey locust native to California?

Human intervention alters species distributions

Invasive Species

From: http://www.invasive.org/

• “A non-native species whose introduction causes or is likely to cause economic harm, environmental harm, or harm to human health. The term "invasive" is used for the most aggressive species. These species grow and reproduce rapidly, causing major disturbance to the areas in which they are present.”

• All non-natives are not invasive

• “Native species can be pests but the introduction of exotic species has the potential to cause greater damage due to the lack of effective biological control agents and the lack of resistance in our native plants.”

Natives can be invasive with changes in climate and habitat, human modifications, etc.
Is the rate of introductions increasing?

Non-indigenous forest insect pests

High impact pests

Aukema et al. 2011
Invasive Species Arrive in Waves

- 1635 - first tree pest - codling moth
- 1820 – 1860 - beetles in ballast
- 1860’s - urban forest pest, gypsy moth
- 1890 - 1930 - many scales arrive
- 1900 – 1930 - aphids dominate
- 1900 – 1940 - foliage feeders including caterpillars, sawflies, and beetles
- 1980 – 2006 - phloem feeding and wood boring beetles

Sailer 1978, Aukema et al. 2010
How do these exotic invaders arrive?
Most of our non-native pests continue to arrive on shipments of live plants

AM Liebhold et al. Forest pest invasions via live plant imports

Figure 4. Frequency (number of shipments infested) and taxonomic characterization of pests detected in shipments of live plants, fiscal years 2003–2010. (a) Types of pests detected. (b) Breakdown among insect Orders.

Pest Insects of Eucalyptus

Photo credits - UC System
Accumulation of Pest Insects on Eucalyptus in California: Random Process or Smoking Gun - Timothy D. Paine, et al. 2010

- In California, two species of insect herbivores were introduced between 19th century and 1983.

- Between 1983 and 2008, an additional 16 Australian insect pests of eucalyptus have become established.

- It is possible that they occurred because of increased trade or movement of people, but the hypothesis that there were intentional introductions also must be considered.

Why should we care about the establishment of exotic species in North America?

Photos: Chris Carlsson, USDA
Invasive Species

• Develop large population sizes very rapidly
  - Lack of biological control and plant defense in native plants

• Cause economic or environmental harm, or harm to human health

• Types of harm
  - Out-compete, displace or kill native species
  - Reduce wildlife food and habitat
  - Disrupt vital ecosystem functions, such as water flow, nutrient cycling, or soil decomposition
  - Cause significant damage or harm through direct losses to crops, forests, landscapes, man-made structures and aquatic environments
  - Cause direct harm to humans or domestic animals
  - Result in quarantines that restrict movement of a commodity

Exotic plants and insects can de-stabilize food web dynamics

Evolutionary relationships can be important
Pests outbreak more frequently in managed than unmanaged ecosystems

Urban Landscapes

• Unique features and properties relative to natural and other managed systems

• Features include contrived plant communities resulting from:
  – widespread use of alien (= exotic, non-native) plants
  – impervious surfaces
  – simplified designs (vegetation complexity and diversity)
  – common maintenance practices such as pulsed inputs of fertilizers, water, and pesticides

Urbanization = Large scale replacement of native plants with aliens

- What effect does this have on arthropod community composition and ecosystem services in urban environments, particularly as it relates to biological control services and pest outbreaks?

Differing Schools of Thought

-Negative effects on herbivore diversity and abundance-

- Many herbivores tend to specialize to some degree
- Herbivores restricted to plants with which they share an evolutionary history
- Native plants should host a resident, coevolved population of herbivores and their natural enemies
- Enemy release hypothesis predicts
  - alien plants are less palatable to herbivores than native plants on which they have co-evolved
  - alien plants are expected to host fewer herbivores than natives
Implications of alien plants to biological control in urban environments:

- Support a less diverse community of herbivores (alternative prey)
- Support fewer natural enemies
- May result in dramatic pest outbreaks

Suggests using native plants in landscapes should enhance biological control

Differing Schools of Thought

Studies countering predictions for reduced herbivore richness and abundance on alien plants

- Native specialists that switch from indigenous hosts to alien plants that are congeners (similar chemistries)
- Native generalists that incorporate introduced plants into their diet (ex. fall webworm)
- Specialist herbivores from the endemic range of alien plants have often been co-introduced with their host to new regions and become key pests
  - ex. azalea lace bug and euonymus scale
  - When their natural enemies are lacking, exotic herbivores of alien plants may be more prone to outbreaks
Differing Schools of Thought

Studies countering predictions for reduced herbivore richness and abundance on alien plants

Defense Free Space (Gandhi and Herms 2009)

- Lack of evolutionary history between native herbivore and alien host affords no time for resistance (plant defenses) to evolve in alien host (herbivores outbreak)

- Examples
  - Bronze birch borer (native) - native birches are resistant, European and Asian birches are not
  - Hemlock woolly adelgid (exotic) - Native eastern hemlocks are not resistant, Western and Asian hemlocks are resistant

Coevolutionary matrix:

- Native plants / native insects (stable)
- Exotic plants / exotic insects (enemy release)
- Exotic plants / native insects (community simplification; defense free space)
- Native plants / exotic insects (enemy release; defense free space)
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- Native plants / exotic insects (enemy release; defense free space)
How do we know it's enemy release?

Entomophaga maimaiga – imported twice, once in early 1900’s and again in 1980’s
"The ash whitefly invaded California in 1988. A single species of parasitic wasp was imported from Europe. Within two years of its release, this wasp greatly reduced the ash whitefly population."

California Department of Food and Agriculture
**Coevolutionary matrix:**

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- Exotic plants / native insects (community simplification; defense free space)
- Native plants / exotic insects (enemy release; defense free space)

Exotic plants / native insects (diversity of the community simplified)

Some exotic plants support few or no herbivores

= de-stabilize food web
Greater biodiversity associated with native plants.

Increase plant diversity to increase prey and predators - natives will be better for this.
Is there evidence that alien plants support fewer herbivores?

• Studies show alien plants support:
  – Less herbivory or less herbivore diversity
    Samways et al. 1996, Wolfe 2002
    Siemann and Rogers 2003, Agrawal et al. 2005
    Carpenter and Capuccino 2005
    Burghardt et al. 2009
  – More or equal herbivory or herbivore diversity
    Maron and Vila 2001, Keane and Crawley 2002,
    Parker and Hay 2005, Agrawal 2005,
    Liu et al. 2006

• Need for further research

Urban Landscapes

• Unique features and properties relative to natural and other managed systems

• Features include contrived plant communities resulting from:
  – widespread use of alien (= exotic, non-native) plants
  – impervious surfaces
  – simplified designs (vegetation complexity and diversity)
  – common maintenance practices such as pulsed inputs of fertilizers, water, and pesticides

Greatest Abundance along Gradient

Number of Taxa

Urbanization Gradient

More Urban Intermediate Less urban Variable

scales, spider mites leps
leps heterop., spider mites

General patterns - there are exceptions


Woods

Representative treatment pair

Controller for plant species richness and structural complexity

Plants for sentinel herbivore survival studies in center

Shrewsbury, Raupp, Tallamy, Vodraska, in prep.
Community Diversity in Native and Alien Landscapes

<table>
<thead>
<tr>
<th></th>
<th>Simpson Diversity Indices</th>
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</thead>
<tbody>
<tr>
<td>Arthropods</td>
<td>0.90 (Native), 0.85 (Alien)</td>
</tr>
<tr>
<td>Herbivores</td>
<td>0.90 (Native), 0.85 (Alien)</td>
</tr>
<tr>
<td>Natural Enemies</td>
<td>0.95 (Native), 1.00 (Alien)</td>
</tr>
</tbody>
</table>

Values range from 0-1 (0 is no diversity, 1 is infinite diversity)
Community "Dissimilarity" in Native and Alien Landscapes

Herbivore (Chewing) Abundance

Values range from 0-1 (0 is identical, 1 is no similarity at all)

Shrewsby, Raupp, Tallamy, Vodraska, in prep.

* ≤ 0.1000
** ≤ 0.05
Shrewsbury, Raupp, Tallamy, Vodraska, in prep.
Conclusion - Plant origin may drive Lepidopteran patterns, however, other features of urbanization likely influence outbreaks of sucking arthropods in cities.

Features of urban landscapes:
- widespread use of alien (= exotic, non-native) plants
- impervious surfaces
- simplified designs (vegetation complexity and diversity)
- common maintenance practices such as pulsed inputs of fertilizers, water, and pesticides

Shrewsbury, Raupp, Tallamy, Vodraska, in prep.
“Don’t judge species on their origins”

Conservationists should assess organisms on environmental impact rather than on whether they are natives, argue Mark Davis and 18 other ecologists.

“...it is time for conservationists to focus much more on the functions of species, and much less on where they originated.”

Davis et al. 2011, Nature. 474:153-154
**Coevolutionary matrix:**

- Native plants / native insects (stable)
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- Native plants / exotic insects (enemy release; defense free space)
Lessons from large scale disasters in “natural systems” – Mother Nature’s plan undone by foolish man.

**Chestnut blight** - Nursery stock from Asia was imported to NY with the chestnut blight fungus in the early 1900's.

By 1940, three and one half billion chestnuts were dead (Griffin 2003).

The eastern hardwood forest became more diverse.

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American Elms - Low diversity in a “managed landscape”

**Suitable Host** - American Elm

**Pathogen** - DED, *Ophiostoma ulmi*

**Vector** - Smaller European Elm Bark Beetle

40 million elm trees killed by DED in North America since 1930
Birch resistance to bronze birch borer

Interspecific Variation in Resistance of Asian, European, and North American Birches (*Betula* spp.) to Bronze Birch Borer (*Coleoptera: Buprestidae*)

DAVID C. NIELSEN, VANESSA L. MUILENBURG, and DANIEL A. HERMS
Department of Entomology, Ohio Agricultural Research and Development Center, The Ohio State University, 1866 Medora Avenue, Wooster, OH 44691


20 year study of variation in birch resistance to the native bronze birch borer

7 species, 200 reps / species, 1400 trees total:

**Native species:**
- *B. nigra*
- *B. papyrifera*
- *B. populifolia*

**Exotic species:**
- *B. pendula*
- *B. pubescens*
- *B. platyphylla*
- *B. maximowicziana*
Conclusion:
no evolutionary history,
no resistance.
Emerald ash borer: hundreds of millions of dead ash trees (and counting)

Experimental Ash Plantation in Michigan: Comparative study of susceptibility to EAB

**North American:**
- *F. pennsylvanica*
- *F. americana*

**Asian:**
- *F. mandshurica*

**Native – Asian Hybrid:**
- *F. nigra* x *F. mandshurica*
Manchurian ash is highly resistant; North American ashes are very susceptible.

Impact of EAB

June 2006  August 2009
What's at Stake?

- ~100% mortality, healthy and stressed trees
- All 16 native ash species susceptible
- Ash saw timber value: $25 billion
- 30-90 million ash in urban forests
- Management costs and losses: $20 - $60 billion

Collateral Damage

- ~Ash is in the olive family and unique
- ~8 billion ash in US forests - key members of forest communities
- More than 20 other species of organisms have unique associations with Fraxinus
- Will these become extinct as well?
Should non-native ashes like Manchurian Ash be used as an ark to preserve native insects from extinction?

Could Asian Longhorned Beetle be in Baltimore already?

New York City, NY (1996)  
Chicago, IL (1998)  
Jersey City, NJ (2002)  
Toronto-Vaughn, Canada (2003)  
Clark, Roselle, Elizabeth, Linden, Woodbridge, NJ (2006-2007)  
Worcester, MA (2008)  
Boston, MA (2010)  
Bethel, OH (2011)  
Tate, GA (2011)

Estimated national urban impact - a loss of 34.9% of total canopy cover, 1.2 billion trees, and value loss of $669 billion.
Defense free space and biological invasions:

Documented examples of low host resistance where coevolutionary history is lacking

- American chestnut and chestnut blight
- Dutch elm disease and N.A. elms
- Bronze birch borer and Eurasian birches
- Pine needle scale and Eurasian pines
- Hemlock wooly adelgid and eastern N.A. hemlocks
- Balsam wooly adelgid and N.A. firs
- Beech bark scale and N.A. beech
- Viburnum leaf beetle and N.A. viburnums
- Redbay ambrosia beetle and N.A. redbay
- Thousand canker disease and eastern walnut
- Emerald ash borer and N.A. ashes

Slide courtesy of Dan Herms

How diverse is the urban forest in eastern North America?
Diversity Dilemma
Street Tree Diversity in Eastern North America

Ann Arbor, Chicago, Florence, Gastonia, Kansas City, Lincolnshire, Marion, Mt. Ranier, New York, Toledo, Toronto, Wilmington – Raupp et al. 2006

Emerald ash borer
Asian longhorned beetle
Conclusions

• Cities face the loss or need for insecticide protection of 29% to 70% of their street trees

• The average percentage of trees at risk was 49.7% (4.0% s.e.)

• No more Acer or Fraxinus

Diversify now or face catastrophic loss

Raupp et al. 2006

Brown Marmorated Stink Bug is an Invasive Species

(Halyomorpha halys)
Pentatomidae

• Native to China, Japan, Korea, and Taiwan.

• Generally considered a minor agricultural and nuisance pest with occasional outbreaks.
History of BMSB in the Mid-Atlantic

- First collected in Allentown, PA
- First properly identified specimen: Hagerstown, MD
- First confirmed WV specimen: Falling Waters, WV
- Nymphs observed in orchards. Serious late season injury in tree fruit observed in WV
- First reports of late season injury in tree fruit in WV
- First confirmed specimen: NJ
- First confirmed MD specimen: Hagerstown, MD

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
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</thead>
<tbody>
<tr>
<td>1996</td>
<td>Introduced into USA?</td>
</tr>
<tr>
<td>1997</td>
<td>Suspected NJ specimen</td>
</tr>
<tr>
<td>1998</td>
<td>First collected in Allentown, PA</td>
</tr>
<tr>
<td>1999</td>
<td>First properly identified specimen: Allentown, PA</td>
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<tr>
<td>2000</td>
<td>First confirmed NJ specimen</td>
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<tr>
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</tr>
<tr>
<td>2002</td>
<td>First confirmed MD specimen: Hagerstown, MD</td>
</tr>
<tr>
<td>2003</td>
<td>First confirmed WV specimen: Falling Waters, WV</td>
</tr>
<tr>
<td>2004</td>
<td>Serious crop injury in WV, MD, NJ, DE, VA and PA in tree fruit, small fruit, vegetables, row crops, and vineyards.</td>
</tr>
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<td>2005</td>
<td>Serious crop injury in WV, MD, NJ, DE, VA and PA in tree fruit, small fruit, vegetables, row crops, and vineyards.</td>
</tr>
<tr>
<td>2006</td>
<td>Serious crop injury in WV, MD, NJ, DE, VA and PA in tree fruit, small fruit, vegetables, row crops, and vineyards.</td>
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</tr>
<tr>
<td>2010</td>
<td>Serious crop injury in WV, MD, NJ, DE, VA and PA in tree fruit, small fruit, vegetables, row crops, and vineyards.</td>
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</table>

Has the potential to become one of the most important pests of specialty crops to appear in the last 100 years. Leskey 2011

Current Distribution of BMSB in the U.S. and Canada

- 41 states
- 2 CA provinces
- Europe

6/2014

From: http://www.stopbmsb.org
BMSB IDENTIFICATION

Adults
- Mottled brown to grey
- ½-⅔" (13-19 mm) long
- White and dark bands on the antennae (5 segments)
- Outer edges of the abdomen alternating white and dark markings
- Smooth, untoothed "shoulders" (pronotum)
- Legs are brown and may have faint white bands
- Emit a pungent odor when disturbed
  - Similar to that of coriander

Brown Marmorated Stink Bug Identification

- Adults
  - White stripes on antennae and faint white bands on legs.
  - ½-⅔" (13-19 mm) long.
  - Outer edges of the abdomen alternating white and dark markings ("marmorated").
  - Underside is pale, sometimes with grey or black markings
  - Emit a pungent odor when disturbed
- Eggs
  - Laid in clusters on undersides of leaves (~28 eggs per egg mass). Light green when first deposited and then turn white
- Nymphs
  - 5 nymphal instars.
  - First instars remain near hatched eggs.
  - 2nd-5th instars extremely mobile.
BMSB - Nuisance Pest

- Adults overwinter in protected locations
  - natural rocky outcroppings, under bark of dead standing trees
  - houses and structures

- BMSB sheltering in homes active on warm days in late winter

Do not mate or feed (usually), or damage structures

Host plants / crops

Movement within and between crop systems throughout the season
BMSB – a pest of woody plants

Damage:
• Wounding / wet spots
• Discoloration, dimpling to foliage, fruit
• Tree stress?
• Plant death reported (herbaceous)
• Disease transmission, secondary infections?

Ornamental plants

Woody plant hosts include: Abelia spp., Acer spp. (maple), Buddleia spp. (butterfly bush), Catalpa spp., Celosia argentea L. (celosia), Cercis canadensis (Eastern Redbud), Cladrastis kentukea (yellow wood), Gleditsia triacanthos (honey locust), Hibiscus rosa-sinensis L. (hibiscus), Liriodendron tulipifera (tulip tree), Lonicera spp. (honeysuckle), Malus spp. (crab apples), Paulownia spp. (princess tree), Platanus spp. (sycamore), Prunus serotina (black cherry), Prunus x yedoensis (Yoshino cherry), Quercus spp. (oak), Rosa rugosa, Syringa spp. (lilac), Ulmus spp. (elm), and Zelkova serrata (zelkova).

Herbaceous plant hosts include: Cleome spp. (spider flower), dahlias spp., Helianthus annuus (sunflower), zinnia spp., and even some weeds such as burdock (Articum spp.).
Can we design stink bug resistant landscapes?

Study Site

Raemelton Farm
Adamstown, MD
Wholesale Commercial Nursery
~300 Acres
178 Cultivars Sampled
Some good news – many plants were never used for egg deposition or feeding by active stages

Number of hosts never observed with eggs = 112 = 63% 🚫

Number of hosts never observed with active stages = 29 = 16% 🚫

Ten most favored hosts for egg deposition

- *Evodia daniellii* Asia Angiosperm
- *Cornus macrophylla* Asia Angiosperm
- *Cladrastis kentukea* North America Angiosperm
- *Tilia tomentosa* Europe + Asia Angiosperm
- *Cercis canadensis* North America Angiosperm
- *Tilia cordata* Europe Angiosperm
- *Ulmus americana* North America Angiosperm
- *Acer rubrum* North America Angiosperm
- *Liquidambar styraciflua* North America Angiosperm
- *Pseudocydonia sinensis* Asia Angiosperm
Ten most favored hosts for active stages

- *Syringa pekinensis* Asia Angiosperm
- *Acer × freemanii* North America Angiosperm
- *Acer rubrum* North America Angiosperm
- *Cercis canadensis* North America Angiosperm
- *Cladrastis kentukea* North America Angiosperm
- *Platanus × acerifolia* North America + Asia Angiosperm
- *Nyssa sylvatica* North America Angiosperm
- *Cladrastis kentukea* North America Angiosperm
- *Prunus serrulata* Asia Angiosperm
- *Ulmus americana* North America Angiosperm

**Taxonomy**

- **Eggs**
  - Angiosperm
  - Gymnosperm

- **Nymphs**
  - Angiosperm

- **Adults**
  - Angiosperm
  - Gymnosperm
### Host Origin

**Egg Masses**
- Asian: 0.01
- NonAsian: 0.02

**Nymphs & Adults**
- Asian: 0.5
- NonAsian: 1.0

### Host Origin by Genus

#### Egg Masses
- Acer: 0.02
- Cornus: 0.04
- Ulmus: 0.1

#### Nymphs & Adults
- Acer: 3
- Cornus: 2
- Ulmus: 4
### Summary of Findings

**BMSB used 150 of 178 cultivars surveyed**

Later life stages use a wider range of hosts

Angiosperms strongly favored

Within closely related taxa (genera) sometimes prefer hosts they “know” evolutionarily (*Cornus*), but some naïve hosts (*Acer, Ulmus*) may be favored

Begin to design BMSB out of landscapes

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#### Cultivars Not Used

<table>
<thead>
<tr>
<th>Average Count</th>
<th>Taxa</th>
<th>Count</th>
<th>Taxa</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Acer davidii</td>
<td>0</td>
<td>Picea glauca 'Majestic Blue'</td>
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<tr>
<td>0</td>
<td>Acer palmatum var. dissectum 'Inaba shidare'</td>
<td>0</td>
<td>Picea pungens 'Glaucia'</td>
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<td>0</td>
<td>Betula nigra 'BNMTF'</td>
<td>0</td>
<td>Picea pungens 'Hoople'</td>
</tr>
<tr>
<td>0</td>
<td>Cedrus atlantica var. clausa</td>
<td>0</td>
<td>Picea pungens 'Fat Albert'</td>
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<tr>
<td>0</td>
<td>Chamaecyparis nootkatensis 'Pendula'</td>
<td>0</td>
<td>Thuja plicata 'Zebrina'</td>
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<tr>
<td>0</td>
<td>Cornus florida 'Jean's Appalachian Snow'</td>
<td>0</td>
<td>Thuja plicata 'Emerald Cone'</td>
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<td>Hamamelis x intermedia 'Arnold Promise'</td>
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<td>Pinus aristata</td>
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</tbody>
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**Develop BMSB resistant landscapes, reduce overwintering populations in structures (?)**

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**Requirements for Controlling BMSB**

- Due to its wide distribution and vast host range, biological control may be effective in maintaining population levels to controllable levels in the long-term.

- A coordinated area wide control program for BMSB will be necessary to combat this pest.

- This program would likely include elements of population monitoring, chemical, cultural, mechanical and biological control.

**Chemical Control of Brown Marmorated Stink Bug**

http://njaes.rutgers.edu/stinkbug/control.asp

<table>
<thead>
<tr>
<th>Active Ingredient</th>
<th>Exterior Use</th>
<th>Ornamental Trees/Shrubs</th>
<th>Vegetables</th>
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</thead>
<tbody>
<tr>
<td>Acetamiprid</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>β-cyfluthrin</td>
<td>Y</td>
<td>Y</td>
<td>N</td>
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<td>Bifenthrin</td>
<td>Y</td>
<td>Y</td>
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<tr>
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<td>Y</td>
<td>Y</td>
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<td>Deltamethrin</td>
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<td>Y</td>
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<td>Dinotefuran</td>
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<td>Fenpropathrin</td>
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<td>A-cyhalothrin</td>
<td>Y</td>
<td>Y</td>
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**Challenges to chemical controls:**

- Knock down and recovery of BMSB following applications of some pesticides
- Season long immigration
- Many not be compatible with IPM and biocontrol
MANAGEMENT: Biological

• USDA-ARS - The search for classical biological control agents and their evaluation is underway

• Evaluation of native parasitoids and predators attacking BMSB (UMD, other institutions)

<table>
<thead>
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<th>In Asia:</th>
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<tbody>
<tr>
<td><strong>Table 1. List of potential biological control agents against <em>Halyomorpha halys</em> identified in Asia</strong></td>
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<tr>
<td>Agent</td>
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<tr>
<td>Parastoid</td>
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<tr>
<td>Aracneodes sp.</td>
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<tr>
<td>Anasaita sp.</td>
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<tr>
<td>Anasaita guttata Ashmead</td>
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<tr>
<td>Balsiella sp.</td>
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<td>Ooencyrtus melanocephalus Ashmead</td>
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<td>Ooencyrtus sp.</td>
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<tr>
<td>Telemonas nigripes Nakagawa</td>
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<tr>
<td>Telemonas nationalistae (Ashmead)*</td>
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<td>Telemonas sp.</td>
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<tr>
<td>Trissolcus mitsukurii (Ashmead)</td>
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<td>Trissolcus jeh Ryu [Kastonyi]</td>
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<td>Trissolcus platynus (Watmabe)</td>
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<tr>
<td>Trissolcus flavipes Thomson</td>
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<td>Trissolcus hyalospermus Yang</td>
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<tr>
<td>Predator</td>
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<tr>
<td>Arma chinensis (Fallou)</td>
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<td>Astochus virginicus Coquillett</td>
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<tr>
<td>Hyllus obscurus (Dallas)</td>
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<td>Mnais selenopaea (F.)</td>
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<td>Nycterences pruinosus Hyllus</td>
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<td>Orius sp.</td>
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</table>

Biological Control – international parasitoids

- USDA ARS (K. Hoelmer) – foreign exploration in Asia to find natural enemies adapted to BMSB
- Egg parasitoids seem to be the most promising
  - Brought back 3 species of *Trissolcus*
  - In Asia these species display high rates of parasitism (50-80%)
- These parasitoids are clearly adapted to BMSB
- Evaluation underway in quarantine on full host range of these species

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*Trissolcus spp.* parasitize stink bug eggs by inserting one of their own eggs inside the host’s egg. Usually will utilize 100% of the eggs in a clutch.
Main Objective

- Survey and identify native natural enemy activity in ornamental systems
  - BMSB egg mortality
  - Parasitoid complex and parasitism rates
  - Predator complex
    - Field: BMSB and Predator density
    - Lab: Feeding Trials

Methods

- Sampled three nurseries at regular intervals from late May through September 2012 and 2013
No mortality

Mortality factors

BMSB Egg Mortality Factors
Total Mortality ~ 58%
Parasitoids

Biological Control - Predators
Threats to the Sustainability

1. Lack of plant and animal biodiversity
2. Importation of exotic, invasive species to US
3. Substitution of exotic plants for native plants
4. Climate change – the warming of our cities
5. Impervious surfaces – water infiltration, compaction, stress
6. Anthropogenic inputs of nutrients and pesticides

Exotic plants and insects can de-stabilize food web dynamics

Evolutionary relationships can be important
Invasive Species

• Develop large population sizes very rapidly
  – Lack of biological control and plant defenses in native plants

• Cause economic or environmental harm, or harm to human health

• Types of harm
  – Out-compete, displace or kill native species
  – Reduce wildlife food and habitat
  – Disrupt vital ecosystem functions, such as water flow, nutrient cycling, or soil decomposition
  – Cause significant damage or harm through direct losses to crops, forests, landscapes, man-made structures and aquatic environments
  – Cause direct harm to humans or domestic animals
  – Result in quarantines that restrict movement of a commodity

How can we reduce the impact of invasive species?

• Reduce the source of invasive, exotic species (USDA APHIS)
• Reduce the movement / spread of invasive species (ex. firewood)
• Use natives (and even some exotics) plants that support biodiversity and ecosystem services (ex. biological control)
• Diversify urban forests (ex. less maples, ash)
• Report invasive species to Dept. of Ag, UME
• Volunteer for removal programs
• Avoid practices that disrupt food web dynamics / ecosystem balance (ex. high N fertilizer, pesticides, reduction in plant diversity / complexity)
“Don't judge species on their origins”

Conservationists should assess organisms on environmental impact rather than on whether they are natives, argue Mark Davis and 18 other ecologists.

“...it is time for conservationists to focus much more on the functions of species, and much less on where they originated.”


THANK YOU!

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How can we enhance sustainability?

1. Increase biodiversity - genetic, species, plant communities - involve landscape architects and urban planners

2. Use native plants to enhance ecosystem services - alternative resources for pollinators and natural enemies - more flowering plants

3. Reduce threats of importing exotic species - legislation - tools, education, and training needed to enhance early detection

4. Mitigate climate change though use of fossil fuels, plant more trees, shrubs and ground covers

5. Replace impervious surfaces with ones that allow infiltration - more green spaces in urban areas

6. Apply soil amendments, nutrients and pesticides on a prescription basis

Michael J. Raupp

2. Substitution of exotic plants for native plants
   a. Uncouples herbivores from plants, collapse food web
   b. Creates defense free space, allows native pests to outbreak
   c. Allows exotic pests to “outbreak” on exotic plants