EAB & Other Invasive Forest Insects: 400 Years of Bad News

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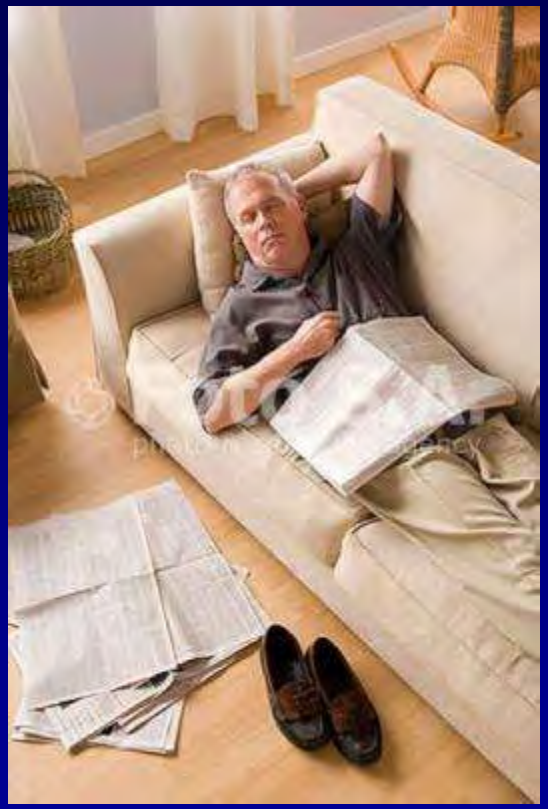
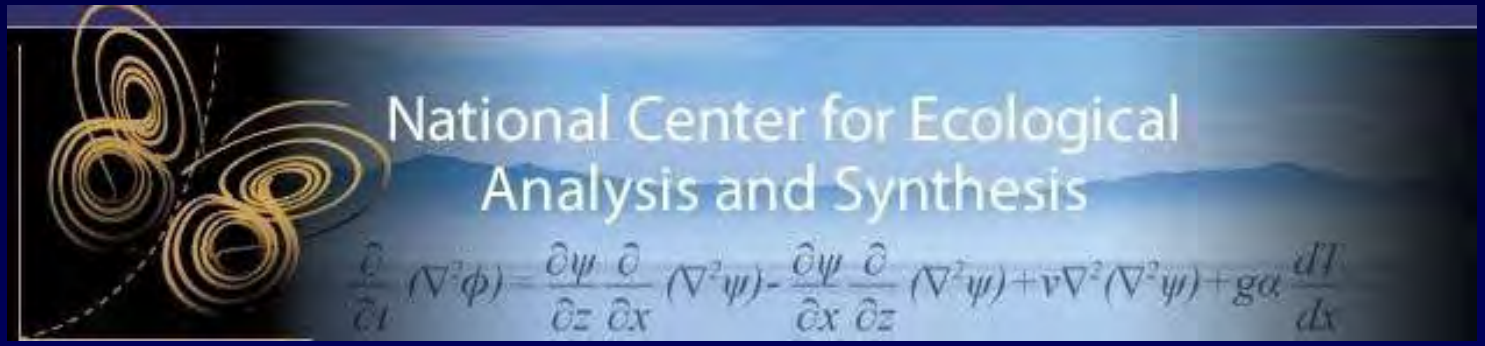
Impacts of Exotic Forest Insects & Pathogens

- Productivity & biodiversity
- Ecosystem functions
- Endangered species
- Quarantines & regulatory actions
- Pesticide load
- Diminished use of IPM or biocontrol

Easy to ignore invasive forest pests



Unless YOUR tree is affected!



The Nature Conservancy
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NCEAS Working Groups established in 2007 by The Nature Conservancy

Working Group 1: *Assess Economic Impacts of Invasive Forest Pests*

Economic Impacts of Invasive Forest Pests

Insect Ecology

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Plant Pathology

Kerry Britton (USFS, VA)

Susan Frankel (USFS, CA)

Invasive Forest Insects in the US

- How many non-native forest insects are established in the US?
- What percent are invasive & cause damage?
- How frequently is a new non-native insect detected? Is the rate increasing?
- What kinds of non-native forest insects are here? (orders & families, feeding guilds)
- Where are those non-native insects established?

Our Approach…

1. **Long list:** inventory of non-native forest insects established in U.S.
2. **Short List = High Impact Pests:** Insects & pathogens reported to cause economic damage in U.S.
3. For each pest, we recorded:

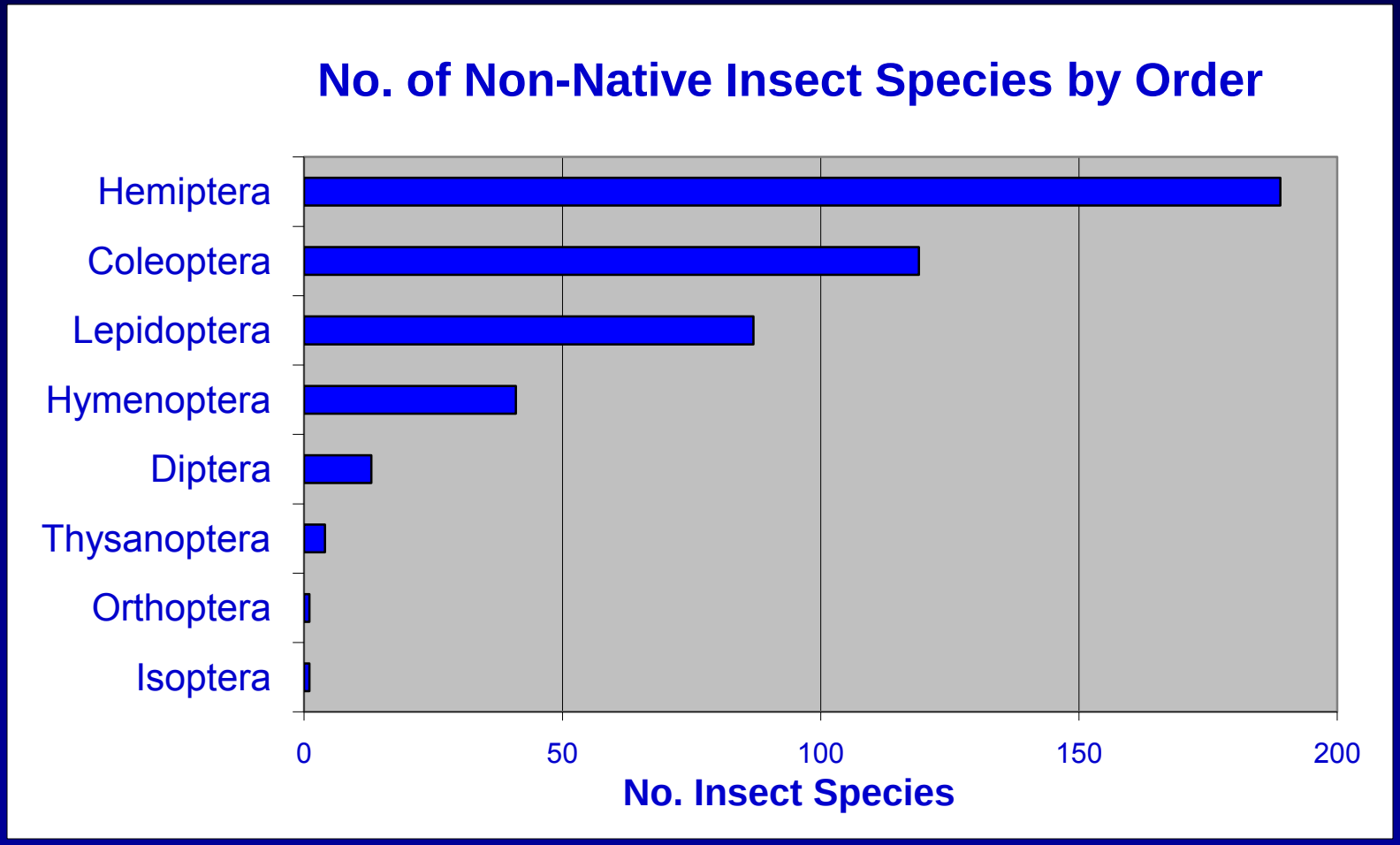
   Order, Family, Primary host(s), Host range,

   Feeding guild, Year detected (if known)

   Distribution within US for High Impact pests

Long list: established forest insects in the U.S.

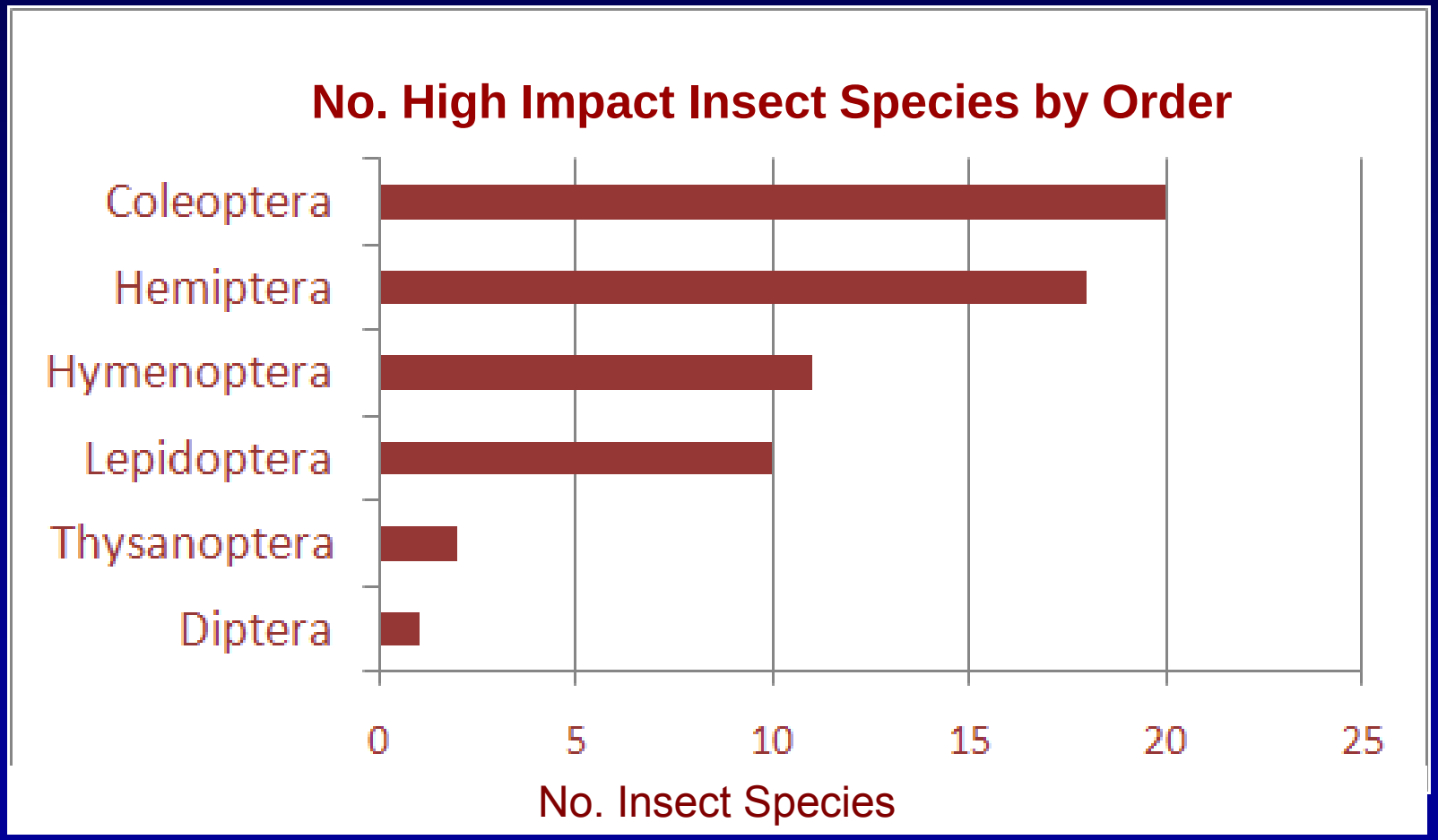
455 insect species: 8 orders & 64 families



High Impact list: damaging insect pests + 16 pathogens

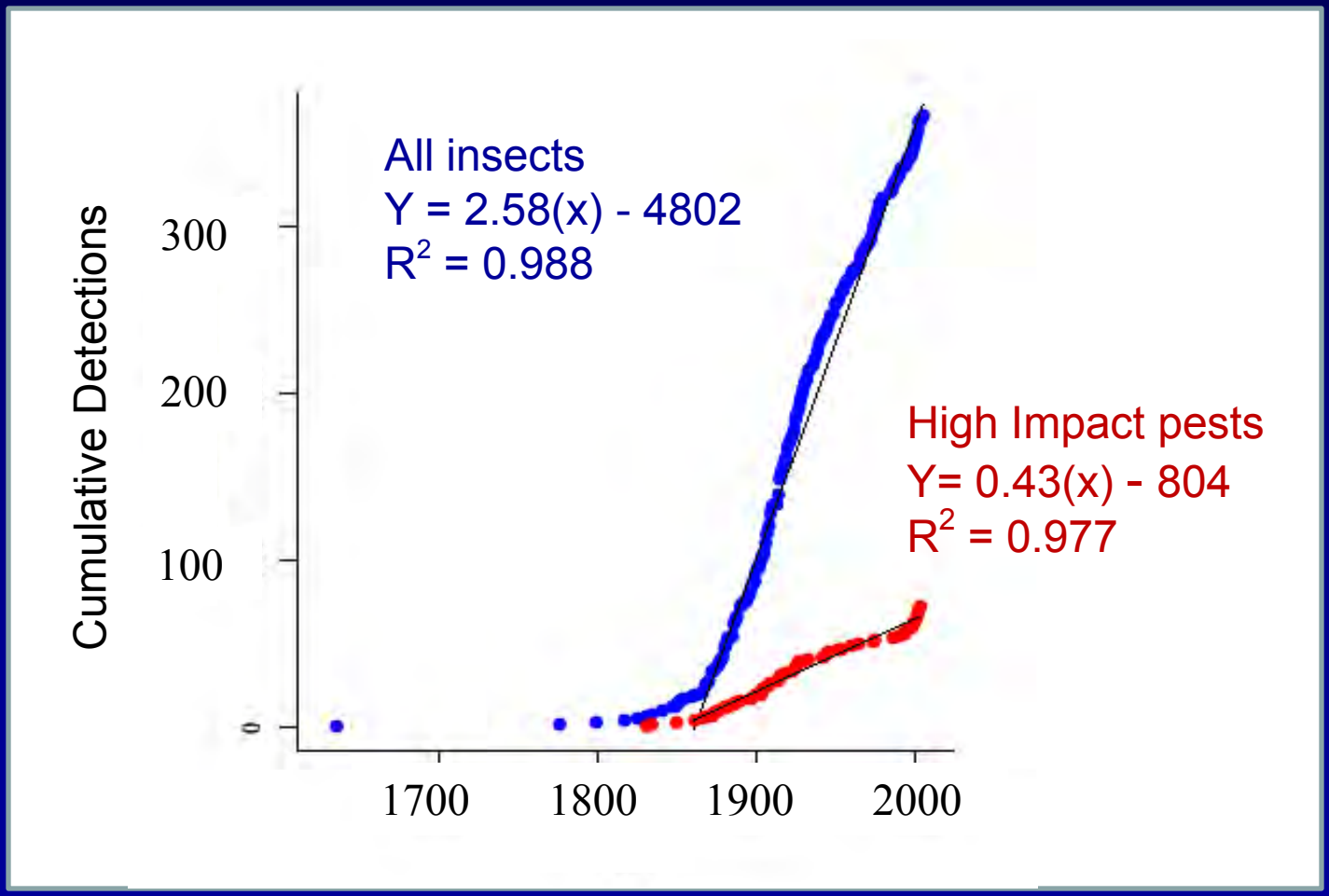
62 insect species representing 6 orders, 26 families

Represents 14% of Long List

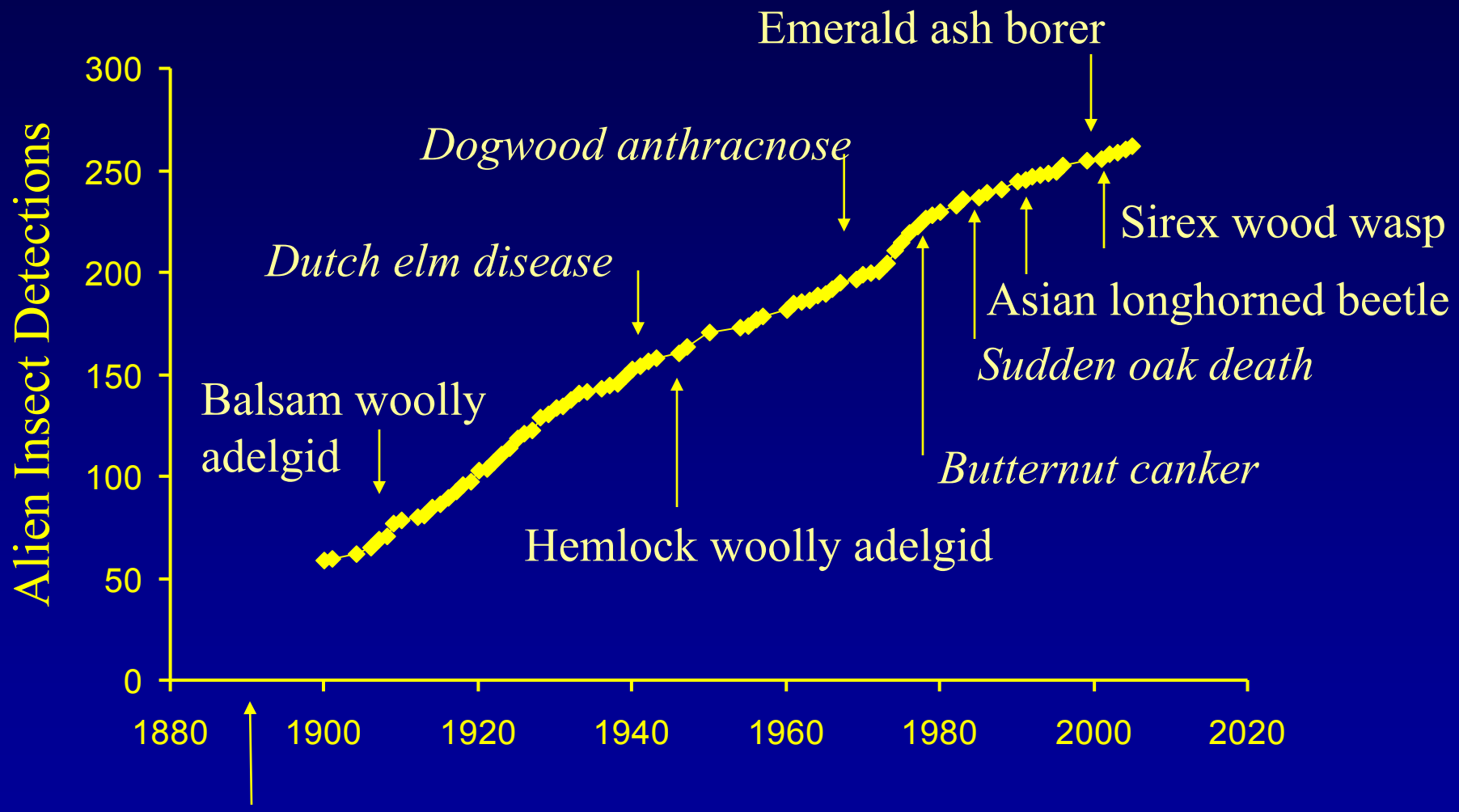


Roughly 2.5 non-native forest insects detected per year since 1860. Linear accumulation = steady rate.

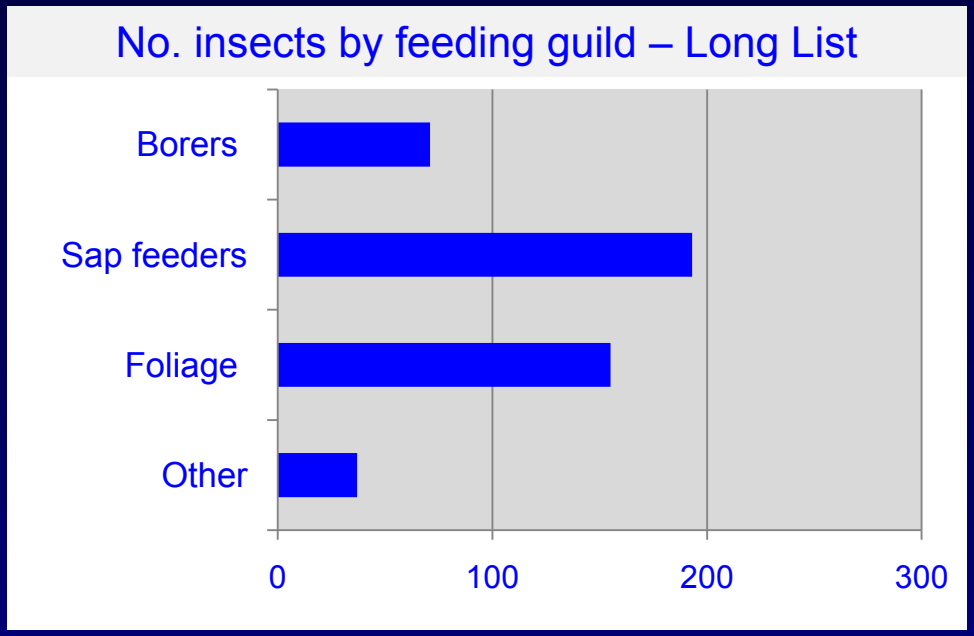
One High Impact Pest detected about every 2 years.



Some Notable Pest & Pathogen Introductions



Pre 1900: gypsy moth, beech scale, *Chestnut blight, WPBR*



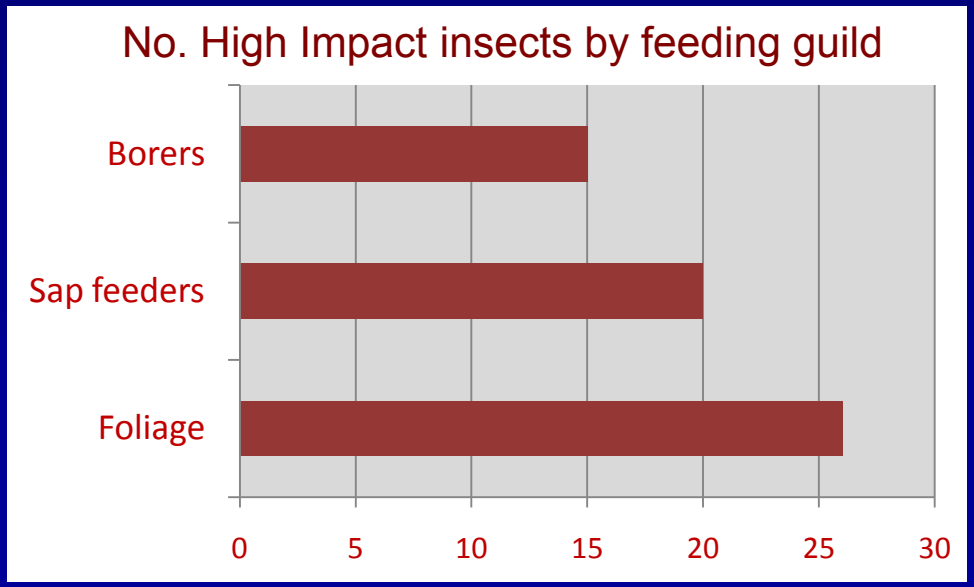
Long List (455 sp)

Sap feeders = 42%

Foliage feeders = 33%

Borers = 16%

Other = 8%

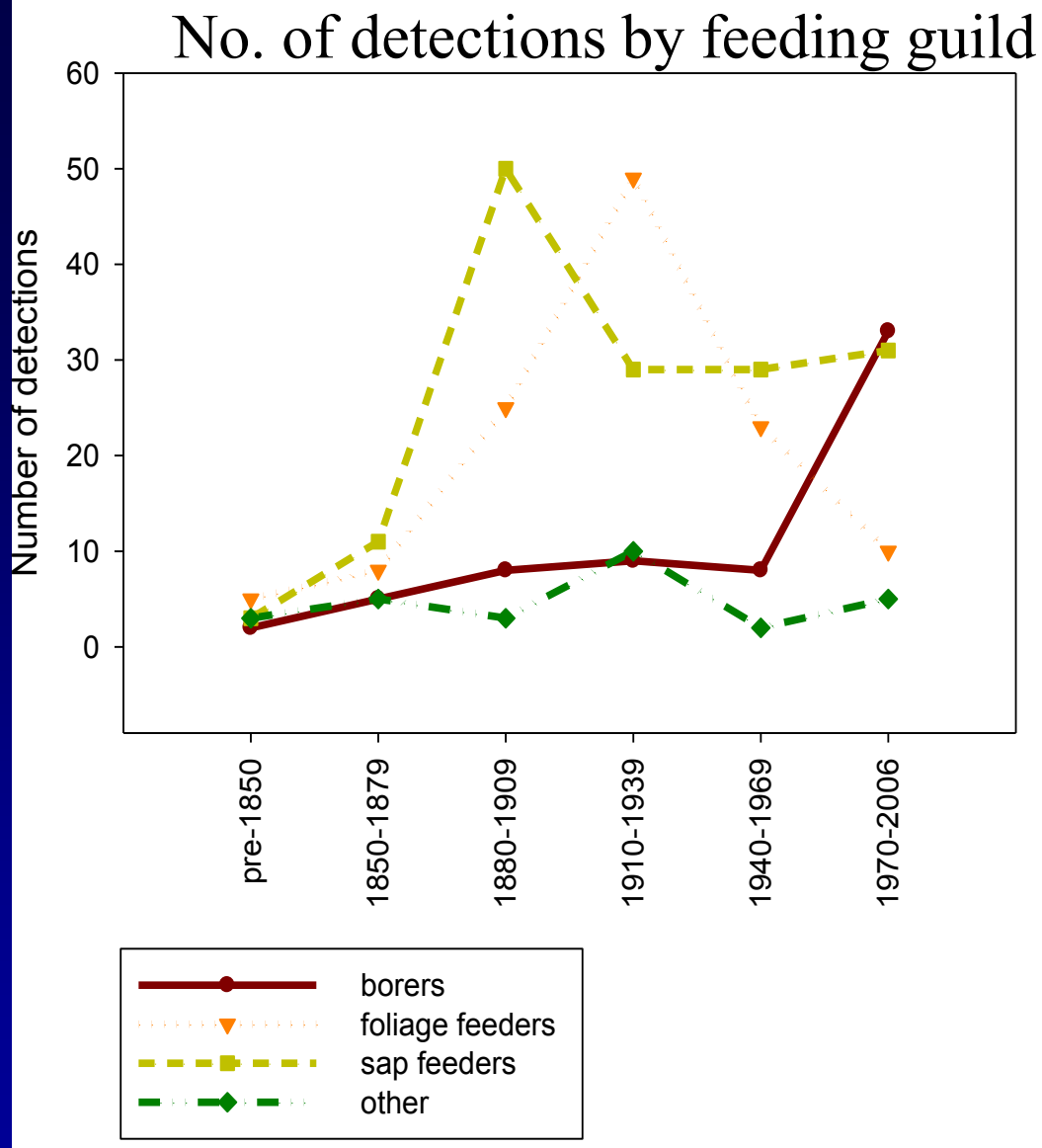


High Impact List (62 sp)

Sap feeders = 34%

Foliage feeders = 42%

Borers = 24%



Foliage feeders: Declining since 1920s; Maybe 1912 Plant Pest Act?

Sap feeders: similar decline but still steady; Maybe nursery plants?

Borers: sharp increase since 1980s. Maybe SWPM?

How are invasive forest pests distributed across the U.S.?

Short list: High Impact Forest Pests

62 insect species + 16 pathogens

1. Distribution data acquired for each pest species
2. Primary host(s) distributions, volume & basal area acquired from FIA database
3. Current distribution of alien forest pests & their potential hosts mapped; maps available on internet on Alien Forest Pest Explorer web site
   (created by Liebhold et al.)

US FOREST SERVICE

Alien Forest Pest Explorer

enter query Search
- Northern Research Station
- Research Work Unit 4557
- Forest Health Technology Enterprise Team
- Remote Sensing Applications Center
- GIS Data Download
- View Mapping Application
- FAQs
- Links
- Send us your comments

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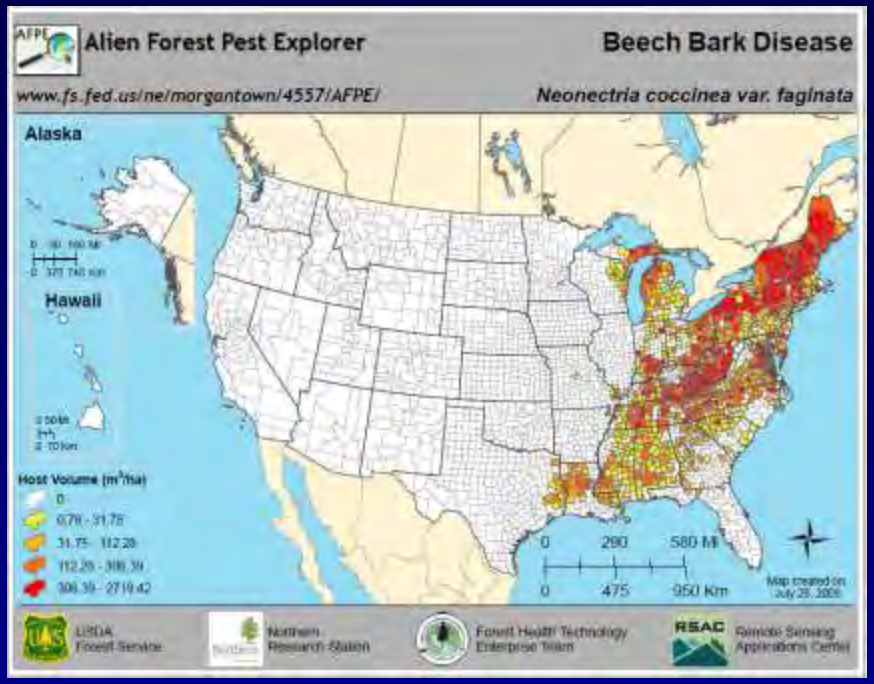
Click the AFPE logo to go to the explorer.

This site is maintained as a portal for the exploration of spatial data relating to non-indigenous forest pests. It can be used to generate customized maps that depict historical and future range expansion, historical damage and forest susceptibility. Currently, the Explorer contains data for 19 forest pests in the eastern US. Plans are underway to include data from other pests as well as selected invasive plants. For more information on forest pests, please visit the Links page.

Things to keep in mind when viewing the mapping application

- **Allow pop-ups on this page, this site will create pop-up windows to tell you the current active layer and to create a print page.**
- **Using your browser's refresh button reloads the entire ArcIMS site, use the Refresh Map button on the layer tab to redraw the map layers.**
- **Using your browser's back button will also reload the entire ArcIMS site. If you would like to go back to your last view extent, click the button.**
- **ArcIMS works best with Internet Explorer v. 5 or newer and Netscape Navigator v. 6 or newer.**

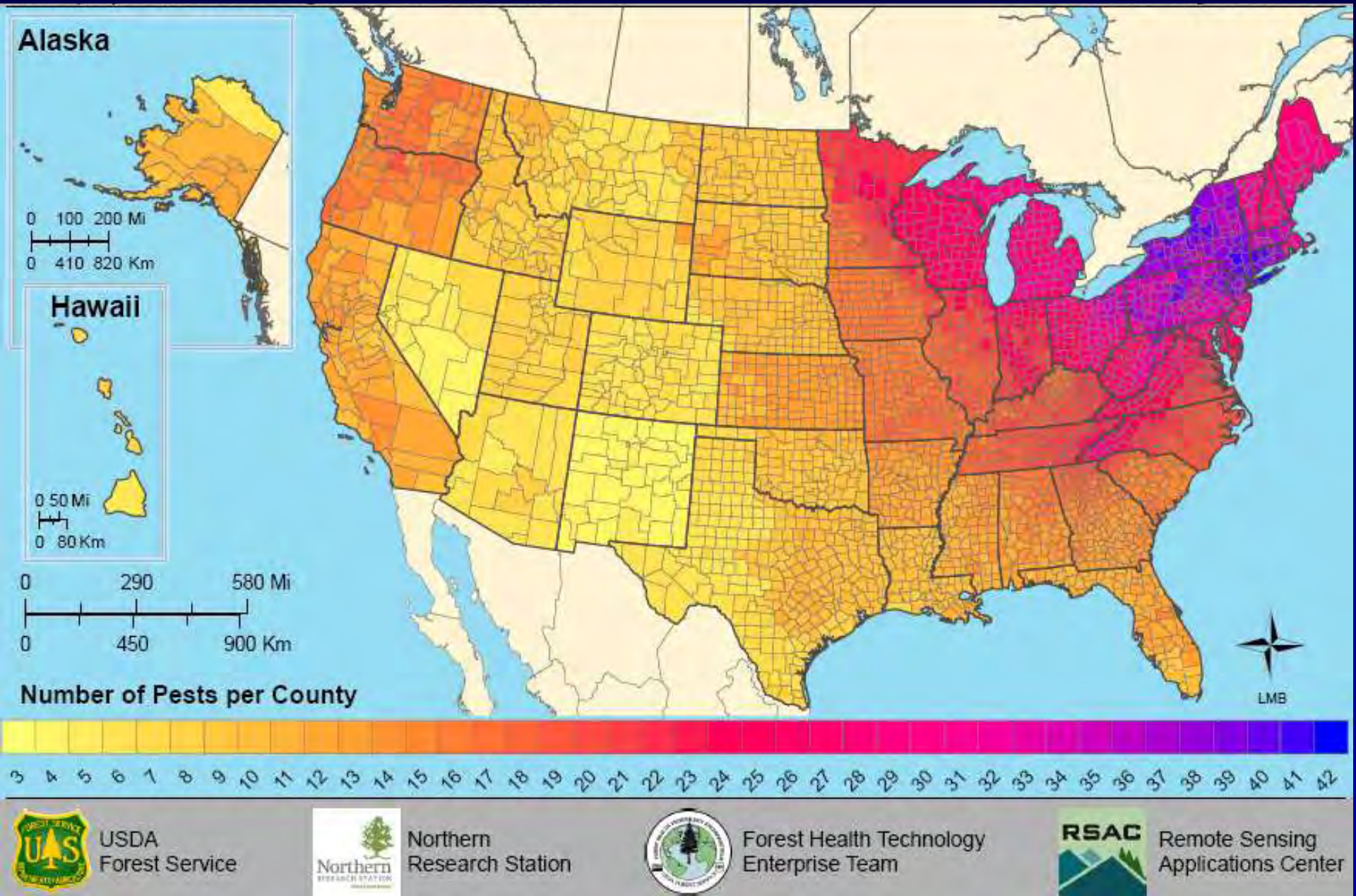
Beech distribution



Beech Bark Disease

Alien Forest Pest Explorer: distribution map for each High Impact pest & its hosts

Northeastern US gets clobbered!



USDA Forest Service

Northern Research Station

Forest Health Technology Enterprise Team

RSAC Remote Sensing Applications Center

What explains the spatial distribution of invasive forest pests in the U.S?

European colonization?

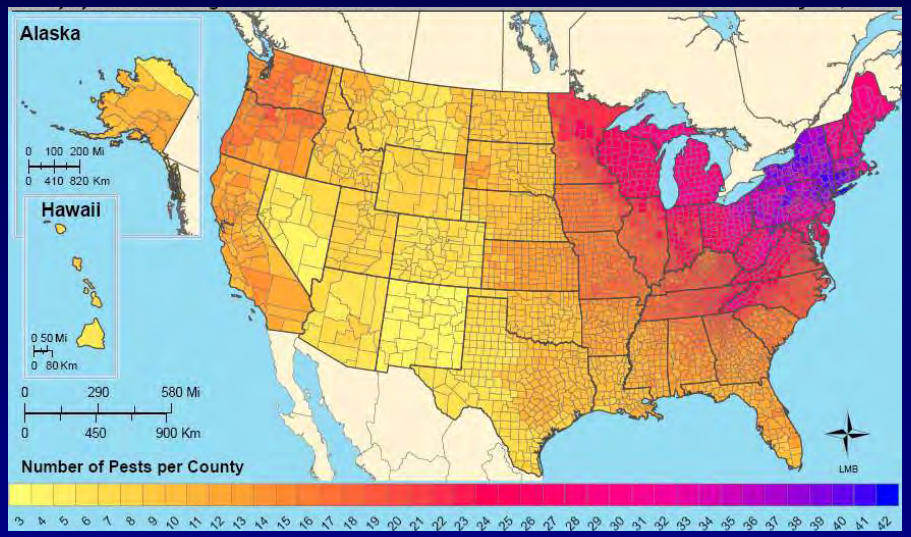
Immigration?

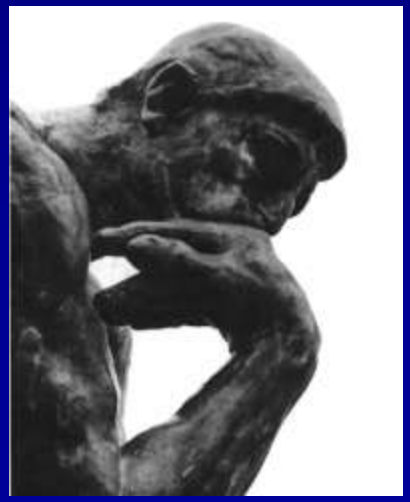
Historical trade?

Commodities imported?

Forest species diversity?

Cargo arrival, shipping?

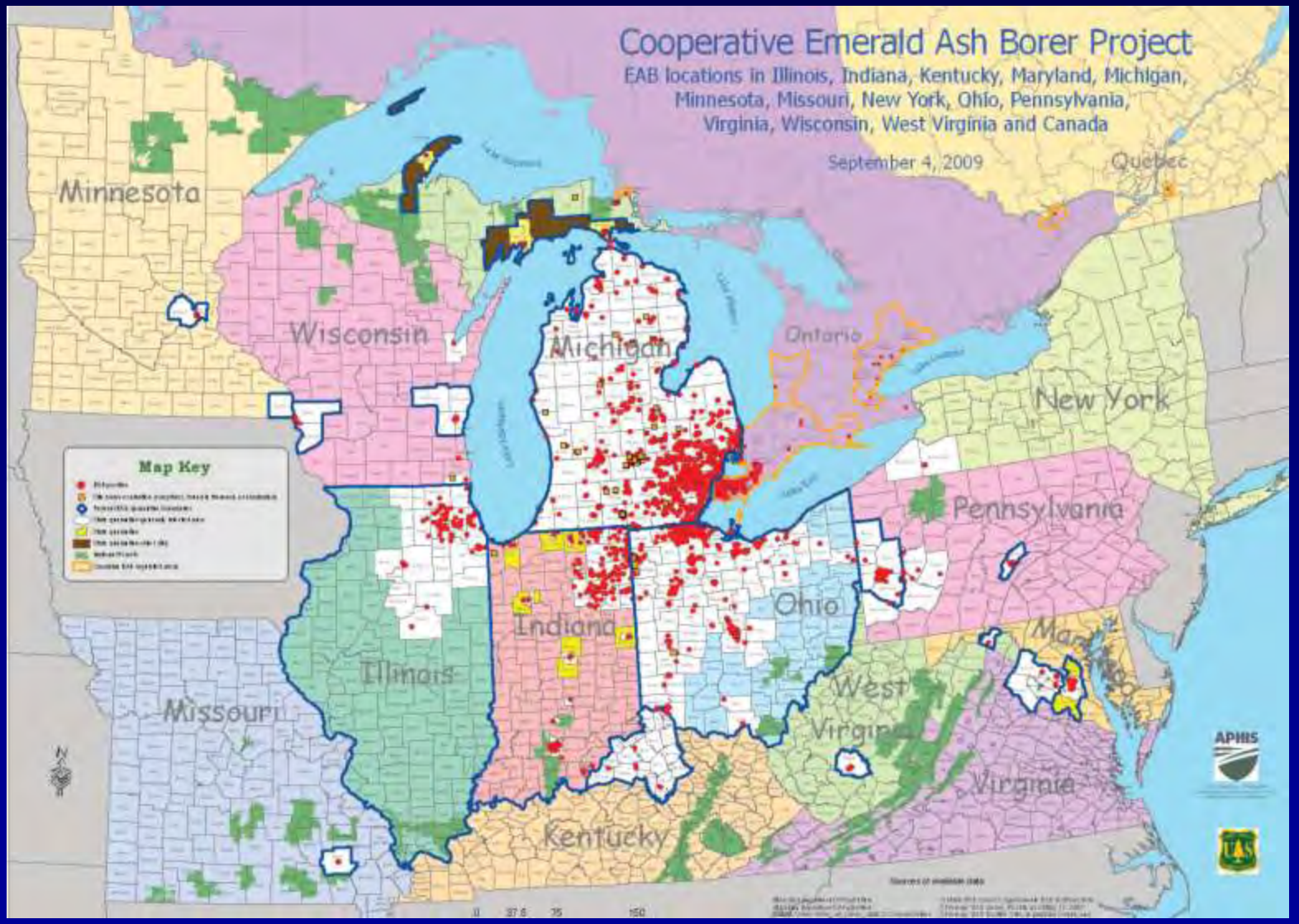




Something to ponder…!

Emerald Ash Borer – One of the Worst Invaders?

Current EAB distribution: 13 states & 2 provinces



Our Approach…

1. **Long list:** Non-native, established forest insects
2. **High Impact list:** Insects & pathogens reported to cause economic damage
3. **Poster Pests:** a "big name" pest per feeding guild. In-depth assessment of direct economic impacts & potential effects on ecosystem services.

EAB (borers) Gypsy moth (defoliators)
Hemlock woolly adelgid (sap feeders)
Sudden oak death (pathogens)

Economic Impacts of EAB

Kovacs, Haight, McCullough, Mercader, Siegert, Liebhold. 2009. Ecological Economics. In press.

Estimated discounted costs of insecticide treatment or removal & replacement of ash trees on developed land through 2020.

25-state study area centered on Detroit = EAB origin

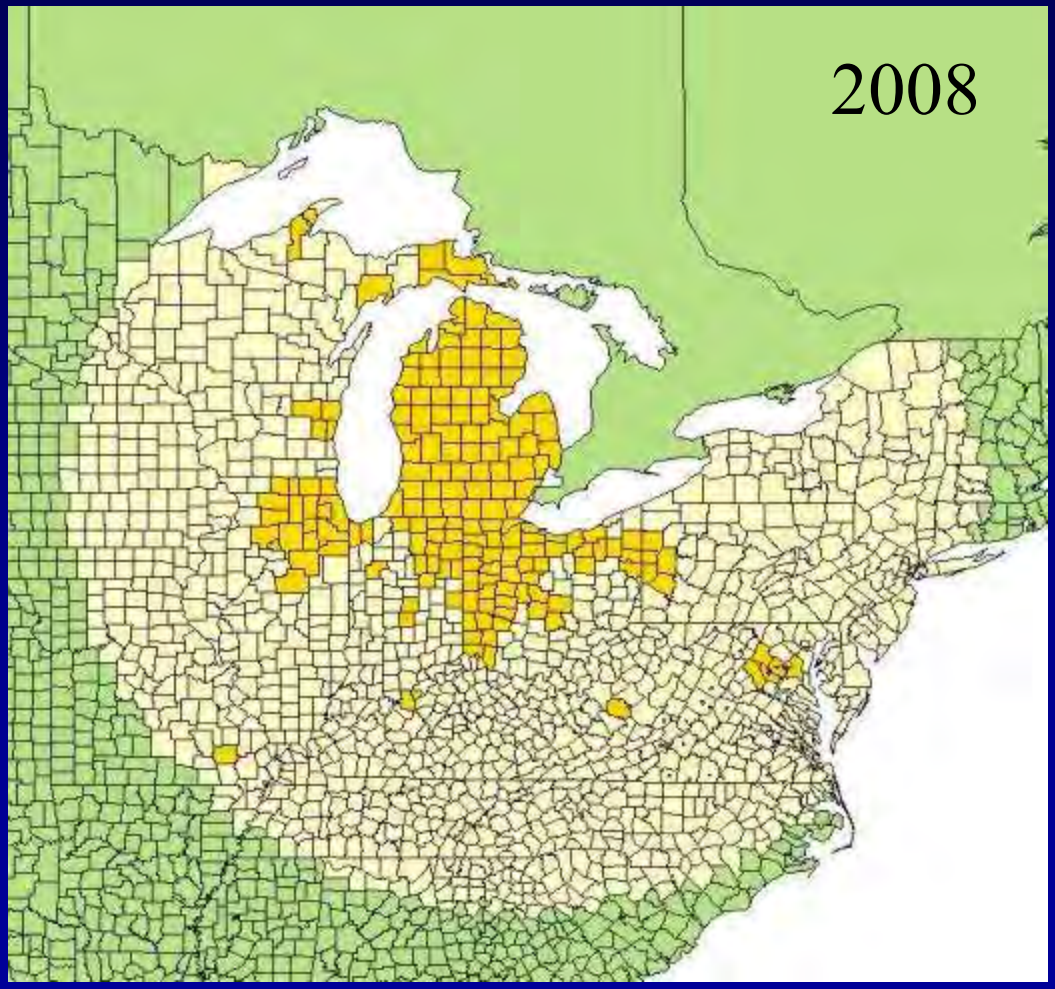
Predicting EAB Spread

If current situation of "no-action" at outlier sites continues, where will EAB be established in 2020?

Stochastic simulation model can be used to predict EAB distribution over time, using what we know about current EAB infestations.

Predicting EAB Spread

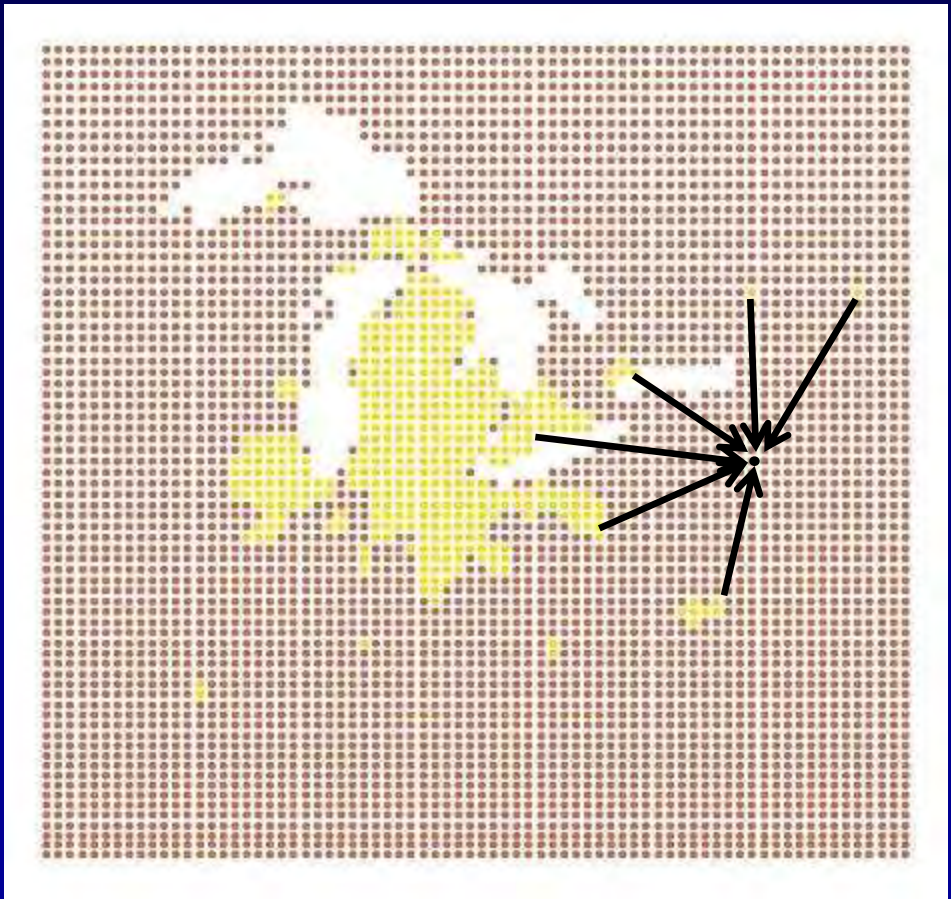
- Started with counties infested December 31, 2008

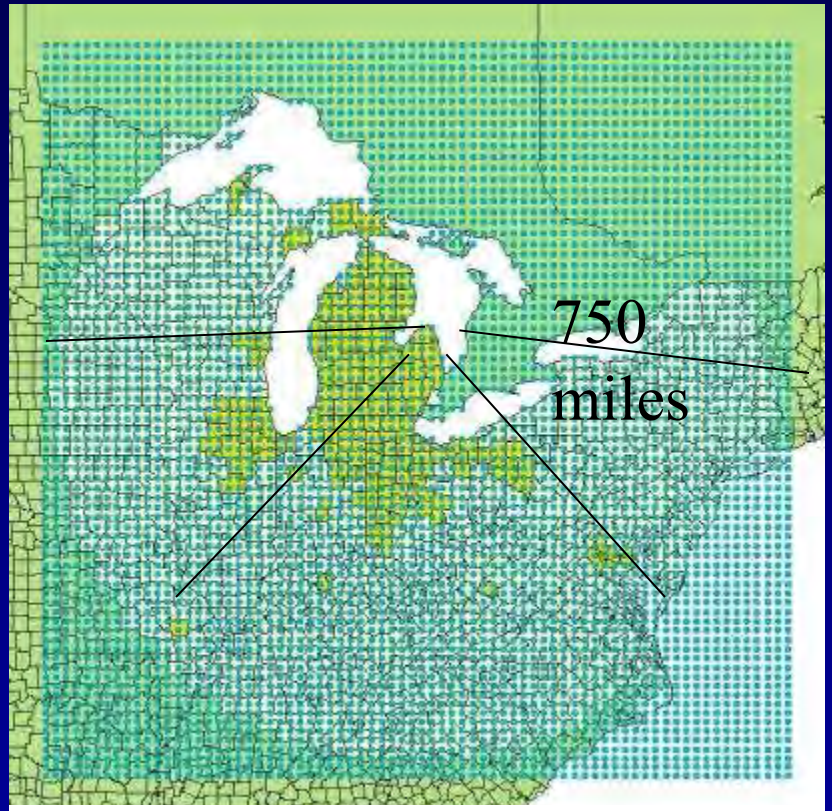


Simulating EAB Spread

- Used initial EAB infestation in Detroit in 1994 (based on Siegert et al. dendrochronlogy data)
- Overlaid grid of 5000 points (25 km^2) centered on Detroit & extending 750 miles in all directions.
- Plotted the distance of infested points in December 2008 to Detroit.
- Used Negative Exponential Function to describe relation between infested points & distance to Detroit.
- Ran 500 simulations over 14 year period to identify model with the best fit to 2008 EAB distribution.

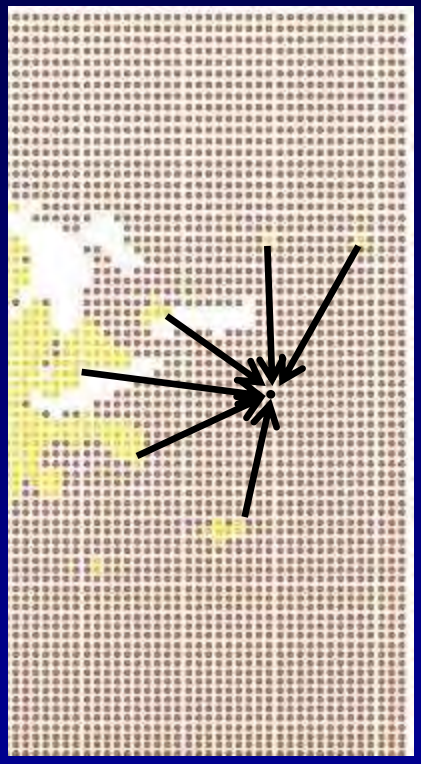
Stochastic Simulation Model: What is the likelihood that any one point will become infested?





county & state boundaries

Steps in the Stochastic Simulation Model



1) Probability point j will infest point I

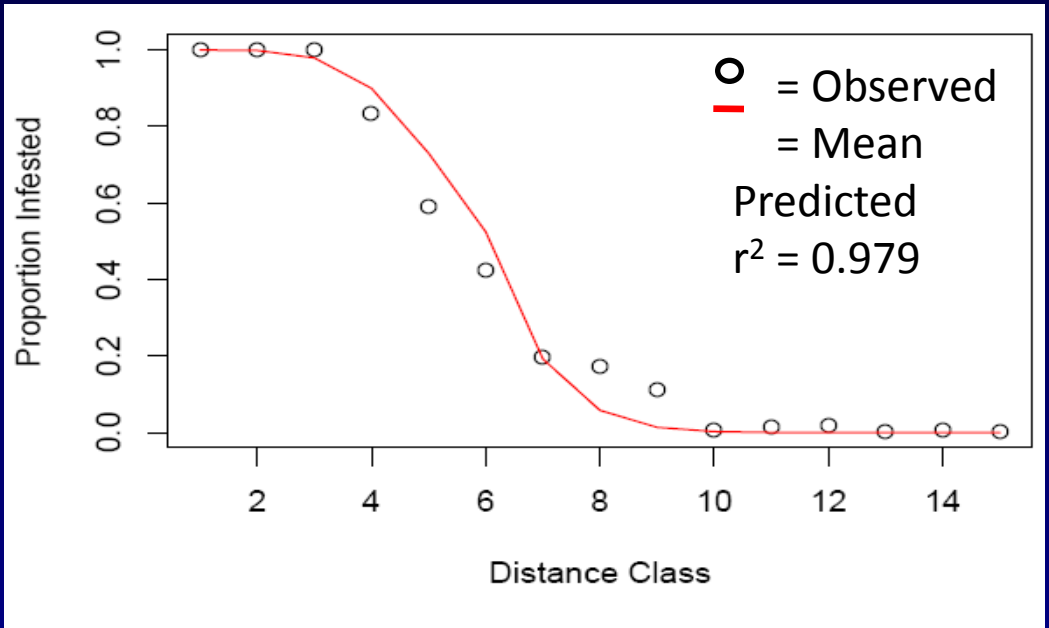
$$P_{ij} = ae^{(-b*D_{ij})}$$

a = 0.94, b = 0.06, D = distance i to j (km)

2) Probability used in random number generator based on binomial distribution to determine if infestation realized.

3) If infestation realized from any point j to i, then i was considered to be infested.

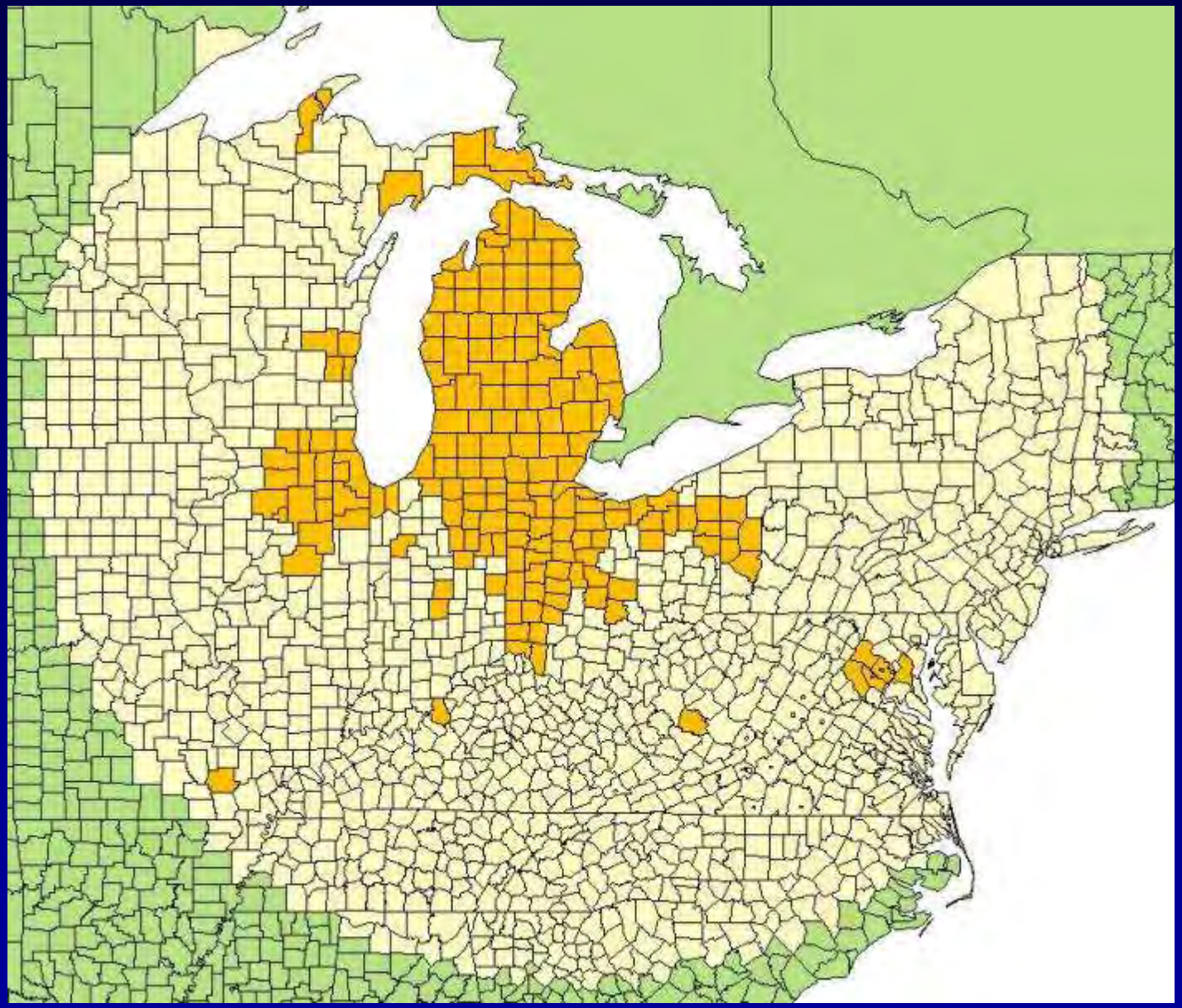
Model fit to distribution of infested counties (2008)



- Selected the best function & ran it 500 times for the period 2009 to 2020.
- Determined probability of any given point in the grid becoming infested each year.

EAB Forecast Simulation Results

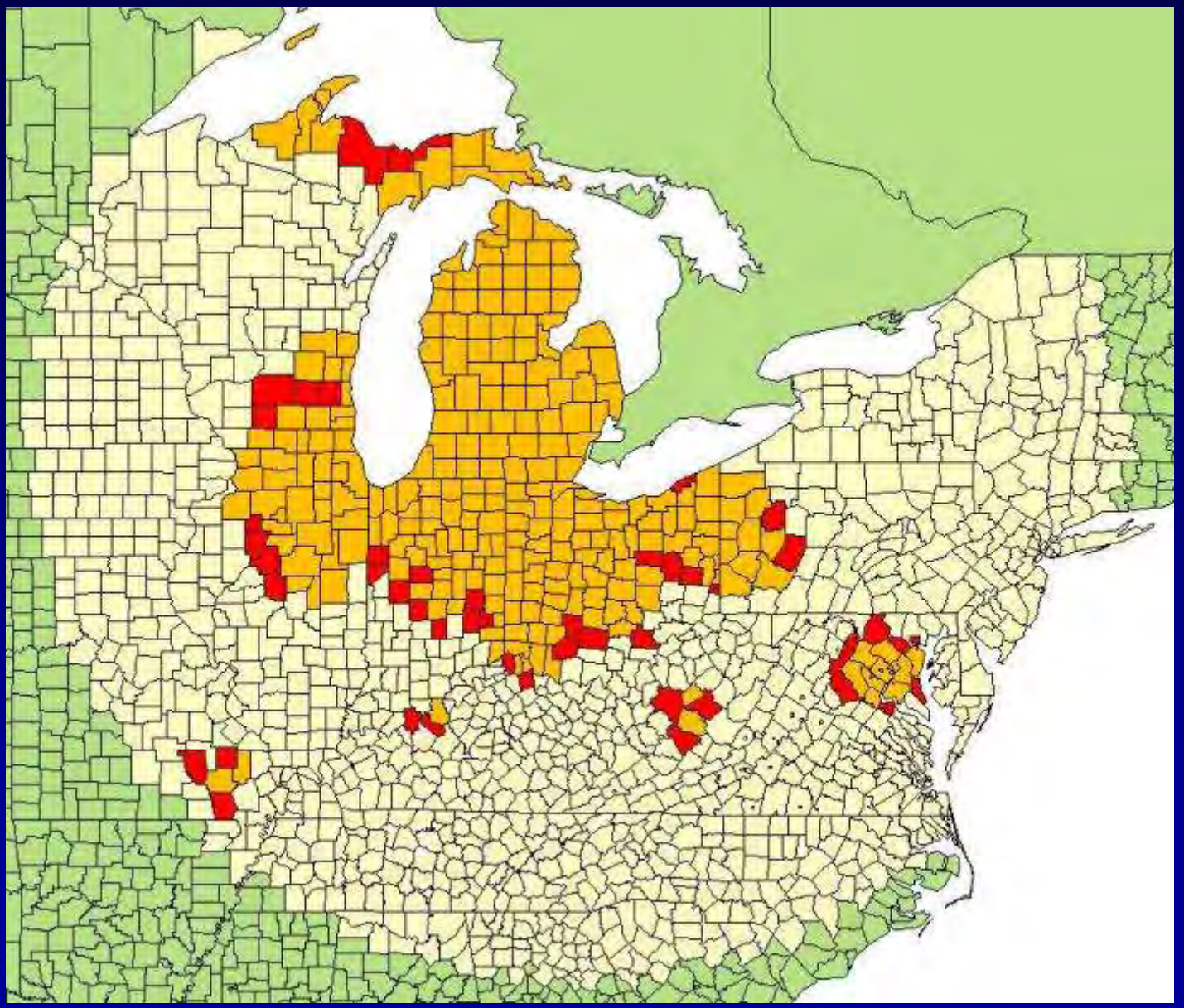
2008



EAB Forecast Simulation Results

2008

2010

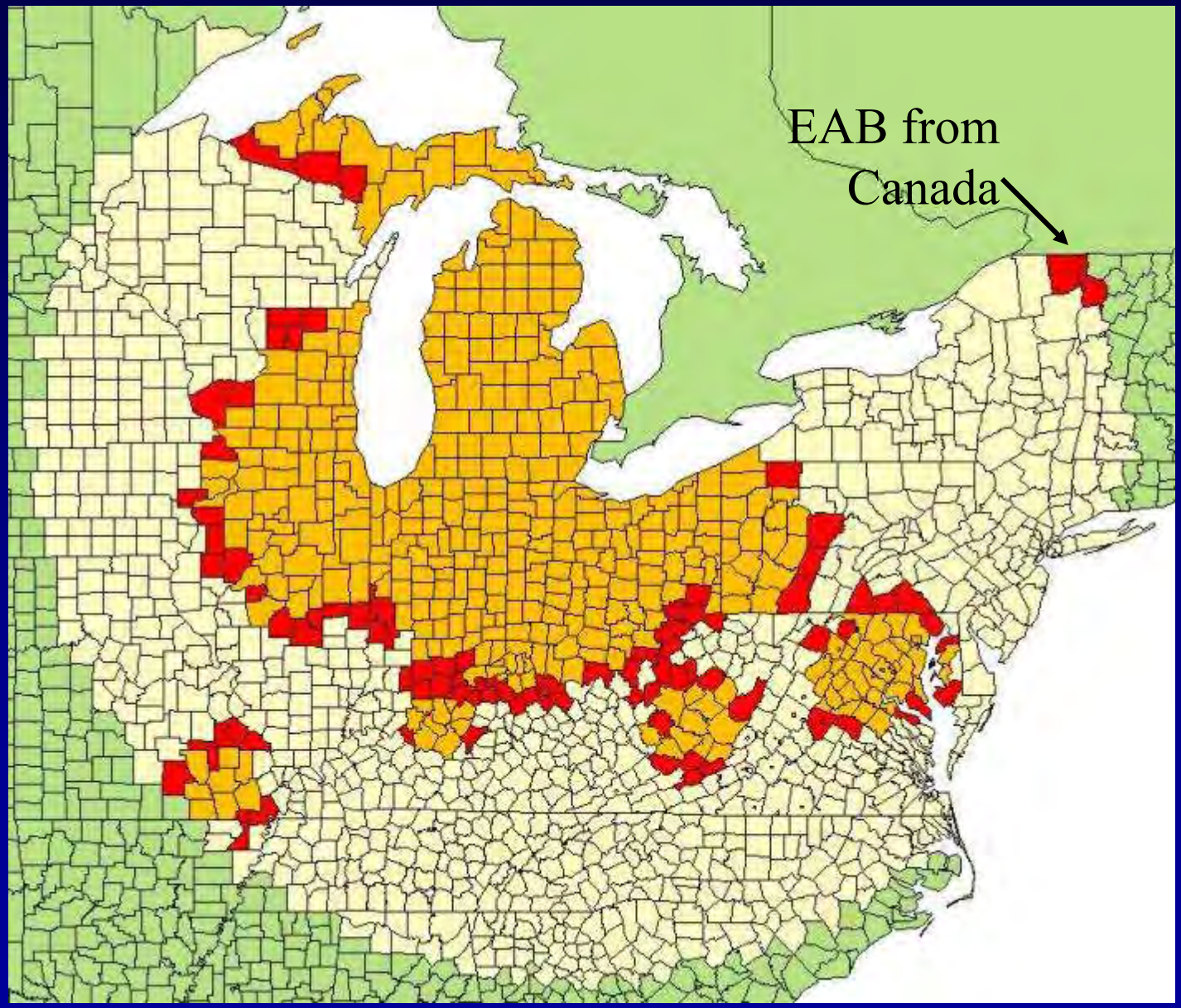


EAB Forecast Simulation Results

2008

2010

2012



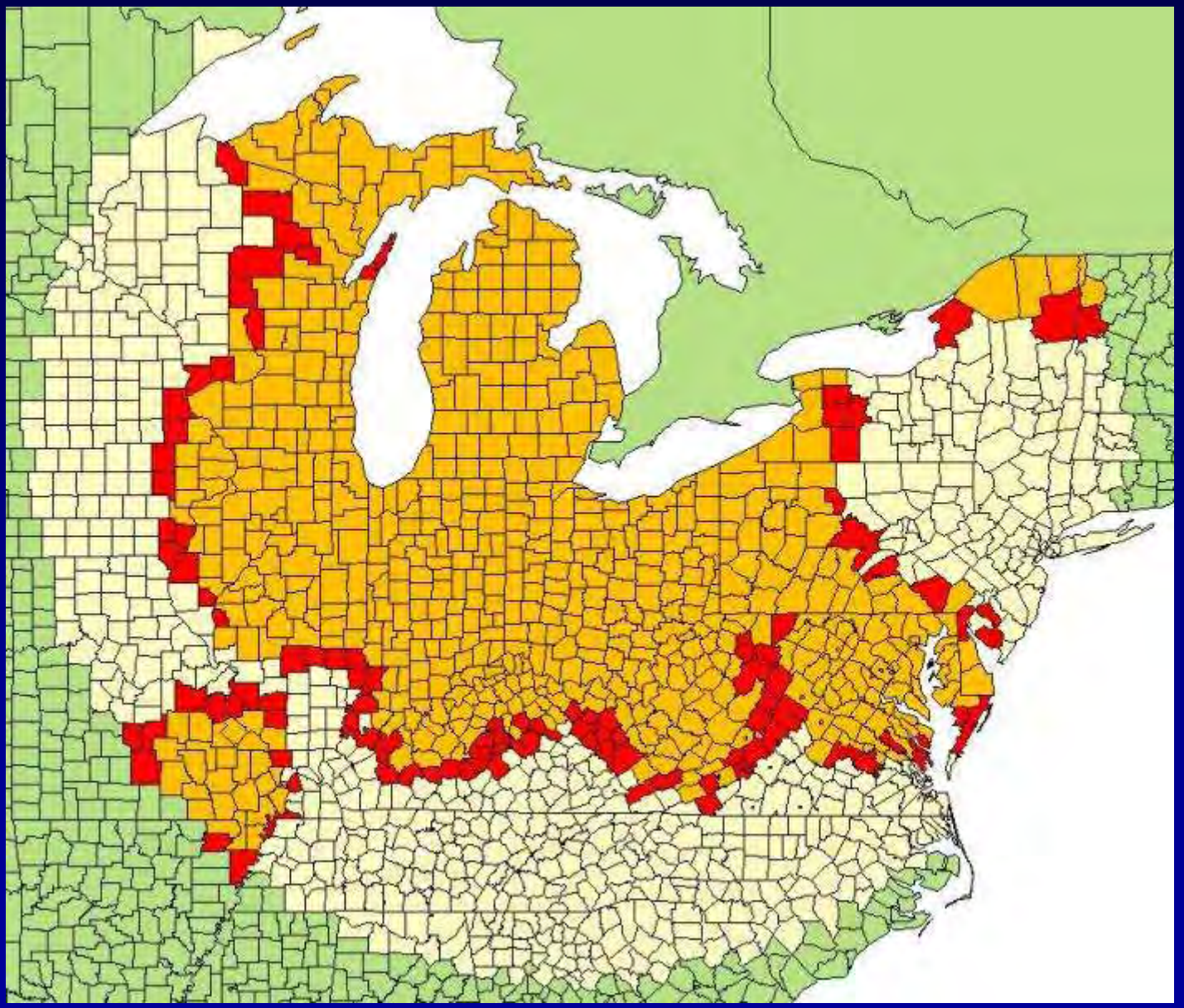
EAB Forecast Simulation Results

2008

2010

2012

2014



EAB Forecast Simulation Results

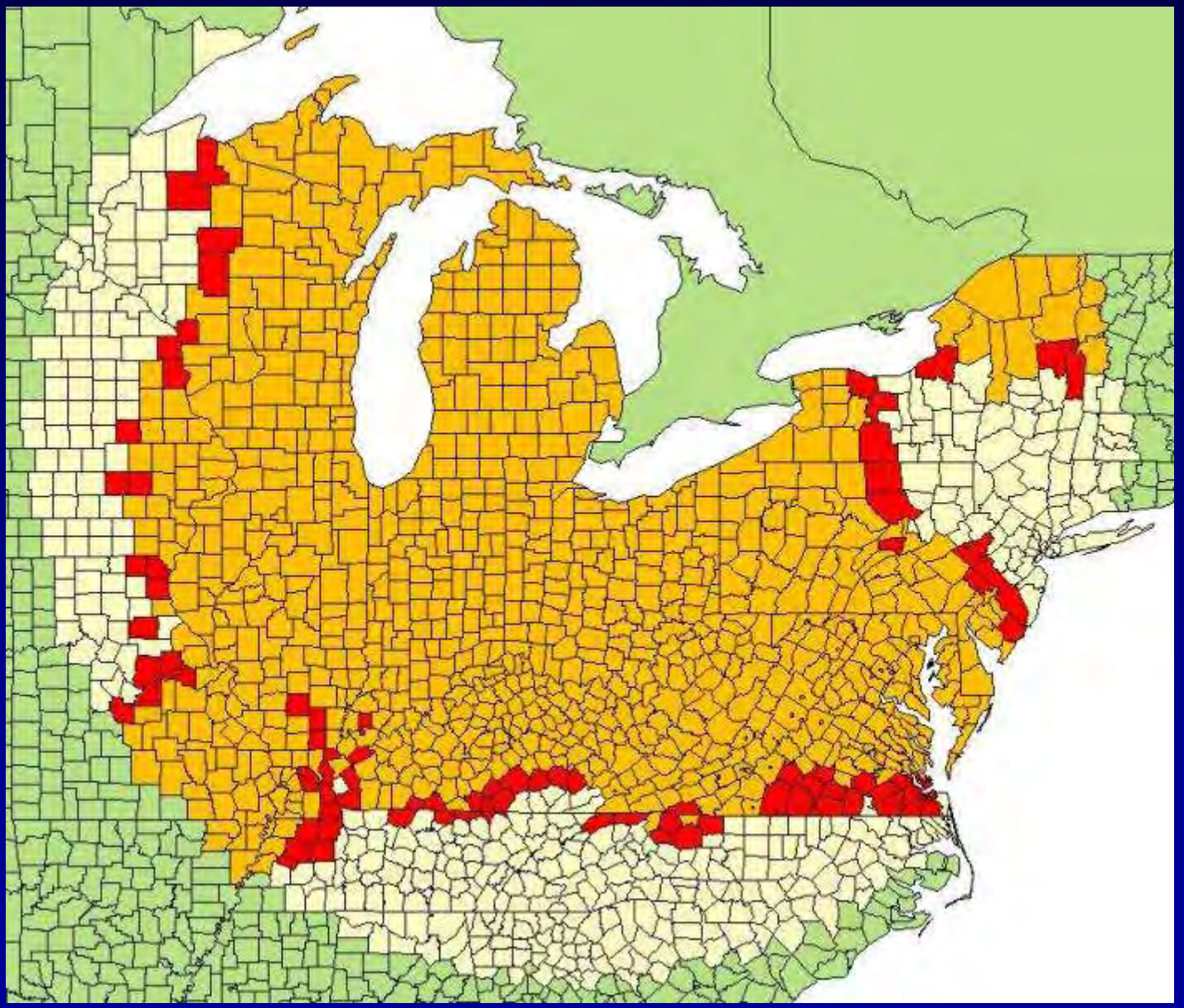
2008

2010

2012

2014

2016



EAB Forecast Simulation Results

2008

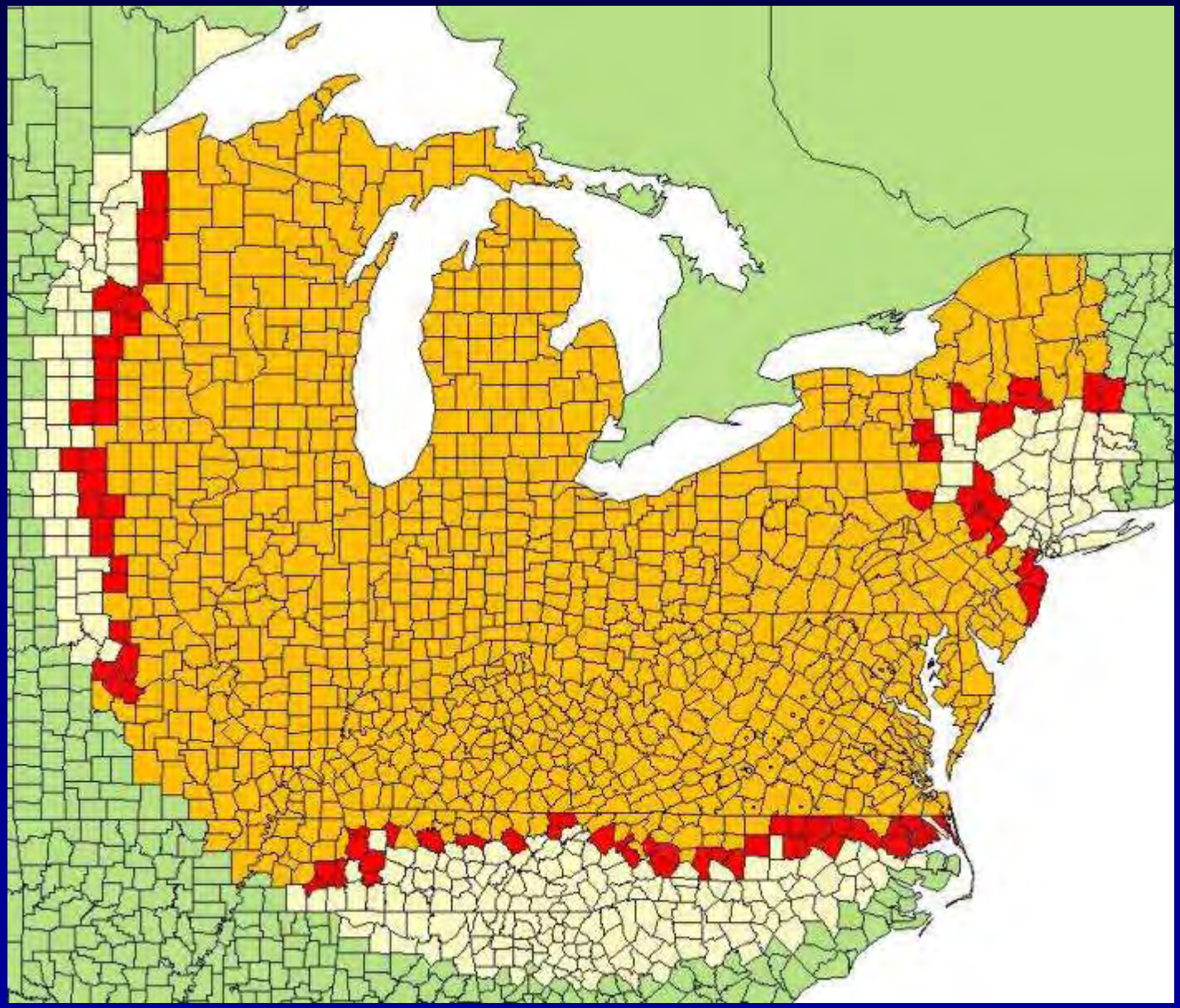
2010

2012

2014

2016

2018



EAB Forecast Simulation Results

2008

2010

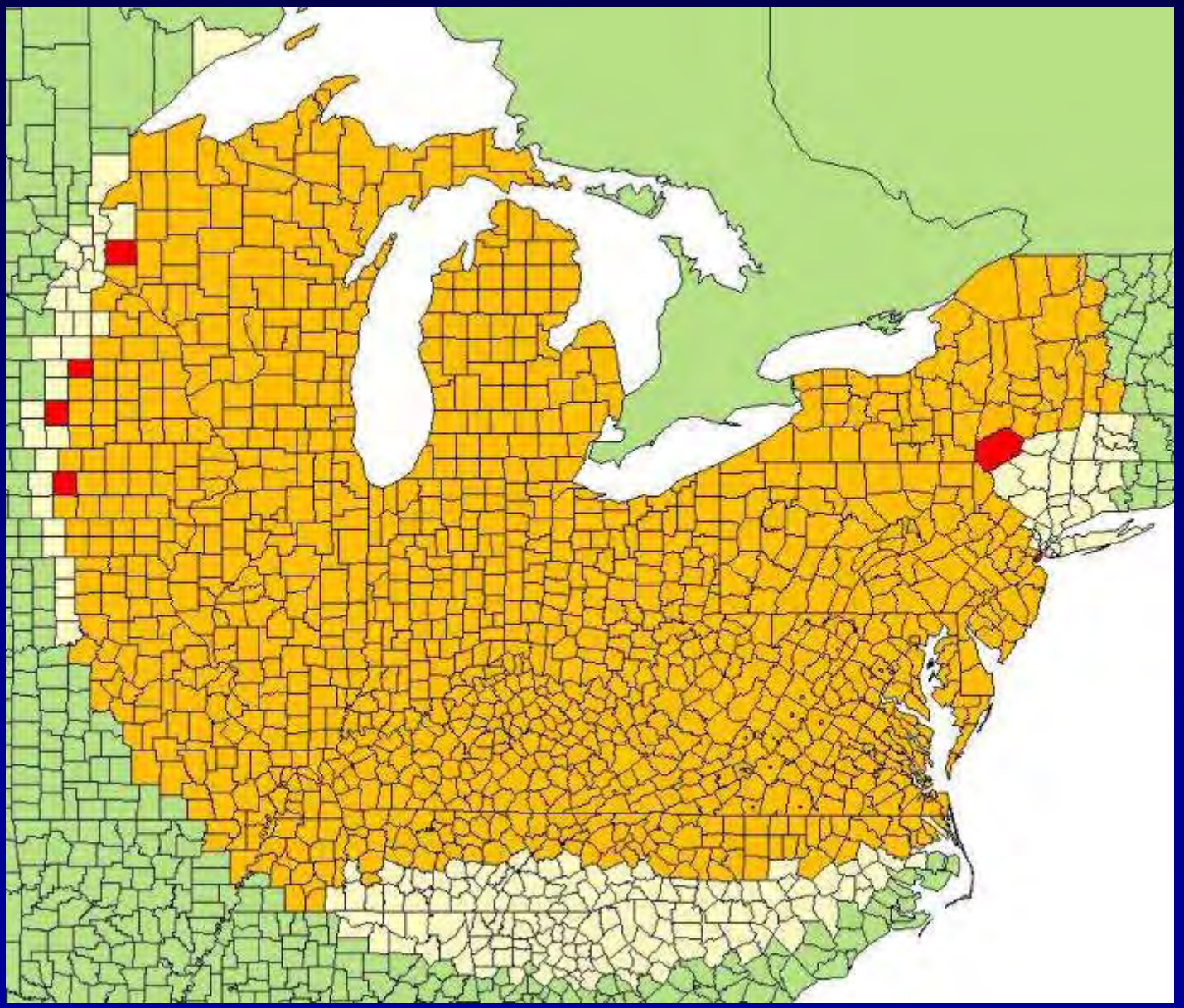
2012

2014

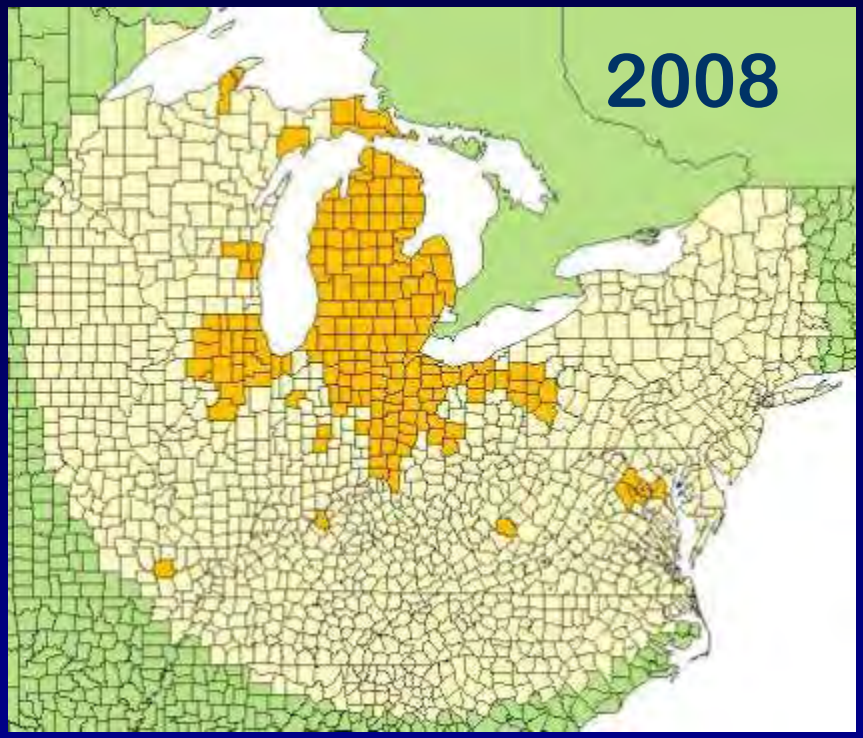
2016

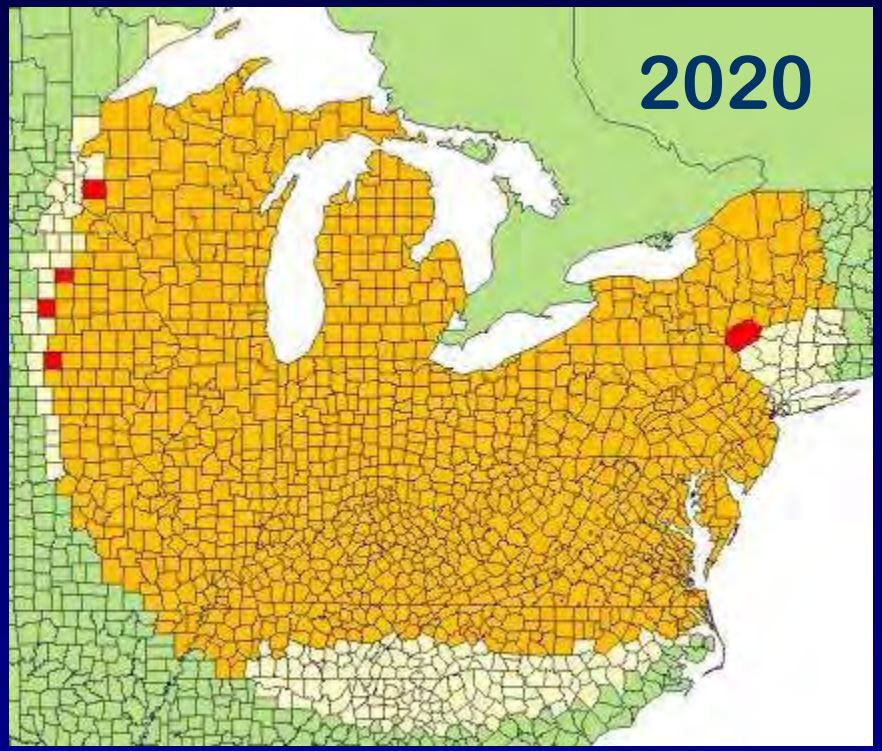
2018

2020



Simulation Results – Predicted EAB Expansion





Model results are quite conservative

- Spread constrained by 750 mile radius from Detroit
- No long-distance outliers included
- 2009 outliers would increase rate of spread

Economic Impacts of EAB - Results

An estimated 38 million ash trees occur on the urban land base in the 25 state area.

EAB infestation likely to encompass at least 17 million landscape ash trees that will require treatment or removal & replacement.

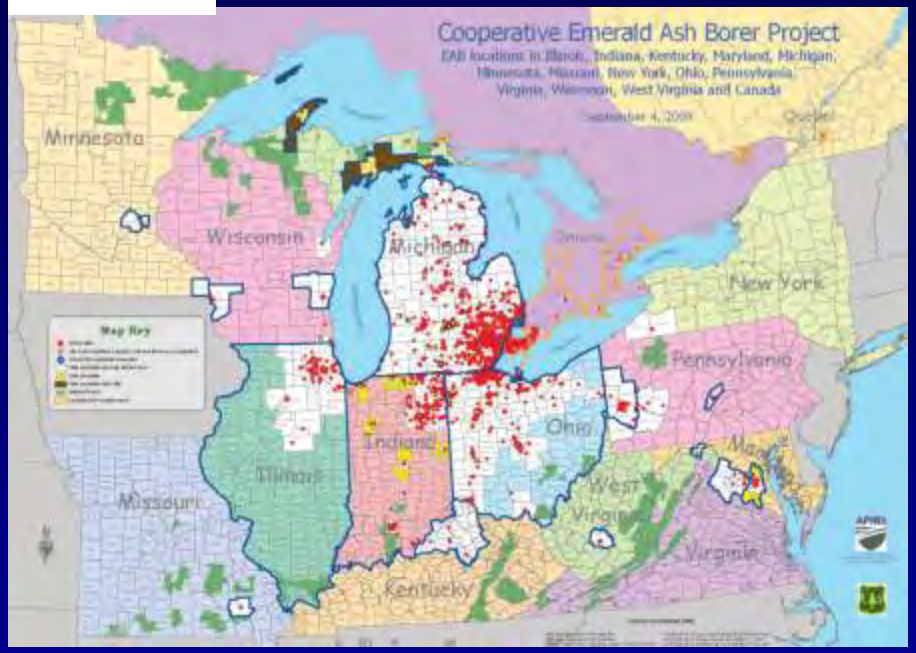
Average discounted cost = $10.7 billion over 10 years.

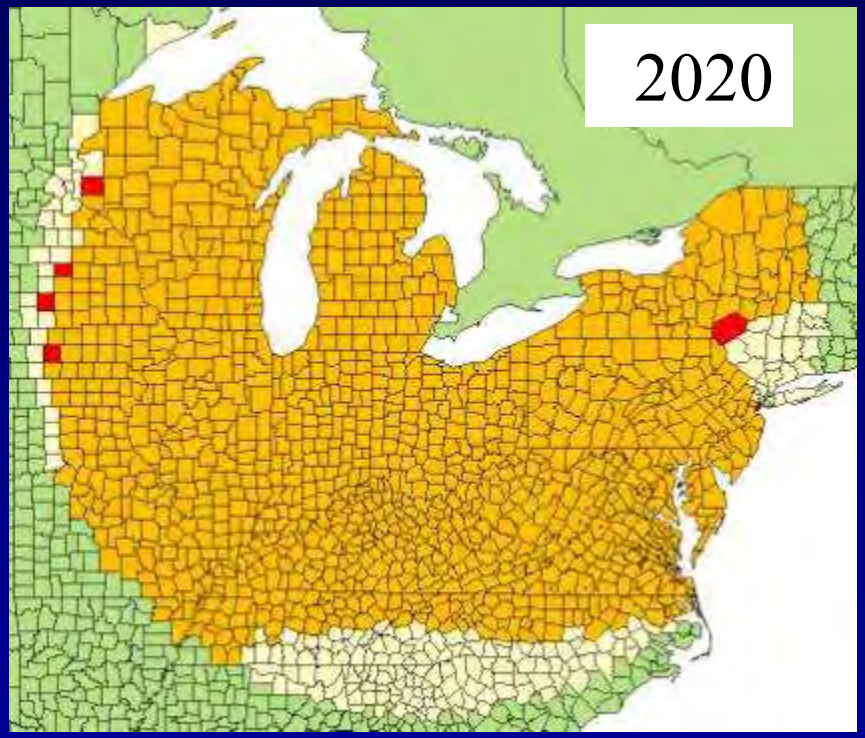
Including developed suburban land ***nearly doubles*** the number of affected ash trees & the associated cost.
Kovacs et al. 2009. Ecological Economics

EAB costs appear much higher than other Poster Pests.

Is there anything we can do?

2009





EAB Efforts to date…

- Detection surveys
- Regulation of ash trees, logs, wood
- Eradication attempts
  - Expensive
  - Unpopular
  - Poor rate of success
- Outliers are generally left untreated, effectively a “do-nothing” approach.

- EAB has killed nearly 100% of ash trees in forested sites in SE MI *(OSU data - Smith, Ghandi, Herms)*
- Ash mortality not related to stand, site or tree traits (no effective silvicultural solutions)
- Potentially 15 native ash species in U.S. at risk

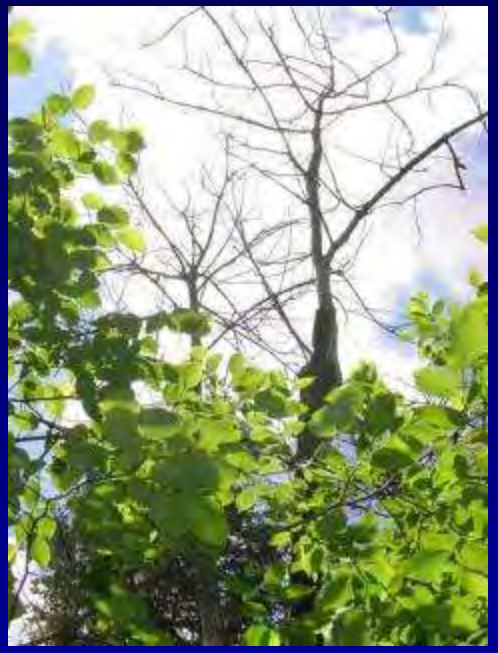
A "do-nothing" approach to EAB likely means the demise of the North American ash resource.

EAB management must evolve…

Can we integrate the available tools & strategies to slow EAB population growth & expansion in outlier sites?

- Delay the onset & advance of ash mortality
- Slow overall spread of EAB in North America
- Buy time for planning & research

SLAM: An Integrated Approach to SL.owing A.sh M.ortality Caused by Emerald Ash Borer



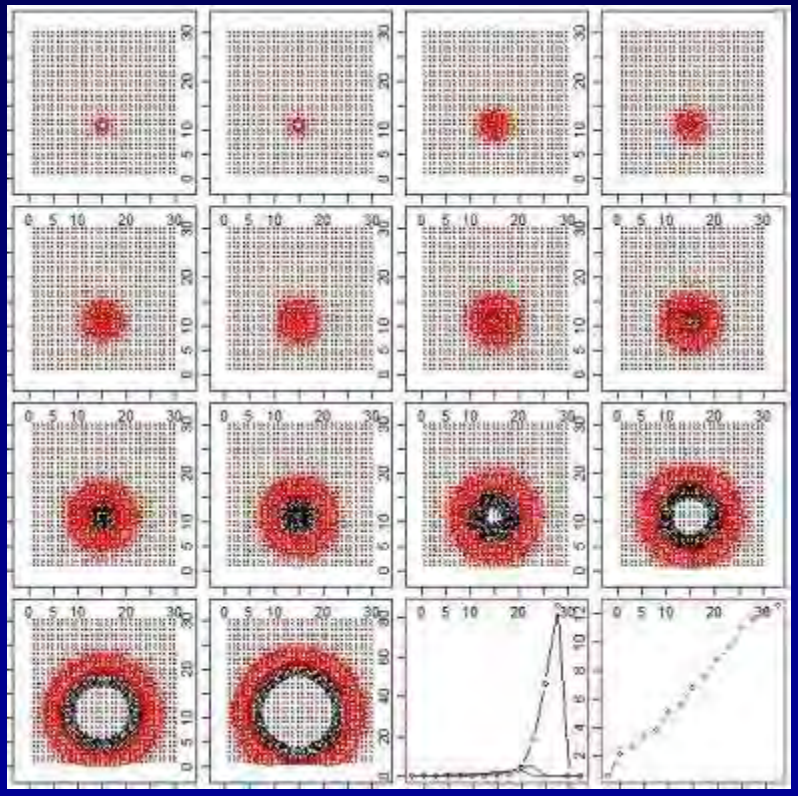
What tools are available for SLAM?

Girdled ash trees: highly attractive to adult EAB

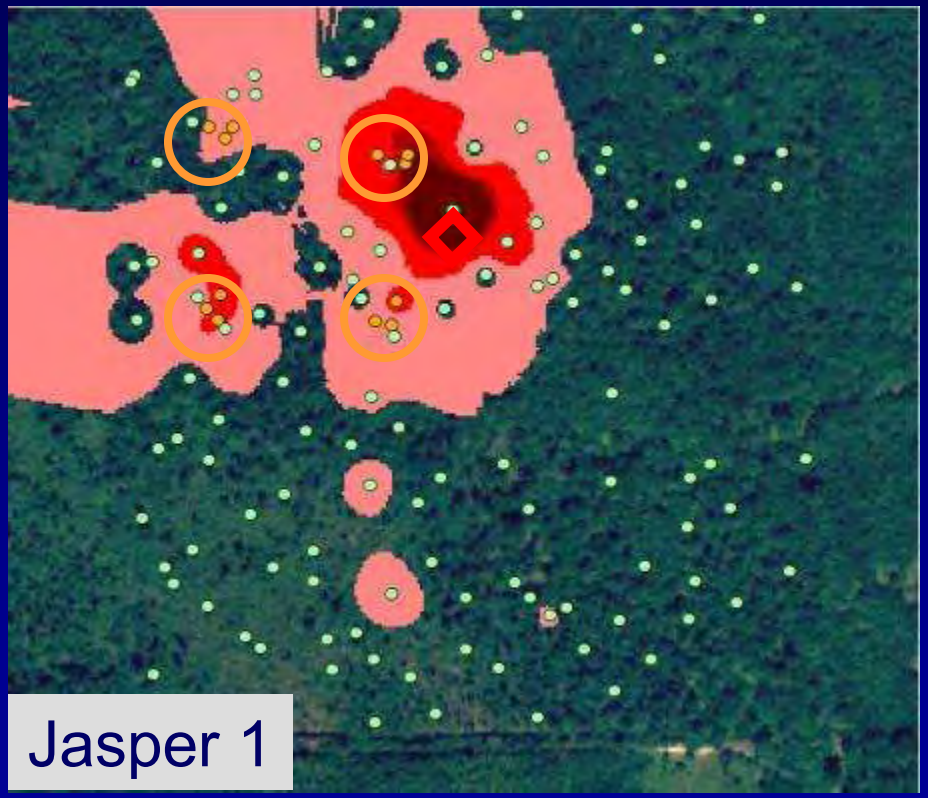
- Track low density EAB populations;
- Provide distribution, density & development data.
- Reduce phloem - fewer EAB produced.

Girdled Trees in Low Density EAB Populations

Function as "sinks" to reduce population growth



Influence EAB spread



What tools are available for SLAM?

Girdled ash trees – debarked or destroyed

Insecticides

- Protect landscape trees
- Reduce EAB density
- Integrate into SLAM?

Systemic Insecticides for EAB Control: 2-Year Evaluation

D.G. McCullough[1], T.M. Poland[2], A. Anulewicz[1], D. Cappaert[1], P. Lewis[3], J. Molongoski[3]

MSU[1], USFS[2], APHIS[3]

Tree-age injection

Imicide injection

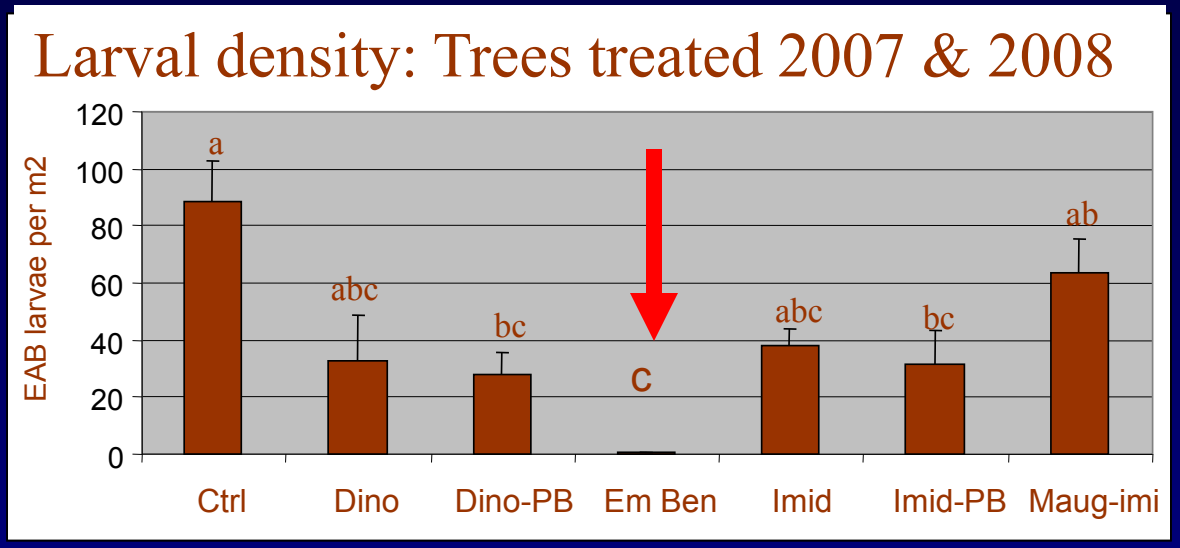
Safari trunk spray

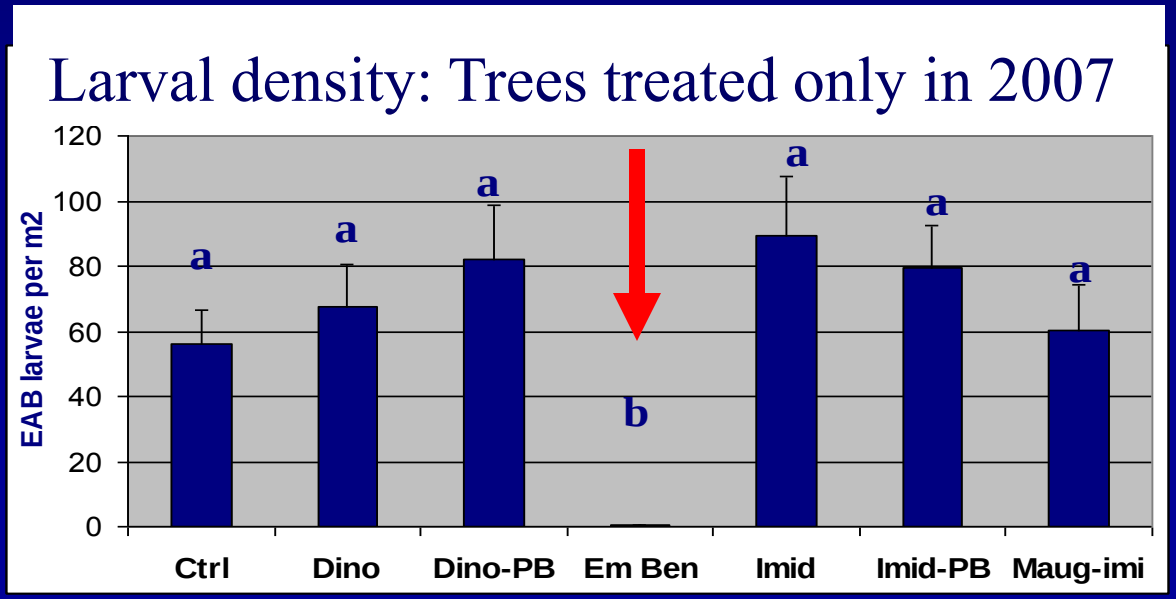
Systemic Insecticides: 2-Year Evaluation

7 trees/block; 25 blocks; 3 sites; DBH 6” to 21”
All trees treated May 2007; Half the trees treated again in May 2008; the other trees were not re-treated in 2008.

Emamectin benzoate (Tree-äge)	Trunk injection
Dinotefuran (Safari 20WP) (with & without Pentra-Bark)	Trunk spray
Imidacloprid (Macho 2F) (with & without Pentra-Bark)	Trunk spray
Imidacloprid (Imicide 10%)	Trunk injection
Controls	No treatment

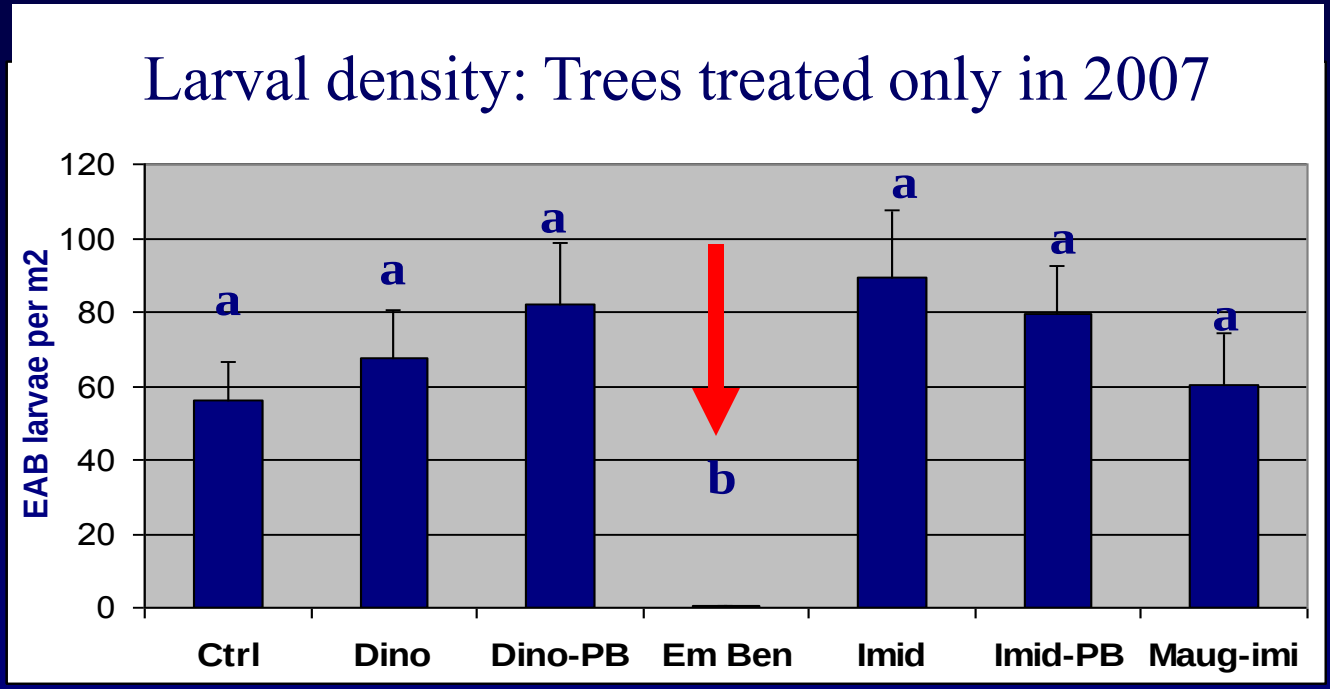
Fall 2008: Trees felled & debarked to count EAB larvae





Neo-nicotinoid products were fairly effective if applied annually.

Emamectin benzoate (Tree-age) ≈ 100% EAB control for at least 2 years with a single injection.



- A single Tree-age injection provided at least 2 years control of EAB adults & larvae.
- Special registration for Tree-age in 10+ states; full registration requested from EPA.
- Changes the economics of treating ash trees.

What tools are available for SLAM?

Girdled ash trees – debarked or destroyed

Insecticides

Ash utilization (timber sales, firewood harvest)

- Reduce phloem – fewer EAB produced
- Value for landowners

What tools are available for SLAM?

Girdled ash trees – debarked or destroyed

Insecticides

Ash utilization (timber sales, firewood harvest)

Biological control: predators & parasitoids?

Woodpeckers

Native parasitoid:
Atanycolus cappaerti

Oobius agrili
from China

What tools are available for SLAM?

Girdled ash trees – debarked or destroyed

Insecticides

Ash utilization (timber sales, firewood harvest)

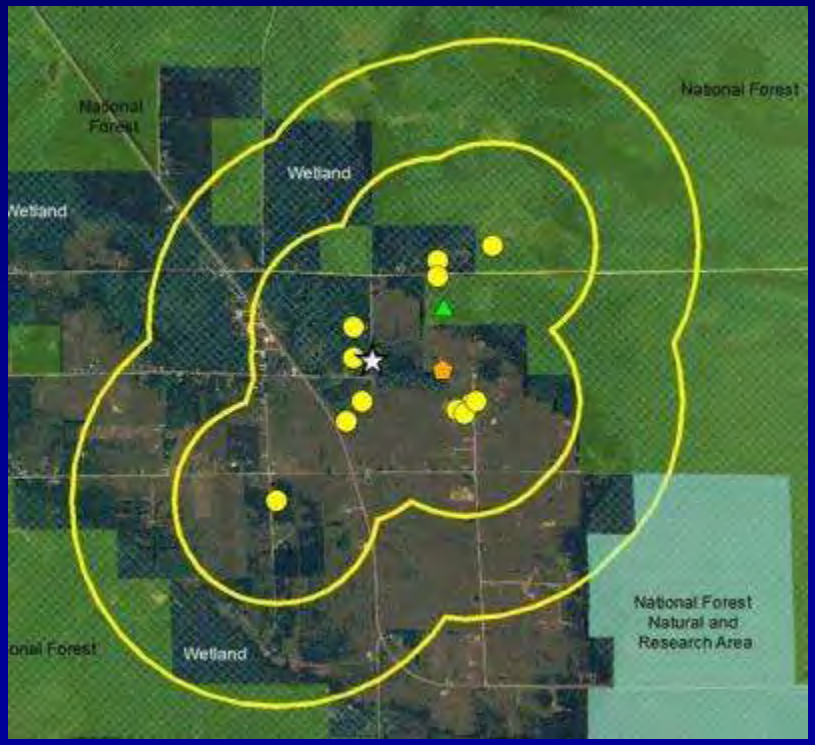
Biological control: predators & parasitoids

Regulations restrict transport of ash trees & wood

Outreach & education

SLAM Pilot Project – Moran & St. Ignace

- Fall 2007: Low-density EAB outlier near Moran, MI located by MDA crew using a girdled detection tree.
- Delimitation survey: 13 trees with larvae in 2007
- Apparently recent origin (2005?); no visible symptoms
- Another infested tree at St. Ignace (7 miles away)
- Mix of national forest land, private property, campground, rural & urban



SLAM Pilot Project: Moran & St. Ignace

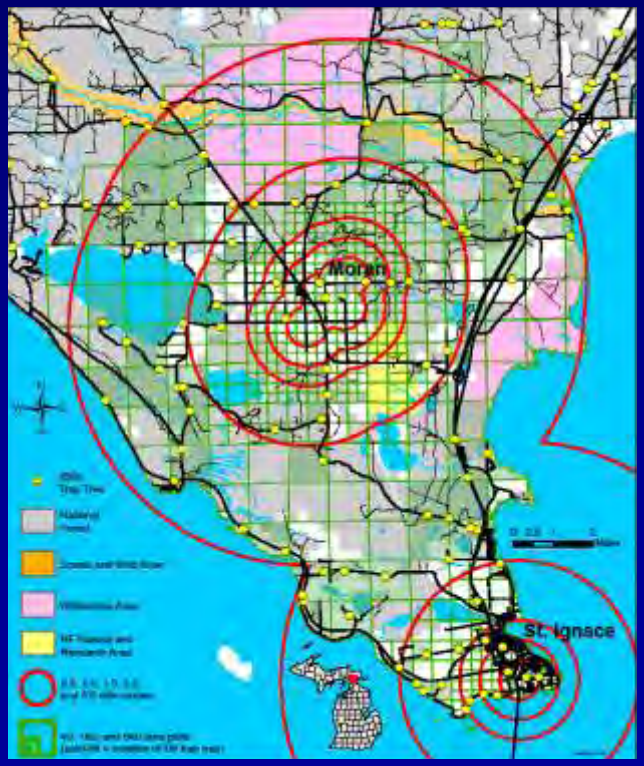
Goals:

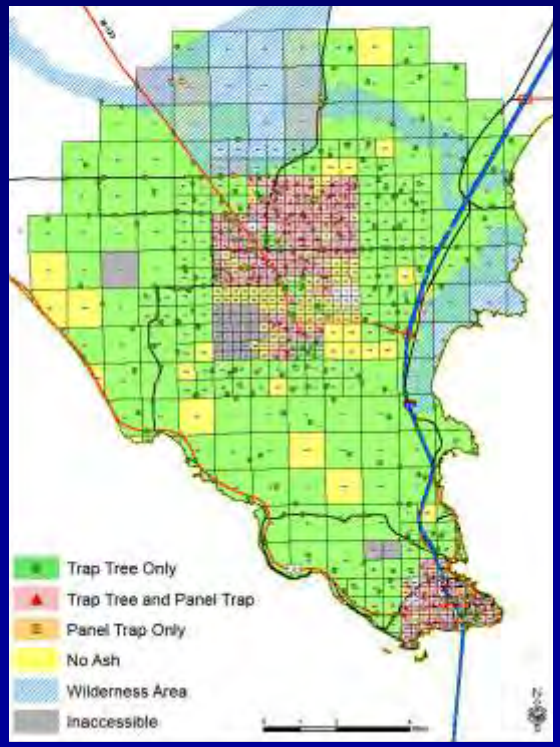
- Assess & monitor EAB distribution & density
- Integrate tools & strategies to delay onset & progression of ash mortality
- Evaluate effectiveness of activities
- Quantify costs & benefits

Cooperators: MI Dept. of Agriculture, Michigan State University, US Forest Service NA FHP & Northern Research Station, MI Dept. of Natural Resources, Michigan Tech University, Hiawatha National Forest, USDA APHIS

2008: Define infestation - grids of girdled trap trees established to assess EAB density & distribution.

- Trap tree density highest in core; 1 to 16 trap trees/mi^2
- APHIS panel traps used if no ash available for girdling. One trap also set in canopy of all girdled trees.

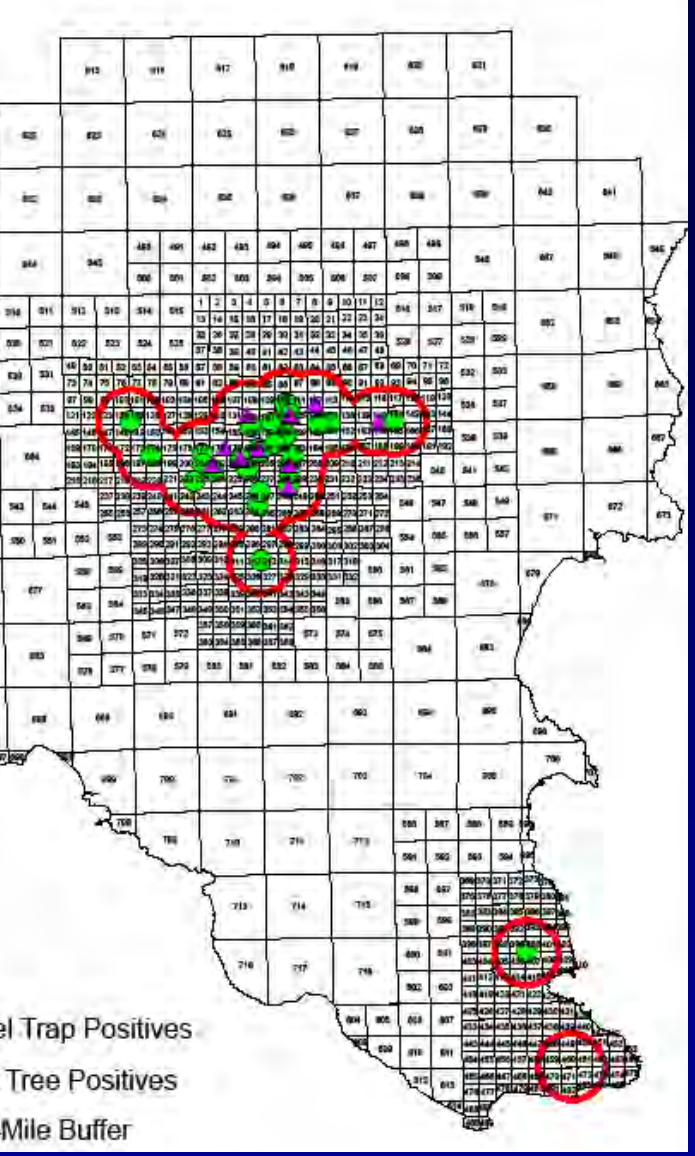




Trap trees (4-8 inches DBH) selected, GPS'd, measured & girdled in May & June.

Traps set in June & collected in September.

Trap trees felled & debarked in fall. Crews recorded number & stage of larvae on positive trees.



Results - Moran

24 positive girdled trees; Average larval density = 8 EAB per m^2

No external symptoms on any tree

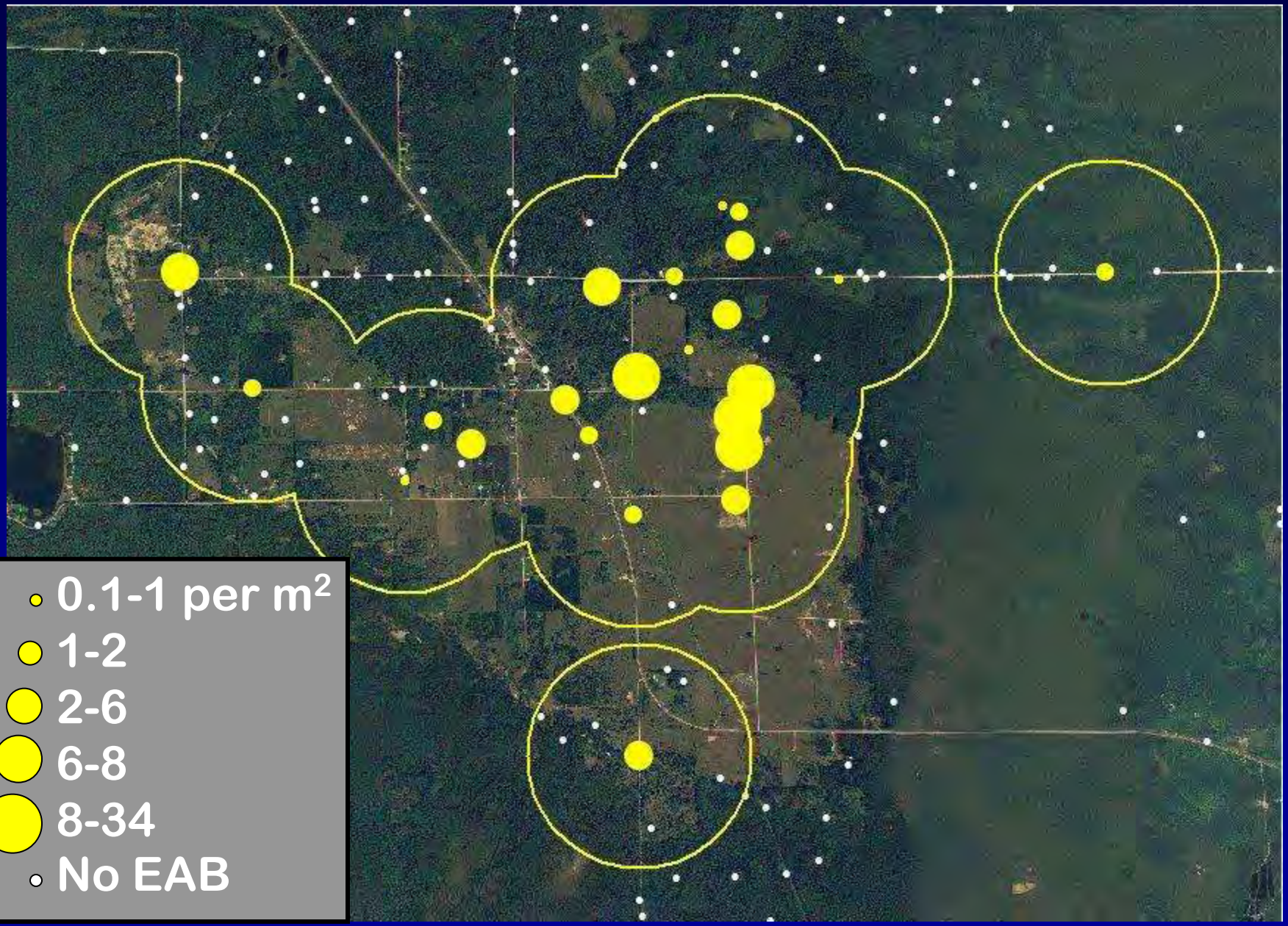
10 positive panel traps; 8 of the 10 were on girdled trees.

Results - St. Ignace *(Storer et al.)*

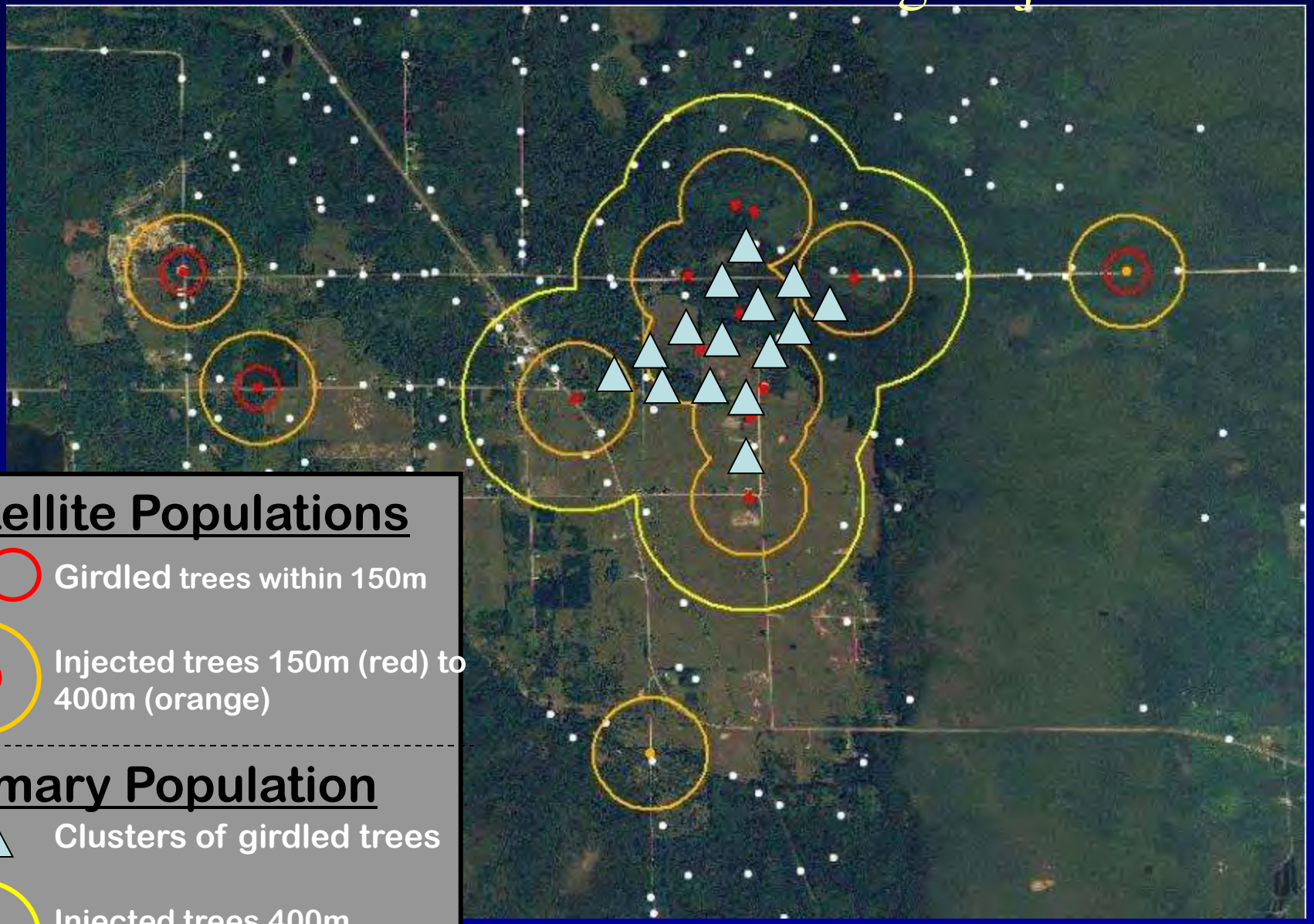
2 positive grid cells;

8 of 20 girdled trees & 1 non-girdled tree had larvae; 1 EAB on sticky band on a girdled tree;
Zero positive panel traps.

Total EAB density (m^2) with 800m buffer



Action Plan for 2009: Sinks + Tree-age injections



Satellite Populations

Girdled trees within 150m

Injected trees 150m (red) to 400m (orange)

Primary Population

Clusters of girdled trees

Injected trees 400m (orange) to 800m (yellow)

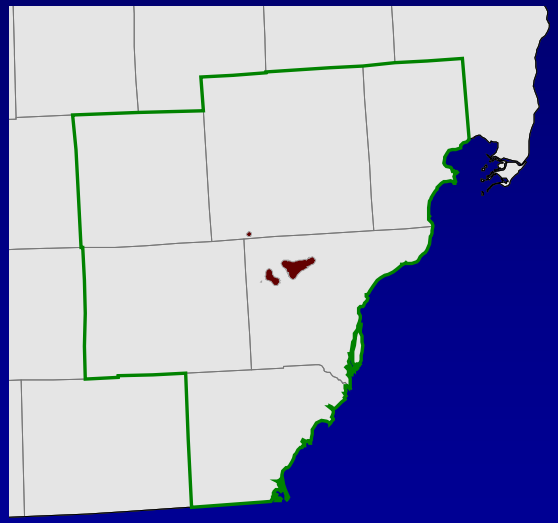
Other Activities

- Ash distribution & abundance survey underway.
- Private landowners contacted; timber sales initiated.
- Hiawatha Forest personnel felled & bucked up large ash trees in remote areas in Feb. 2008
- Cooperation with St. Ignace municipal forester
- Outreach with residents & landowners

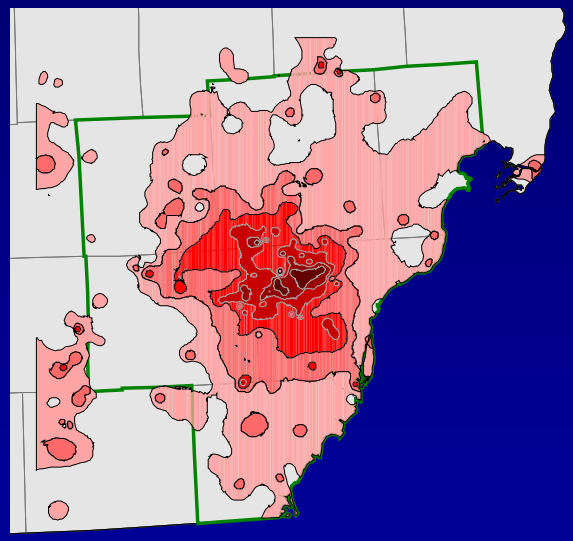
If we implement SLAM, how do we evaluate its effectiveness?

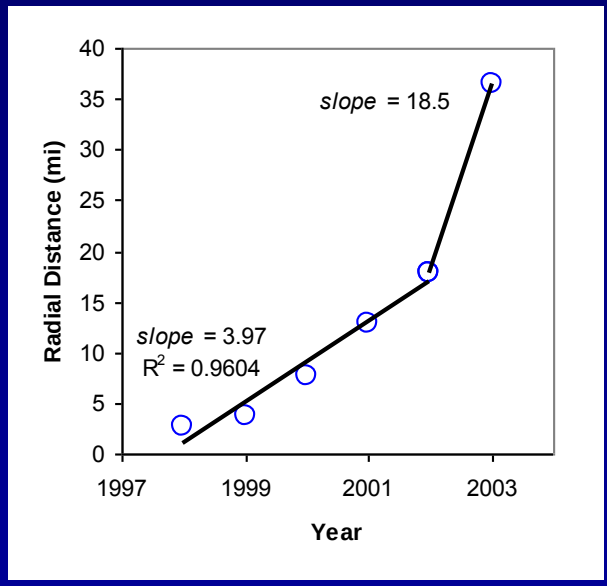
We have historical rate & progression of ash mortality in SE MI (*Siegert et al. dendro analysis)*

1998: ~ 24 mi^2



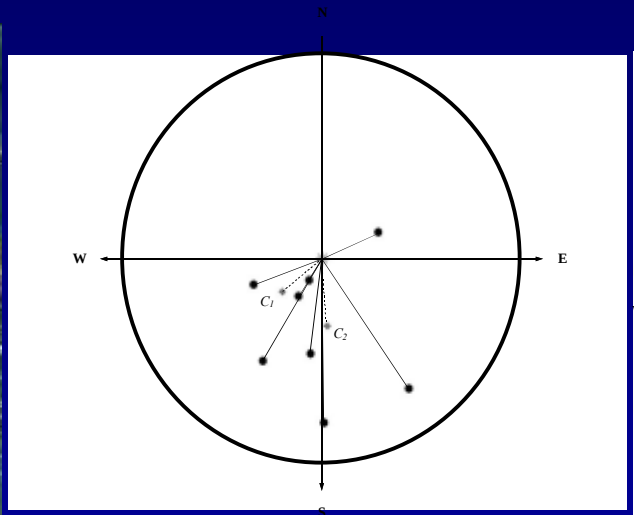
2003: ~ 4094 mi^2

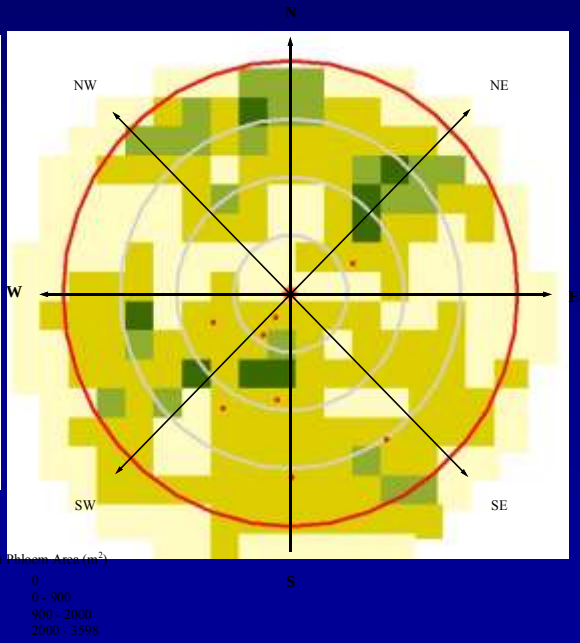




If we implement SLAM, how do we evaluate its effectiveness?

Some information on EAB dispersal & spread from field sampling in low density outliers

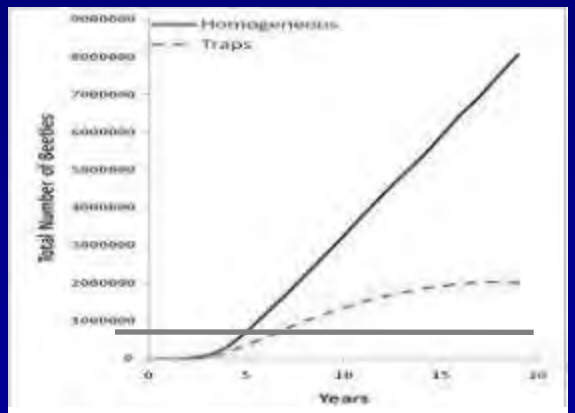




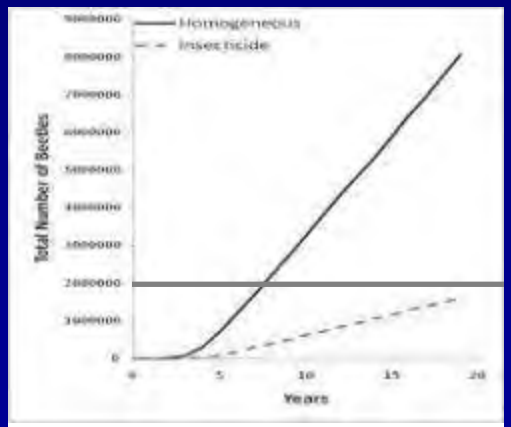
(Siegert et al. 2009; Env Ent, in press)

If we implement SLAM, how do we evaluate its effectiveness?

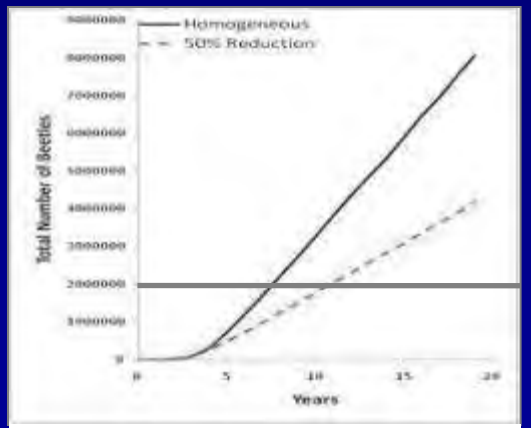
- EAB Population Model: we can predict observed EAB spread & ash mortality with that expected if no action was taken *(Mercader et al. 2009a, 2009b)*



Trap Trees



Insecticides



Phloem reduction

Ongoing & future concerns…

- Accurate ash data & impact plots needed in & around action area
- Multi-year SLAM strategy requires sustained funding commitment
- Economics of SLAM should be evaluated
- Tools & strategies should be adapted to specific sites; Additional pilot sites needed.

We either take action very soon or we will witness the demise of ash in North America…

2009