

Science Can Save Your Ash from EAB

Cliff Sadof

Department of Entomology

Purdue University

Take Home Points

- EAB can kill large ash trees that take decades to replace.
- Early intervention can reduce losses
- Long term protection with insecticides is possible and economically viable
- Injection of emamectin benzoate once every 3 years is sufficient
- Cost cutting measures like reducing injection ports reduces effectiveness





Emerald Ash Borer

EAB
Background

EAB
Lifecycle

**Signs and
Symptoms**

Insecticide
Options

Biological
Control

Signs and Symptoms

Learn what to look for on potentially infested trees and look-alike damage.



Emerald Ash Borer | Signs and Symptoms

Classic symptoms of EAB infestation



John Obermeyer, Purdue Extension Entomology

EAB attack produces a specific set of symptoms and signs on ash trees.

Other factors may produce similar symptoms and signs, however when these are present in combination, a diagnosis of EAB is almost definitive.

- 1. Thinning of leaves in the upper canopy**
- 2. Woodpecker activity**
- 3. Presence of S-shaped larval feeding galleries under bark**
- 4. Vertical splitting in bark**
- 5. Presence of epicormic shoots**
- 6. Appearance of D-shaped exit holes on bark**

Emerald Ash Borer | Signs and Symptoms

1. Thinning of leaves in the upper canopy

Decline usually begins in the top 1/3 of the canopy. Leaves may be lost or appear smaller than normal.



As more EAB larvae begin feeding in the tree, its ability to circulate water and nutrients is destroyed, causing branch decline and death.

Emerald Ash Borer | Signs and Symptoms

2. Woodpecker activity


Increased woodpecker feeding, especially during winter months, is a warning sign of infestation.

Woodpeckers are very good at locating EAB larvae under ash tree bark. They sometimes remove pieces of outer bark searching for them, leaving lighter patches on trunks of infested trees.



Hole left by a woodpecker that extracted an EAB from its pupal chamber





Holes left by
woodpeckers
feeding on EAB

Emerald Ash Borer | Signs and Symptoms

3. Presence of S-shaped larval feeding galleries under bark

These zigzagging feeding tunnels are diagnostic of EAB in ash trees.

Feeding tunnels are packed with sawdust-like *frass*, or insect excrement.



Daniel Herms, The Ohio State University, Bugwood.org



Emerald Ash Borer | Signs and Symptoms

4. Vertical splitting in bark



Vertical splits occur when larval feeding kills vascular tissues underneath bark, causing it to die and split open.



Emerald Ash Borer | Signs and Symptoms

5. Epicormic sprouting



Formation of epicormic shoots or “water sprouts” at the tree’s base, on the trunk, or on large branches is a stress response to loss of leaves in the canopy.

Though leaves on these thin shoots may appear lush and healthy, they will not support the tree.

Heavy epicormic sprouting, such as that seen at left, often appears just before the tree dies.

Emerald Ash Borer

for Master Gardeners


Signs and Symptoms

6. "D" Shaped Exit Holes on Bark

Emerging adult beetles chew their way out from under the bark through tiny D-shaped exit holes. These holes are found on tree limbs and trunks.

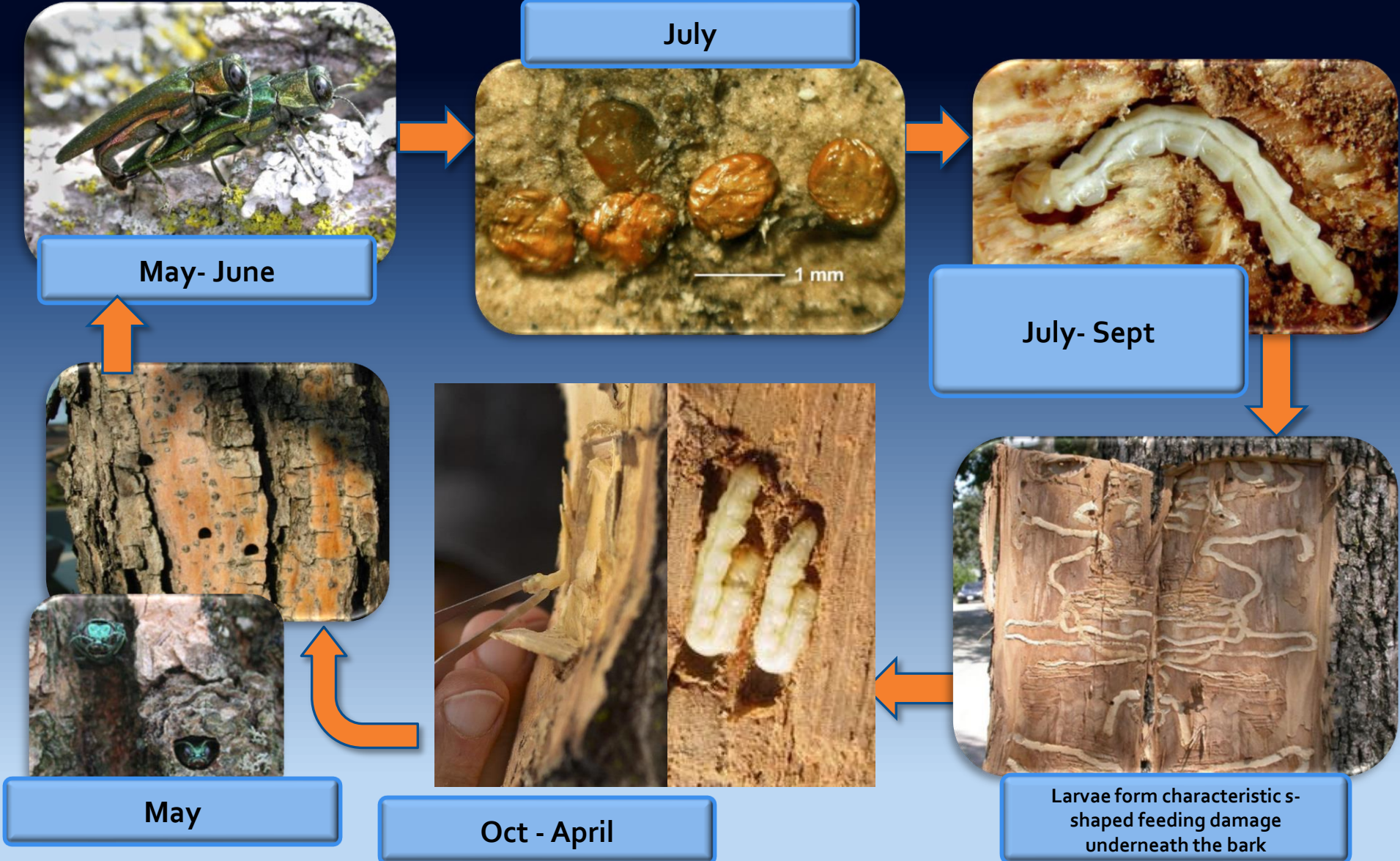
Note their small size; they are about 1/8th inch wide. Exit holes made by native ash borers are typically larger and oval or perfectly round. By the time EAB exit holes are visible on the main trunk, the tree is likely heavily infested.



A close-up photograph of tree bark showing several dark, circular exit holes. A person's finger is visible in the bottom left corner for scale. The bark is heavily textured and cracked. A blue text box is overlaid on the left side of the image.

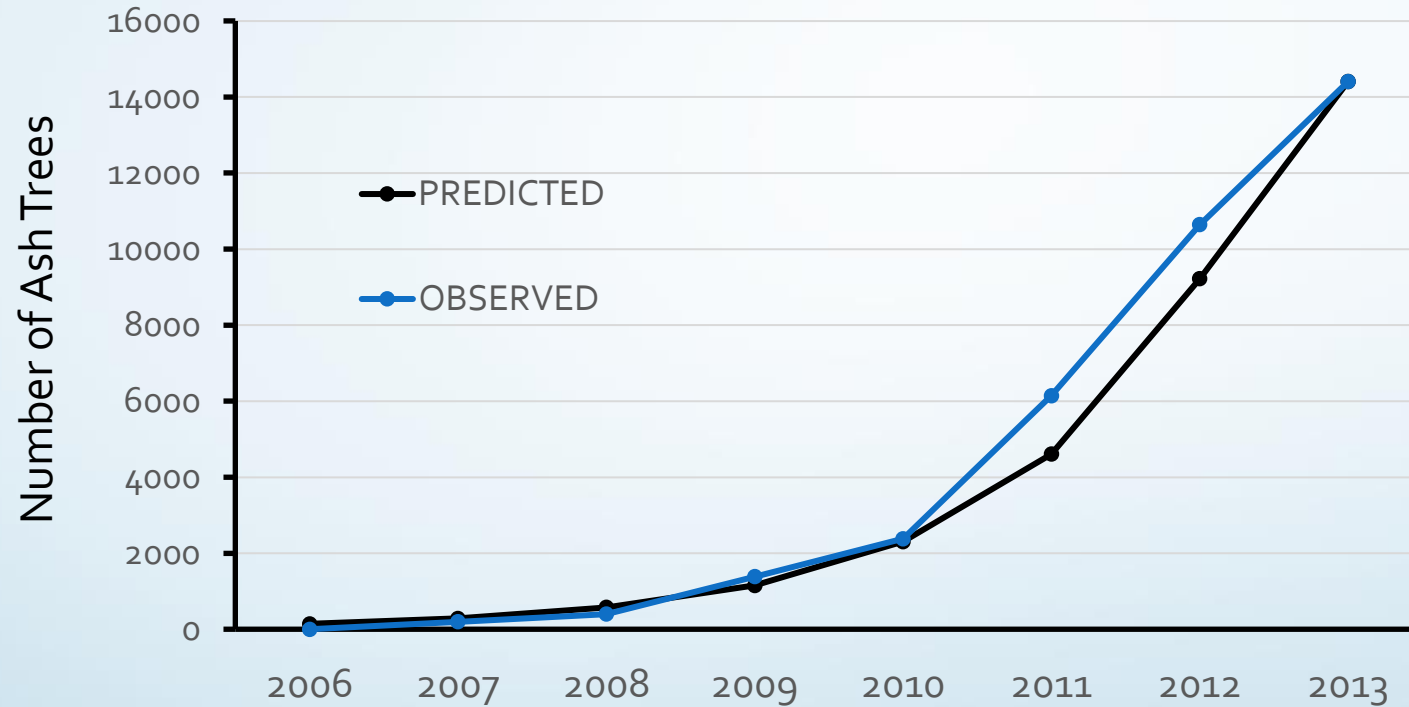
**Heavily infested
trees may have
many exit holes
close together**

Emerald Ash Borer | Life Cycle



Rate of Ash Decline

Observed Ash Removals in Fort Wayne, IN Support Doubling Model



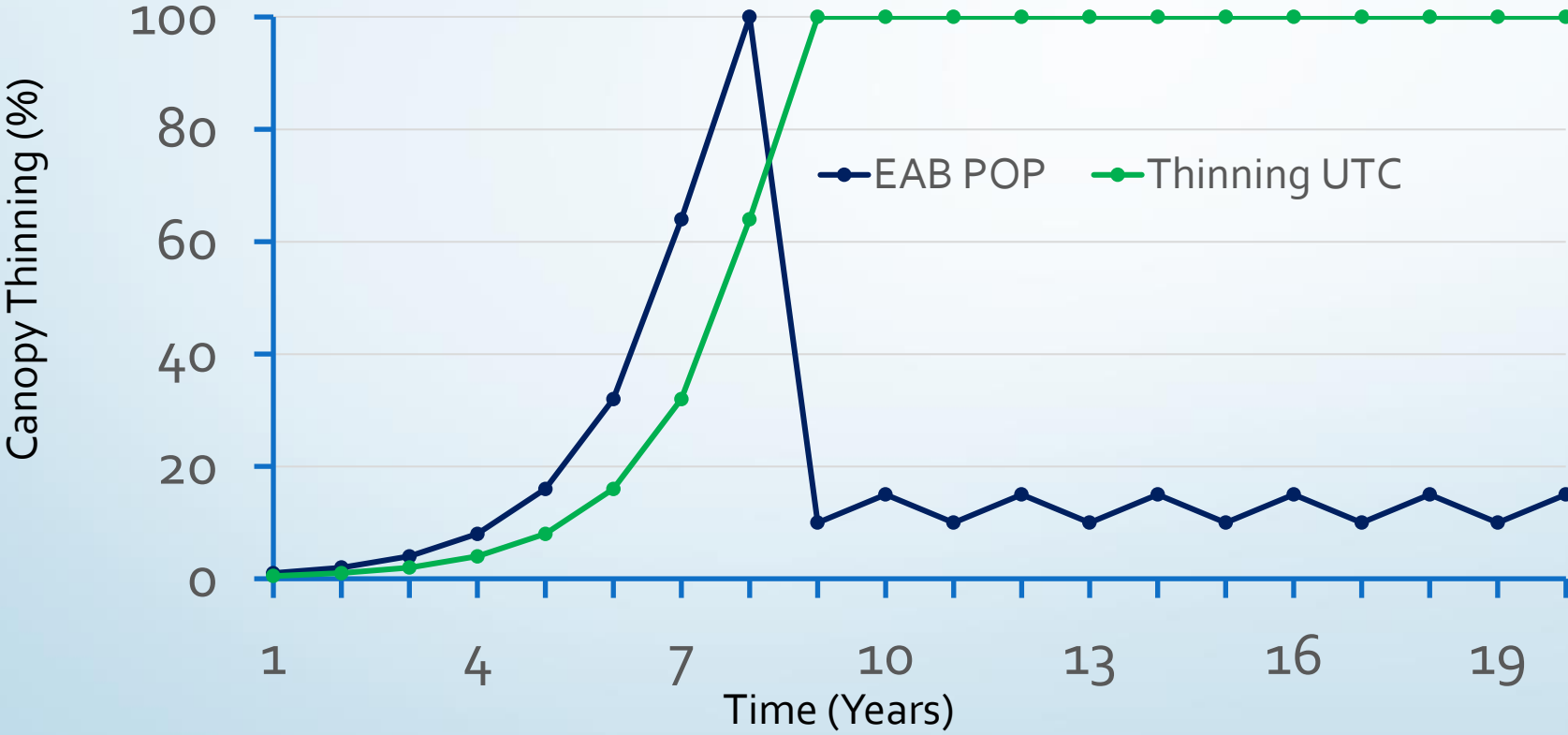
Stage Year	1	2	3	4	5	6	7	8
PCT>removed	1	2	4	8	16	32	64	100

Year Detected

Why must dead ash trees be removed?



EAB Population and Ash Canopy Thinning







**Autumn
Clinton Ave, Fort Wayne**

THIRD EDITION

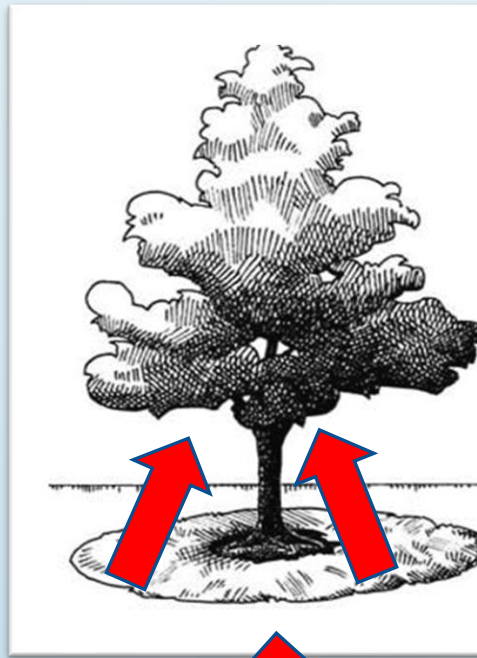
Insecticide Options for Protecting Ash Trees from Emerald Ash Borer

North Central
IPM
Center

Daniel A. Herms,
Deborah G. McCullough,
David R. Smitley,
Clifford S. Sadof,
Frederick D. Miller,
Whitney Cranshaw

<http://www.emeraldashborer.info>

Effects of Insecticides on EAB Life stages



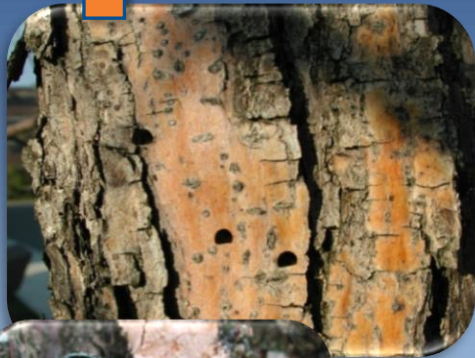
Water carries the pesticide

Insecticide	Egg	Larvae				Toxicity of Poisoned Leaves to adults
		L1	L2	L3	L4	
Imidacloprid	No	Yes	Yes	No	No	Sustained feeding
Dinotefuran	No	Yes	Yes	No	No	A few bites
Emamectin Benzoate	No	Yes	Yes	Yes	Yes	One or two bites
Azadirachtin	No	Yes	Yes	Yes	Yes	Not toxic, but reduces fecundity of adults

HOW INSECTICIDES KILL EAB



May- June



May



July

Poisoned Leaves Kill Adults



Poisoned Cambium Kills Larvae

July- Sept



Oct - April



Characteristic Zig Zag Galleries

How Long Does Protection Last?



Good < 10%

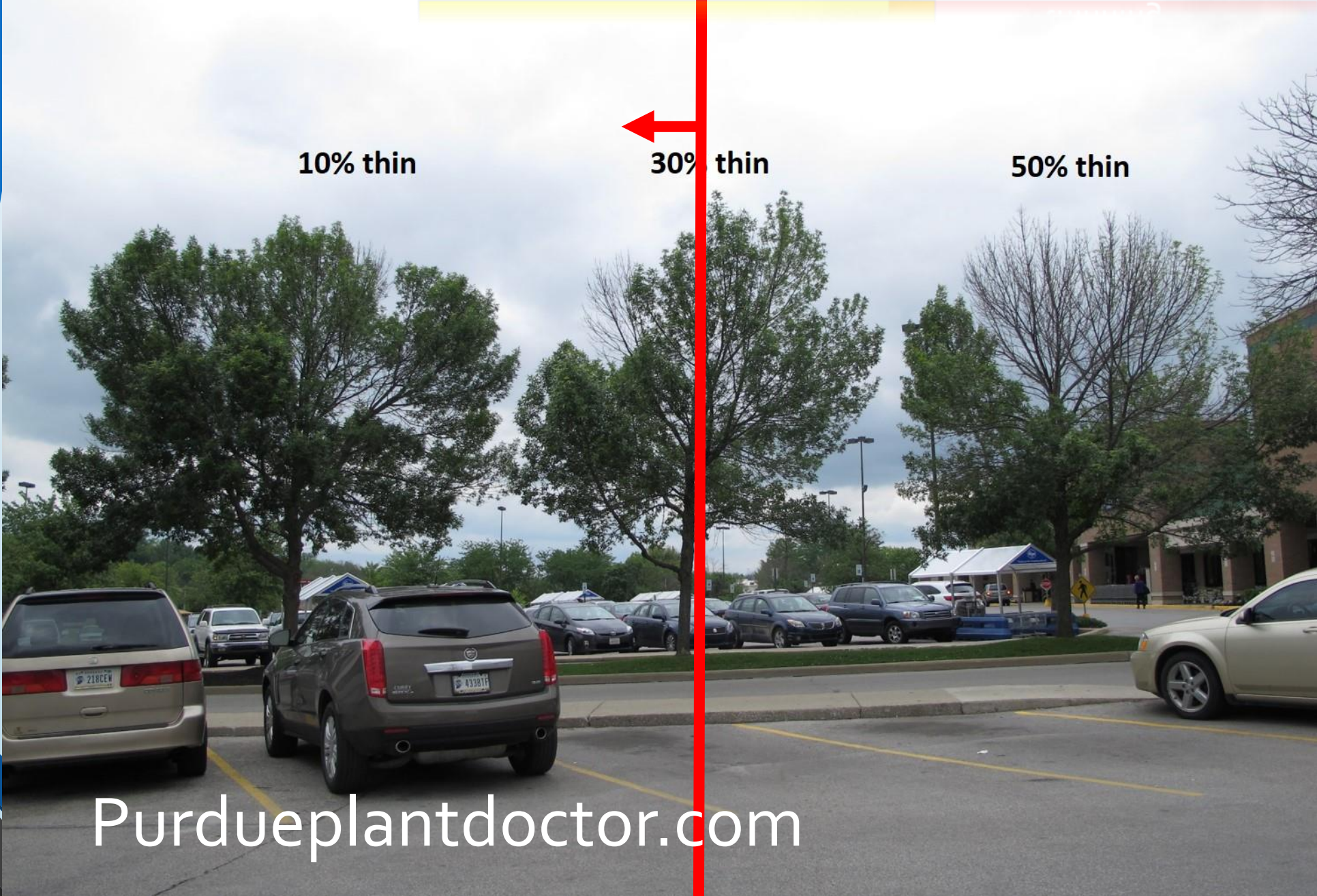
Fair > 10% and ≤ 30%

Poor or worse > 30%
thinning


10% thin

← 30% thin

50% thin

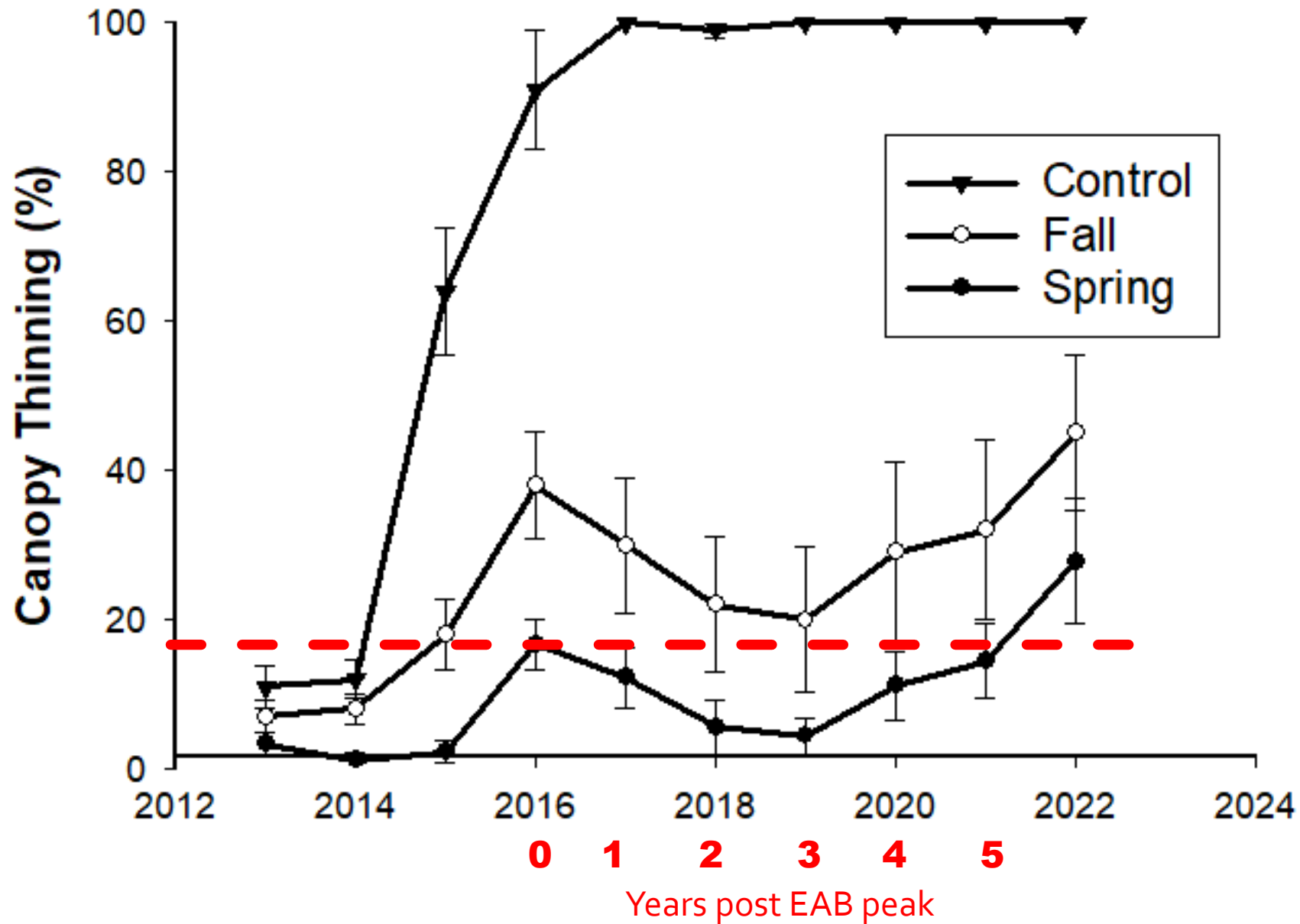


Purdueplantdoctor.com



***EAGLE CREEK
ONCE @ 3 yrs, 5 ml/DBH TreeAGE
Avg DBH= 39 \pm 3.16 in. range=28-62,
10 trees per trt
Applied 2013, 2016***

EAGLE CREEK PARK STUDY



Napkin Economics For Single Ash Tree (30" DBH)

- \$2400-\$4400 -Replacement cost- \$ 2,000-4,000, replant \$400
- \$100/year - Treatment cost- \$300(@\$10/in) @ 3 years
- **24—44 years** - Years until replacement cost reach treatment cost

Potential Impacts of Long-term Study on A City

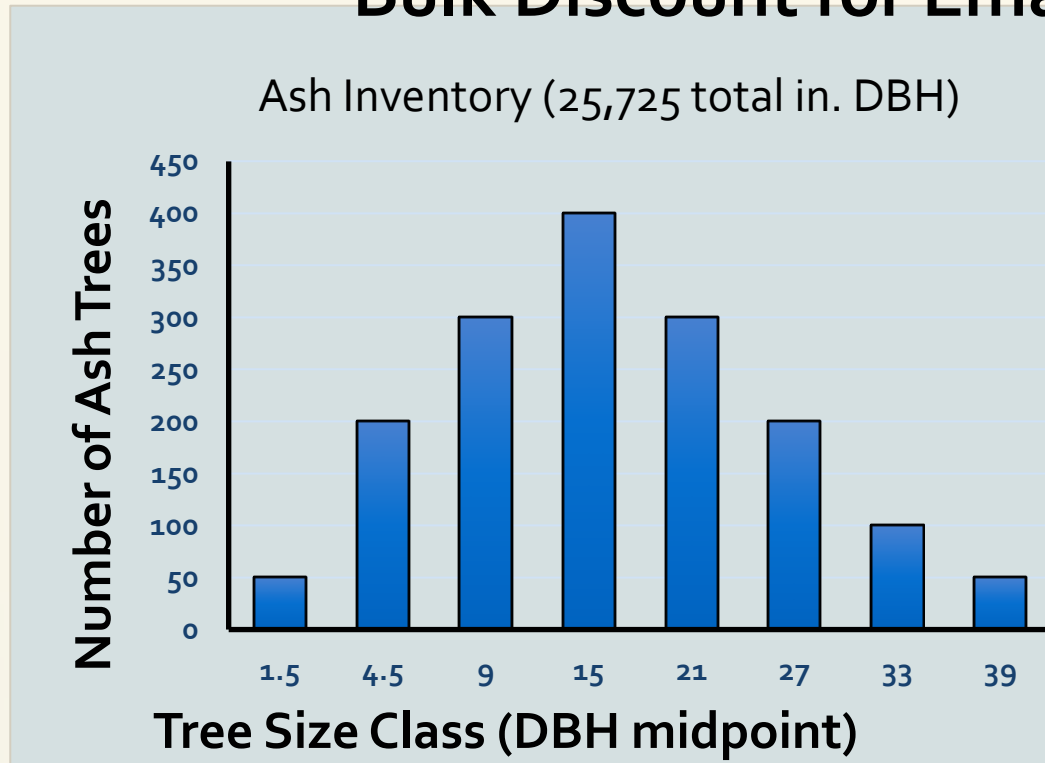
- 1600 tree forest
- Emerald ash borer cost calculator eabIndiana.info



Link to EAB Cost Calculator
And IAA article

Representative Forest with 1600 Ash Trees

Bulk Discount for Emamectin Benzoate Trt



Strategies

Reactive Replace Ash

Replace unsalvageable ash (poor)

Proactively replace ash

Replace over next 7 years

Save all trees with DBH > 12"

Optimize investment in larger trees

Replace the rest over next 7 years

Treatment Assumptions

Costs

\$5.00/ in DBH

Frequency

Aggressive = every **3** years **through yr 10**

Maintenance = **every 5 years**

Treatments save 98% of trees

Annual mortality of replaced or saved tree is 2%

Cost of removal +
Stump grinding
(Actual Indianapolis
Prices)

DBH ¹	Avg. Cost / DBH
1 - 3	\$ 14.00
3 - 6	\$ 14.00
6 - 12	\$ 14.75
12 - 18	\$ 18.00
18 - 24	\$ 21.75
24 - 30	\$ 25.10
30 - 36	\$ 30.50
36 -	\$ 36.00

Replacement Tree Assumptions


Tree Size is 2" DBH


Trees Cost \$400 to purchase, plant and stake

Emerald Ash Borer Cost Calculator

PURDUE
UNIVERSITY

Welcome to the Emerald Ash Borer Cost Calculator 3.0

The calculator has been redesigned to help you and your community understand why it is more economical to protect ash trees than to replace them. This version is driven by an EAB invasion wave model that assumes it takes 8 years from the time EAB is detected in your city until all the untreated ash can no longer be saved  with a pesticide application. In this new version you can:

- Stage your response to an EAB invasion based on the percentage of ash trees that have lost more than 30% of their canopy.
 - Evaluate management plans that reduce the frequency of ash treatment after the initial wave of EAB has passed through your forest.
 - Compare the annual and cumulative costs and the size of the remaining forest over a 25 year period for ANY management strategy that includes a mixture of tree removal, replacement, and insecticide treatment.
 - Generate and share electronic and printed reports of projected costs of up to 3 management strategies at a time.
- 

Available at EABINDIANA.INFO



Delaying action kills trees

% of Trees Damaged or Lost to Date	Years w/ EAB	Years Until All Trees Are Damaged or Lost to EAB
1%	<input type="radio"/> 1	7
2%	<input type="radio"/> 2	6
4%	<input type="radio"/> 3	5
8%	<input type="radio"/> 4	4
16%	<input checked="" type="radio"/> 5	3
32%	<input type="radio"/> 6	2
64%	<input type="radio"/> 7	1
100%	<input type="radio"/> 8	0

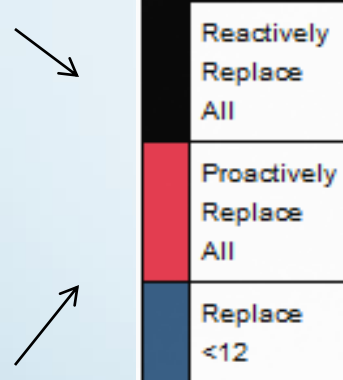


How long will you aggressively protect your trees from EAB? Default value is 10 years to reflect the time it takes from when 1% of trees are beyond saving until all of the remaining untreated ash trees are completely dead and unable to sustain and feed EAB larvae.

Annual Costs for Bulk Spray Bid

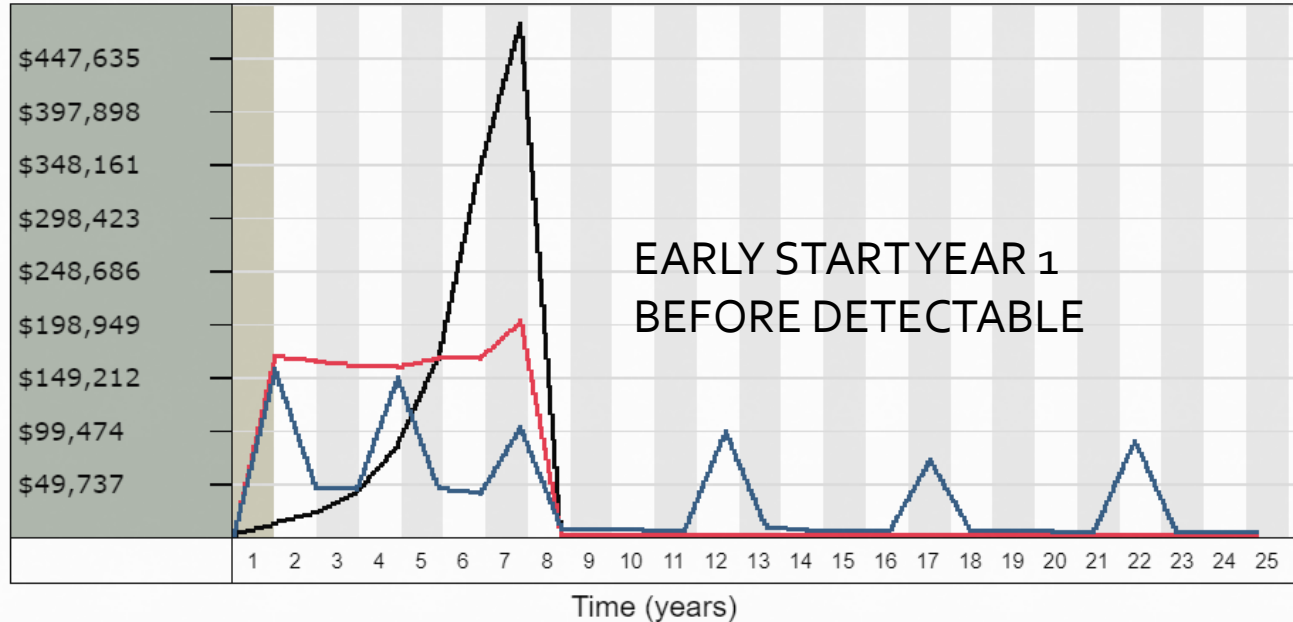
\$5.00/in DBH

Highest annual cost

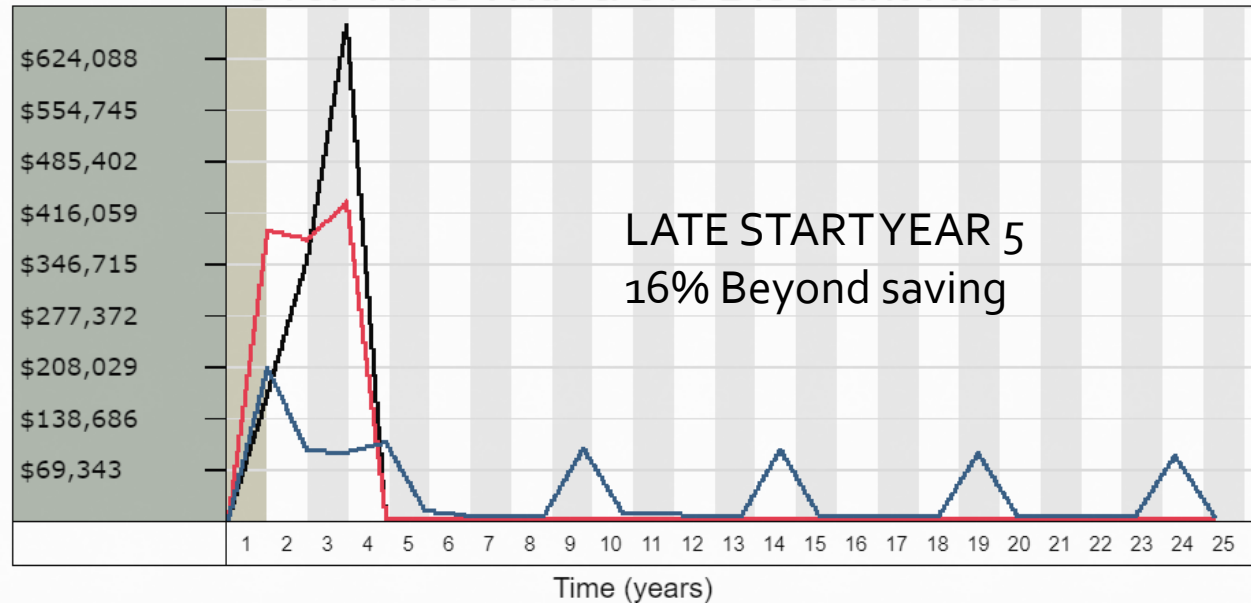


Lowest annual cost

Annual Cost Comparison in Today's Dollars Over Time With a 3% Discount Rate



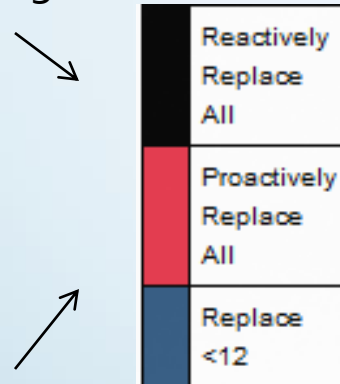
Annual Cost Comparison in Today's Dollars Over Time With a 3% Discount Rate



Aggressive trts @ 3 yrs; Maintenance trts @ 5 yr

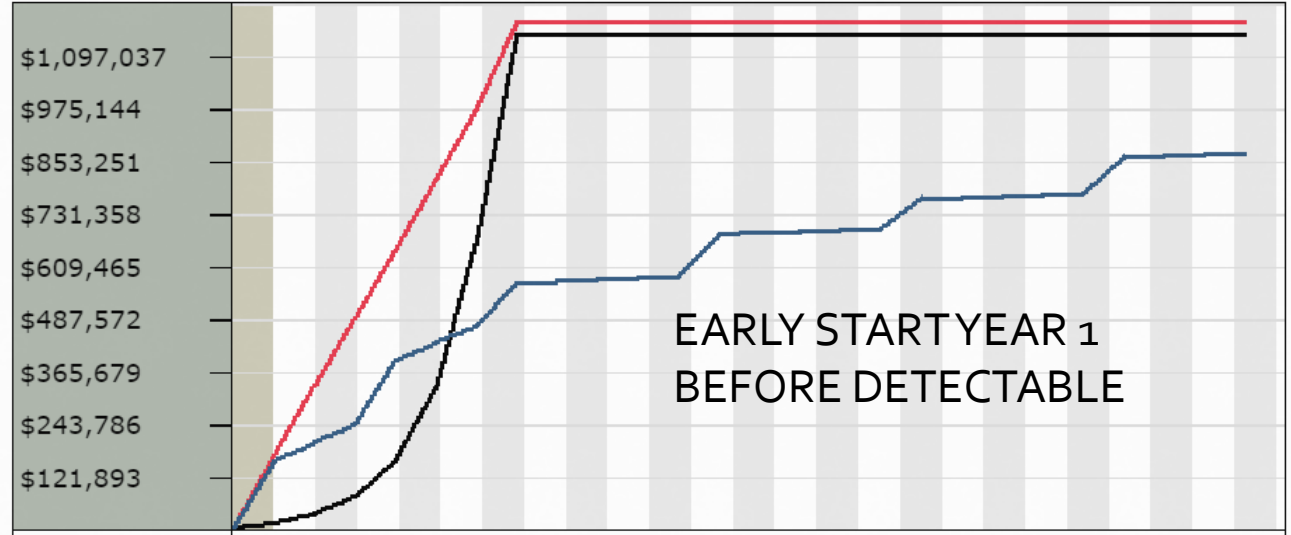
Cumulative Costs for Bulk Spray Bid

Highest cumulative cost

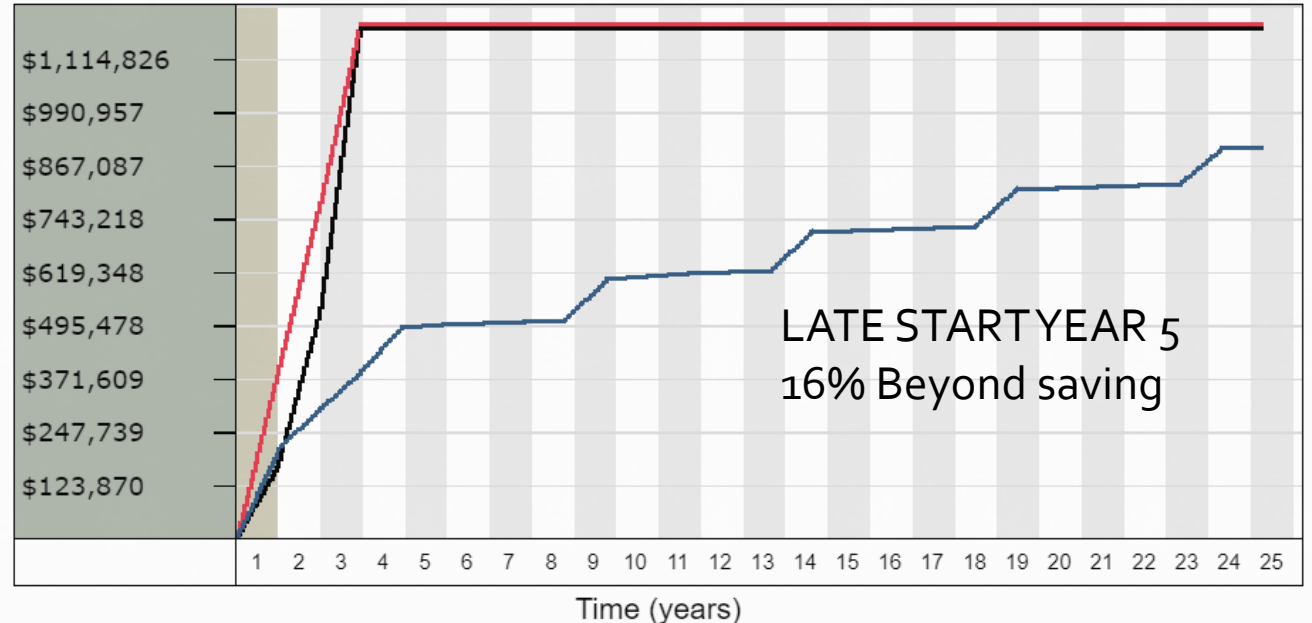


Lowest annual cost

Cumulative Cost Comparison in Today's Dollars Over Time With a 3% Discount Rate



Cumulative Cost Comparison in Today's Dollars Over Time With a 3% Discount Rate



Relative Benefits in Forest Size-Treated forest is largest

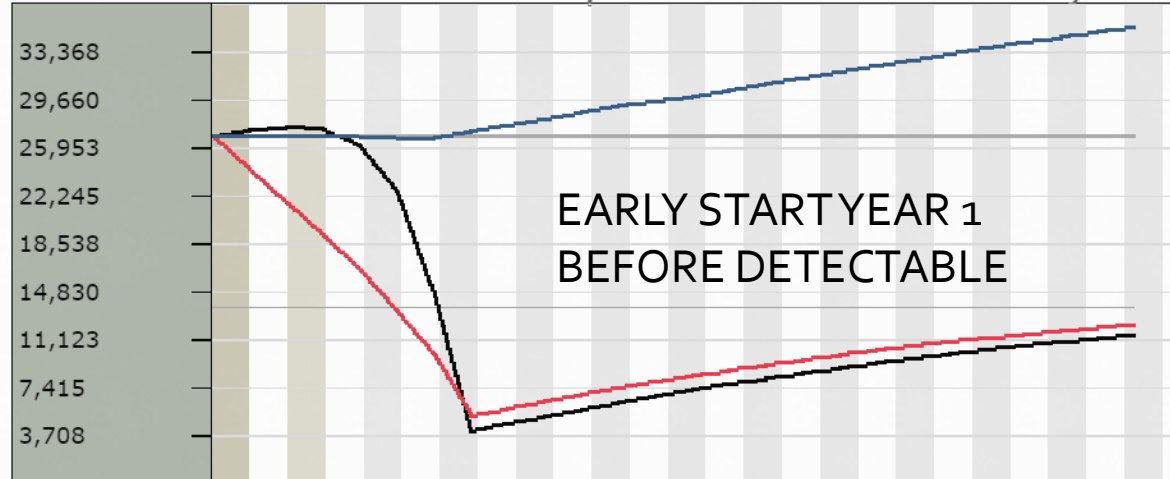
Aggressive trts @ 3 yrs; Maintenance trts @ 5 yr

Smallest forest

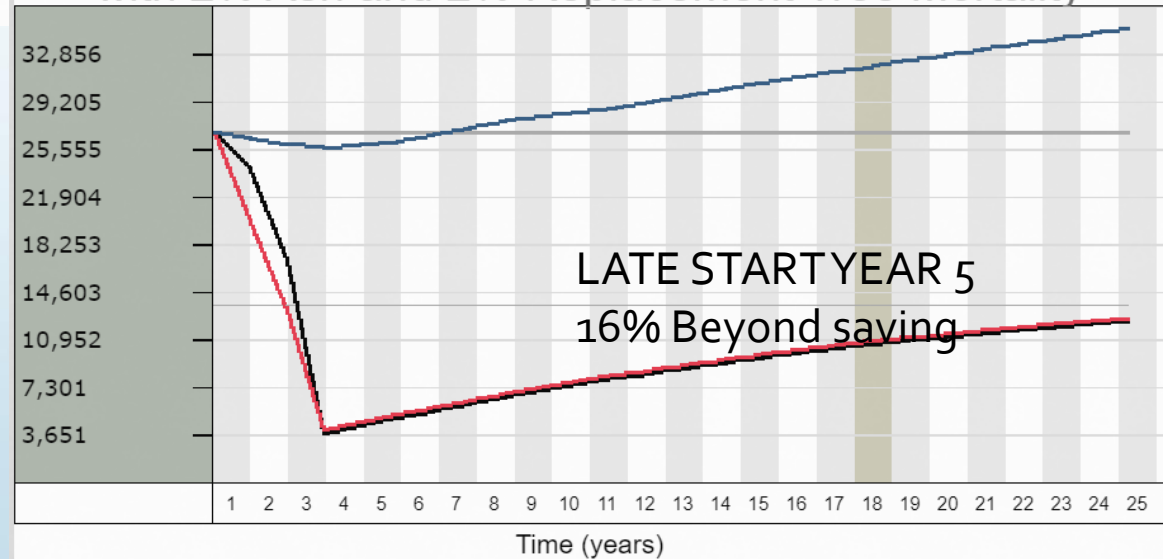
Reactively Replace All
Proactively Replace All
Replace <12

Largest forest

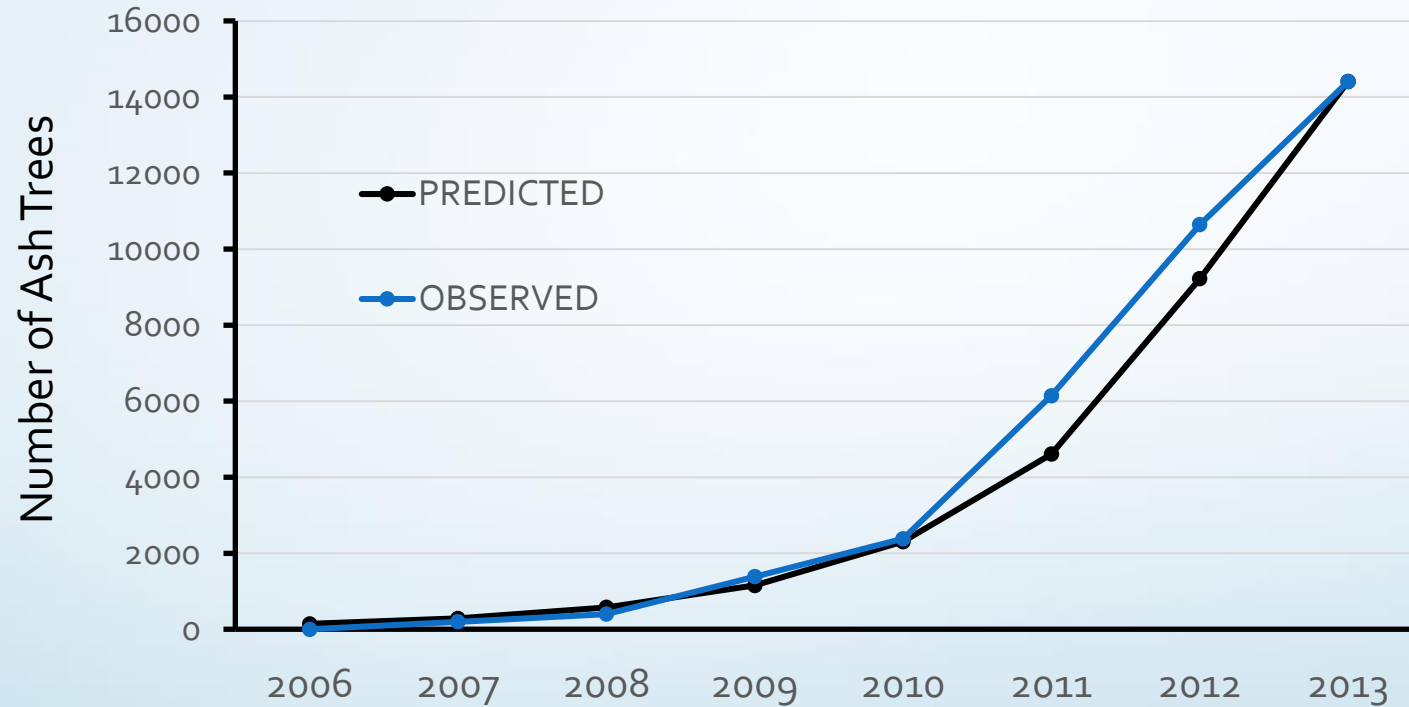
Total DBH Over Time
with 2% Ash and 2% Replacement Tree Mortality



Total DBH Over Time
with 2% Ash and 2% Replacement Tree Mortality



An Early Start is Critical for Success



Stage Year	1	2	3	4	5	6	7	8
PCT>removed	1	2	4	8	16	32	64	100

Year Detected

Can you reduce labor with half the injection holes?



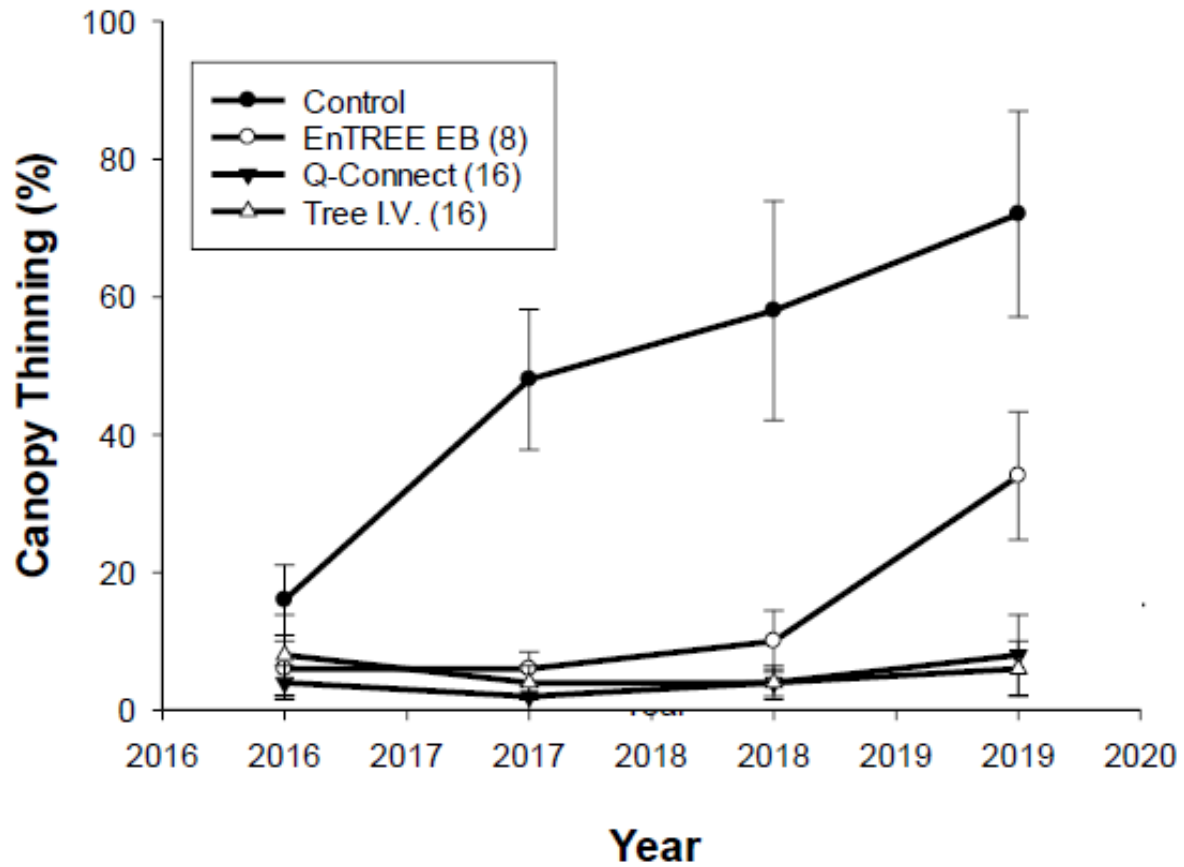
BRANDT
entREE

Advanced
Tree Health
Technology

**TO
BE**



Number of Injection Ports Matter



New Developments

- Improved Delivery
 - 10% soln
 - Quick Jet Air





Questions Up to Now?



Lessons learned from a test of an Urban SLAM Program

Cliff Sadof
Purdue University

Urban Slowed Ash Mortality (SLAM)

- Treat 20% of canopy each year with 2 year insecticide to provide a background of 40% toxic canopy.
- Beetles feeding to mature eggs will encounter toxic leaves and die before laying eggs.
- This slows EAB population build up and rate of ash decline in untreated trees.

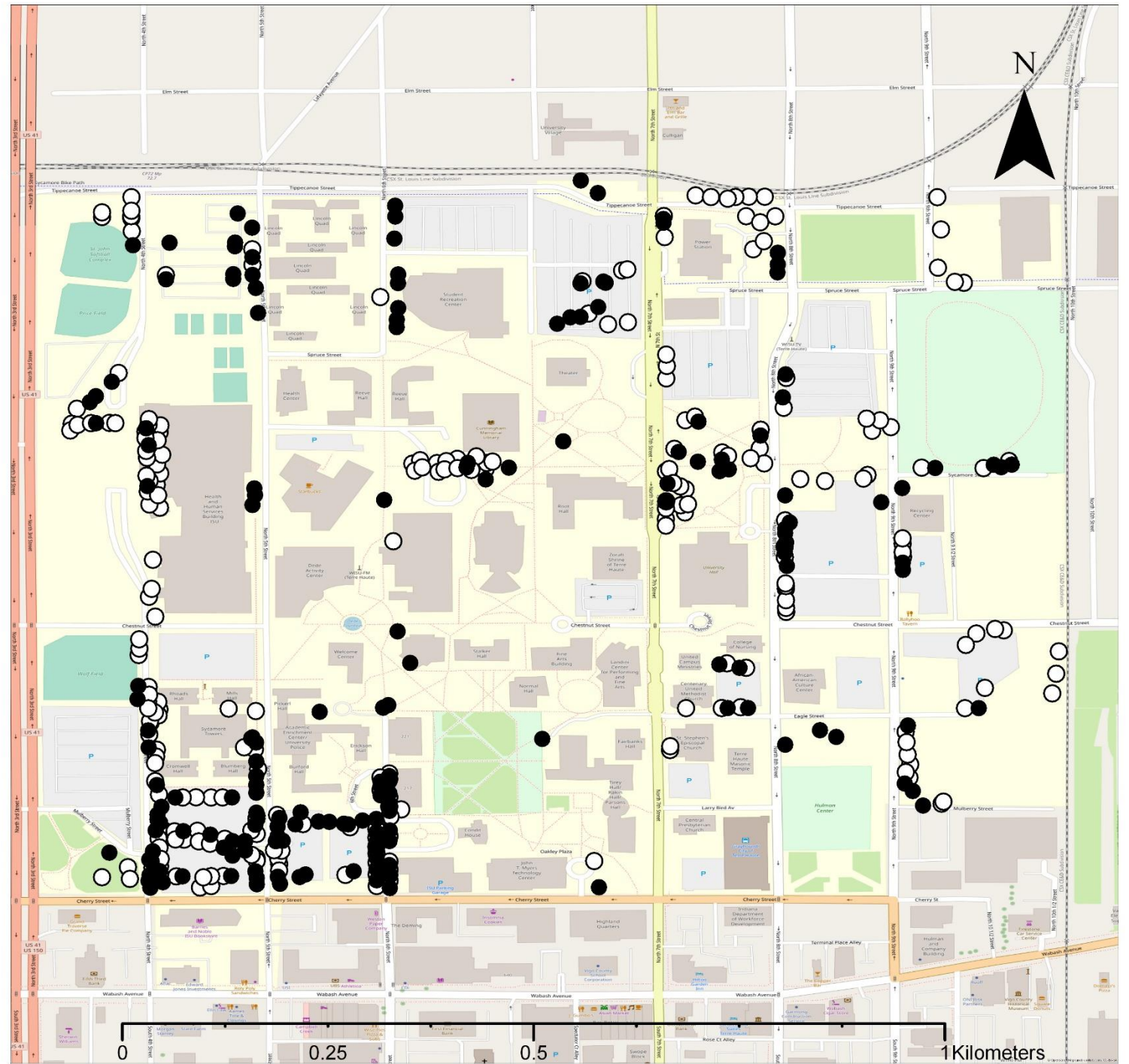
Urban S.Lowed A.sh M.ortality (SLAM)

- Treat 40% of canopy so that 40% is always toxic.
- Poison leaves kill adult females feeding on leaves BEFORE they lay eggs
- Slowed population build up slows ash mortality

Indiana Test

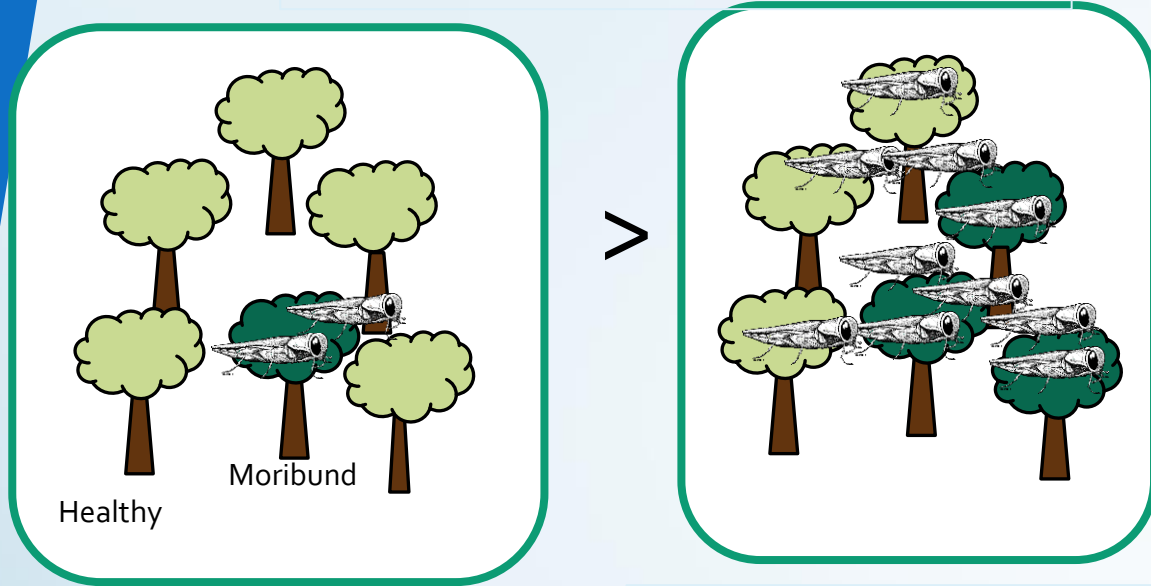
- 3 college campuses
- 40% treated
- Trees evaluated up to 6 years or until most untreated trees died.

- Treated Ash Trees
- Untreated Ash Trees

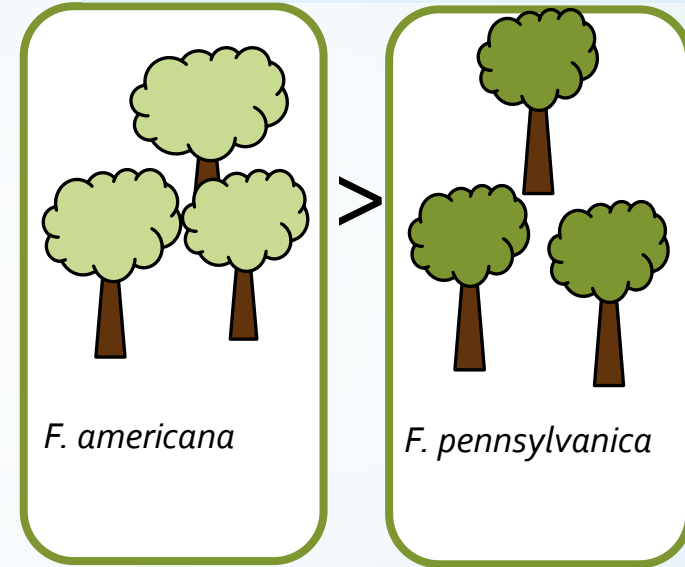


Factors Influencing Ash Tree Survival in Urban SLAM Programs

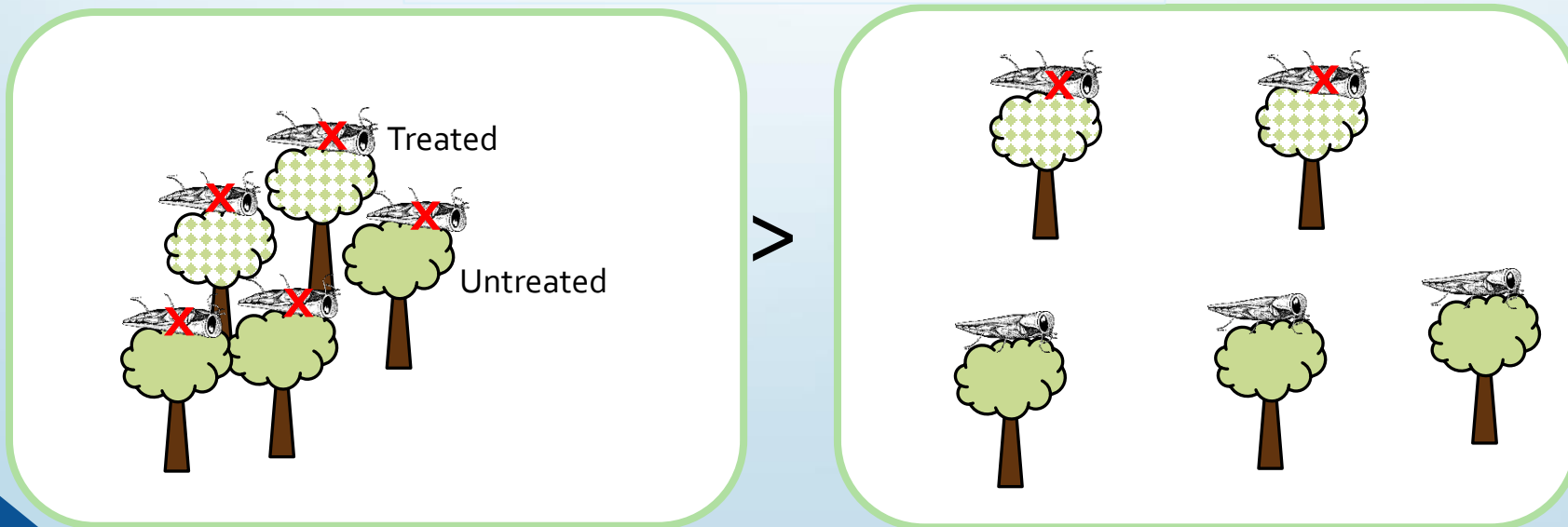
Initial Tree health and EAB Abundance



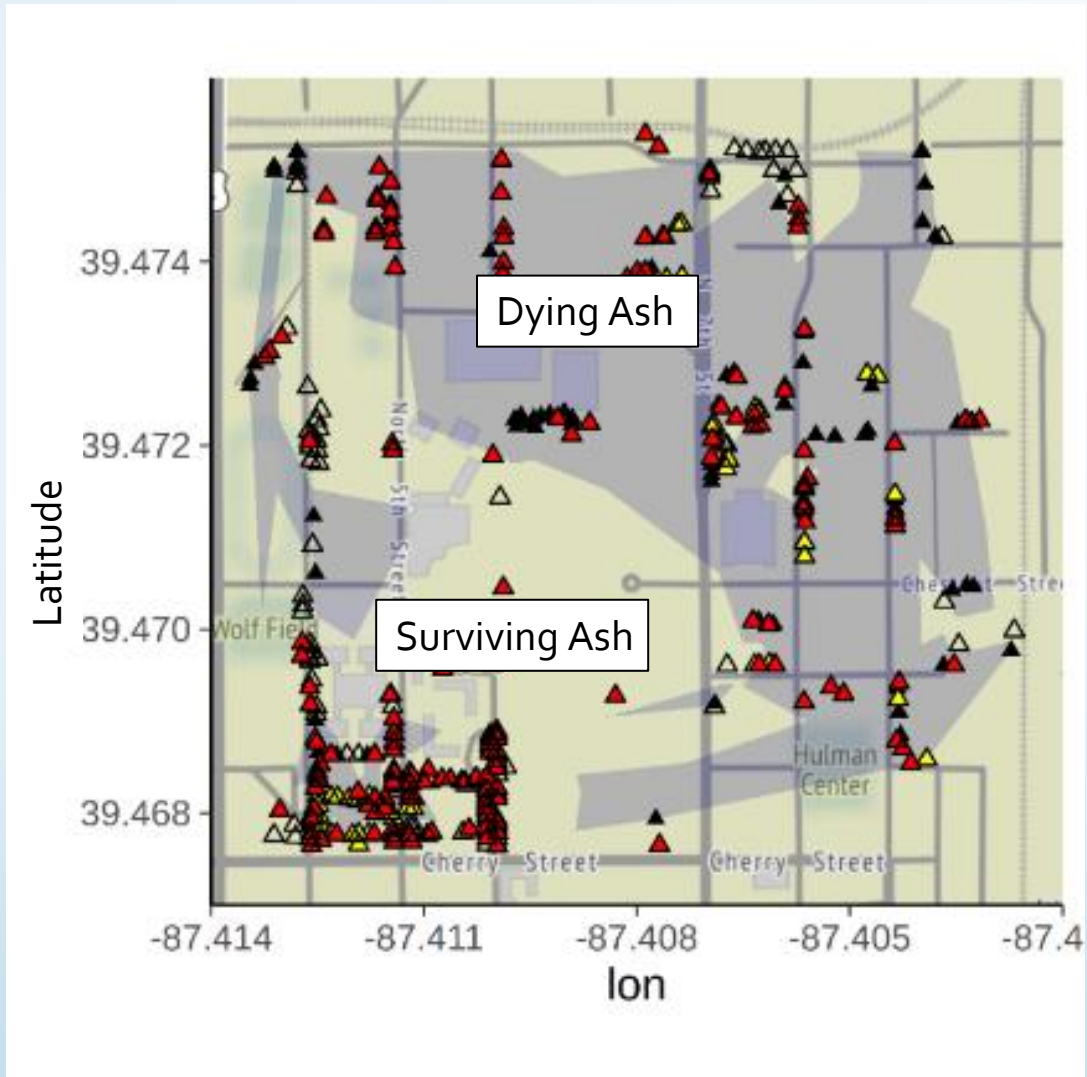
Ash species composition



Proximity of Treated and Untreated Ash

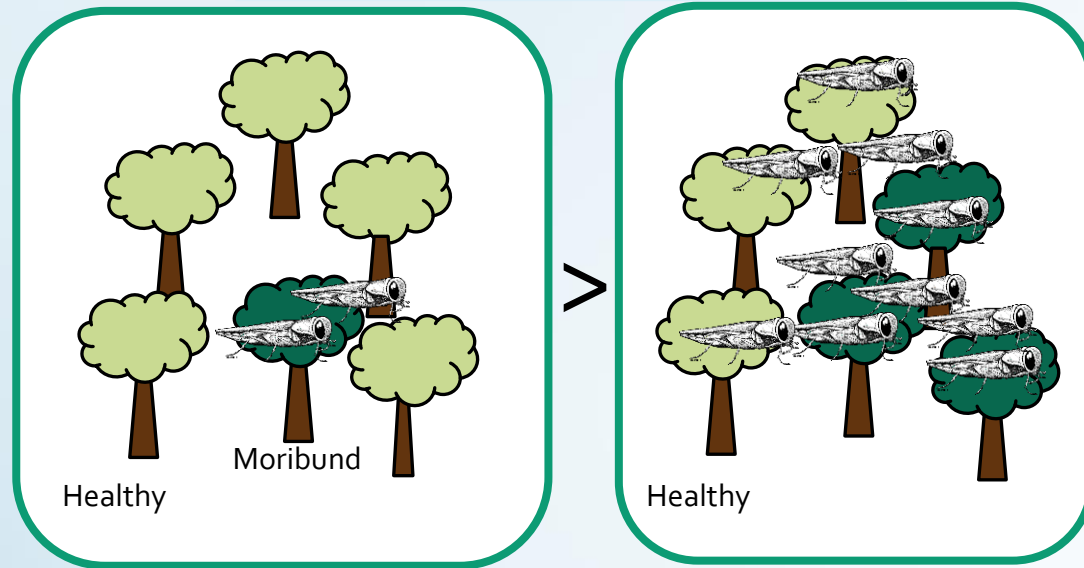


More ash survived in areas where treated and untreated trees were closer together



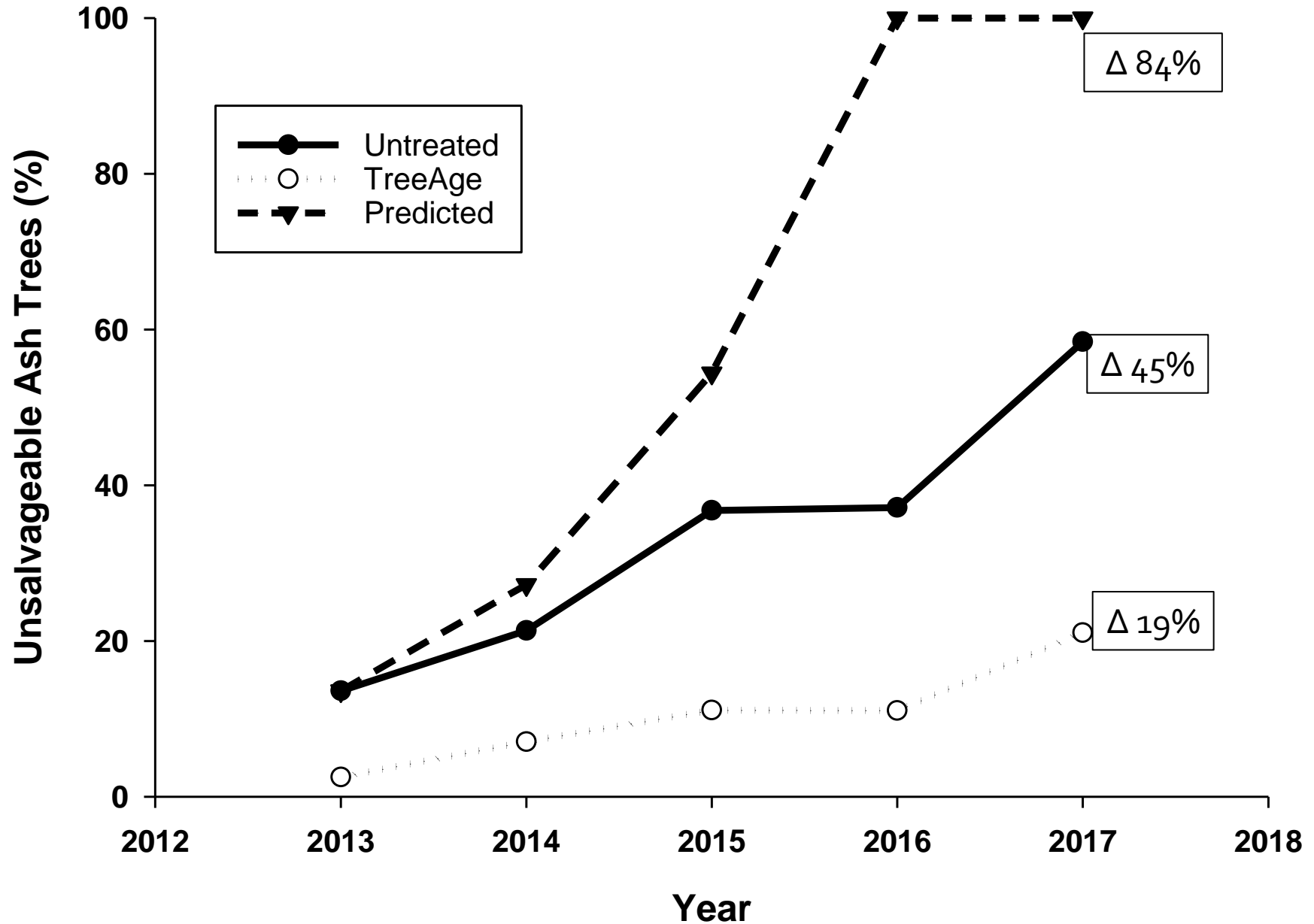
Factors Influencing Ash Tree Survival in Urban SLAM Programs

Tree health and EAB Abundance



Indiana State University, Terre Haute

Initial control trees
 $\geq 30\%$ thin = 16%

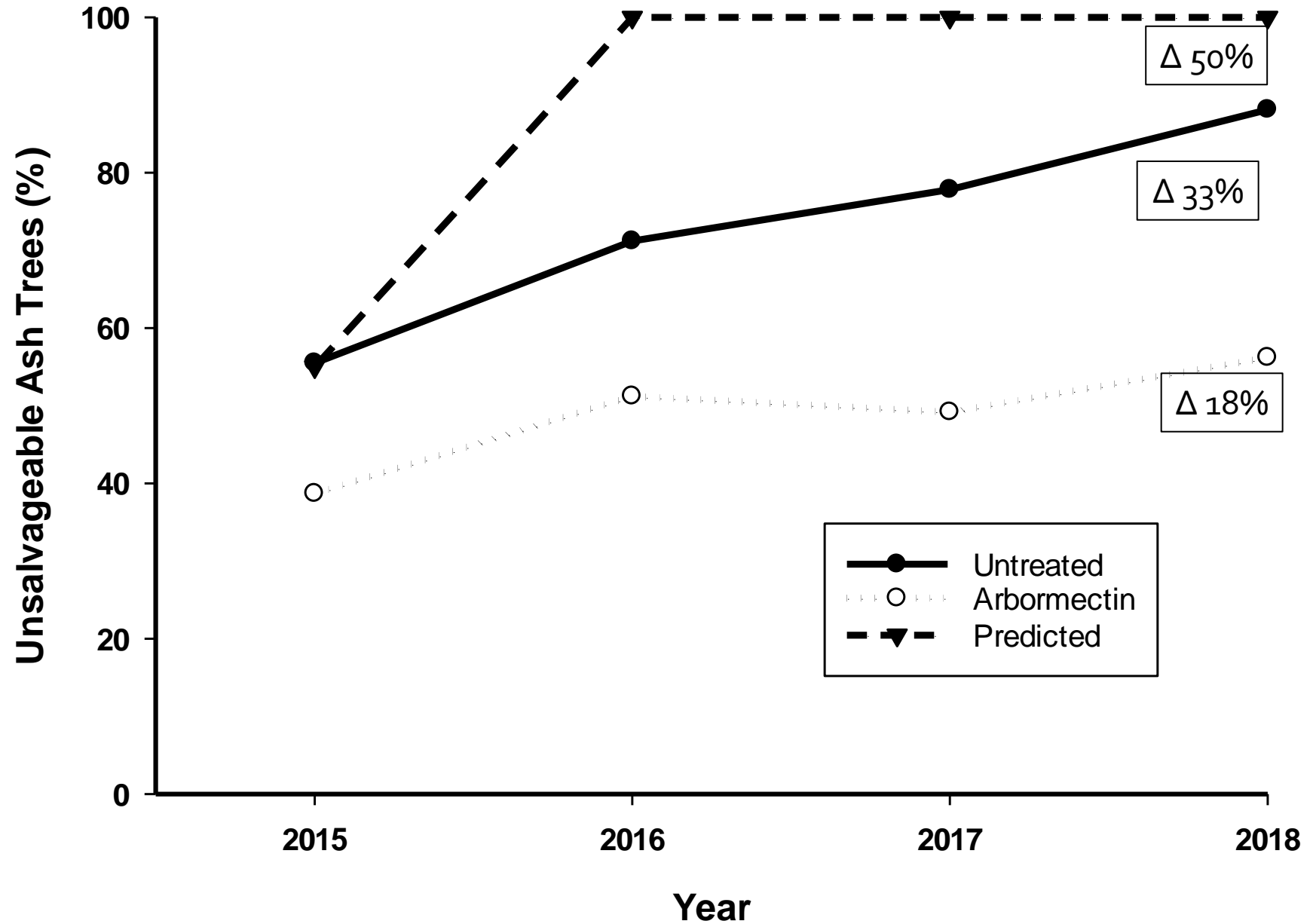


Indiana University, Bloomington Indiana

Initial control trees
 $\geq 30\%$ thin = 51%

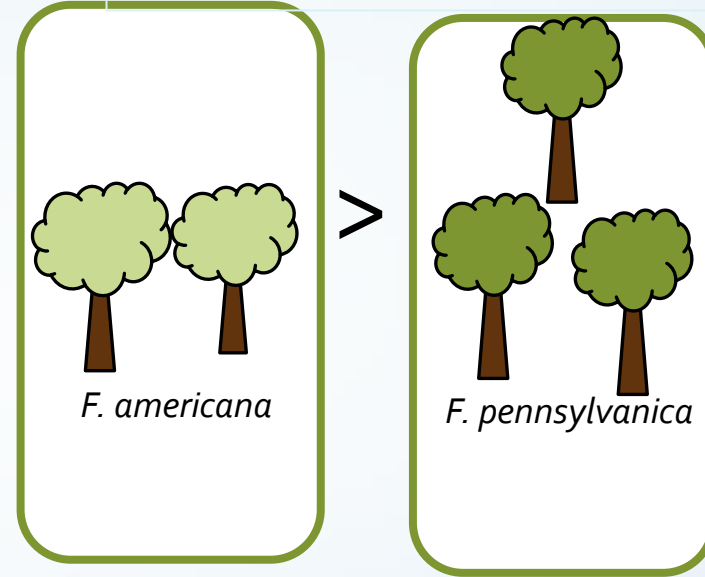


INDIANA UNIVERSITY

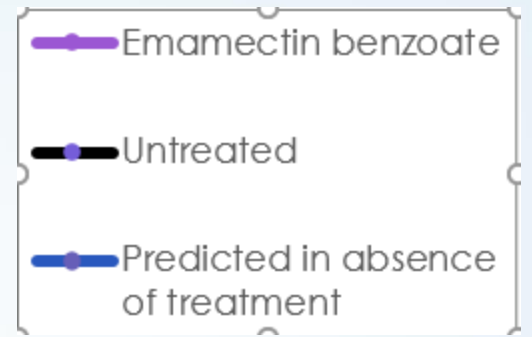


Factors Influencing Ash Tree Survival in Urban SLAM Programs

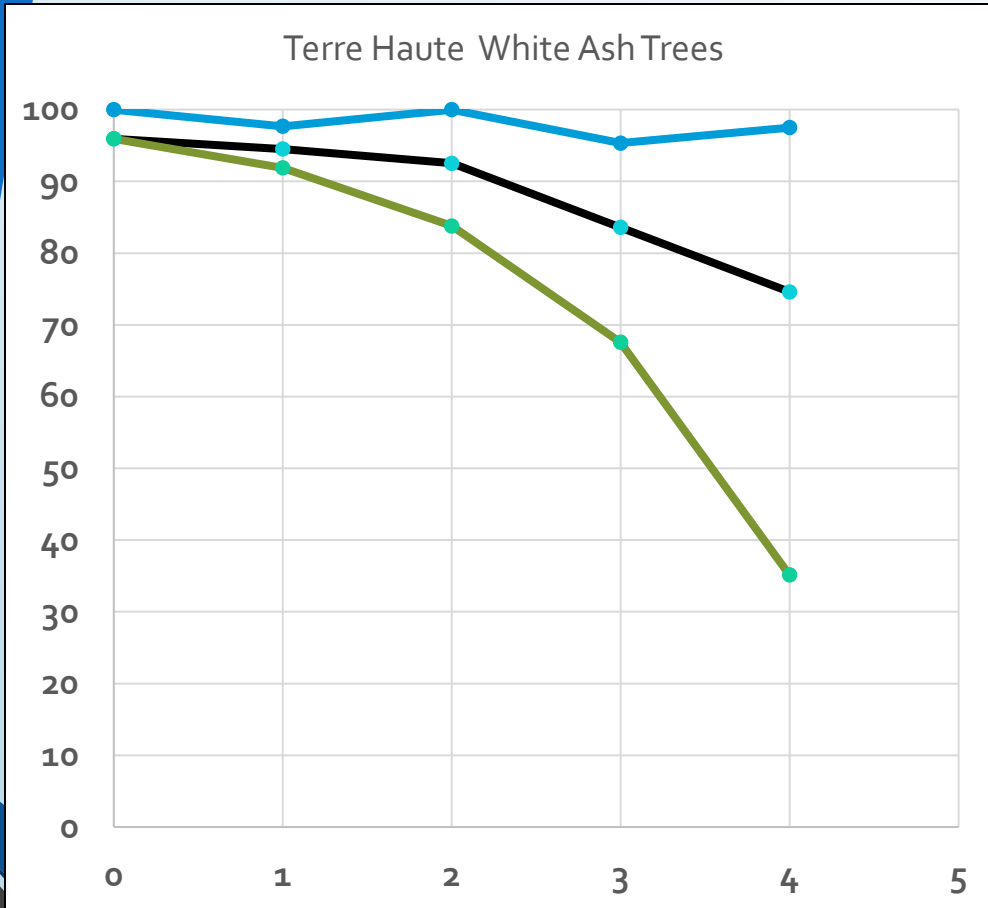
Ash species composition



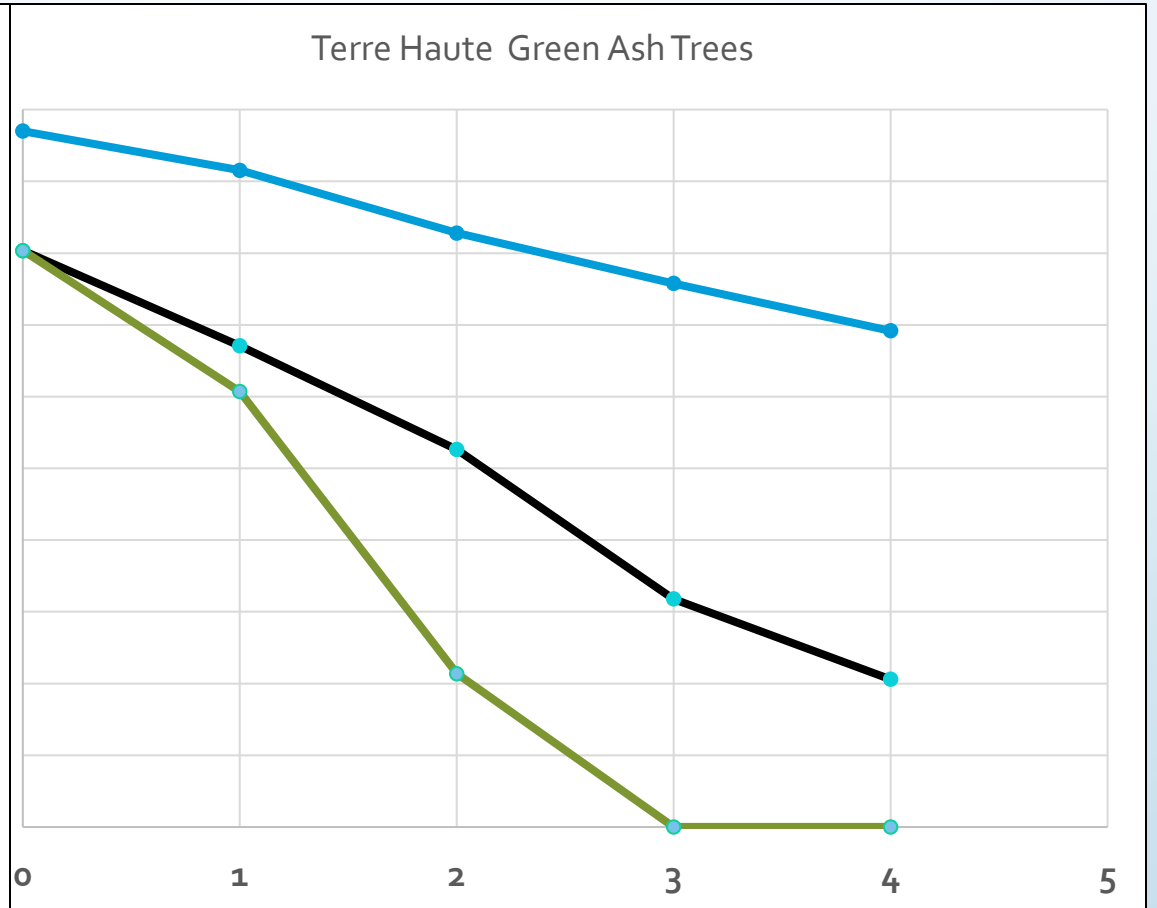
Ash Survival: White > Green



Surviving Ash Trees with < 30% Thinning



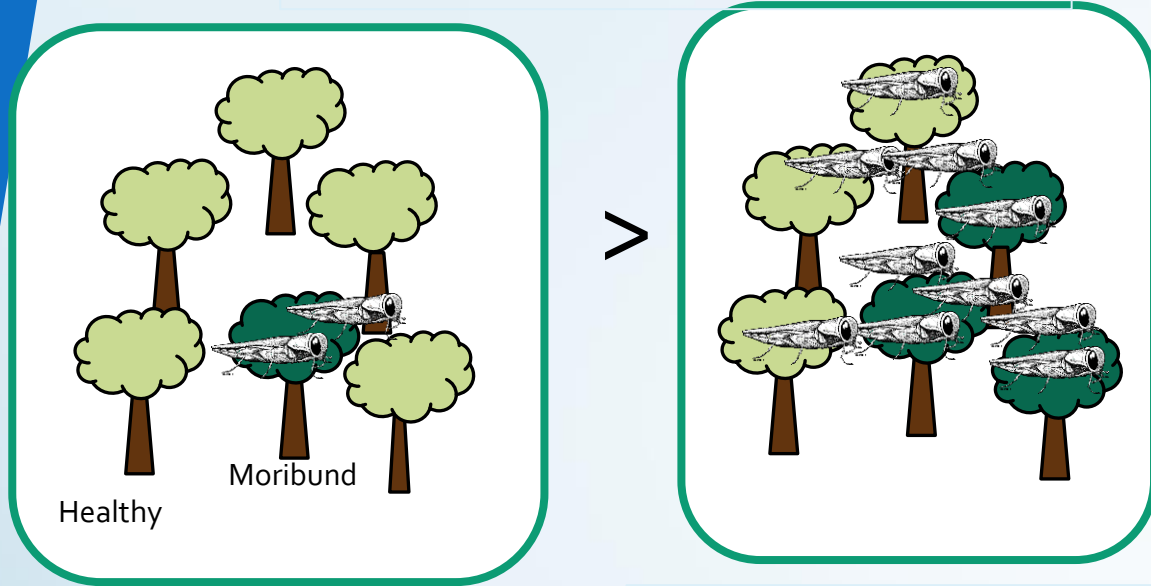
Year of Study



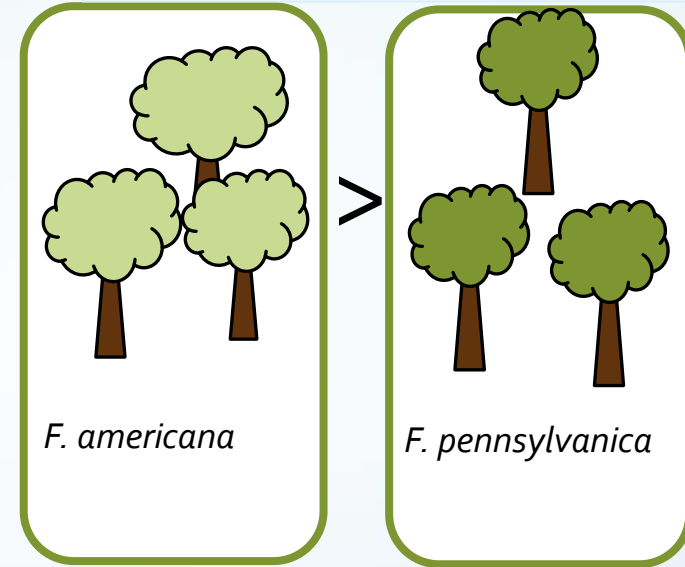
Year of Study

Factors Influencing Ash Tree Survival in Urban SLAM Programs

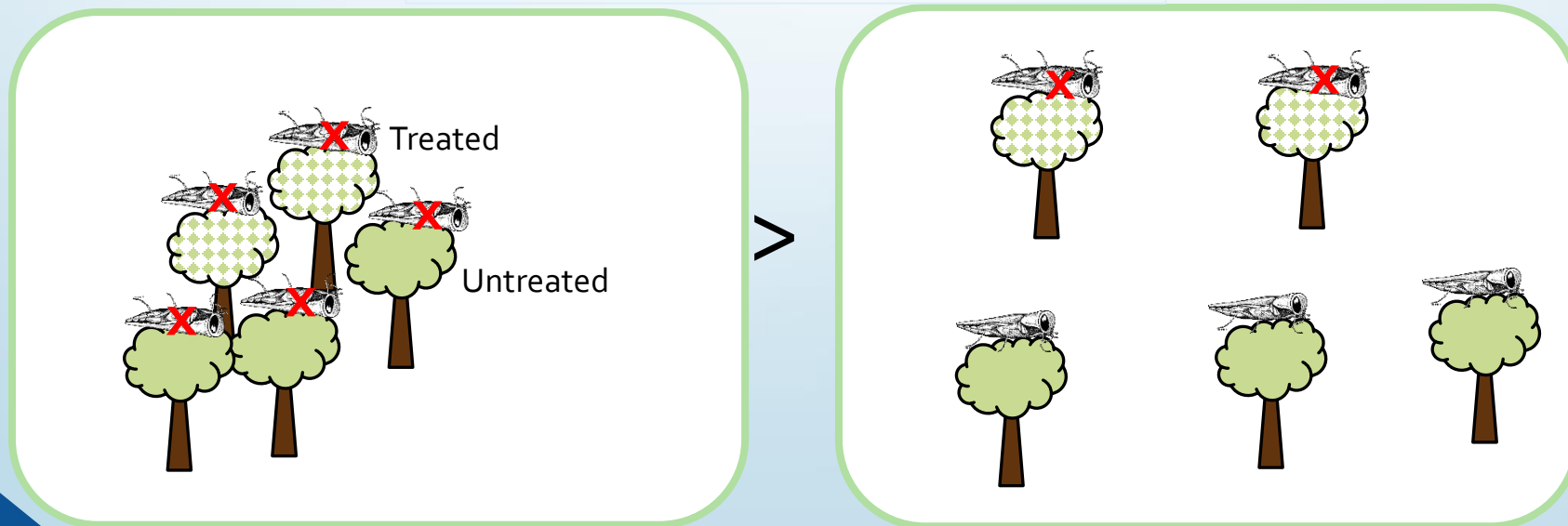
Initial Tree health and EAB Abundance



Ash species composition



Proximity of Treated and Untreated Ash



Acknowledgements

Collaborators

Matt Ginzl
Elizabeth Barnes
Lindsey Purcell

Students

Donnie Peterson
Julia Prado
Gabriel Hughes
Scott Gula
Sara Stack
Carlos Quesada
Adam Witte
Sujan Dawadi

Facilities

Indiana University
Indiana State University
Purdue University

Indiana Cities

Indianapolis
Fort Wayne,
Lafayette,
West Lafayette,
Bloomington

Funding

Purdue Ag Seed Grant
Rainbow Tree Care Science
Arborjet Systems
USDA EIPM
USDA NIFA
USFS USDA EABU

Application

Sam Drahn, Emily Bick
Don Grossman
Indiana State Grounds