The Risks and Benefits of Biological Control: A Case Study of the Emerald Ash Borer

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Mechanical Control

- Expensive
- Usually only cost effective for small infestations.

Chemical Control

- Can be less expensive than mechanical control
- Consequences include non-target mortality, contamination of groundwater, pesticide drift, pesticide poisoning, development of resistance.
- Costly for treating large areas.
- Trunk injections with Emmamectin Benzoate: 99+% effective

Cultural control…

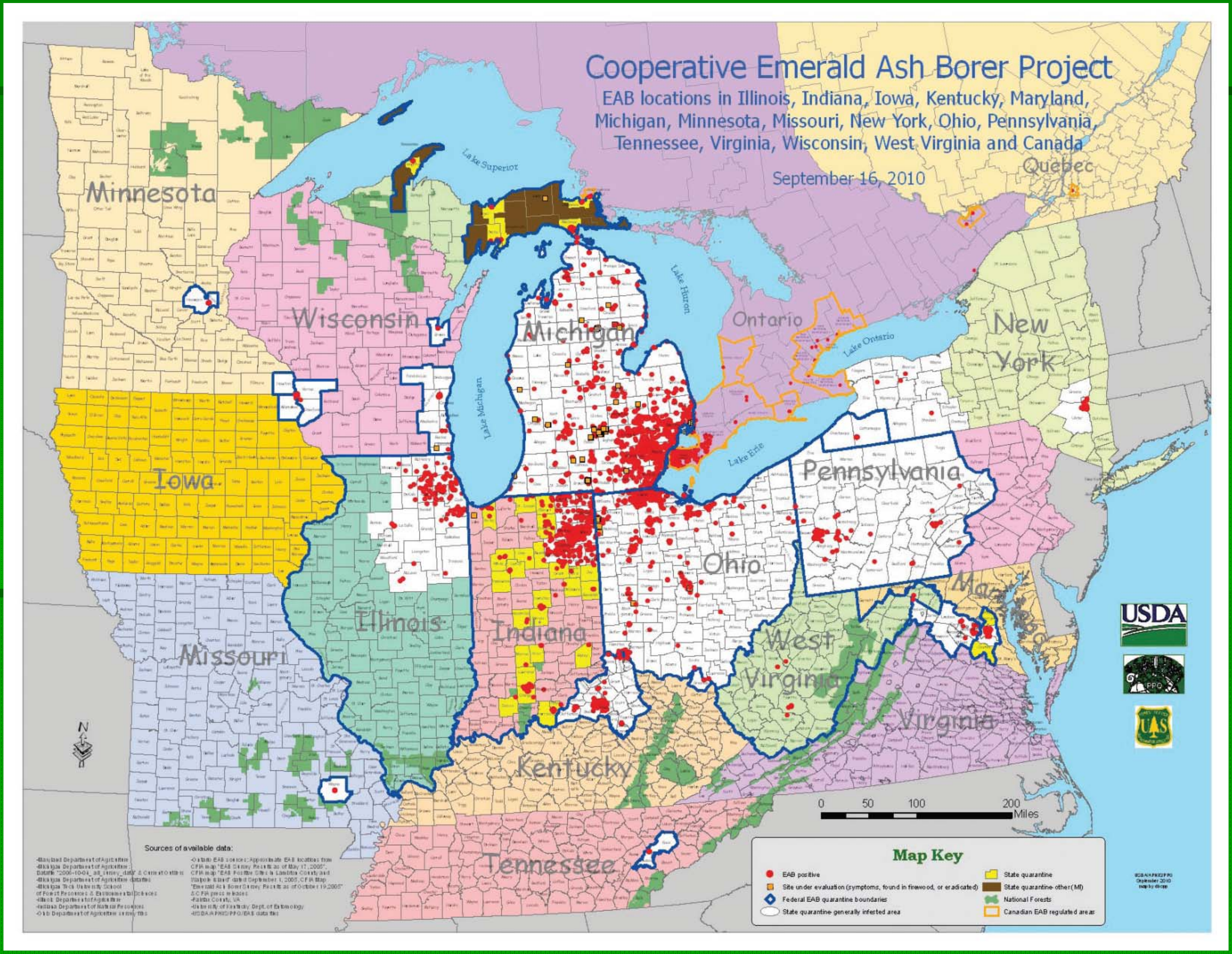
- Regulatory: maintain quarantine compliance
- Outreach: firewood inspections, signage, web site, early detection and public awareness, “The Green Menace”, etc.

EAB Potential for Spread

- Natural Spread:
  - Adults are strong fliers
  - Population can move at least 750 m in one year
- Artificial Spread:
  - Movement of EAB infested firewood
  - Movement of EAB infested logs
  - Movement of EAB infested nursery stock

Difficult to detect low density infestations.

Current EAB Distribution



Integrated Approach

- SLAM (SLow Ash Mortality)
- To slow the rate at which EAB populations build and spread.
- Combines sampling, girdling trees to attract EAB, treating trees with insecticides or destroying to remove EAB, removing ash trees to reduce phloem available as a food source.

Classical Biological Control

- Many exotic invasive pests arrive without the complement of natural enemies that helps regulate populations in the native range.
- Usually, few natural enemies in the introduced range attack the new pest.
- <1% of EAB attacked by native parasitoids, predators, and pathogens.

Classical Biological Control

- The importation of a natural enemy from a foreign country for sustained control of a pest also of foreign origin.
- Successful natural enemies can provide enduring pest control
  - Reproduce and disperse without further human assistance.
  - Persist after pest population reduced to low density.

When is classical biological control used?

When a species is:

- ✓ **not native**
- ✓ **established for at least 5 years**
- ✓ **causing economic or ecological damage**
- ✓ **eradication and control by other means is not possible**

Agrilus planipennis

What steps are involved in biological control?

1. Identify and study biology of the invasive pest
2. Survey for native natural enemies
3. Foreign exploration for natural enemies
4. Select potential biocontrol agents
5. Import & study biocontrol agents in quarantine
6. Prepare "release-justification documents"
7. Request & receive permits for field release
8. Select diverse field sites, mass rear, & release
9. Evaluate efficacy & study impact on nontargets

Benefits of Classical Biocontrol

- Economic
  - Reduction in crop/forest losses.
  - Reduction in costs of other control measures.
- Environmental
  - Reduction in pest damage to natural systems
  - Reduction in pesticide contamination of environment and humans.

Benefits of Classical Biocontrol

- Cottony Cushion Scale almost destroyed the CA citrus industry in late 1800's.
- Successful control with the Vedalia beetle and a parasitoid inspired other projects.
- 5000+ introductions against arthropod pests worldwide since 1889

Cassava Mealybug

- Cassava native to SA but grown extensively in Africa.
- Up to 70% of daily energy intake.
- 1970: Cassava mealybug introduced and caused up to 80% crop loss.
- Host specific parasitoid introduced – highly successful
- Benefit : Cost Ratio 500:1

Benefits of Classical Biocontrol of Arthropods

- 16% complete control
- 42% partial control
- Some projects failed because they were too limited in duration or resources.
- Benefit : Cost ratios range from 3:1 to 100^{+}:1 and benefits continue to accrue.
- In Australia benefit : cost ratios average 10.6:1 for biocontrol compared with 2.5:1 for pesticides.
- Overall benefits from successful projects outweigh the combined costs of unsuccessful projects.

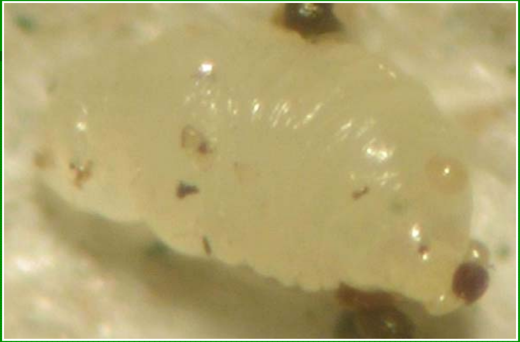
Exploration for Natural Enemies of EAB

- Mongolia
- Russia
- Japan
- South Korea
- China

Changchun, Jilin Province

Oobius agrili (Encyrtidae)

Female lays a single egg inside EAB egg



Parasitoid larva develops inside EAB egg

Oobius pupa (dissected from egg)

Parasite adult chews exit hole & emerges from egg

Tetrastichus planipennisi

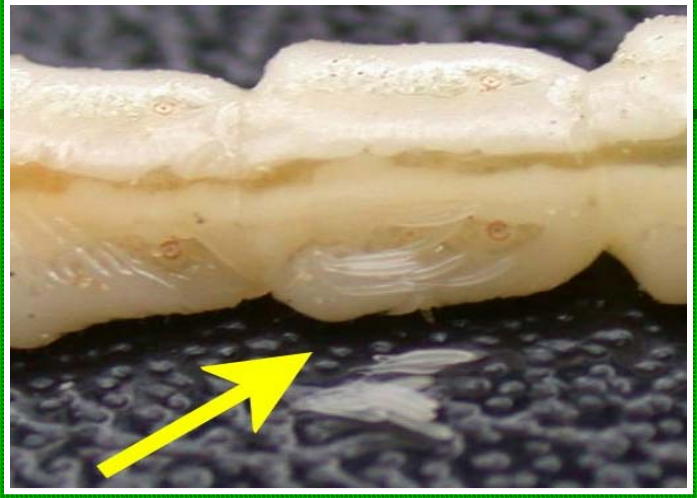
- Gregarious endoparasitoid
- 4-92 per EAB
- 4 generations per year
- Up to 50% parasitism

Tianjin City

Sclerodermus sp.

- Female removes frass from entrance to pupal chamber
- Female paralyzes EAB pre-pupa or pupa and lays 15-20 eggs
- 70-80% females wingless
- % Parasitism low in Tianjin

Spathius agrili



- Paralyzes the host
- Gregarious ectoparasitoid
- 1-20 eggs per host

Spathius agrili

- 3-4 generations per year.
- Up to 90% parasitism in some stands

Unintended Consequences of Classical Biocontrol

- Diluting biodiversity
  - Deliberately introduced natural enemies <0.25% of insect fauna of lower 48 states
- Host Range Expansion through Genetic Shift
  - Considered rare for specialist natural enemies
- Attack of Non-target Insects – Host Specificity

Summary of Host Specificity Evidence for EAB Parasitoids

- EAB parasitoids attack significantly more EAB than non-target insects in laboratory no-choice and choice tests.
- *Spathius agrili* is attracted to leaves of ash but not to most other plants tested. Must be reared in the presence of EAB adults feeding on ash leaves.
- Neither of the two larval parasitoids were reared from any *Agrilus* other than EAB in China.
- *Spathius* native to the USA only sporadically attack EAB. No native *Tetrastichus* have been found ovipositing on EAB. They have not switched hosts.

Benefits of EAB Biocontrol

- Ecological
  - Ecosystem functions
  - Reduce pesticide use
- Safety
  - Trees killed by EAB can lose limbs or topple, injuring or killing people or damaging property.

Benefits of EAB Biocontrol

- Economic
  - APHIS and State Program Costs
    - \$29.5 million per year average; \$206 million total since 2003
  - Urban/Suburban Areas
    - Cost of treating, removing, and replacing all 37.9 million ash trees in 25 states is \$25 billion.
  - Forests
    - Compensatory value of 8 billion ash trees in US timberland potentially infested with EAB is \$282 billion.

Risks of EAB Biocontrol

- Efficacy:
  - Percent parasitism by *Spathius, Oobius,* and *Tetrastichus* are over 50% in China and all three species multivoltine.
  - *Sclerodermus*: low level of attack, females do not fly, some species in the genus sting people. Not imported for testing.

Risks of EAB Biocontrol

- Non-target effects
  - Low levels of attack on native *Agrilus* – EAB is preferred by all three species.
  - No risk of insects attacking humans or invading their houses.

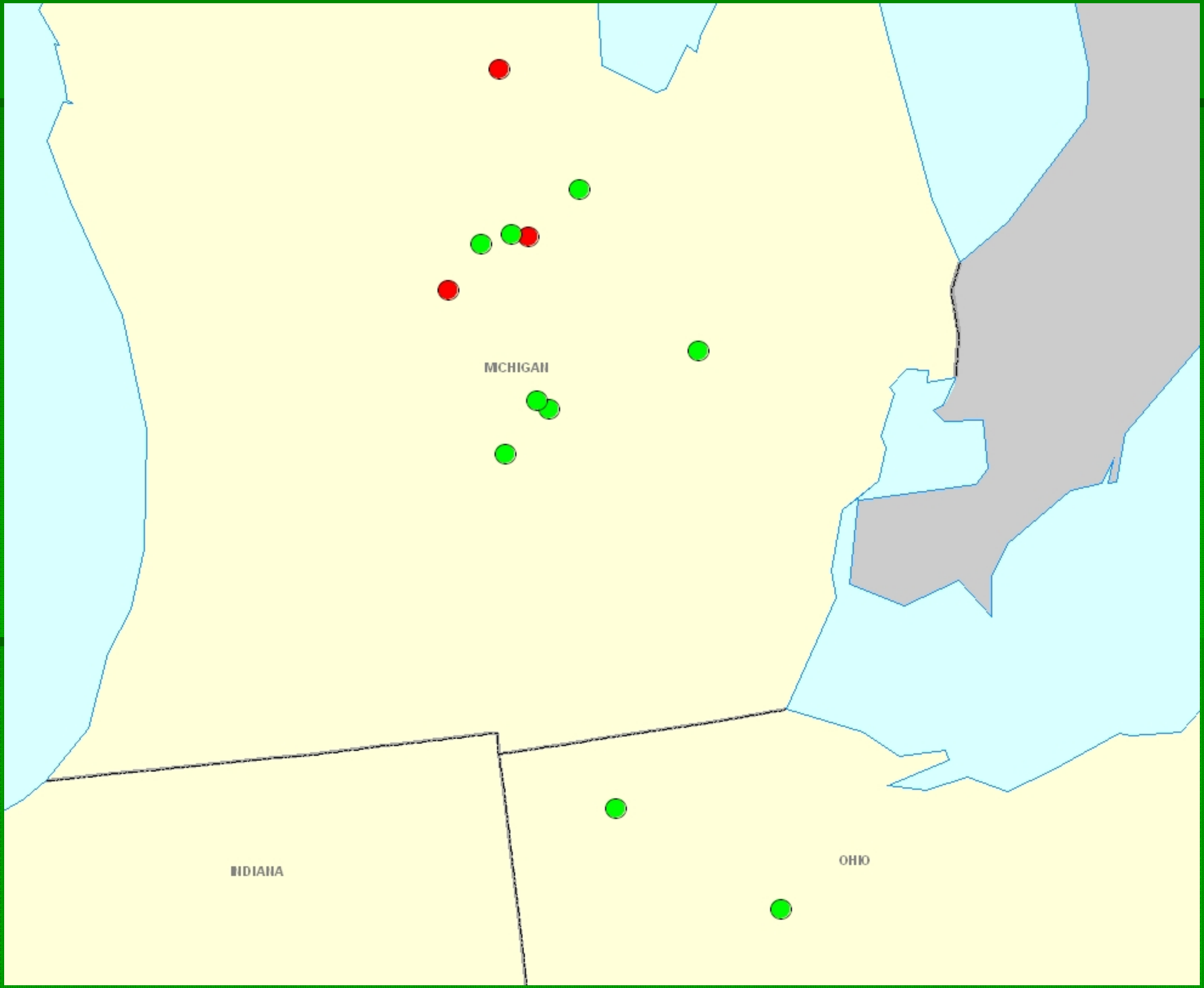
Risk Analysis

- Risk Analysis takes scientific data, which is sometimes uncertain, and assigns societal values to the risks and benefits.
- For EAB it was determined that the benefits outweighed the risks and release permits were granted in 2007.

Release of EAB Parasitoids

- Releases of small numbers began in 2007.
- In 2009, because of advances in rearing techniques and establishment of a mass rearing facility, we released 6,000 *Spathius*, 5,000 *Oobius*, and 16,000 *Tetrastichus.*
- In 2010 over 55,000 *Spathius* and 80,000 *Tetrastichus* were released in 7 states.

Parasitoid Overwintering



Conclusions

- Exotic invasive species continue to establish in the United States.
- Biocontrol may be the best tool for managing problematic species.
- Biocontrol should be conducted within a regulatory framework that:
  - Demonstrates the need (economic, environmental, lack of other options).
  - Determines feasibility (probability of success)
  - Ensures a low probability of non-target impacts