M.L. 2013, Chp. 52, Sec. 2, Subd. 06c-A
M.L. 2016, Chapter 186, Section 2, Subdivision 18 Project Abstract
For the Period Ending June 30, 2017

PROJECT TITLE: Improving Emerald Ash Borer Detection Efficacy for Control – Part A, MDA
PROJECT MANAGER: Mark Abrahamson
AFFILIATION: Minnesota Department of Agriculture
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WEBSITE:
FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2016, Chapter 186, Section 2, Subdivision 18

APPROPRIATION AMOUNT: $240,000.00
AMOUNT SPENT: $240,000.00
AMOUNT REMAINING: $0

Overall Project Outcomes and Results

Emerald ash borer (EAB) was first discovered in Minnesota in 2009 in St Paul and has since spread to 15 counties. Minnesota has more ash than any other area of the U.S. and it's an important component of our rural and urban forests. Detection is a key obstacle to controlling EAB and many of the detection tools have not been calibrated to provide an estimate of what population density of EAB they are able to detect. This is a critical information gap as EAB population density is a critical parameter in determining how and where to implement control measures. This project was undertaken to evaluate detection tools and measure their ability to detect EAB at different population densities and to determine whether these detection tools can inform EAB management in urban areas. Methods included: visual inspection of ash trees during winter months, purple prism trapping during active EAB flight periods and branch sampling under a range of emerald ash borer population densities at 8 sites for three consecutive field seasons throughout the state. This work was conducted in close cooperation with local city governments.

A total of 840 trees were visually inspected, 615 purple prism traps set, 1724 branches and 48 whole trees sampled. Results showed branch sampling was more sensitive than visual observation but the labor costs were approximately four times greater. Visual sampling provided the most positive detections at all levels of EAB densities in the least amount of time and at the lowest cost. However, all survey methods evaluated had some utility at detecting EAB at sites before significant canopy decline had occurred. This is important information as the project demonstrated the value of monitoring to prevent opportunities for EAB management from being lost.

Project Results Use and Dissemination

The primary audience for this work was disseminated to municipalities and other entities responsible for managing EAB at the local level. Information was conveyed through meetings held throughout the year, both at MDA through the EAB Forum (bimonthly meeting) and also through conferences, meetings and workshops held around the state and also at professional and technical conferences.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2013 Work Plan Final Report

Date of Status Update Report: August 11, 2017
Date of Next Status Update Report: Final Report
Date of Work Plan Approval: June 11, 2013
Project Completion Date: June 30, 2017 **Is this an amendment request?** Yes

PROJECT TITLE: Improving Emerald Ash Borer Detection Efficacy for Control – Part A, MDA

Project Manager: Mark Abrahamson
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Location: Region: Statewide, Metro, Southeast
Counties: Statewide, Hennepin, Houston, Ramsey, Winona

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$240,000**
	Amount Spent:	**$240,000**
	Balance:	**$0**

Legal Citation: M.L. 2013, Chp. 52, Sec. 2, Subd. 06c-A
M.L. 2016, Chapter 186, Section 2, Subdivision 18

Appropriation Language:
$600,000 the first year is from the trust fund to evaluate and implement options for effective detection of the presence of emerald ash borer. Of this appropriation, $240,000 is to the commissioner of agriculture and $360,000 is to the Board of Regents of the University of Minnesota. This appropriation is available until June 30, 2016, by which time the project must be completed and final products delivered.

Carryforward: (a) The availability of the appropriations for the following projects are extended to June 30, 2017: (6) Laws 2013, chapter 52, section 2, subdivision 6, paragraph (c), Improving Emerald Ash Borer Detection Efficacy for Control.

I. PROJECT TITLE: Improving Emerald Ash Borer Detection Efficacy for Control – Part A, MDA

II. PROJECT STATEMENT:

Emerald ash borer (EAB) was first discovered in Minnesota in 2009 in St Paul. It is now known to occur in four Minnesota Counties (Ramsey, Hennepin, Houston and Winona) as of September, 2012. Minnesota has more ash than any other area of the U.S. and ash is an important component of our rural and urban forests. Much work has been done to stem the spread of EAB throughout Minnesota including education, quarantine, detection surveys and biological control efforts. The likely consequence of taking no action against EAB is its rapid spread through most of the state and the resulting death of > 99% of the ash trees in those areas.

Detection is a key obstacle to controlling EAB. Minnesota has worked with the United State Department of Agriculture (USDA) to conduct detection surveys for EAB since 2003 using a variety of techniques – most recently large, purple traps. However, EAB detection tools have not been calibrated to provide an estimate of what population density of EAB they are able to detect. This is a critical information gap as EAB population density is a critical parameter in determining how and where to implement control measures.

This project will evaluate a range of detection tools and measure their ability to detect EAB at different population densities. We will also evaluate aspects of EAB biology that are critical in estimating dispersal and consequently, spread. We will use different detection techniques in and around EAB-infested areas in order to compare their ability to detect EAB. We will work with local governments to implement this work.

Through this project we will gain a better understanding as to the feasibility of using EAB detection surveys to inform EAB management for local governments or others.

III. PROJECT STATUS UPDATES:

Project Status as of November 15, 2013**:**
This project is off to a good start and on track with work goals and planned spending. Work has been initiated for both activities and is on schedule with targeted outcomes. No problems have been encountered to date that will delay or change the planned schedule of work. Specific details on work accomplished to date are provided under each of the activity sections below.

Project Status as of May 15, 2014**:**
This project continues to proceed as planned and on schedule for both work goals and spending. No problems have been encountered that will delay or change the planned schedule of work. Specific details on work accomplished to date are provided under each of the activity sections below.

Project Status as of November 15, 2014**:**
This project continues to move forward on schedule. 156 purple prism traps were placed and serviced throughout the summer among the 8 sites. The yearly “canopy-on” visual assessment of 35 trees at each site was completed in late August and early September. Branch sampling has been initiated at the Fort Snelling and Great Rivers Bluff park sites and Joint Powers Agreements are in process to facilitate sampling at municipal sites. A summary of the first year of work was provided at the 2014 Upper Midwest Invasive Species Conference. Preliminary conclusions presented indicated that branch sampling was a more sensitive survey tool than visual observation but that the labor costs were approximately four times greater. The degree of sensitivity gained in branch sampling may not have been great enough to justify the increase in labor costs. Also, all survey methods had some utility at detecting EAB at sites before significant canopy decline had occurred and opportunities for management were lost. No problems have been encountered to date that will alter the planned schedule of work.

Amendment Request 11/15/2014
We have found that we have been able to be more efficient than expected during the summer months in conducting trapping - resulting in less than full utilization of salary dollars during this timeframe. We have also found that increasing the amount of sampling we are able to conduct during the winter would be helpful. We would use two permanent intermittent staff to help conduct sampling during winter, increasing the amount of work we are able to do and utilizing the salary savings from summer. This work would be during a time of year when these two staff would otherwise not be in work status. As a result, even though we would be utilizing permanent staff, we would not be supplanting regular work conducted by MDA. This should not result in a budget change as we will still be utilizing salary dollars to pay salary.
Amendment Approved: December 2, 2014

Project Status as of May 15, 2015**:**
This project continues to move forward and is on schedule for completion of activities and use of all funds. Purple prism traps are now being placed and will be completed by the first week of June. All visual assessments, branch sampling, and whole tree sampling has been completed and data has been sent to the University of Minnesota for continued analysis and summarization. Four sites: Fort Snelling, St. Paul and both sites at Great River Bluffs State Park have had to be modified due to high EAB caused mortality and city tree removals and treatments (See figures 26-29 of new sites and trees). All sites were relocated as close as possible to the original site, had approximately the same amount of EAB pressure and were approximately the same size. Thirty five sample trees at 7 sites are now available for upcoming sampling and assessment. We are waiting for our state permit to be able to select new trees at the 8th site, Fort Snelling.

Amendment Request 11/15/2015
In the last year of this project we plan to develop materials to summarize the project for urban foresters and others who will benefit from the findings of this study. We would like to incorporate time from two additional temporary, unclassified staff at the MDA to work on the development of these materials. We anticipate producing web content as well as printed materials to distribute as products from this work. Our original budget contained $1,000 for the printing of materials generated by this project. Salary for these additional staff will primarily be paid from dollars budgeted to cover cooperator costs for removal of branches and trees for sampling which have been less than originally anticipated. To cover the increased salary costs we request permission to use $15,000 that was originally designated for city reimbursement. In addition, supply costs have been less than anticipated but travel costs have been more. We request permission to move $2,000 from supplies to travel in the Activity 1 budget.
Amendment Approved: November 19, 2015

Project Status as of November 15, 2015**:**
This project continues to move forward and is on schedule for completion of activities. 159 purple prism traps were placed and serviced throughout the summer at each of the 8 study sites. The yearly “canopy-on” visual assessment of 35 trees at each site was completed in late August and early September. Branch and whole tree sampling has been completed in Duluth and has been started at Fort Snelling. Sampling at Great River Bluffs will take place early November while the rest of the sites will be sampled in November and December.

Amendment Request 3/18/2016
The MDA requests to extend this project until June 30, 2017. An unexpected change in personnel will create issues with completing this project before the current end date of June 30, 2016. Extending the end date will allow time to replace personnel and complete all components of the project. In addition, this extension would have the advantage of re-aligning this portion of the project with the University of Minnesota’s portion. Much of the work that remains to be done on this project is the development of materials that describe the results of the project and allow for dissemination. Extending the end date will allow these materials to be inclusive of the data analyses the University will conduct for this project.
Amendment Approved: May 25, 2016

Project Status as of May 15, 2016**:**

The project is moving forward and data collection activities are complete. Branch and whole tree sampling of the remaining study sites took place between November and January. Samples were dissected by MDA staff between November and April. MDA staff completed the winter "canopy-off" visual assessment of 35 trees each study site as well.

Project Status as of November 15, 2016:
Work since May 15, 2016 mostly consisted of entering, collating and reviewing data. The U of M is conducting statistical analyses on the project data and we are prepared to complete outreach materials for the project once that work is completed.

Retroactive Amendment Request 11/28/16
We are finished with most phases of the project except for the final analysis and reporting. We request to move remaining funds in the amount of $1,505 from the Professional Technical category to the Travel category. Expenses for both travel and professional/technical services are now complete for the project. We request to move the remaining $1,104 from the Professional/Technical category to Personnel. We also request to move the remaining $2,538 from the Supplies category to Personnel. All supply needs for the project are now complete and were less than initially anticipated due to the fact that USDA APHIS provided traps and lures at no cost. Regarding our Professional Technical funds, we found that our municipal cooperators were able to accomplish the necessary tree pruning and removal more economically than originally anticipated. This allowed us to increase the fieldwork resulting in higher personnel and travel costs.
Amendment Approved: 12/9/2016

Retroactive Amendment Request 8/10/17
Management guidelines were produced and will be available online. Our audience prefers this electronic format so we did not print hard copies. We request to redistribute the $1,000 budgeted for printing to the following categories:

- Salary = $765 – We worked extensively during the last six months of this project to disseminate the project results to stakeholders. This included many field workshops with arborists and foresters as well as regional meetings with city foresters and managers. Salary expenses during this time were for the project coordinator to disseminate project information at the meetings and we request to partially recover those costs with dollars not utilized for printing.
- Supplies = $28 – An error was made in the 11/28/16 amendment request. $2,990 had already been spent on supplies for the project at that point. However, the amended budget mistakenly requested that the supply budget be adjusted to $2,962 which resulted in a $28 deficit for this category.
- Travel = $207 – When we requested the 11/28/16 budget amendment we did not anticipate that travel costs would remain. However, we did incur travel costs through the dissemination of project information at the field workshops and regional meetings described above. We are requesting that the final $207 not utilized for printing be moved to the travel category to cover a portion of lodging costs incurred for the project manager to provide the field workshops.

Overall Project Outcomes and Results:

Emerald ash borer (EAB) was first discovered in Minnesota in 2009 in St Paul and has since spread to 15 counties. Minnesota has more ash than any other area of the U.S. and it's an important component of our rural and urban forests. Detection is a key obstacle to controlling EAB and many of the detection tools have not been calibrated to provide an estimate of what population density of EAB they are able to detect. This is a critical information gap as EAB population density is a critical parameter in determining how and where to implement control measures. This project was undertaken to evaluate detection tools and measure their ability to detect

EAB at different population densities and to determine whether these detection tools can inform EAB management in urban areas. Methods included: visual inspection of ash trees during winter months, purple prism trapping during active EAB flight periods and branch sampling under a range of emerald ash borer population densities at 8 sites for three consecutive field seasons throughout the state. This work was conducted in close cooperation with local city governments.

A total of 840 trees were visually inspected, 615 purple prism traps set, 1724 branches and 48 whole trees sampled. Results showed branch sampling was more sensitive than visual observation but the labor costs were approximately four times greater. Visual sampling provided the most positive detections at all levels of EAB densities in the least amount of time and at the lowest cost. However, all survey methods evaluated had some utility at detecting EAB at sites before significant canopy decline had occurred. This is important information as the project demonstrated the value of monitoring to prevent opportunities for EAB management from being lost.

The primary audience for this work was disseminated to municipalities and other entities responsible for managing EAB at the local level. Information was conveyed through meetings held throughout the year, both at MDA through the EAB Forum (bimonthly meeting) and also through conferences, meetings and workshops held around the state and also at professional and technical conferences.

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Implement detection surveys for EAB to evaluate efficacy of different detection techniques under different abundances of EAB

Description:
We will conduct detection surveys for EAB in and around infested areas. The purpose of working in these areas will be to measure the efficacy of different detection techniques. The techniques will include visual evaluation (low labor input), purple traps and / or EAB cadaver traps (moderate labor input) and removal and sampling tree branches (high labor input). We will also visually evaluate tree canopy and stem condition in these areas so as to relate the results of the detection work to tree health. We will gather data from trees felled by cooperators for EAB sanitation when possible to estimate EAB population density in these areas. This is a labor intensive task, but important to understanding the efficacy of the detection techniques (i.e., at what population density are they detecting EAB?).

MDA – Part A
This work will be coordinated by MDA who will hire one temporary employee for this task. The employee is anticipated to spend 80% of their time on this project. In addition, MDA staff funded by other EAB projects will collect information that will contribute to this project as well. MDA intermittent staff will help with winter sampling work up to 280 hours in total in each of years 2 and 3.

UMN – Part B
Sampling design and analysis will be coordinated by Drs. Aukema and Venette. One graduate student and one undergraduate student advised by Dr. Aukema will also work on sampling design and analysis as well as data collection. All sampling work will be coordinated by MDA with local government cooperators who will also assist by felling branches for sampling.

Summary Budget Information for Activity 1, MDA – Part A:	**ENRTF Budget:**	**$ 240,000**
	Amount Spent:	**$ 240,000**
	Balance:	**$ 0**

Activity Completion Date:

Outcome	Completion Date	Budget
1. Year 1 visual assessment of canopy condition in detection areas - associated data management and analysis	September 2013	$ 13,667
2. Year 1 Branch and tree sampling in detection areas, visual assessment of stem condition - associated data management and analysis	April 2014	$ 59,167
3. Year 2 Trap survey for EAB in detection areas, visual assessment of canopy condition, associated data management and analysis	September 2014	$ 20,500
4. Year 2 Branch and tree sampling in detection areas, visual assessment of stem condition - associated data management and analysis	April 2015	$ 59,167
5. Year 3 Trap survey for EAB in detection areas, visual assessment of canopy condition - associated data management and analysis	September 2015	$ 20,500
6. Year 3 Branch and tree sampling in detection areas, visual assessment of stem condition - associated data management and analysis	April 2015	$ 59,167
7. Develop, print and distribute informational materials related to project	June 2016	$ 7,833

Activity Status as of November 15, 2013**:**

MDA-Part A

The project partners met in early June to plan the statistical methods and sampling regime for this project. We also determined the number of sites that would be evaluated (8) and identified potential sites that would represent a range of conditions from urban to rural and a range of EAB abundances from low to high. Since this meeting was held before the official start of the project, no project funds were used for staff time.

In August the 8 study sites were selected and cooperators were contacted for permission to work at each. As planned, sites were selected that offered a range of estimated EAB densities and a range of conditions including urban and natural settings based on previous experiences. Figure 1 shows the general locations of the study sites. A detailed map of each study site including location of site boundaries, locations of study trees and approximate size of site can be found in Figures 2-9.

Also in August a project coordinator, William Martin, was hired at MDA to implement all aspects of the project related to EAB. William proceeded to evaluate each site, select study trees for this year and assess the condition of each study tree. This work was conducted during August and September while tree canopies were still intact (Aug 20 – Oct 1) and represents the planned yearly “canopy-on” assessment. The same criteria used in other EAB assessments in Minnesota were used.

The canopy of each tree was rated for condition as follows:

1 – No canopy loss
2 – Some canopy loss (loss apparent, but less than half of canopy lost)
3 – Significant canopy loss (half of canopy lost)
4 – Major canopy loss (more than half of canopy lost)
5 – No canopy present

In addition, each tree was assessed for

- epicormic shoots (along with canopy condition an indicator of stress)
- woodpecker damage (a key indicator of EAB activity)
- EAB galleries and exit holes

Finally, the specific location of each tree, DBH (diameter at breast height) measured and species of the tree (green, white or black ash) was recorded. Summarized results from this initial site assessment are available in Table 1.

Table 1. Summarized results from the "canopy-on" visual assessment of 35 trees at each study site, August 20 – October 1, 2013. Canopy condition was rated 1 (best) to 5 (worst).

Site	Est. EAB Density	Setting	Mean DBH (inches)	Mean Canopy Condition	Number Trees Woodpecked	Number Trees EAB Positive
GRB K. Bluff	Very High	Wooded	7.9	3.3	35	15
GRB K. Valley	High	Semi-wooded	9.7	3.2	11	0
Fort Snelling	Moderate	Wooded	9.6	1.9	6	0
Roseville	Moderate	Urban	16.9	1.7	0	0
Minneapolis	Low	Urban	18.2	1.5	0	0
St Paul	Low	Urban	16.9	1.6	0	0
Shoreview	Very Low	Urban	18.3	1.5	0	0
Duluth	Very Low	Semi-wooded	13	2.1	0	0

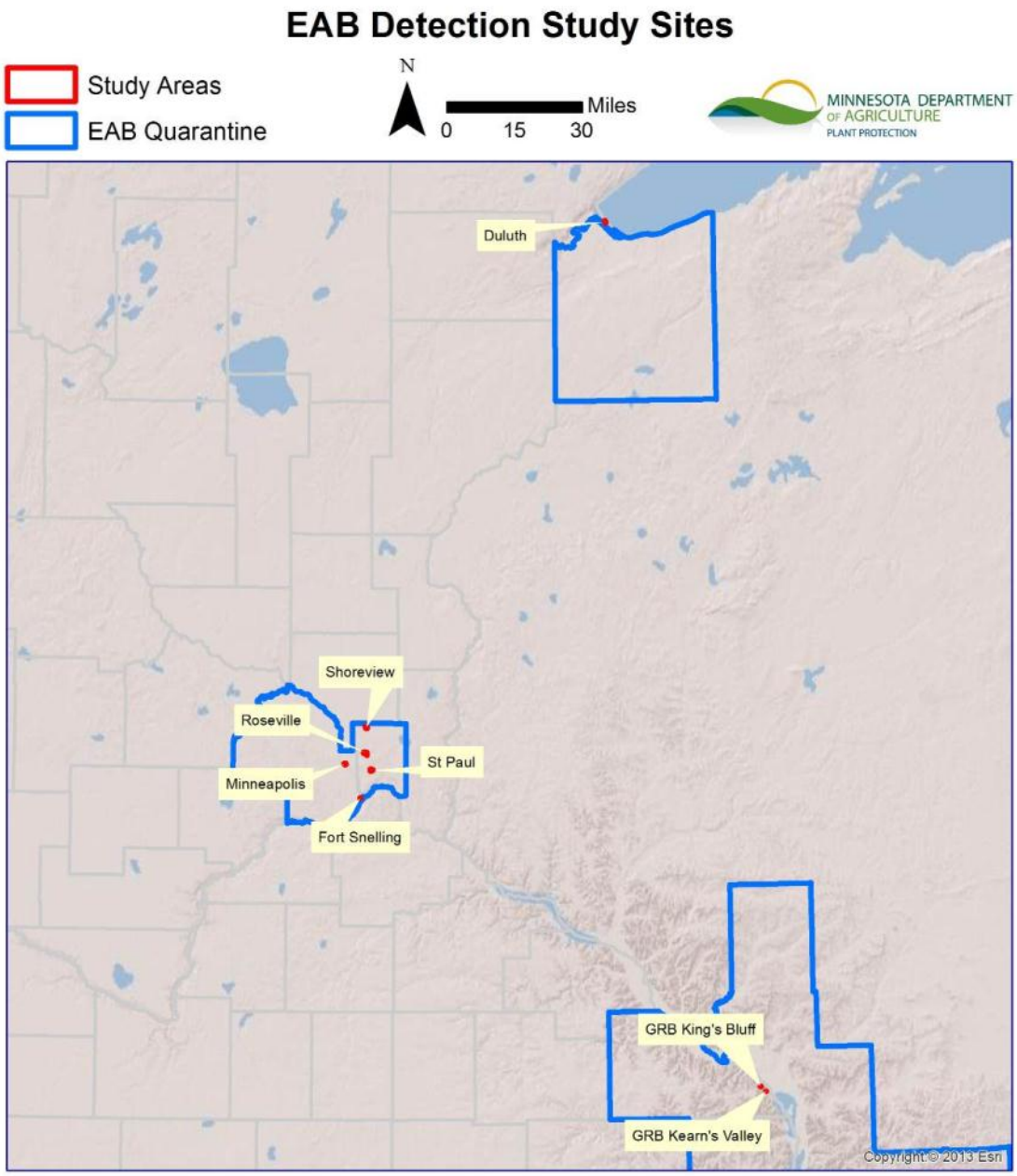


Figure 1. EAB study sites identified and established in August, 2013. All study sites are within or adjacent to known EAB-infested areas.

Branch sampling was conducted at Fort Snelling State Park and Great River Bluffs State Park (both sites) October 8 – November 1 (summarized results in Table 2). Some trees did not have branches that could be reached for sampling – at Fort Snelling only 33 trees were branch sampled as a result.

Branch sampling at the remaining 5 sites will be conducted between November 1 and April 30. The remaining 5 sites are all in urban areas and municipal cooperators will remove branches for sampling. Each cooperator will be reimbursed up to $5,000 for their time and expense in doing this work each year. MDA is in the process of getting Joint Powers Agreements approved for each municipal cooperator to facilitate the payment of these funds.

Table 2. Summarized results from branch sampling at study sites, October 8 – November 1. For Great River Bluffs sites the data are still in the process of being recorded.

Site	Est. EAB Density	Setting	Number Trees Sampled	Number Trees Infested	Average EAB Galleries / square meter
GRB K. Bluff	Very High	Wooded	35	35	78.5
GRB K. Valley	High	Semi-wooded	34	31	22.4
Fort Snelling	Moderate	Wooded	33	28	10.4
Roseville	Moderate	Urban			
Minneapolis	Low	Urban			
St Paul	Low	Urban			
Shoreview	Very Low	Urban			
Duluth	Very Low	Semi-wooded			

Figures 2 – 9. Project study sites and study trees for 2013/2014. Approximate size of each study area is indicated on the individual maps. These figures were omitted from this report as the document size was too large to email.

UMN-Part B-See UMN Project Report for description of progress for UMN work.

Activity Status as of May 15, 2014**:**

Three components of work were completed or initiated since the last report submitted 11/15/2013.

1. Stem / branch visual evaluation was completed at all sites independently by three individuals. Staff examined trees for symptoms of EAB infestation such as woodpecker damage and splitting bark, as well as signs of EAB infestation including larval galleries and adult exit holes. All observations were made from the ground with unaided vision or binoculars and the amount of time spent examining each tree was recorded. Trees were examined until signs or symptoms were discovered or the individual determined no signs or symptoms were visible. The initial assumption was that trees with heavier levels of infestation would require less time to determine their status as infested.

Table 3. Summarized results from the "canopy-off" visual assessment of 35 trees at each study site, November 14, 2013 – April 18, 2014.

Site (Dates of assessment)	Number Trees Woodpecked			Number Trees EAB Positive			Average Time Spent Assessing Each Tree		
	Person1	Person2	Person3	Person1	Person2	Person3	Person1	Person2	Person3
GRB K. Bluff (11/14, 12/19)	35	35	35	27	27	23	< 10 seconds	1–3 minutes	1-3 minutes
GRB K. Valley (11/14, 12/19)	32	32	34	11	17	10	1-3 minutes	1-3 minutes	1-3 minutes
Fort Snelling (1/16)	20	20	20	4	6	3	10-60 seconds	10-60 seconds	10-60 seconds
Roseville (12/17, 12/23, 1/9)	3	2	9	2	0	1	1-3 minutes	10-60 seconds	1-3 minutes
Minneapolis (12/26, 12/30, 1/27)	4	6	13	0	1	1	1-3 minutes	1-3 minutes	1-3 minutes
St Paul (12/13, 12/24, 12/31)	11	12	14	4	2	0	1-3 minutes	10-60 seconds	1-3 minutes
Shoreview (12/12, 12/13, 1/10)	2	2	4	1	1	1	1-3 minutes	10-60 seconds	1-3 minutes
Duluth (3/25, 4/18)	0	0	0	0	0	0	10-60 seconds	10-60 seconds	10-60 seconds

2. Branch and whole tree sampling was completed at 3 sites (both Great River Bluffs State Park sites and Fort Snelling State Park) prior to November 15 (see report for previous period). Branch sampling at the remaining 5 sites was mostly completed between November 15 and May 15 with the exception of the Duluth site. Due to heavy snow, 7 of the 35 trees at the Duluth site could not be accessed when the rest of the trees were sampled on April 17. Those 7 trees will be sampled after May 15 when the snow has melted and the ground dries out enough for equipment to be brought in for sampling.

   Prior to branch sampling, Joint Powers Agreements were put in place with the 5 municipal cooperators to enable them to collect branches and remove whole trees for sampling. The branch sampling protocol was to collect two branches from each of the study trees that had suitable branches available. Branches must be live, in the size range of 2-6" in diameter and attached to a stem (rather than attached to a lateral branch). Some trees only had one branch suitable for sampling. In a few cases the identified study tree did not have suitable branches but an adjacent tree did and the adjacent tree was sampled instead.

Two whole trees were felled and sampled at each site to estimate EAB density within stems as well as branches. The trees to be removed were selected by numbering the available trees and then choosing the numbers using a random number generator. Only trees 20" in diameter or less were included in the sample pool for logistical purposes. The whole trees were sampled completely including the entire stem and also branches down to 2" in diameter. For both branch and whole tree sampling, each EAB gallery was recorded along with information about the development and condition of the gallery and life stage (if present).

Table 4. Summarized results from branch sampling at study sites, October 8 – April 18. Seven trees remain to be sampled at the Duluth site. Fewer than 35 trees were branch sampled at some sites due to a lack of suitable branches on some trees.

Site	Est. EAB Density	Setting	Number Trees Branch Sampled	Number Trees Infested	Average EAB Galleries / square meter in branches*	Size of Whole Trees Sampled (DBH inches for 2 trees)	Average EAB Galleries / square meter in whole trees**
GRB K. Bluff	Very High	Wooded	35	35	79.3	(4.5, 13.0)	99.5
GRB K. Valley	High	Semi-wooded	34	31	22.4	(9.5, 9.25)	13.4
Fort Snelling	Moderate	Wooded	33	28	9.3	(7.0, 9.25)	6.4
Roseville	Moderate	Urban	35	6	4.3	(15.0, 9.0)	0.04
Minneapolis	Low	Urban	35	3	2.9	(6.25, 9.75)	0
St Paul	Low	Urban	35	15	9.6	(5.5, 8.25)	0***
Shoreview	Very Low	Urban	35	1	0.3	(12.5, 12.5)	0
Duluth	Very Low	Semi-wooded	27	0	0	(5.0, 6.5)	0

*Total number of EAB galleries found / total surface area of all branches sampled
**Total number of EAB galleries found / total surface area of both trees that was sampled
***St Paul removed trees that were discovered to be infested through this work and 2-3 logs were sampled from the stems of each of 8 of those trees. EAB was found in samples from 7 of the trees and the average density of galleries was 10.3 galleries / square meter.

Figures 10 – 17. Status of EAB within study sites during winter 2013/2014. These figures were omitted from this report as the document had become too large to email.

3. Purple prism trap placement began on April 22 and was ongoing at the time of this report. Targeted density for traps is approximately 1 trap per hectare (~2.5 acres) or as many as the site will support. Traps will be monitored throughout the summer for EAB activity.

Table 5. Numbers of purple prism traps placed per site.

Site	Area – Hectares (Acres)	Number of traps placed
GRB K. Bluff	1.3 (3.3)	2
GRB K. Valley	0.3 (0.8)	1
Fort Snelling	2.3 (5.7)	2
Roseville	62.8 (155.2)	48
Minneapolis	27.6 (68.3)	27
St Paul	43.0 (106.3)	30
Shoreview	38.9 (96.1)	38
Duluth	8.6 (21.2)	Not placed yet

Activity Status as of November 15, 2014**:**

Chris Mallet was hired by MDA as the new project coordinator after William Martin resigned from that position. Chris has implemented or initiated three aspects of the project since the last update on May 15, 2014: prism trap survey, canopy condition assessment and 2014/2015 branch sampling.

Prism Trap Survey

Prism trap placement was completed and traps were monitored and serviced throughout the summer at each site. Traps were checked for presence of EAB at approximately two month intervals. EAB lures were also changed at this time. Figures 18 – 25 show trap results with status of study trees as known at this time.

Table 7. Number of purple prism traps placed per site including results

Site	Area – Hectares (Acres)	Number of traps placed	Traps/Hectare	Number of Positive Traps (and %)
GRB K. Bluff	1.3 (3.3)	2	1.5	2 (100%)
GRB K. Valley	0.3 (0.8)	1	3.3	1 (100%)
Fort Snelling	2.3 (5.7)	2	0.87	2 (100%)
Roseville	62.8 (155.2)	48	0.76	12 (25%)
Minneapolis	27.6 (68.3)	27	0.97	0 (0%)
St Paul	43.0 (106.3)	30	0.69	9 (30%)
Shoreview	38.9 (96.1)	38	0.97	0 (0%)
Duluth	8.6 (21.2)	8	0.93	0 (0%)

Figures 18 – 25. Purple prism trap placement in relation to known infested study trees. These figures were omitted from this report as the document had become too large to email.

Canopy Condition Assessment

The "canopy on" visual assessment of 35 trees within each study area was accomplished from August 18 to September 15. The trees were evaluated by the same criteria as the previous year.
The canopy of each tree was rated for condition as follows:
1 – No canopy loss
2 – Some canopy loss (loss apparent, but less than half of canopy lost)
3 – Significant canopy loss (half of canopy lost)
4 – Major canopy loss (more than half of canopy lost)
5 – No canopy present

In addition, each tree was assessed for

- epicormic shoots (along with canopy condition an indicator of stress)
- woodpecker damage (a key indicator of EAB activity)
- EAB galleries and exit holes

Table 6. Summarized results from the "canopy-on" visual assessment of 35 trees at each study site

Site	Est. EAB Density	Setting	Mean DBH (inches)	Mean Canopy Condition 2014	Number Trees Woodpecked
GRB K. Bluff	Very High	Wooded	8.3	4.4	35
GRB K. Valley	High	Semi-wooded	9.8	3.4	34
Fort Snelling	Moderate	Wooded	10.5	1.6	22
Roseville	Moderate	Urban	17.3	1.6	3
Minneapolis*	Low	Urban	18.5	1.5	0
St Paul**	Low	Urban	17.6	1.4	0
Shoreview***	Very Low	Urban	18.4	1.2	0
Duluth	Very Low	Semi-wooded	13.2	1.8	0

* 3 trees evaluated in 2013 were removed and assessment were made on 3 new trees at the site
** 14 trees evaluated in 2013 were removed and assessment were made on 14 new trees at the site
*** 2 trees evaluated in 2013 were removed and assessment were made on 2 new trees at the site

2014/2015 Branch Sampling

Branch sampling has recently started. Sampling by MDA staff was conducted at the Fort Snelling site October 7 - October 9 (summarized in table 8). At this time 15 trees have been sampled and the remaining trees will be sampled at a later date. Sampling at Great River Bluffs will begin on November 12. Joint Powers Agreements are in process with the 5 municipal cooperators to enable them to collect branches and remove whole trees for sampling. This work will be completed between the end of November and April 30.

Table 8. Summary of branch sampling results to date

Site	Est. EAB Density	Setting	Number Trees Branch Sampled	Number Trees Infested
Fort Snelling	Moderate	Wooded	15	12

Activity Status as of May 15, 2015:

Three components of work were completed or initiated since the last report submitted 11/15/2014: stem/branch visual evaluation of trees with canopy off, branch sampling for the 2014/2015 winter and purple prism trap placement.

1. "Canopy off" stem/branch visual evaluation was completed at all sites independently by three individuals. Staff examined trees for symptoms of EAB infestation such as woodpecker damage and splitting bark, as well as signs of EAB infestation including larval galleries and adult exit holes. All observations were made from the ground with unaided vision or binoculars and the amount of time spent examining each tree was recorded. Trees were examined until signs or symptoms were discovered or the individual determined no signs or symptoms were visible.

Table 9. Summarized results from the "canopy-off" visual assessment of 35 trees at each study site, 1/20/15-4/29/15.

Site (Dates of assessment)	Number Trees Woodpecked			Number Trees EAB Positive			Average Time Spent Assessing Each Tree		
	Person1	Person2	Person3	Person1	Person2	Person3	Person1	Person2	Person3
GRB K. Bluff (4/22) *	35	35	35	32	32	32	10-60 seconds	10-60 seconds	10-60 seconds
GRB K. Valley (4/22) **	35	35	35	27	23	31	10-60 seconds	1-3 minutes	10-60 seconds
Fort Snelling (4/14, 4/15, 4/29) ***	28	30	32	21	22	21	1-3 minutes	1-3 minutes	1-3 minutes
Roseville (10/11, 1/26, 3/9)	7	10	10	1	1	1	1-3 minutes	1-3 minutes	10-60 seconds
Minneapolis (1/26, 3/6)	1	1	2	0	0	0	1-3 minutes	1-3 minutes	10-60 seconds
St Paul (1/20)	8	9	9	1	2	2	1-3 minutes	1-3 minutes	10-60 seconds
Shoreview (1/20)	1	1	1	0	0	0	10-60 seconds	10-60 seconds	10-60 seconds
Duluth (3/2, 3/26)	0	0	0	0	0	0	1-3 minutes	1-3 minutes	3-5 minutes

* 15 new trees were selected within the study site to assess due to tree removals during sampling
** 13 new trees were selected within the study site to assess due to tree removals during sampling
*** 9 new trees were selected within the study site to assess due to tree removals during sampling

2. Branch and whole tree sampling was completed at each of the study sites. 35 trees were sampled at each site with the exception of Fort Snelling. 17 trees were branch sampled at Fort Snelling. The remaining trees did not have accessible branches and were too large to fell safely by MDA staff. New trees were selected for sampling this year to replace trees that were removed since last year's sampling. Fourteen trees in St. Paul, 9 in Roseville, 3 in Minneapolis and 2 in Shoreview were selected as replacement trees this year. The branch sampling protocol was to collect two branches from each of the study trees that had suitable branches available. Branches must be live, in the size range of 2-6" in diameter and attached to a stem (rather than attached to a lateral branch).

   Two whole trees were felled and sampled at each site to estimate EAB density within stems as well as branches. The trees to be removed were selected by numbering the available trees and then choosing the numbers using a random number generator. Only trees 20" in diameter or less were included in the sample pool for logistical purposes. The whole trees were sampled completely including the entire stem and also branches down to 2" in diameter. For both branch and whole tree sampling, each EAB gallery was recorded along with information about the development and condition of the gallery and life stage (if present).

Table 10. Summarized results from branch sampling at study sites, October 7 – April 15. Fewer than 35 trees were branch sampled at some sites due to a lack of suitable branches on some trees.

Site	Est. EAB Density	Setting	Number Trees Branch Sampled	Number Trees Infested	Average EAB Galleries / square meter in branches*	Size of Whole Trees Sampled (DBH inches for 2 trees)	Average EAB Galleries / square meter in whole trees**
GRB K. Bluff	Very High	Wooded	35	35	70.54	(7.5, 6.3)	57.84
GRB K. Valley	High	Semi-wooded	35	35	55.18	(8.5, 6.25)	64.69
Fort Snelling	Moderate	Wooded	17	14	17.78	(8, 6)	13.32
Roseville	Moderate	Urban	35	8	5.77	(19.3, 6)	0.038
Minneapolis	Low	Urban	35	1	0.75	(14.5 , 18.5)	0.00
St Paul	Low	Urban	35	9	2.34	(8, 8.6)	0.30
Shoreview	Very Low	Urban	35	0	0.00	(16.6, 17)	0.00
Duluth	Very Low	Semi-wooded	35	0	0.00	(3.5, 8.5)	0.00

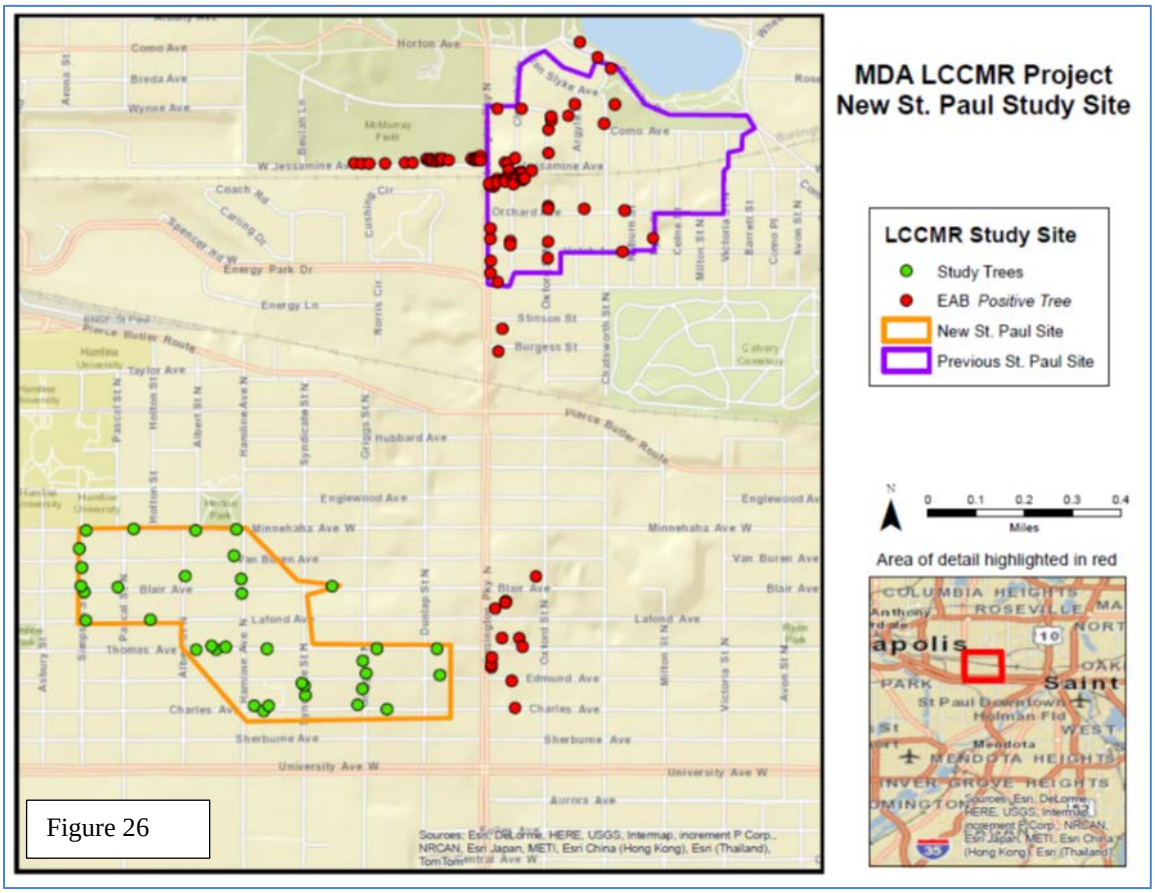
*Total number of EAB galleries found / total surface area of all branches sampled
**Total number of EAB galleries found / total surface area of both trees that were sampled

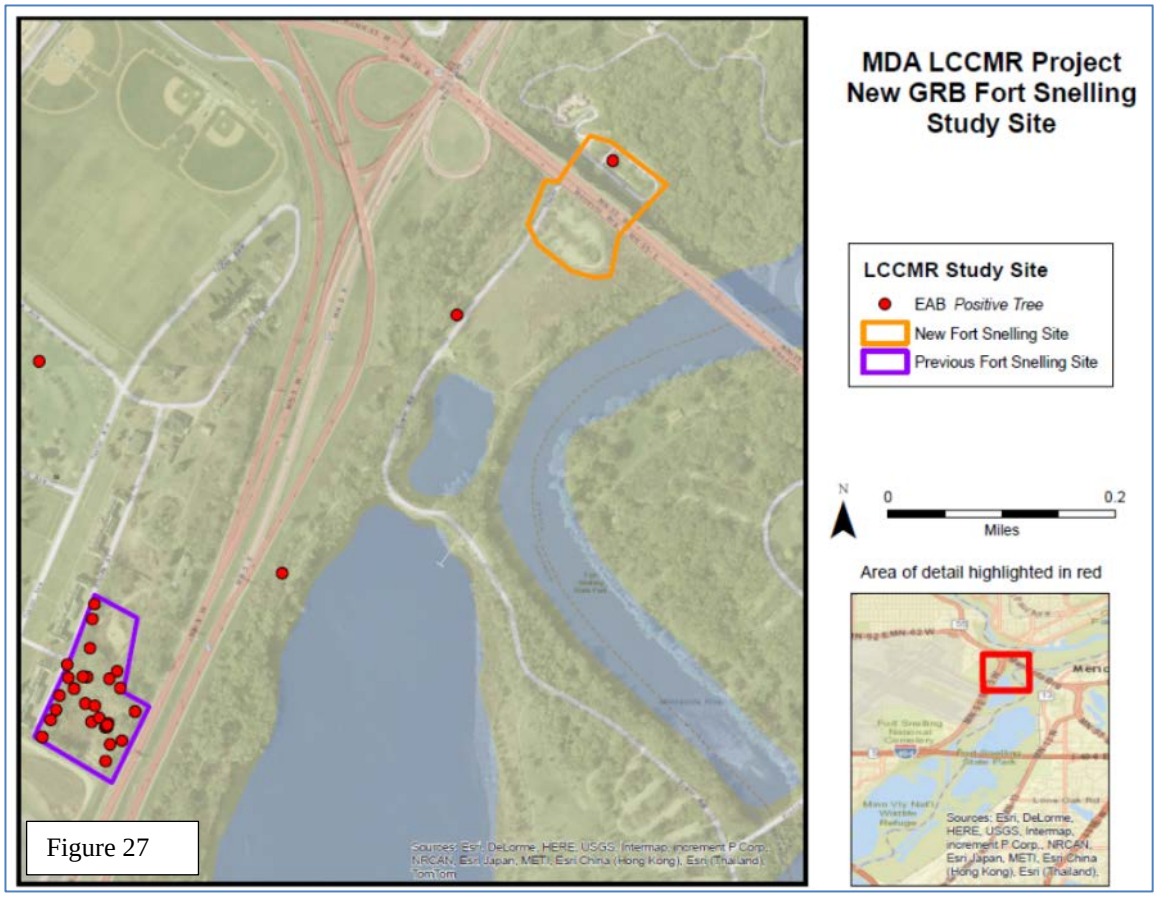
3. Purple prism trap placement began on April 29, 2015 and was ongoing at the time of this report. Targeted density for traps is approximately 1 trap per hectare (~2.5 acres) or as many as the site will support. Traps will be monitored throughout the summer for EAB activity.

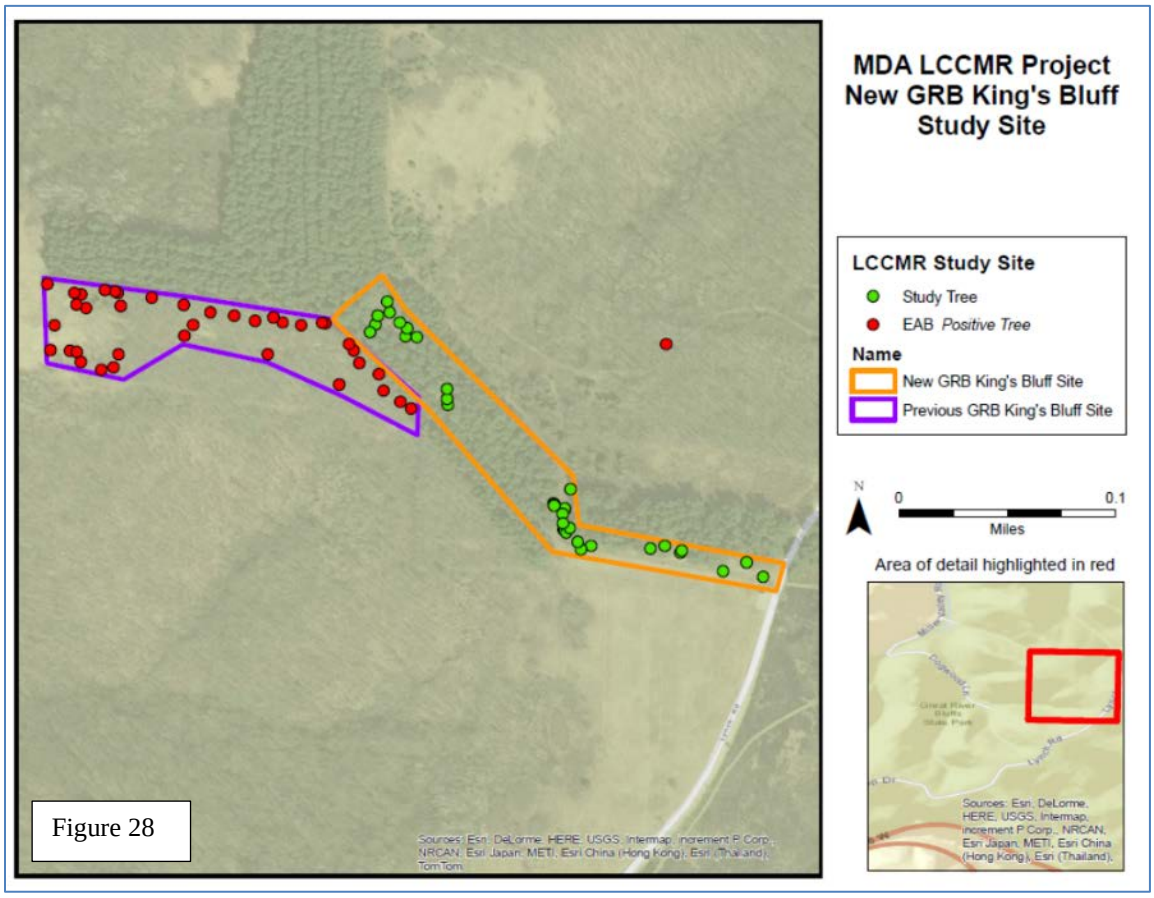
Table 11. Numbers of purple prism traps placed per site.

Site	Area – Hectares (Acres)	Number of traps placed
GRB K. Bluff	1.3 (3.4)	2
GRB K. Valley	1.1 (2.7)	2
Fort Snelling	2.2 (5.4)	
Roseville	62.8 (155.2)	
Minneapolis	27.6 (68.3)	
St Paul	45.5 (112.4)	
Shoreview	38.9 (96.1)	
Duluth	8.6 (21.2)	

Alternative site selection was also completed for St. Paul, Fort Snelling and Great River Bluffs State Park. The St. Paul study site was relocated due to the high number of ash tree removed as part of city EAB management. The new study site is located less than a mile from the original site and less than a half mile from trees known to be infested with EAB. The Fort Snelling site was moved due to the lack of trees that can be sampled by MDA staff. The new location is about one half mile from the current site with EAB present within the site. News trees have not yet been selected. New trees were selected at each of the sites at Great River Bluffs State Park due to high levels of EAB mortality of study trees. Living trees were selected to use for trap placement, canopy assessment and branch sampling during the next project year. Figures 26-29 show locations of the new study sites relative to previous locations.


MDA LCCMR Project
New St. Paul Study Site
LCCMR Study Site
Study Trees
EAB Positive Tree
New St. Paul Site
Previous St. Paul Site
N
0 0.1 0.2 0.3 0.4
Miles
Area of detail highlighted in red
Figure 26


MDA LCCMR Project
New GRB Fort Snelling
Study Site
LCCMR Study Site
EAB Positive Tree
New Fort Snelling Site
Previous Fort Snelling Site
N
0 0.2
Miles
Area of detail highlighted in red
Figure 27



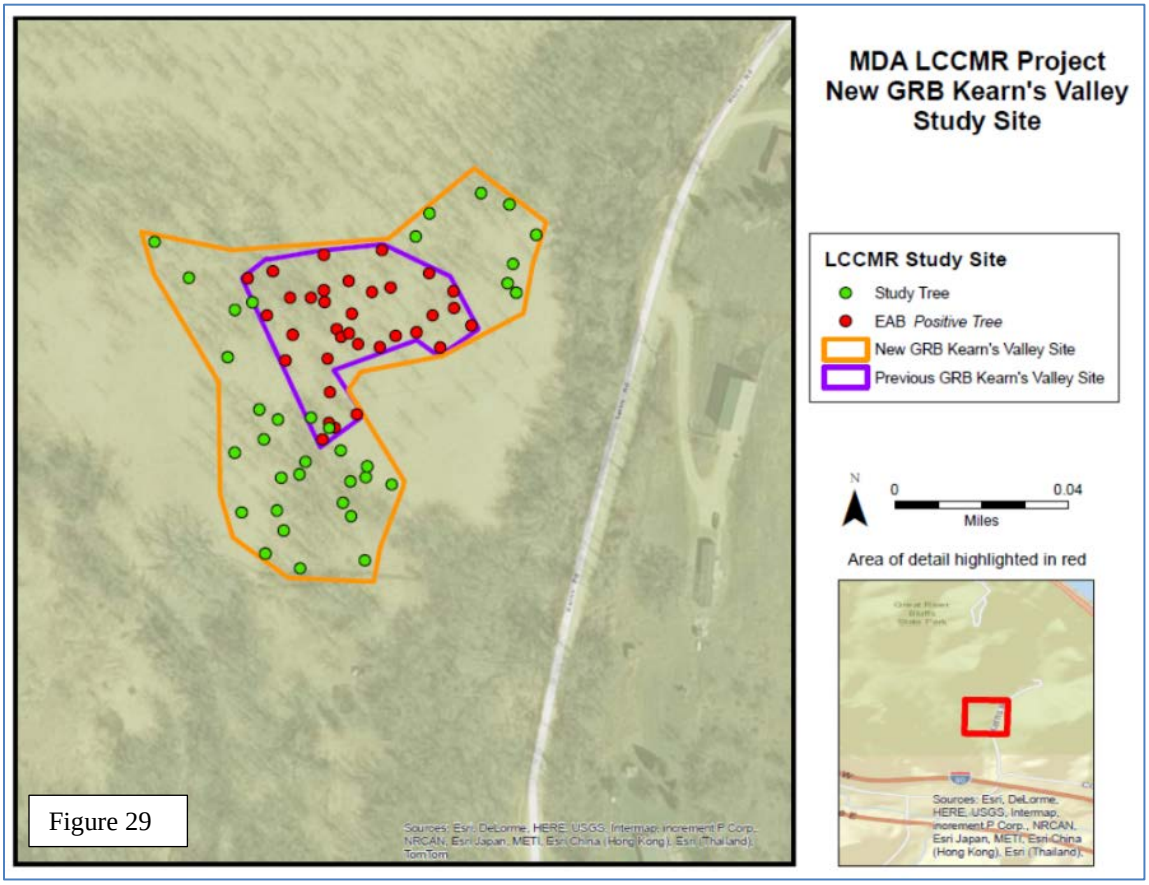


Figure 26-29 show new locations of study sites relative to initial study sites and infest trees.

Activity Status as of November 15, 2015:

Three components of the project were completed or initiated since the last report submitted 5/15/2015: prism trap survey, canopy condition assessment and 2014/2015 branch sampling.

1. Prism trap placement was completed and traps were monitored and serviced throughout the summer at each site. Traps were checked for presence of EAB and lures were changed at approximately two month intervals.

Table 12. Summarized results from prism taps placed from 4/30/2015-11/2/2015

Site	Area – Hectares (Acres)	Number of traps placed	Traps/Hectare	Number of Positive Traps (and %)
GRB K. Bluff*	1.38 (3.41)	2	1.44	2 (100%)
GRB K. Valley*	1.09 (2.70)	2	1.83	2 (100%)
Fort Snelling*	2.05 (5.07)	2	0.97	1 (50%)
Roseville	62.80 (157.24)	45	0.71	18 (40%)
Minneapolis	27.65 (68.32)	26	0.94	0 (0%)
St Paul*	45.5 (112.49)	36	0.79	1 (2.7%)
Shoreview	38.91 (96.15)	38	0.97	2 (5.2%)
Duluth	8.61 (21.29)	8	0.93	0 (0%)

* New study site location – as described in the last update, these sites needed to be moved slightly due to extensive loss of ash trees

2. The "canopy on" visual assessment of 35 trees within each study area was accomplished from August 12 to August 31. Trees were evaluated by the same criteria as previous years.
   The canopy of each tree was rated for condition as follows:
   1 – No canopy loss
   2 – Some canopy loss (loss apparent, but less than half of canopy lost)
   3 – Significant canopy loss (half of canopy lost)
   4 – Major canopy loss (more than half of canopy lost)
   5 – No canopy present
   In addition, each tree was assessed for
   - epicormic shoots (along with canopy condition an indicator of stress)
   - woodpecker damage (a key indicator of EAB activity)
   - EAB galleries and exit holes

Table 13. Summarized results from the "canopy-on" visual assessment of 35 trees at each study site

Site	Est. EAB Density	Setting	Mean DBH (inches)	Mean Canopy Condition 2015	Number Trees Woodpecked
GRB K. Bluff*	Very High	Wooded	4.7	2	30
GRB K. Valley*	High	Semi-wooded	8.3	3	29
Fort Snelling*	Moderate	Wooded	8	1.4	2
Roseville**	Moderate	Urban	16.1	1.4	3
Minneapolis***	Low	Urban	18.6	1.7	0
St Paul*	Low	Urban	17.1	1.3	0
Shoreview****	Very Low	Urban	18.6	1.3	0
Duluth*****	Very Low	Semi-wooded	13.3	1	0

* New study site location for 2015-2016 winter. Trees were not evaluated in previous years.

** 7 new trees were selected due to removals within the study site

*** 8 new trees were selected due to removals and treatments within the study site
**** 2 new trees were selected due to removals and treatments within the study site
***** 1 new tree was selected due to a removal within the study site

3. Branch sampling has begun for this winter. MDA staff have completed sampling at the Fort Snelling site as well as Great River Bluffs. MDA was assisted by a Conservation Corps Crew for sampling in Great River Bluffs. Duluth sampling has also been completed in conjunction with the city. Duluth was completed early this year as to not wait for snow melt to occur in the spring to allow crews to access the site. The remaining study sited will be sampled in November and December.

One exciting occurrence this field season was first detection of EAB for a Minnesota county using the branch sampling/peeling method. Emerald ash borer was found on Monday October 20, while branch sampling at the Park Point study site in Duluth. The following day, two more trees were also found to have EAB. This infestation was discovered very early and it is estimated EAB has only been present on the site for about 2 years.

A second success this field season was the recovery of the EAB parasitoid, *Tetrastichus planipennisi*. The parasitoid was found multiple times in EAB galleries while branch sampling at the Great River Bluffs field site. These parasitoids were released as part of a different LCCMR project entitled "Biosurvelliance and Biocontrol" of EAB. The branch sampling from this project is directly aiding in the data collection for this project and validating the presence *T. planipennisi* and its ability to overwinter and establish in Minnesota.

Table 14. Branch sampling progress to date.

Site	Est. EAB Density	Setting	Number Trees Branch Sampled	Whole Trees Sampled
GRB K. Bluff	Very High	Wooded	35	2
GRB K. Valley	High	Semi-wooded	35	2
Fort Snelling	Moderate	Wooded	35	2
Duluth	Very Low	Semi-wooded	35	2

Activity Status as of May 15, 2016

Two components of the project were completed since the last report was submitted: branch and whole tree sampling for the 2015/2016 winter and the "canopy-off" visual evaluation of the 35 study trees at each site.

1. Branch sampling has been completed for the final season. MDA staff dissected 70 branch samples from each of the 8 study sites. Branches were removed from the canopy and the outer bark was removed to find present EAB larvae or galleries from past larvae. Two whole trees were felled and dissected at each site as well.

Table 15. Branch sampling results from 2015/2016 winter.

Site	Est. EAB Density	Setting	Number Trees Branch Sampled	Number Trees Infested	Average EAB Galleries / square meter in branches*	Size of Whole Trees Sampled (DBH inches for 2 trees)	Average EAB Galleries / square meter in whole trees**
GRB K. Bluff	Very High	Wooded	35	34	53.87	(3.7, 4.3)	19.71

GRB K. Valley	High	Semi-wooded	35	35	87.9	(6.2, 4.1)	3.95
Fort Snelling	Moderate	Wooded	33	14	3.98	(5.8, 9.6)	3.92
Roseville	Moderate	Urban	35	6	5.18	(6.4, 6.9)	0
Minneapolis	Low	Urban	35	0	0	(14.3, 8.7)	0
St Paul	Low	Urban	35	2	0.19	(6.5, 11.3)	0
Shoreview	Very Low	Urban	35	0	0	(19.8, 19)	0
Duluth	Very Low	Semi-wooded	35	1	1.14	(4.0, 4.2)	0

*Total number of EAB galleries found / total surface area of all branches sampled

**Total number of EAB galleries found / total surface area of both trees that was sampled

2. "Canopy off" visual evaluation was completed at all sites independently by three individuals. Staff examined trees for symptoms of EAB infestation such as woodpecker damage and splitting bark, as well as signs of EAB infestation including larval galleries and adult exit holes. All observations were made from the ground with unaided vision or binoculars and the amount of time spent examining each tree was recorded. Trees were examined until signs or symptoms were discovered or the individual determined no signs or symptoms were visible.

Table 16. Visual survey results from 2015/2016 winter.

Site (Dates of assessment)	Number Trees Woodpecked			Number Trees EAB Positive			Average Time Spent Assessing Each Tree		
	Person1	Person2	Person3	Person1	Person2	Person3	Person1	Person2	Person3
GRB K. Bluff (11/2/15)	31	32	33	25	24	26	1-3 min.	10-60 sec.	1-3 min.
GRB K. Valley (11/2/15)	35	34	35	31	32	32	1-3 min.	10-60 sec.	1-3 min.
Fort Snelling (10/5/215, 10/7/215, 10/9/215)	8	7	4	4	2	3	10-60 sec.	1-3 min.	10-60 sec.
Roseville (12/21/15)	9	11	9	1	1	1	1-3 min.	1-3 min.	1-3 min.
Minneapolis (12/22/15)	0	7	1	1	0	0	1-3 min.	1-3 min.	1-3 min.
St Paul (12/21/15)	1	3	4	0	0	0	1-3 min.	1-3 min.	10-60 sec.
Shoreview (1/21/16)	2	6	6	0	0	1	1-3 min.	1-3 min.	1-3 min.
Duluth (10/15/15, 10/19/15)	0	0	0	0	0	0	10-60 sec.	1-3 min.	1-3 min.

The preliminary results of this project (prior to analysis by U of M) indicate that visual survey is a good indicator of the presence of significant EAB infestations. We used a risk map developed by the US Forest Service for EAB to identify areas at high risk of invasion but not yet confirmed as EAB infested. In addition to work at the study sites, MDA also conducted randomized visual survey for EAB in areas. We identified these areas (see Figure 30) and then created random points along roadways. Points were visited during the winter and ash trees within site of the road were visually inspected for signs of EAB infestation (as at the study sites) along a 100 m stretch of road.

We were able to inspect about 250 ash trees at 60 sites in the greater Twin Cities area (Figure 31). We did not find any evidence of EAB which based on our preliminary project results is indicative of no significant infestation present yet at these sites. In the Duluth area we were able to inspect about 850 trees at 213 sites (Figure 32). We were not able to find any evidence of EAB infestation in this area either, although this project did discover the first occurrence of EAB in Duluth on Park Point in October, 2015.

Moreover, we also applied the information gained through this project to assist cities with recent finds of EAB to better gauge the level of infestation in their city through visual evaluation of ash trees during the winter. We assisted 6 communities to better determine the distribution and abundance of EAB within their cities (Table 17).

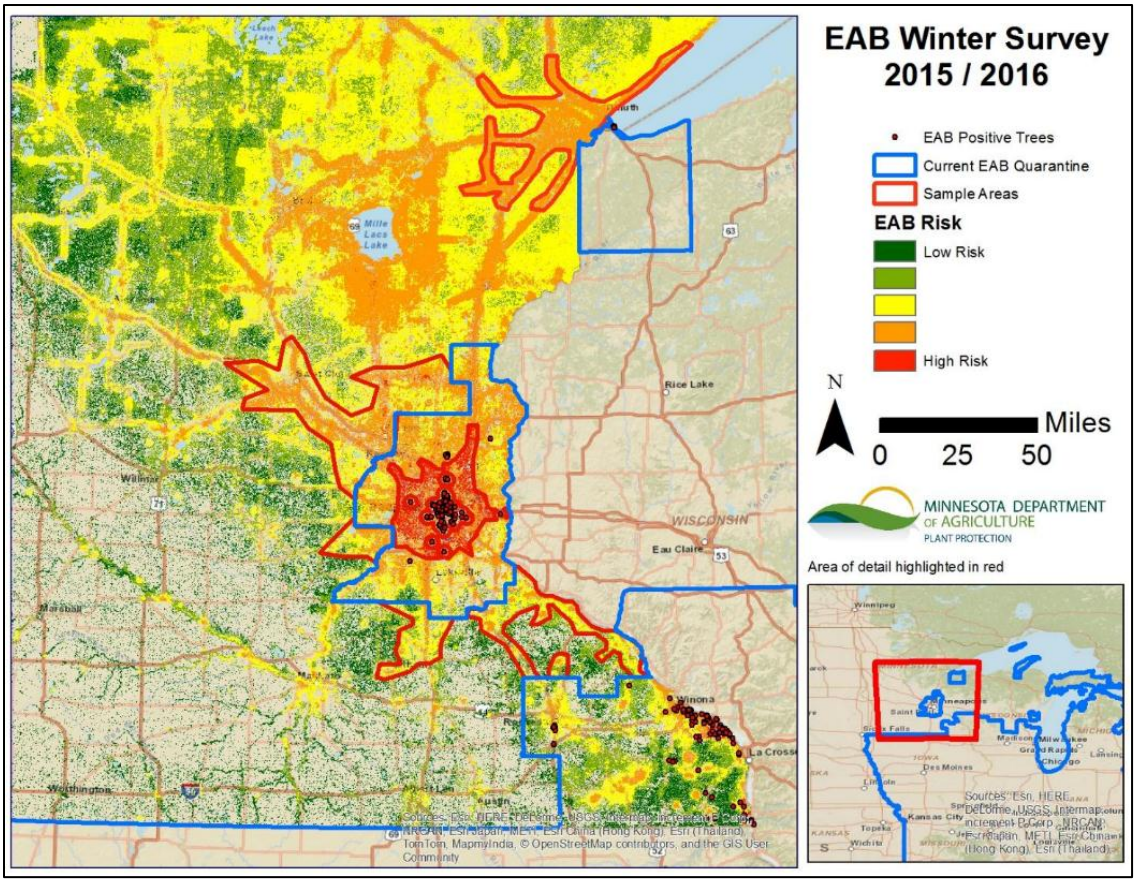


Figure 30. Risk map for EAB and areas selected for survey outside of known EAB-infested areas.

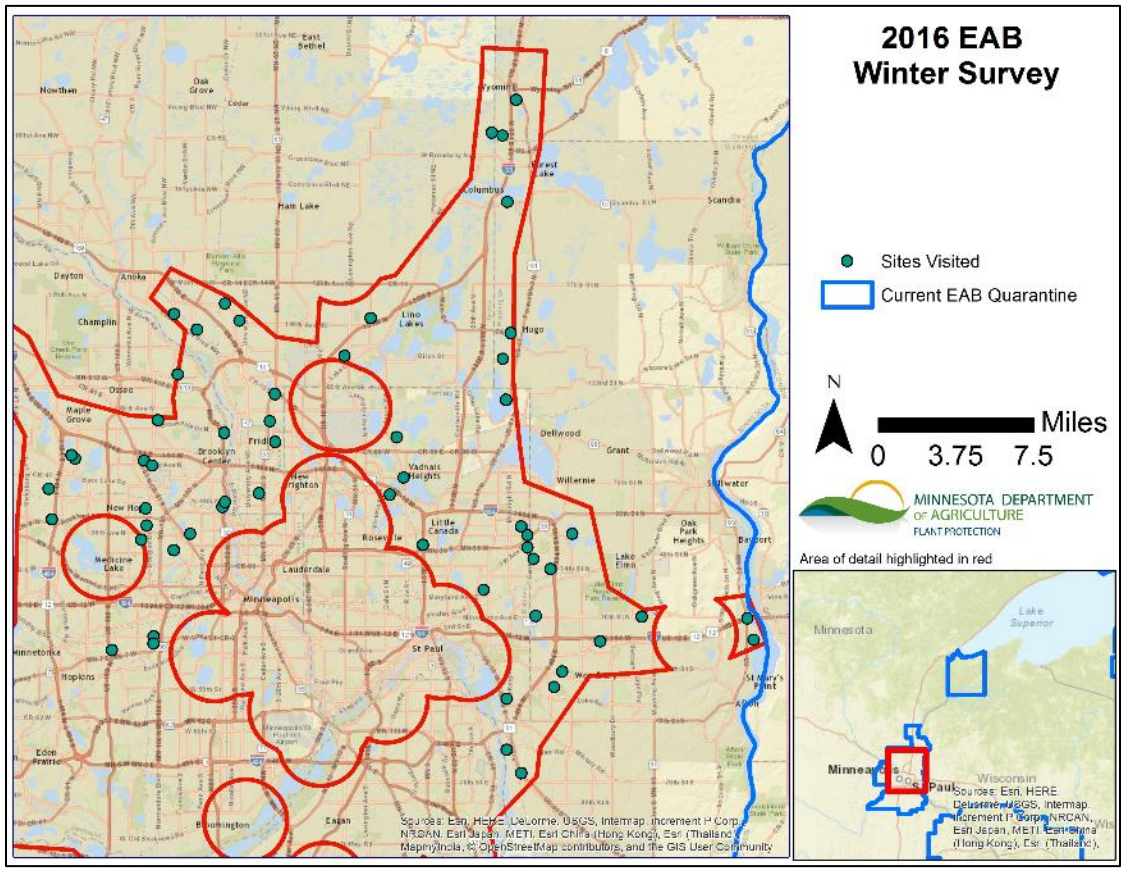


Figure 31. Randomized EAB survey in the Greater Twin Cities area.

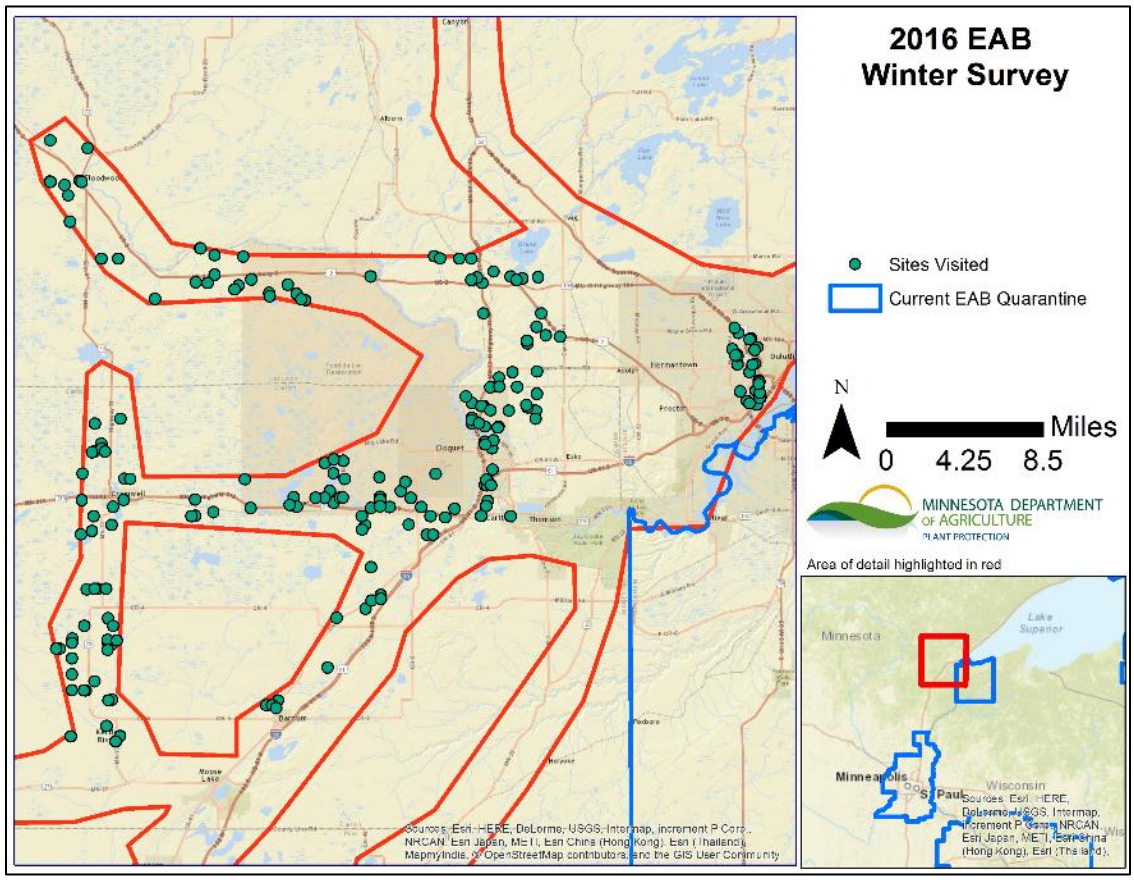


Figure 32. Randomized EAB survey in the Greater Duluth area.

Table 17. Results from visual surveys in communities during 2015/2016 winter.

Date	City	Results
March 10	Plymouth	Discovered 3 infested trees in known infested area
April 1	Apple Valley	Discovered 21 infested trees outside but near known area
April 5	Prior Lake	Found 6 infested trees in known infested area
April 8 and 22	West St Paul	Found 2 new locations of infested trees 1.5 miles apart
April 26	Chisago / Washington County	Found infested trees in known infested area
April 27	Roseville	Found 72 infested trees in multiple new locations
May 3	South St Paul	Did not find any infested trees

Activity Status as of November 15, 2016

During this activity period we prepared the final data set summarizing all three years of field studies and delivered the data to the U of M. We have made some preliminary assessments of the data which indicate that all three survey methods were successful at detecting EAB and would have been able to inform management efforts at study sites prior to significant damage from EAB. The U of M analytical work will provide a finer grained analysis as to the relative efficacy of each of the sampling methods. The primary findings of the project indicate that monitoring for EAB can be an effective addition to a communities EAB management plan.

Final Report Summary:

The emerald ash borer detection project was initiated in the summer of 2013. At that time EAB infestations were documented in Ramsey, Hennepin, Houston, Winona counties. Eight study sites with varying ranges of EAB densities in both rural and urban setting were chosen. The yearly sampling regime for the course of the project was as follows:

- May through September, purple prism traps were placed in the sites at a target density of one trap/hectare and monitored for EAB adults.
- In August, all observable ash trees were evaluated for canopy condition as well as any visible signs of EAB. These observations were made by a single individual and was meant to be a general measure of tree health at the study site.
- Fall through spring when no leaves were present, 35 trees at each study site were visually evaluated for symptoms of EAB such as woodpecker foraging or loose, splitting bark. This observation was made independently by three individuals. To score a tree as EAB positive, two of the three individuals must have observed EAB symptoms.
- Fall through spring, two branches were removed from each of the 35 trees and the bark removed to search for EAB larval feeding tunnels. In addition, two entire trees were felled and sampled in order to gauge the EAB density in standing trees.

In total, two years of purple prism trapping, three years of leaf canopy condition observations, three years of no leaf stem/branch condition evaluations, and three years of branch and tree sampling occurred (Table 18).

Table 18. Results of project activities over 3 years

Year	Branch Samples Peeled	Positive Trees from Branch Sampling	Whole Trees Sampled	Infested Whole Trees	Trees Visually Surveyed Canopy-Off	Average Positive from Visual Survey*	Purple Prism Traps Set	Positive Prism Traps
2013-2014	632	127	16	7	280	46.3	156	26
2014-2015	533	102	16	8	280	80	459	26
2015-2016	560	92	16	5	280	61.3	NA**	NA**
Total	1,724	321	48	20	840	187.6	615	52

* Positive from visual survey is an average of 3 staff evaluations

** Traps were only planned for the first two years of the project due to the original project timeline

At the start of this project information on all available ash trees was gathered including exact location, DBH (diameter at breast height) and species (green, white or black ash) for each of the 8 study sites. The first canopy condition observations were made to determine the general initial health of each study site. Based on these observations the EAB densities were estimated at two very low (urban and semi-wooded), two low (urban), two moderate (urban, wooded), one high (semi-wooded), and one very high (wooded) site. Four of the sites were moved in 2015 due to high EAB caused mortality and city tree removals or treatments. The new site locations were as close as possible to the original site, had approximately the same amount of EAB pressure, and were approximately the same size. Throughout the course of the project new trees were selected at sites if the original tree was removed or chemically treated.

Highlights over the course of this project include:

- First detection of EAB for a Minnesota county using the branch sampling/peeling method occurred on Park Point in Duluth in 2015. This detection was very early in the process of infestation. Emerald ash borer had only been present in this site for no more than one year. All trees showed no visible outward signs of EAB infestation.
- Recovery of the EAB parasitoid, *Tetrastichus planipennisi*, in EAB galleries while branch sampling/peeling occurred at Great River Bluffs in 2015. The parasitoids were released as part of a different LCCMR project, "Biosurveillance and Biocontrol" of EAB.
- The total number of ash trees evaluated for canopy health was 3,266. Canopy health ratings are used by EAB managers to determine if a tree is a candidate for insecticide treatments.
- Through branch sampling and whole tree sampling we evaluated 10,137 larval galleries.
- Preliminary results indicated visual survey was a good indicator of the presence of significant EAB infestations. We visited 273 randomized points in high risk areas during the 2015/2016 winter, visually inspecting approximately 1,100 trees. No evidence of EAB was found which is indicative of no significant infestations.
- We assisted 14 cities in visually evaluating their ash trees in the winter to gauge the level of EAB infestation in their city. Three new locations were discovered within cities that were over a mile apart, as well as hundreds of trees in the areas surrounding the initial infested trees.
- Over 380 people participated in 2017 EAB Field Workshops where preliminary results were presented. The workshops were conducted through a Forest Service EAB project and also instructed participants in canopy off visual survey techniques.
- More than 120 municipality foresters and ash managers participated in the 2017 EAB Regional Meetings where preliminary results were discussed.
- Contributions were made to a cohesive EAB Management Guidelines document to educate EAB managers on the results of this project as well as other EAB projects funded by LCCMR, USDA and the Forest Service.

During the final activity period we applied the information gained through this project to assist cities with recent finds of EAB to better gauge the level of infestation in their city through visual evaluation of ash trees during the winter. We assisted 8 communities to better determine the distribution and abundance of EAB within their cities (Table 19). To further assist communities, MDA contributed to management guidelines clearly summarizing current EAB research in a single organized document. Contributions are included in the Supplementary Materials and are available on the MDA's EAB webpage, www.mda.state.mn.us/eab.

Table 19. Results from visual surveys in communities during 2016/2017 winter.

Date	City	Results
January 12	Maple Grove	Infested trees within the known infested neighborhood
February 9	Lake City	Infested trees along river and two central neighborhoods 0.5 miles apart

March 30	Eagan	Infested trees throughout a 1 mile radius of the original 2014 tree
April 6	Coon Rapids	Infested trees within the known infested neighborhood
April 17	Wabasha	Infested trees in 5 new areas within the city and along the river
April 21	Andover	New infestation location 1.3 miles from original infested tree
April 26	Red Wing	Infested trees in a new neighborhood and along the river
May 3	Hastings	Infested trees throughout a 0.5 mile radius of the original infested tree

State general funds were used for administration and oversight of this project which included:

- coordination with the University of Minnesota and others working with EAB
- hiring and training temporary employees to implement monitoring work
- development and maintenance of online mapping and reporting systems
- budget administration and report submissions

The MDA also provided the use of office and lab space and equipment, as well as IT equipment and support for the temporary staff working on this project.

US Forest Service funds were used during EAB workshops, meetings, surveys and in the development of a "How to Visually Evaluate Trees for EAB Infestation" video that is available on the MDA's YouTube site, https://youtu.be/Bq9mZKy-3Ao. This video teaches communities all the necessary techniques they need to effectively visually assess ash trees for signs of EAB.

ACTIVITY 2: Implement field and laboratory experiments to examine factors affecting dispersal distances and winter survival of EAB.

Description:

UMN - Part B
We will measure the effect of winter cold on dispersal by measuring the fat content of beetles held under different temperature regimes. It is possible that beetles held at lower temperatures will have lower lipid reserves and therefore shorter dispersal ability. This is an important consideration when predicting spread rates of EAB in different areas of the state. We will also model the relationship between air temperature and the temperature within trees where EAB overwinter. This is a critical gap in our understanding of the impact of winter on EAB. This work will be conducted by Dr. Venette, one graduate student and one undergraduate assistant. Initial work on the overwintering biology of EAB is being completed by Dr. Venette as a result of the ENRTF project "Ecological and Hydrological Impacts of Emerald Ash Borer" which was initiated in July 2010. That work investigated the effect of host (green ash vs black ash) on the supercooling point and lower lethal temperature of EAB. The proposed project would take the next step to investigate the impact of non-lethal cold temperatures on the ability of EAB to disperse. This is an important component in understanding how Minnesota winters will affect the rate of spread and ultimately the impact of EAB.

Summary Budget Information for Activity , MDA – Part A:

ENRTF Budget: $ 0
Amount Spent: $ 0
Balance: $ 0

Activity Completion Date:

Outcome	Completion Date	Budget
1. Measure effect of cold on EAB lipid content and create model.	June, 2016	$ 0
2. Measure relationship between air and within-tree temperatures and create model.	June, 2016	$ 0

Activity Status as of November 15, 2013**:**

See UMN Project Report for description of progress for UMN work.

Activity Status as of May 15, 2014**:**
Activity Status as of November 15, 2014**:**
Activity Status as of May 15, 2015:
Activity Status as of November 15, 2015:
Final Report Summary:

V. DISSEMINATION:

Description:
The primary audience for this work will be municipalities and other entities responsible for managing EAB at the local level. There are many opportunities to address this audience through meetings held throughout the year, both at MDA through the EAB Forum (bimonthly meeting) and also through conferences and meetings held around the state throughout the year. MDA is often invited to provide information about EAB at these meetings and conferences which is likely to continue in the future.

We anticipate that this work will result in the development of guidelines or documents meant to convey the findings of this work and what it means for local level management of EAB. In addition, we expect that this work will result in articles in scientific journals as well as presentations at national scientific meetings. However, ENRTF funds will not be used for travel to national meetings. Significant findings through this work may be communicated through the news media as well as social media.

Status as of November 15, 2013**:**
To date, the purpose and design of this project have been described to municipal foresters and other interested parties at the following events:

- EAB Forum, August 8 – the EAB Forum is a bimonthly EAB update meeting at MDA for federal, state and local units of government. Approximately 25 people attend the meeting in person or via conference call and 135 receive the update which the meeting is based on.
- North Central Forest Pest Workshop, September 24 – Mark Abrahamson gave a presentation on EAB management in the Twin Cities and described this project and how it would benefit that management. The audience of approximately 70 people included representatives from federal, state and provincial governments and University researchers from across the Great Lakes region.
- EAB Forum, October 10

Status as of May 15, 2014**:**
Information about this project was shared at the following events:

- EAB Forum December, St Paul - October 12
- Wisconsin Arborists Association Annual Meeting, Green Bay - January 28 (no project funds were used to attend this meeting)
- EAB Forum, St Paul – December 12
- EAB Forum, St Paul – February 6
- Municipal EAB Meeting, Minneapolis – February 26
- EAB Forum, St Paul – April 3
- North Dakota EAB visit, Fort Snelling – April 8

Status as of November 15, 2014**:**
Information about this project was shared at the following events:

- EAB Forum, St Paul – June 12
- EAB Forum, St Paul – August 14
- EAB Forum, St Paul – October 2

- Manitoba EAB visit, Fort Snelling – October 7-8
- Upper Midwest Invasive Species Conference, October 20 – Mark Abrahamson provided a 20 minute presentation entitled "Efficacy of Emerald Ash Borer Sampling Methods and Application to Management". The presentation explained the need for this work and summarized the findings of the first year. Preliminary conclusions presented indicated that branch sampling was a more sensitive survey tool than visual observation but that the labor costs were approximately four times greater. The degree of sensitivity gained in branch sampling may not have been great enough to justify the increase in labor costs. Also, all survey methods had some utility at detecting EAB at sites before significant canopy decline had occurred and opportunities for management were lost.

Status as of May 15, 2015**:**
Information about this project was shared at the following events:

- EAB Forum, St Paul – December 4, 2014
- EAB Forum, St Paul – February 12, 2015
- EAB Forum, St Paul – April 9, 2015

Status as of November 15, 2015**:**
Information about this project was shared at the following events

- EAB Forum, St Paul – June 4, 2015
- EAB Forum, St Paul – August 6 , 2015
- EAB Forum, St Paul – October 8, 2015
- Results were presented by Mark Abrahamson at an Emerald Ash Borer University Webinar entitled "Manage EAB or Manage the Forest?" Seminar date Thursday October 15, 2015 at 11 am ET: https://www.youtube.com/watch?v=bYQfV6GFBsk&feature=youtu.be
- This study was highlighted in the MDA press release regarding the first detection of EAB in St. Louis County on Park Point in Duluth on October 23, 2015. http://www.mda.state.mn.us/en/news/releases/2015/nr20151023-eabduluth.aspx

Status as of May 15, 2016**:**
Information about this project was shared at the following events

- Regional workshops on EAB management in Rochester on 12/2/15 and Shoreview on 12/9/15
- EAB Forum on 2/11/16
- Minnesota Shade Tree Short Course through presentations entitled "Manage EAB or Manage the Forest?" given on March 15 and 16, 2016
- Minnesota Invasive Species Advisory Committee Quarterly Meeting on April 27, 2016

Status as of November 15, 2016**:**

- Upper Midwest Invasive Species Conference, October 18 – Mark Abrahamson provided a 20 minute presentation on the project and summarized the results demonstrating that all sampling methods were useful for detecting EAB before significant tree damage at study sites. No project funds were used in providing this presentation.

Final Report Summary:
The primary audience for this work was disseminated to municipalities and other entities responsible for managing EAB at the local level. Information was conveyed through meetings held throughout the year, both at MDA through the EAB Forum (bimonthly meeting) and also through conferences and meetings held around the state throughout the year and also at professional and technical conferences.

This work resulted in contributions to a set of draft EAB Management Guidelines to educate EAB managers on the results of this project and others. The draft is included with the final report and will next be reviewed with

partner agencies and other stakeholders. Significant findings from this work were also communicated through the news and social media.

Since the last status update, Information about the results of this project was shared at the following events

- Northern Green Expo, Minneapolis 1/10/17
- EAB Municipal Staff Trainings
    - Maple Grove 1/12/17
    - Lake City 2/9/17
    - Coon Rapids 4/6/17
    - Wabasha 4/17/17
    - Andover 4/21/17
    - Red Wing 4/26/17
    - Hastings 5/3/17
    - Hugo 5/11/17
- EAB Forum, St. Paul 2/2/17
- EAB Field Workshops
    - Rochester - February 21-23, 2017
    - St. Paul – February 27-March 3, 2017
    - Duluth – March 7-9, 2017
- EAB Regional Meetings
    - Twin Cities Metro, Blaine 5/17/17
    - SE MN, Rochester 5/18/17
    - NE MN, Duluth 5/23/17

As new municipalities find EAB infestations we have been able to share the results of this project with them.

V. PROJECT BUDGET SUMMARY:

A. ENRTF Budget:

Minnesota Department of Agriculture

Budget Category	$ Amount	Explanation
Personnel:	~~$163,642~~ $164,407	- One 3 year 80% time Coordinator at the Research Scientist 1 level with mean salary $30,000/year + fringe. MDA anticipates either employing this position at 32 hours per week or funding the remaining 20% through other projects. - Two intermittent staff to help with winter sampling at ~280 hours total per year. - Two temporary staff to help develop materials summarizing results from project
Professional/Technical/Service Contracts:	$57,391	Contract with local units of government cooperators to conduct branch removal for Activity 1 - $19,310/year total among all cooperators for 3 years. Branches will be removed for evaluating the effectiveness of different detection techniques. There are many instances when cooperators will supply labor and equipment as in-kind donations. For instance, we will base estimates on EAB population size from samples taken from trees felled by cooperators. Cooperators will not be reimbursed for

		this activity as the tree felling can be considered part of their normal activities. However, with the threat of EAB, it is not efficient for cooperators to use resources for pruning of ash trees. Since we will be asking them to do something for us they wouldn't otherwise do and city budgets for dealing with EAB are already tight, we will need to be able to cover their time and equipment costs.
Equipment/Tools/Supplies:	~~$2,962~~ $2,990	Supplies for conducting survey and sampling (traps, lures, etc.) - $987/year for 3 years
~~Printing:~~	~~$1,000~~	~~Outreach materials such as fact sheets/brochures (approximately 5,000 copies for $1,000)~~
Travel Expenses in MN:	~~$15,005~~ $15,212	Vehicle and Fuel = $10,505 • Mileage for vehicle rental and fuel at $3,000/year for 3 years • We have 3 options for travel – use MDA minipool, use a personal vehicle, use a rental vehicle – the best option will depend on daily mileage and area traveled – we will choose among these 3 options to be most cost effective Meals and lodging = $4,500 • Coordinator: approx. 15 days of travel/year for 3 years • Project Manager: approx. 5 days of travel/year for 3 years
TOTAL ENRTF BUDGET:	**$ 240,000**	

Explanation of Use of Classified Staff:
MDA would like to use two intermittent Plant Industry Inspectors to help out with winter sampling work on this project. Although these are permanent positions, they are also intermittent meaning that the staff are only employed when work is available. At this point in time we do not foresee other work for these positions during the periods when help is needed on this project and we anticipate that these staff will not be working unless working on this project.

If additional work becomes available that would have resulted in these intermittent position being employed during this time period on other funding, MDA will hire additional temporary staff to perform that other work. Thereby the funds provided by the ENRTF will be used to supplement, not supplant MDA work.

Explanation of Capital Expenditures Greater Than $3,500:
N/A

Number of Full-time Equivalent (FTE) funded with this ENRTF appropriation:
MDA Coordinator: 3 years @ 32 hours / week = 4,992 total hours
MDA Staff to Assist with Sampling: 2 years @ 280 hours total = 560 total hours
MDA Staff to Develop Materials Summarizing Results: 2 staff @ 250 hours = 500 hours
Total Hours = 6,002
Total FTE's = 6,002 hours / 2080 hours per year = 2.92

Number of Full-time Equivalent (FTE) estimated to be funded through contracts with this ENRTF appropriation:
Branch sampling and related work is estimated to require ~500 hours from cooperators over 3 years = 1,500 hours
Total FTE's = 1,500 hours / 2080 hours per year = 2.4

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
USDA Forest Service – MDA has funds to support work related to EAB management from July 1, 2012 through June 30, 2014. There are opportunities to leverage work conducted with these funds towards this project and vice versa.	$187,000	$187,000	These funds support MDA staff working on EAB management.
State			
Field equipment, lab equipment and lab space, computing/software, GIS and data management ($10,000 for MDA), project coordination and overseeing detection and sampling efforts ($35,000 at MDA)	$45,000	$45,000	
TOTAL OTHER FUNDS:	**$232,000**	**$**	

VII. PROJECT STRATEGY:

A. Project Partners:

Receiving funds: Improving EAB detection is a collabrotive effort between MDA (**receiving $240,000**) and University of Minnesota (**receiving $360,000**). MDA will oversee Part A of the project and coordinate detection work among project partners and cooperators. U of M will oversee Part B of the project and lead research efforts for both evaluating EAB detection efficacy and evaluating the impact of temperature on dispersal capability of EAB. Other EAB projects at MDA will be leveraged to support this work where common goals are found. Both MDA and U of M will supply in-kind support through facilities, IT support, equipment and intellectional input.

Cooperators on this project will include entities with EAB infestations on or adjacent to their jurisdiction such as the cities of St Paul, Minneapolis and Shoreview, Ramsey County, DNR and DOT. We will work with cooperators to implement detection activities within their jurisdictions – particularly in the removal of branches for EAB sampling. Some cooperators may be able to donate their time for this work in-kind, other cooperators will be reimbursed for their services using ENRTF funds (**$75,000** total among all cooperators for the entire project – these funds will be passed through from the amount designated for MDA).

Not receiving funds: US Forest Service will provide in-kind support through use of facilities, equipment and intellectual input. Some cooperators at the local level will provide in-kind support through the use of staff and equipment as described above. Like other EAB work within Minnesota, the progress of this project will be shared with a wide group of stakeholders including federal and state agencies, local governments and industry groups.

B. Project Impact and Long-term Strategy:

A more thorough understanding of the capabilities and limitations of detection techniques for EAB will provide a more solid basis for local governments and other entities in making management decisions related to EAB. For instance, current recommendations on when to begin chemical treatment for EAB indicate that trees within 10-15 miles of known EAB infestations are at significant risk of becoming infested and should be considered for treatment. However, our experience in Minnesota indicates that a much tighter buffer should be considered around infested trees which would potentially lead to fewer chemicals used but with greater impact due to concentrating efforts where they are truly needed.

Municipalities are at great risk from EAB due to the heavy reliance on ash in urban areas. Currently, there are no guidelines based on quantitative studies as to what the most efficacious technique for EAB detection is, and what the results from using a given technique mean. Consequently, municipalities are left without good information for detecting EAB and consequently without good information for making decisions related to EAB management.

The outcomes from this project should provide municipalities and other local land managers in Minnesota with the information they need to more confidently assess the presence/absence or distribution of EAB in their community and as a result to plan the most appropriate management actions.

C. Spending History:

Funding Source	M.L. 2007 or FY08	M.L. 2008 or FY09	M.L. 2009 or FY10	M.L. 2010 or FY11	M.L. 2011 or FY12-13
USDA APHIS PPQ – Funds for EAB detection survey (regional level)	$18,000	$330,000	$425,000	$375,000	$425,000
USDA Forest Service – Funds for EAB detection and management (local level)	$50,000	$40,000	$133,500	$133,500	$187,000

VIII. ACQUISITION/RESTORATION LIST:
N/A

IX. MAP(S):
N/A

X. RESEARCH ADDENDUM:

N/A

XI. REPORTING REQUIREMENTS:

Periodic work plan status update reports will be submitted not later than November 15, 2013, May 15, 2014, November 15, 2014, May 15, 2015, November 15, 2015, May 15, 2016, November 15, 2016 and May 15, 2017. A final report and associated products will be submitted between June 30 and August 15, 2017 as requested by the LCCMR.

Final Attachment A: Budget Detail for M.L. 2013 Environment and Natural Resources Trust Fund Projects

Project Title: Improving Emerald Ash Borer Detection Efficacy for Control
Legal Citation: M.L. 2013, Chp. 52, Sec. 2, Subd. 06cA
Project Manager: Mark Abrahamson
M.L. 2013 ENRTF Appropriation: $ 600,000 between MDA ($240,000) and U of M ($360,000)
Project Length and Completion Date: 4 year project, to be completed June 30, 2017
Date of Update: August 11, 2017

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Revised Activity Budget 08/11/2017	Amount Spent	Balance	Activity 2 Budget	Amount Spent	Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM					**Implement field and laboratory experiments to examine factors affecting dispersal distances and winter survival of EAB**				
Personnel (Wages and Benefits) - Direct appropriation to MDA	~~$163,642~~	$164,407	$164,407	$0			$0	$163,642	$0
MDA Coordinator: $139,020 (62% salary, 38% fringe), 80% FTE									
Two intermittent staff to help with winter sampling: $5,980 (88% salary, 12% fringe) at ~280 hours total per year.									
Professional/Technical/Service Contracts - Direct appropriation to MDA									
Joint power agreement for removal of branches for EAB sampling with local government cooperators. Likely cooperators are City of St Paul, Minneapolis Park and Recreation Board, City of Shoreview, potentially others depending on survey design and ability of cooperators to provide in-kind services.	$57,391		$57,391	$0			$0	$57,391	$0
Equipment/Tools/Supplies - Direct appropriation to MDA									
Supplies for conducting survey and sampling - includes, traps, lures, collection bags and vials, handheld tools for dissecting branches, personal protective equipment, etc.	~~$2,962~~	$2,990	$2,990	$0			$0	$2,962	$0
Printing - Direct appropriation to MDA									
Outreach materials such as fact sheets, brochures, etc to provide guidelines regarding EAB detection based on study results (approximately 5,000 copies for $1,000)	~~$1,000~~	$0	$0	$0			$0	$1,000	$0
Travel expenses in Minnesota - Direct appropriation to MDA									
- Vehicle rental and fuel (estimated $9,000) - Meals and lodging for MDA Coordinator (15 days of travel per year for 3 years and MDA Project Manager (5 days of travel per year for 3 years - estimated $2,500)	~~$15,005~~	$15,212	$15,212	$0			$0	$15,005	$0
COLUMN TOTAL			**$240,000**	**$0.00**	**$0**	**$0**	**$0**	**$240,000**	**$0**

Emerald Ash Borer

2017

DEPARTMENT OF AGRICULTURE

mda.state.mn.us/eab

Agenda

Emerald Ash Borer

Life Cycle

Host Trees

Recognizing EAB

Signs & Symptoms

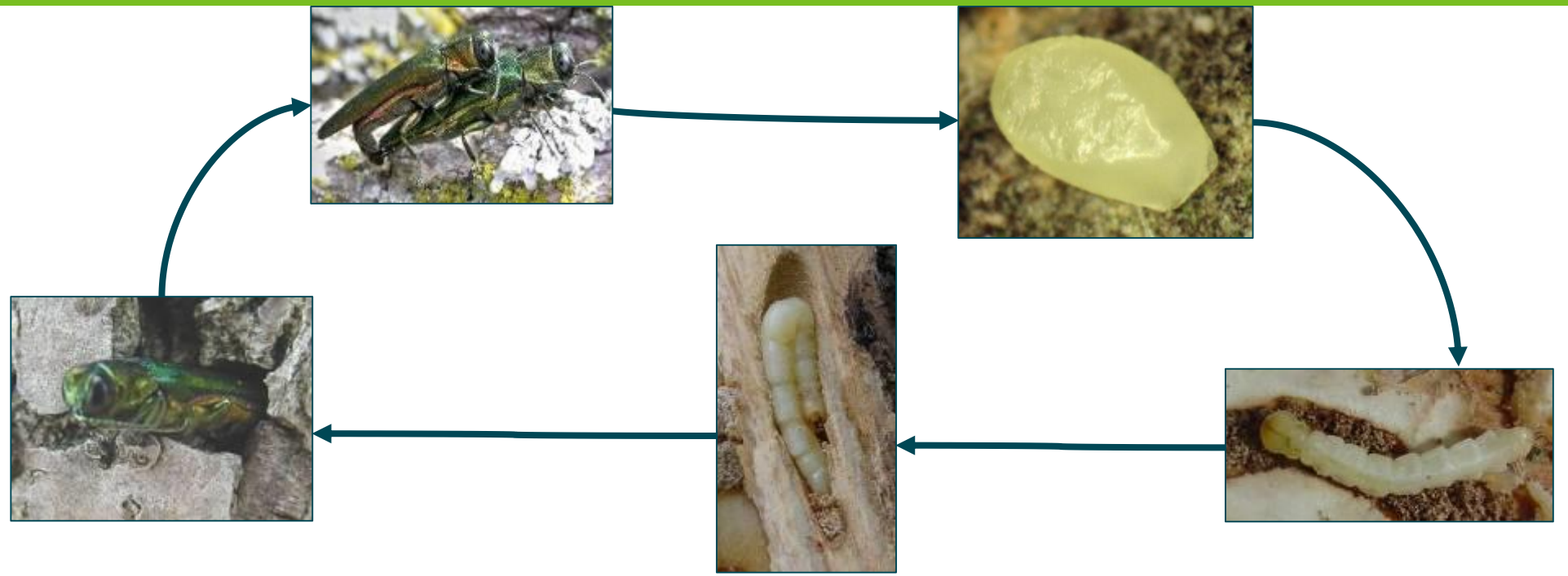
Distribution

Management

Reporting

Life Cycle

Life Cycle



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Immature (under bark)	■	■	■	■	■	■	■	■	■	■	■	■
Adult (free living)					■	■	■	■	■			

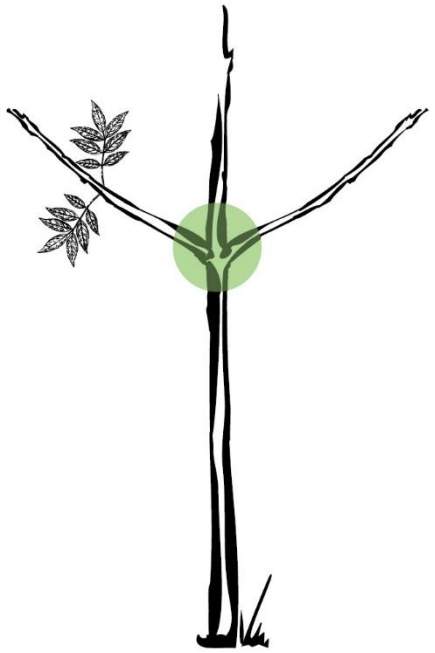
How Does EAB Kill Trees?

DEPARTMENT OF AGRICULTURE

Host Trees

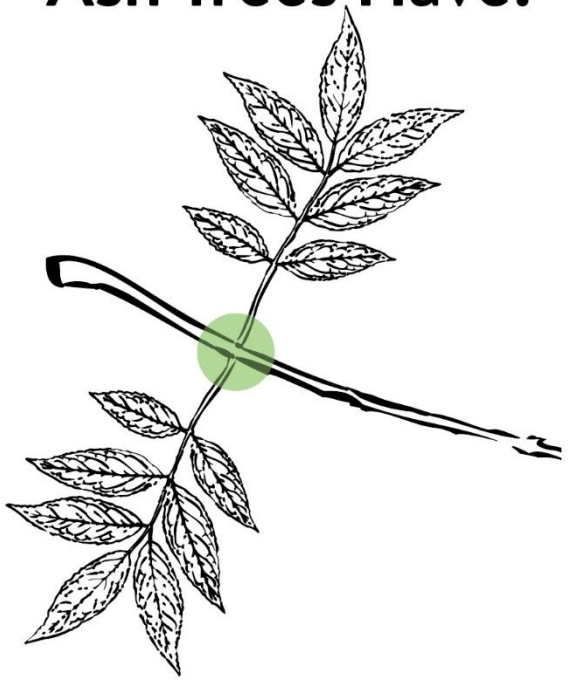
Ash Tree ID

Ash Trees Have:



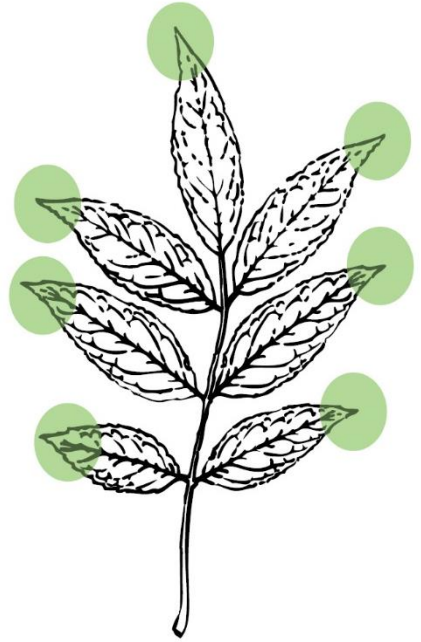
Opposite Branching

Ash Trees Have:



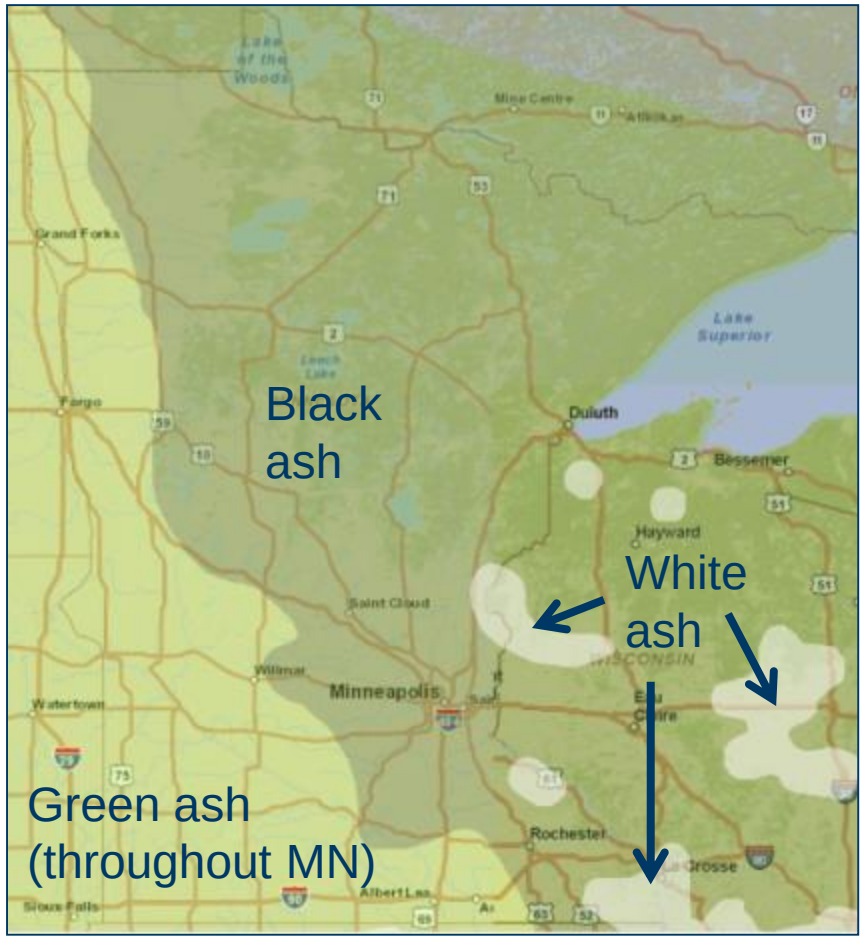
Compound Leaves

Ash Trees Have:

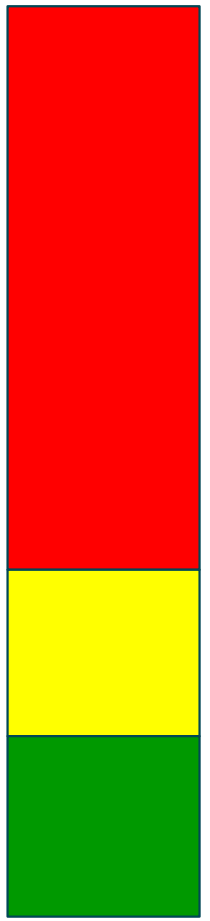


5 to Many Leaflets

Host Trees



Susceptibility



high

Black ash

Green ash

White ash

Blue ash

Manchurian ash

low

Black Ash Cultivars

- Fallgold

Green Ash Cultivars

- Bergeson
- Cimmaron
- Marshall
- Patmore
- Summit

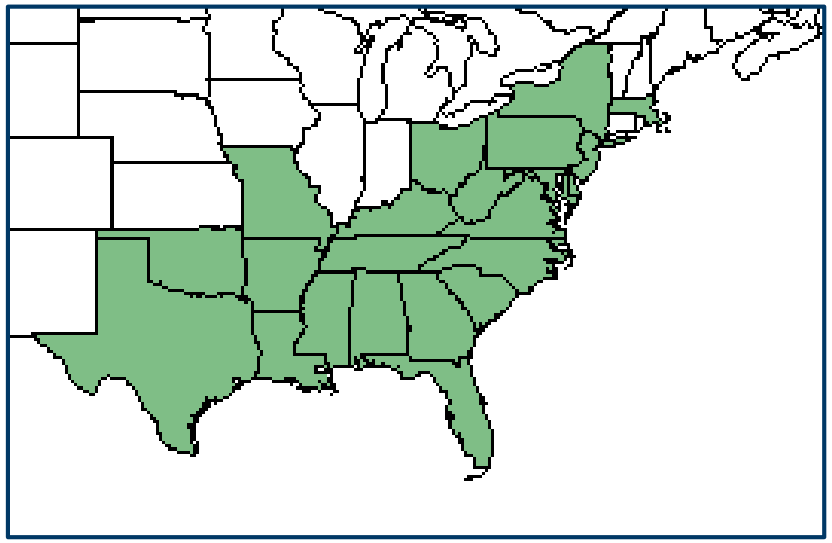
White Ash Cultivars

- Autumn Applause
- Autumn Blaze
- Autumn Purple
- Baltimore
- Greenspire
- Northern Blaze
- Rosehill
- Skyline

mda.state.mn.us/eab

Secondary Host Tree

- Olive Family - Oleaceae
- White Fringetree, *Chionanthus virginicus*
- AKA fringe tree, snowflower tree, flowering ash, old man's beard, grandfather graybeard



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Recognizing EAB

Confirmation

"S" shaped galleries

EAB Larva

Confirmation

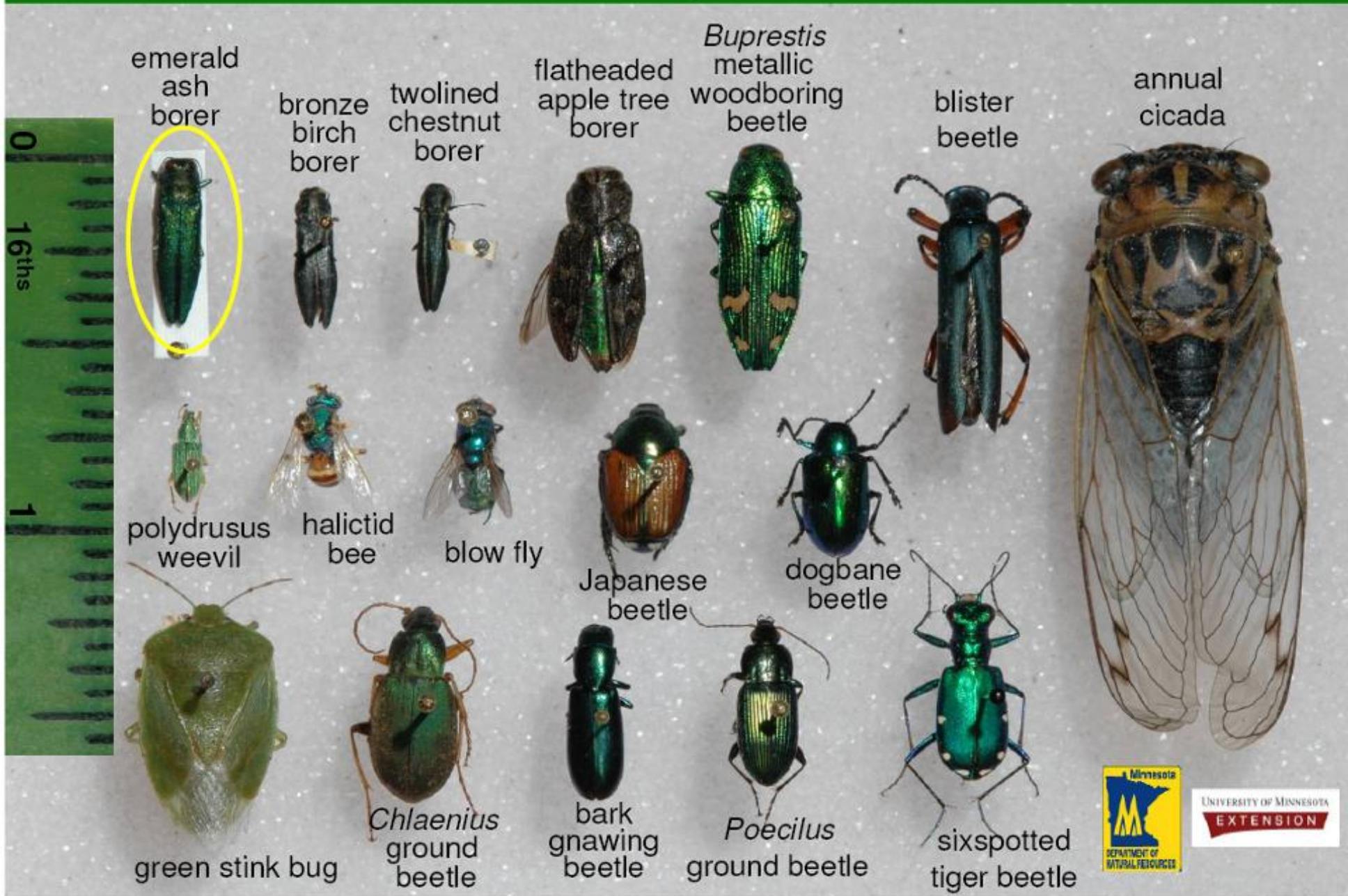
1/8” width

“D” shaped exit holes

EAB Adult

Insects in Minnesota That May Be Confused with Emerald Ash Borer

Jeff Hahn, University of Minnesota Extension
Val Cervenka Minnesota Dept. of Natural Resources



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Signs & Symptoms

Symptom Progression

EAB Status	Symptoms	Years Infested
Small larvae present	None	1
Large larvae present / Emerging adults	Woodpecking possible	2
Increasing larvae numbers 	Woodpecking likely Bark splits possible	3
	Canopy impacts visible	4
	Dead trees present	5-6

Woodpecker Damage

- Mid / Top canopy
- Branches 3-6” in diameter
- Bark transitions to rough
- Bark blonding / flaking
- Dime sized woodpecker holes
- Light colored woodpecker holes
- Oval shaped

Woodpecker Damage

Bark Splits

Native Damage

- Trunk
- Lower canopy
- Dead limbs

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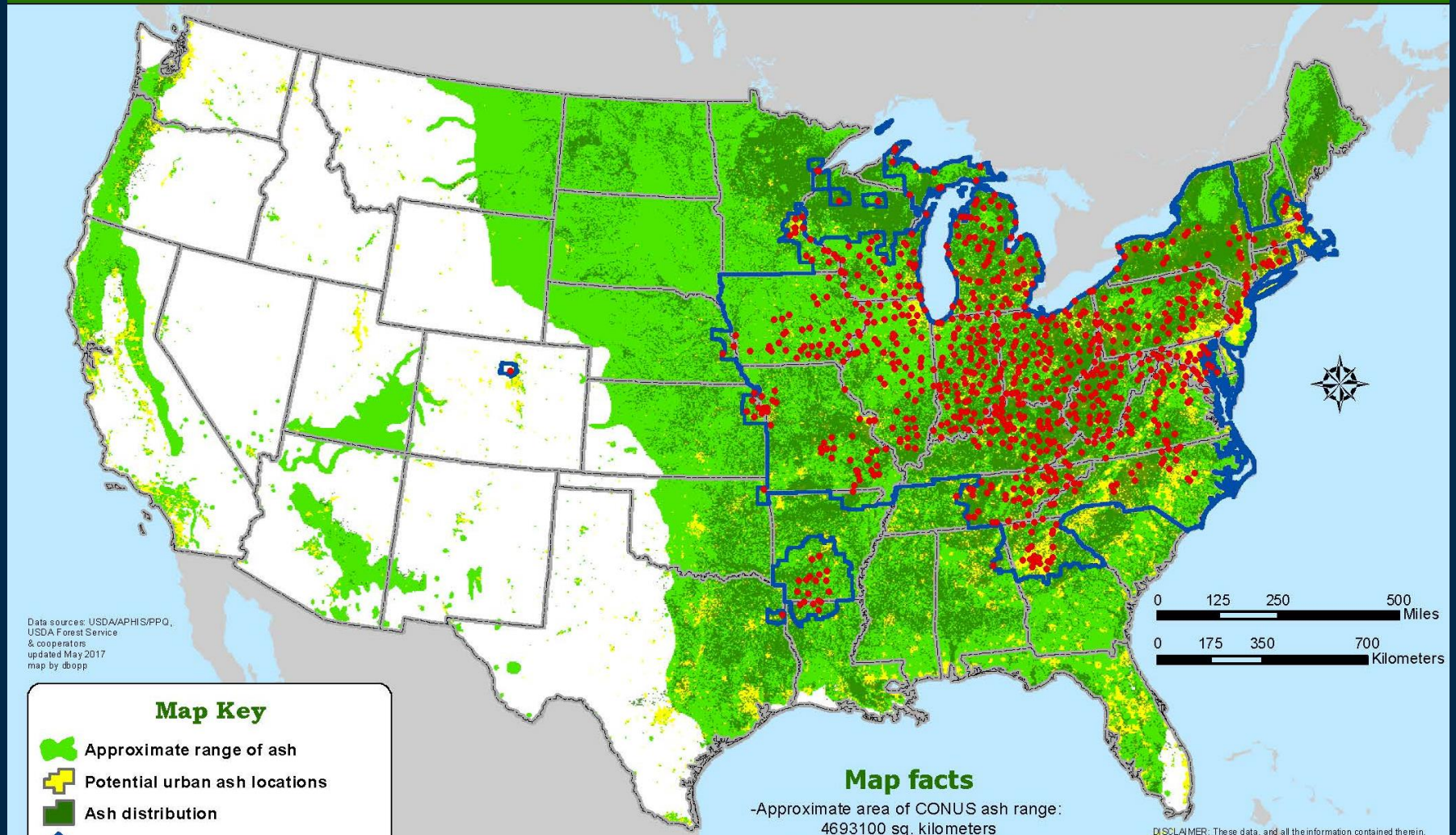
Distribution

USDA United States Department of Agriculture

Cooperative Emerald Ash Borer Project

Approximate range of ash species in the Contiguous U.S.
with EAB positives and Federal quarantines

May 1, 2017



Data sources: USDA/APHIS/PPQ, USDA Forest Service & cooperators
updated May 2017
map by dbopp

Map Key

- Approximate range of ash
- Potential urban ash locations
- Ash distribution
- Federal EAB quarantine boundaries
- Initial county EAB detection

Ash species distribution map source:
USDA, Forest Service, Forest Health Technology Enterprise Team (FHTET).

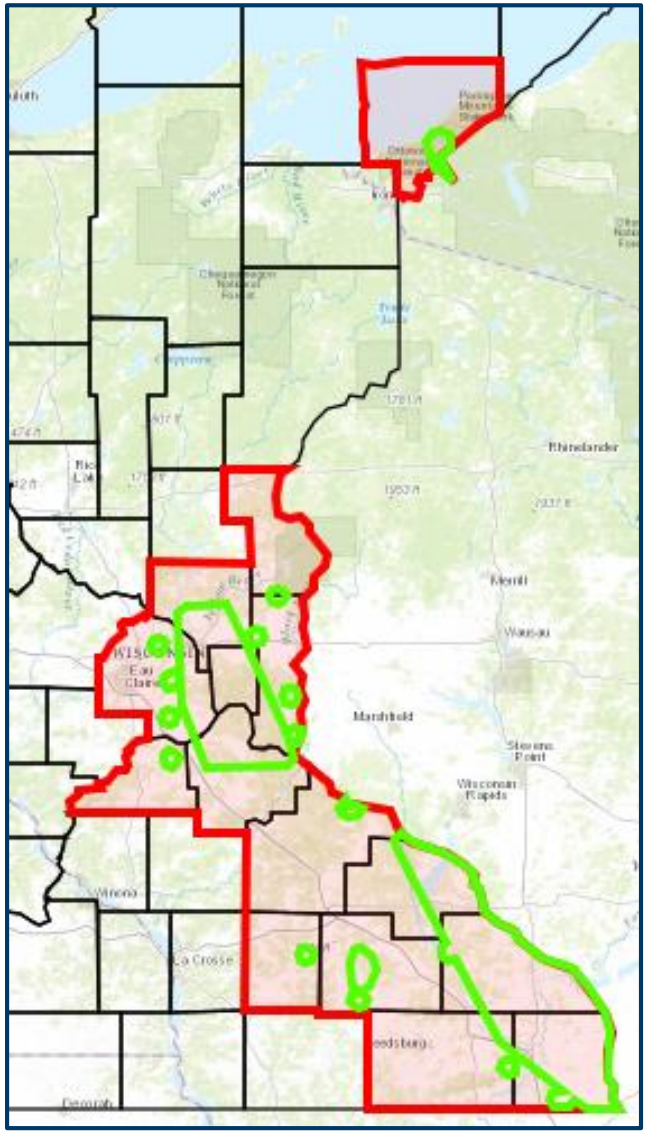
Link to FHTET species distribution maps:
http://foresthealth.fs.usda.gov/host/

Map facts

-Approximate area of CONUS ash range:
4693100 sq. kilometers
-Area of U.S. Federal quarantine:
1850714 sq. kilometers
-Total area of counties where EAB is present:
1220538 sq. kilometers

Minnesota Distribution

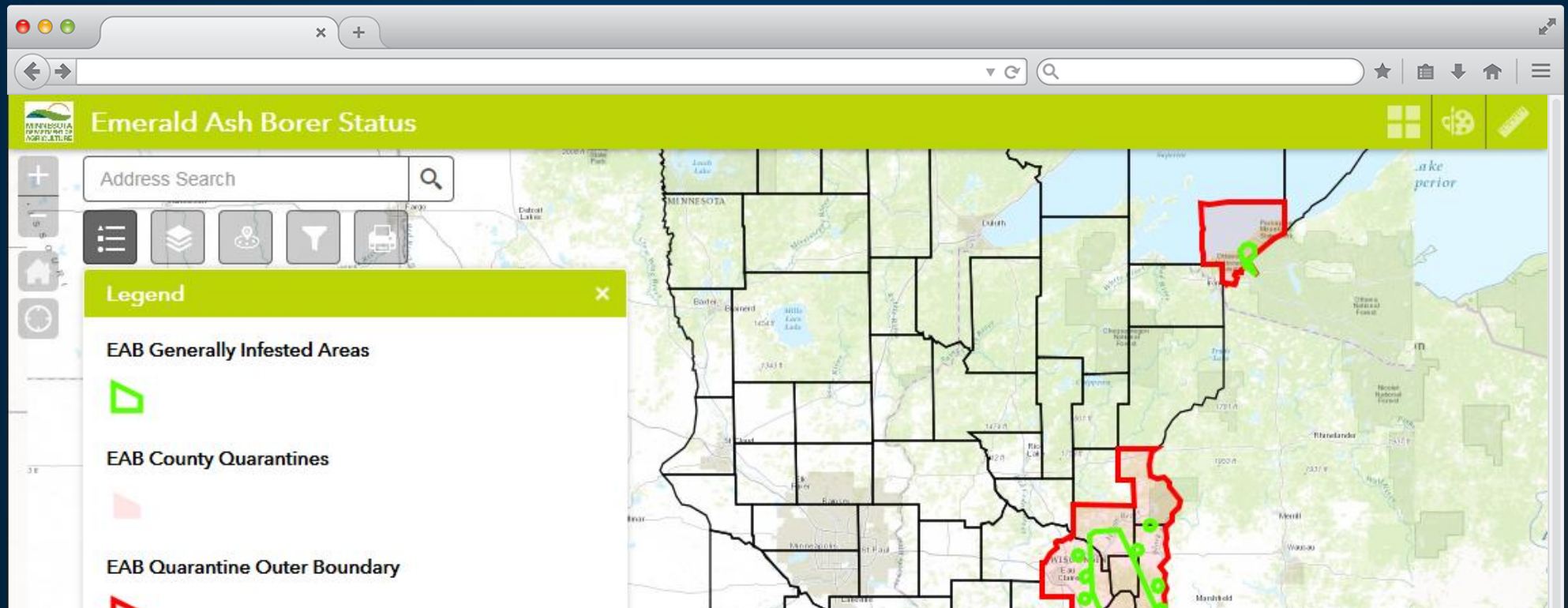
- Generally infested area in green within red EAB quarantined counties
- Quarantined Counties
  - Ash
  - EAB
  - Hardwood Firewood (<4 feet in length)



mda.state.mn.us/eab

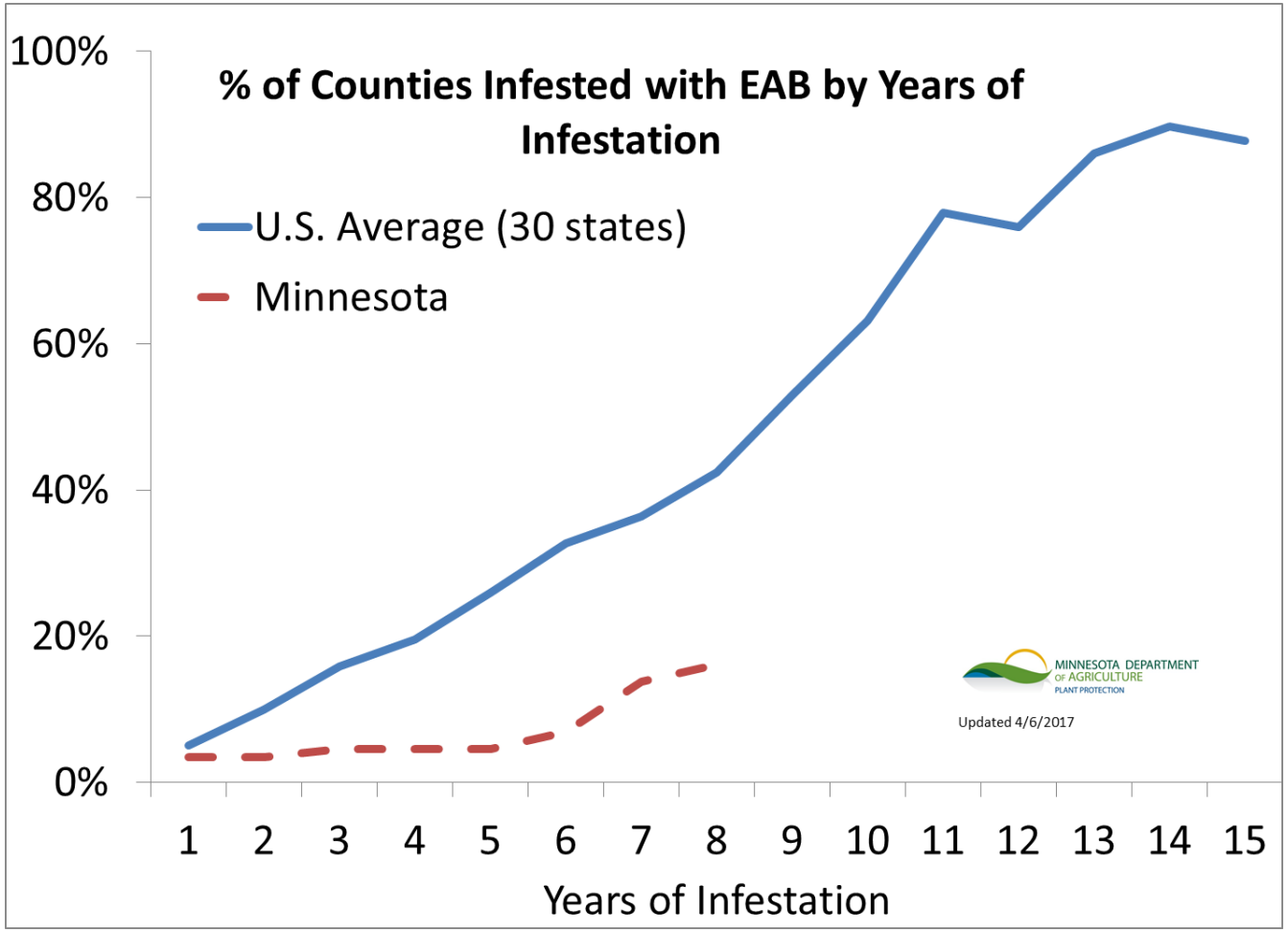
Interactive Map

- mda.state.mn.us/eabstatus
- Closest known infested ash tree



Slow Spread

- Cold weather
- Education
- Outreach
- Aggressive management
- Quarantines
- Sanitation



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Management

Management Options

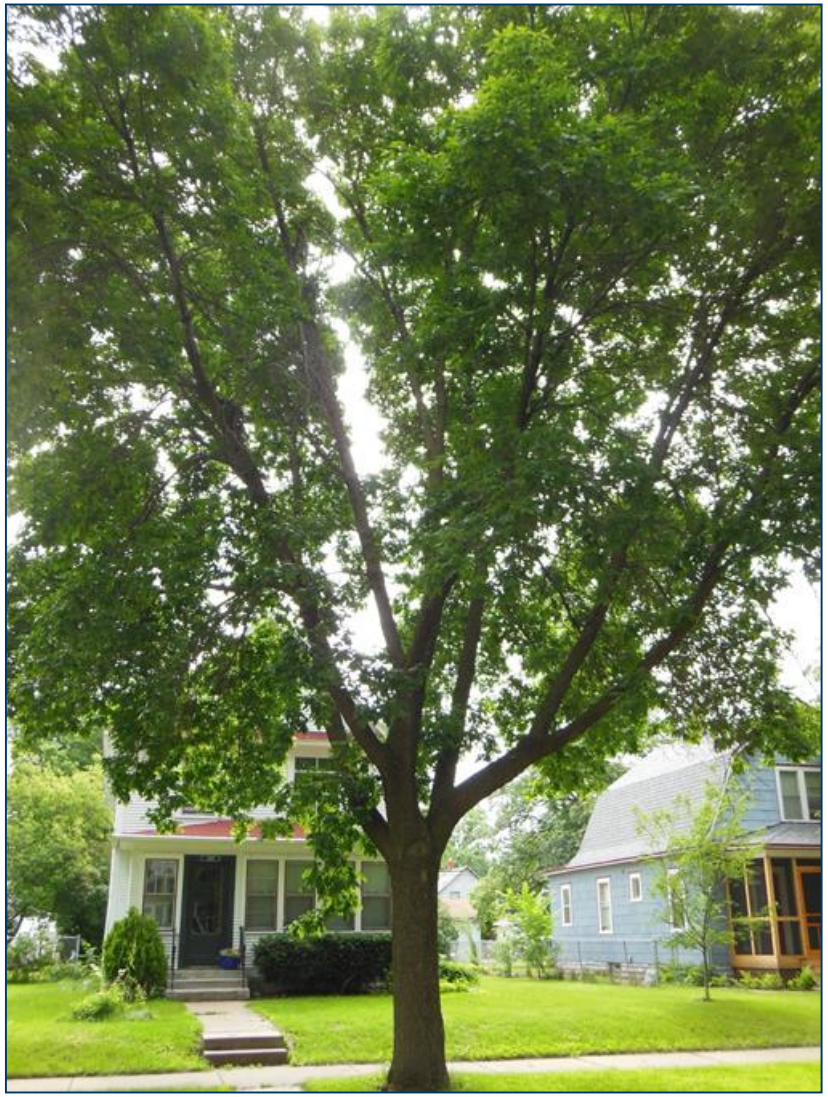
- Removals
  - Before EAB
  - Trees exhibiting woodpecker damage
  - Dead trees
- Treatments
  - Before EAB
  - After EAB infests a tree
- Do Nothing
- Wait, decide later

City Management

- Designated Staff
  - Visual survey and monitoring
  - Permits for private treatment of public trees
  - City's contracted treatment rate for private trees
  - In-house treatments ($4.77/diameter inch)
- Diseased Tree Ordinance
- Hazard Tree Ordinance
- Diversified Replanting

Considering Insecticides

- How close is EAB?
- How healthy is the tree?
- How large is the tree?
- How many ash are there?
- How important is the tree?



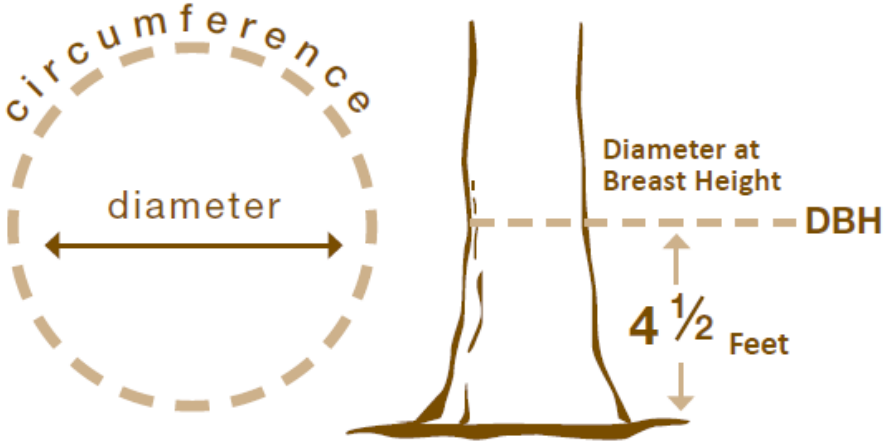
Insecticide Treatments

- What is the risk?
- Treatments need to be repeated
- Timing is everything

Insecticide Treatments

- Measure your ash tree

It is important to measure your ash tree to determine the appropriate treatment and to accurately follow the use instructions on insecticide labels.



trunk diameter = trunk circumference X 0.32

CONVERSION TABLE Tree Measurements at 4½ Feet Above Ground Level	
Circumference – Inches	Diameter at Breast Height (DBH) – Inches
15	5
20	6
25	8
30	9.5
35	11
40	13
45	14
> 48 inches	**> 15 inches**

In general, large trees are best treated by a professional. For exceptions, check specific pesticide product labels.

How Insecticides Work

- Systemic
- Moves up the xylem and into leaves
  - Affects adults
- Can also move to the phloem and affect larvae

Forested Environments

- Egg Parasitoid
  - *Oobius agrili*
- Larval Parasitoid
  - *Tetrastichus planipennisi*
- Larval Parasitoid
  - *Spathius galinae*

Biosurveillance

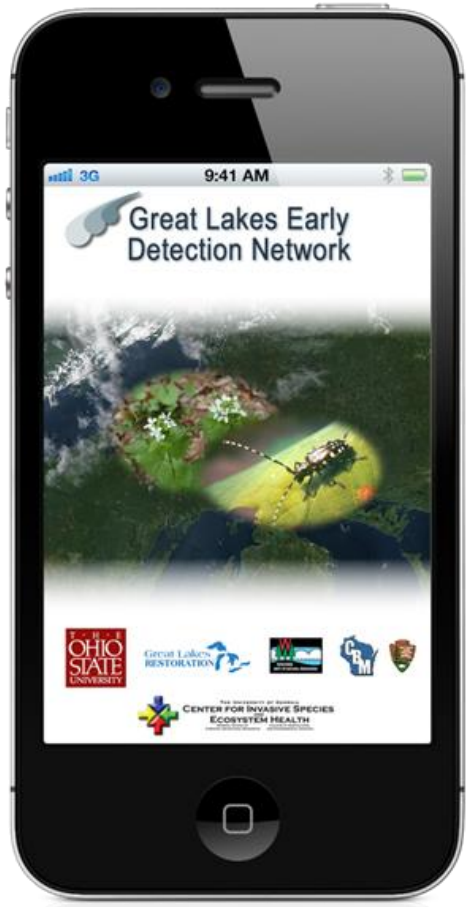
- Smoky winged beetle bandit wasp
  - *Cerceris fumipennis*
- Volunteer Program – Wasp Watchers

DEPARTMENT OF AGRICULTURE

Reporting

Arrest the Pest

- Take pictures and notes
- Capture the insect or take a sample of the plant
- Report
  - City forester or designated staff
  - GLEDN app (Great Lakes Early Detection Network)
  - mda.state.mn.us/arrestthepest
  - Arrest.the.pest@state.mn.us
  - Call 888-545-6684 and leave a detailed message



DEPARTMENT OF AGRICULTURE

Thank you!

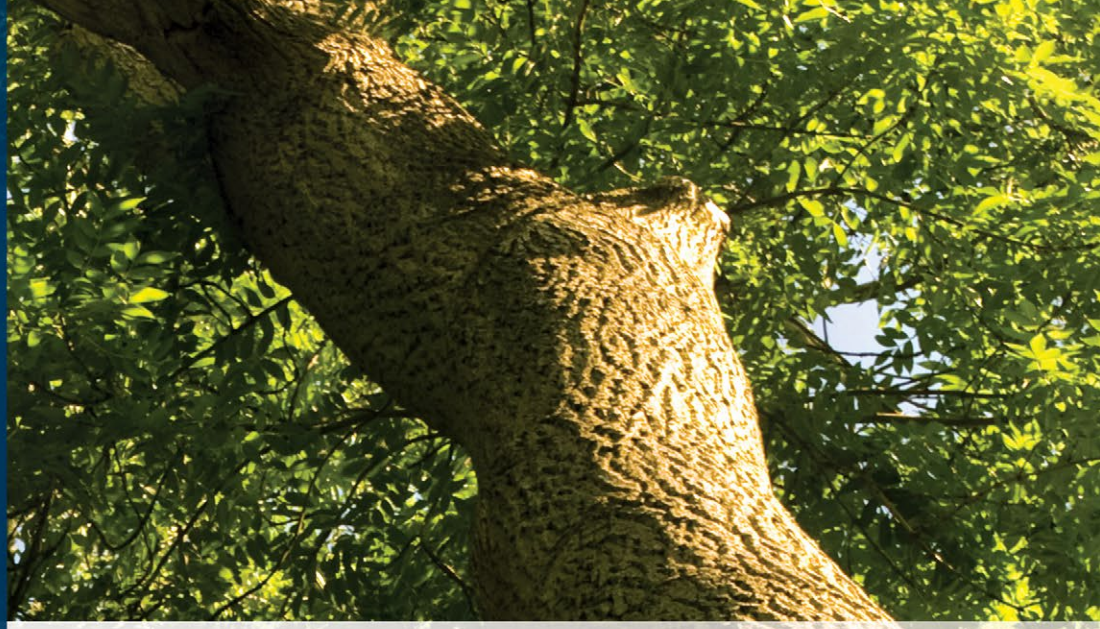
Arrest the Pest

Arrest.the.Pest@state.mn.us

888-545-6684

EMERALD ASH BORER

MANAGEMENT GUIDELINES



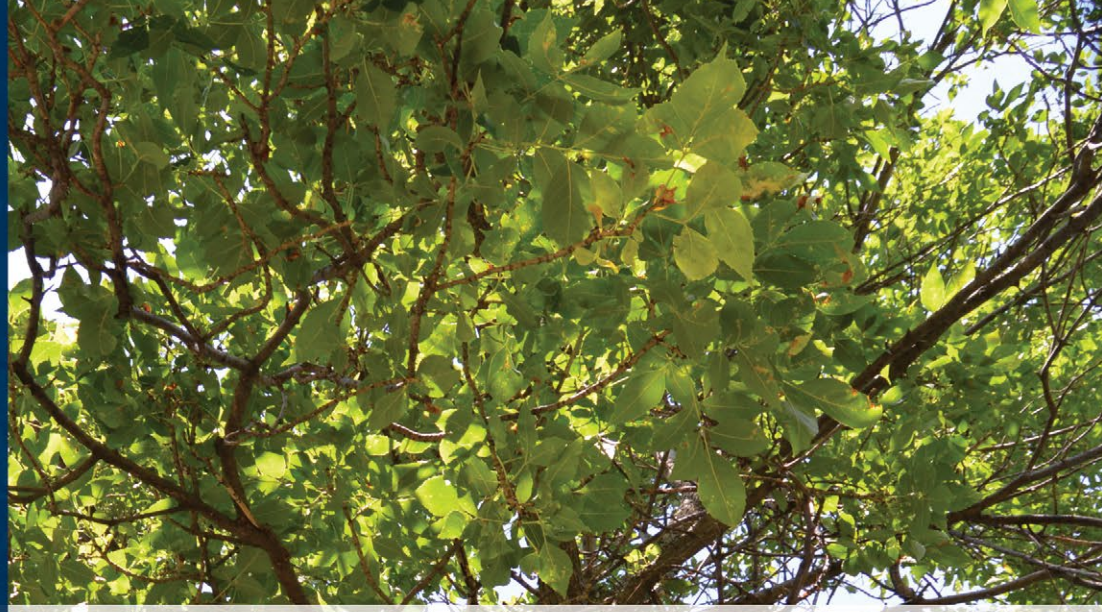
Background

Emerald ash borer (EAB), *Agrilus planipennis*, is an invasive wood-boring beetle first detected in the U.S. near Detroit, Michigan, in 2002. Since that time EAB has been responsible for killing millions of ash trees. All ash trees native to Minnesota are considered highly susceptible to EAB. Minnesota has about one billion ash trees in our forests and ash accounts for about 15 percent of trees in the average community (Natural Resources, 2010).

A single generation of EAB is completed in one to two years. Eggs are laid during the summer on trunks and branches of ash trees. Larvae hatch from the eggs and tunnel beneath the bark. Larvae make distinct “S”-shaped (serpentine) galleries and feed on the phloem of the tree. Larvae may spend the winter inside pupal chambers in the outer sapwood, bark, or in feeding galleries, and some larvae will feed for another summer before completing development. Adults emerge from ash trees through a distinct “D”-shaped exit hole during May through September. Upon emergence, adults will feed on ash leaves in the canopy before mating and laying eggs.

Trees are killed by continual insect larval feeding, and tree mortality accelerates as EAB populations increase in density. Although the beetle is capable of spreading to nearby areas through flight, the primary means of long distance EAB spread to new areas is through transport of firewood or other woody material from ash trees.

DEPARTMENT OF AGRICULTURE



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SGSTANDARDS

How to Confirm and Report EAB

To confirm that a tree is infested with EAB there must be at least one of these symptoms.

A larva pulled out from a suspect ash tree and identified as EAB. Emerald ash borer larvae look much like our other native flatheaded borers but they have a characteristic urogomphi, which look like small spine-like projection at the tail end of the insect.

An "S"-shaped gallery visible underneath the bark of the suspect ash tree. There are many native insects that will make galleries under the bark of ash but none will be "S"-shaped.

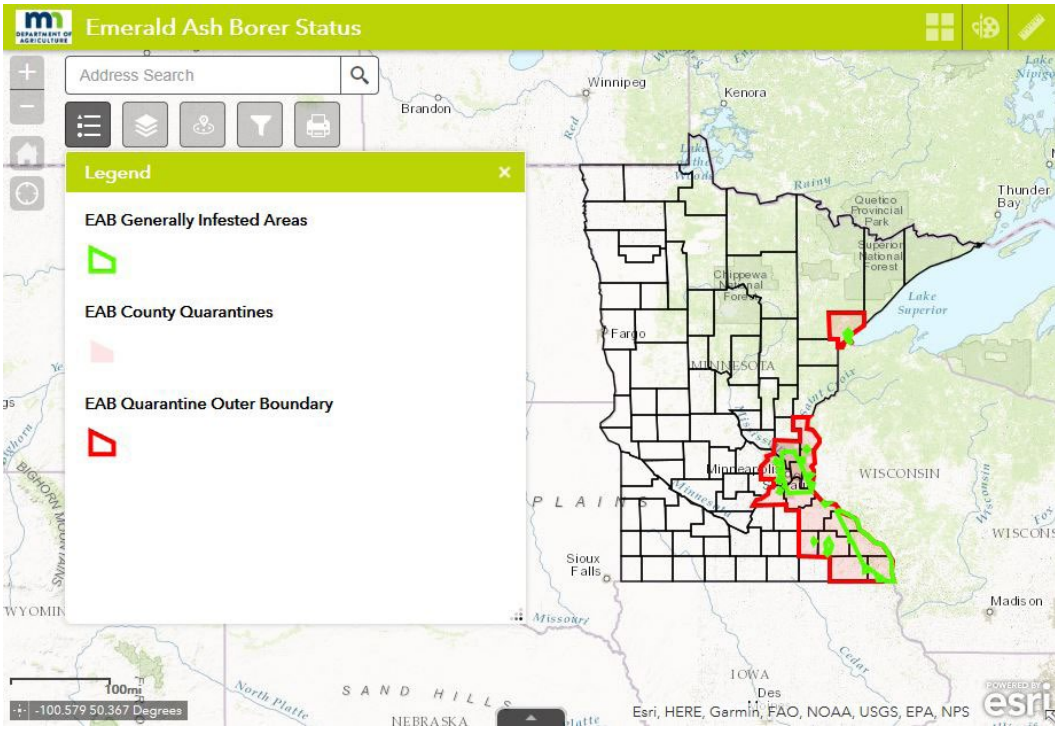
An adult EAB identified by the Minnesota Department of Agriculture (MDA) (see how to report EAB). This will be a very rare occurrence. Adult insects are not commonly seen except in areas of high insect pressure.

A "D"- shaped exit hole; however, if you think you have this, you should peel back the bark of the tree and make sure you can find the "S"-shaped gallery. "D"- shaped exit holes are easily misidentified. Only peel back bark when and if the tree is on your property or you have the permission to do so.

If EAB is suspected in a new area (town or city) of an already quarantined county, gallery photos and/ or samples of larvae, adult insects and/or photos may be submitted to the MDA for identification. This allows us to keep our online map updated and allows the public access to this information.

EAB does not need to be reported to or identified by the MDA in areas that are considered generally infested (these are areas where EAB is already known to occur). These generally infested areas are outlined in green on our online map.

Visit the MDA EAB webpage to **view a map of EAB finds in Minnesota.**



There are two main ways to report EAB to the MDA: Arrest the Pest and the Great Lakes Early Detection Network Application (GLEDN App) which is free for iOS and android smart phones and tablets.

GLEDN App: The GLEDN App is the easiest way to report EAB and other invasive species. It is designed so that all the necessary information can be taken from the field and sent to a verifier; the MDA in the case of EAB. The app allows you to take a GPS point of the location and take a picture of the insect or insect damage to send to the MDA. Your contact information is also sent so the MDA can follow up or make a confirmation quickly.

The GLEDN App also allows you to see locations of past reports of EAB while in the field. This is a helpful tool to track EAB infestations reported within your community, as well as monitor management activities such as chemical treatments and removals.

Photographing EAB

Pictures should focus on definitive symptoms of EAB. A picture of a standing ash tree will not give enough detail to identify EAB. Try to get a picture of an EAB insect gallery, EAB larva, adult beetle, or woodpecker damage (if taking pictures of woodpecker damage, try to get clear close-up pictures if possible)

**Reminder – If you think the symptoms of the tree you are reporting were caused by EAB and definitive symptoms are not present please make sure to look at other ash trees in the immediate area.*

If a clear, focused photo of symptoms is not possible, then detailed notes on the location and type of damage are very important.

Arrest the Pest: Go to **www.mda.state.mn.us/arrestthepest** for instructions. You can email at **Arrest.the.pest@state.mn.us** or call and leave a detailed message at 888-545-6684 and a specialist will get back to you. You can also submit a sample. Request a prepaid envelope from the MDA to mail in submissions. Information to submit to Arrest the Pest:

- **Pictures of suspect trees:** Pictures should be as detailed as possible and show individual symptoms rather than the whole tree. If possible, take pictures of individual woodpecks or a gallery.
- **Location of suspect trees:** Address or GPS coordinates. Either is acceptable. Also include details of location within property; including any landmarks or other features to help easily identify suspect pest location.
- **Contact information of reporter** so that the MDA can contact you if we need further clarification.

Planning for EAB

Preparing for EAB before it has been identified in your community or in close proximity is a key component of EAB management and maintaining overall tree canopy. If communities are prepared, the inevitable impact from EAB may be spread over many years as opposed to a relatively short amount of time.

Inventory

Having a tree inventory is essential to general planning and estimating the costs associated with EAB. At minimum an inventory should include species, location information, size class and condition of the tree. If a complete tree inventory is not available you should at least have an inventory of ash trees. With this information predictions can be made about how the community will be impacted by the loss of all ash trees. It is also important, if possible, to make note of the ash population on private property and in natural areas.

Detection

Early detection of EAB will allow for more management options rather than just widespread tree removal and also results in more time to manage the trees and spread the cost over a longer period of time.

Costs to consider

Removal – EAB will eventually kill most ash trees and these trees will have to be removed. Removal costs will vary depending on the size of the tree. Delaying removal of infested trees will increase costs as dead ash trees become brittle and hazardous.

Disposal of material and utilization – Ash material will have to be taken to a disposal site. State quarantines prohibit the removal of ash material out of quarantined areas without a compliance agreement. Residents should be made aware of the restrictions of wood transportation and encouraged to dispose of wood near its origin.

Insecticide treatments – Treatments for EAB can be both therapeutic and preventative. Costs will vary depending on the size of the tree. There are many benefits to having large ash trees in the environments and preserving the forest canopy. Homeowners may also be interested in treating public boulevard trees. Managers should develop a method to track treated trees within the community. Treatments can also be used to delay the cost of removal.

Reforestation – Decline in ash tree populations will require planting new trees to restore the lost canopy. It would be best to use this as an opportunity to further diversify the urban forest and plant in a purposeful and strategic manner.

For more information regarding estimating future costs or EAB, Purdue University has developed a cost calculator. It can be found at: **http://int.entm.purdue.edu/ext/treecomputer/**

Private trees

Trees on private property will have to be a part of the overall EAB management. Private trees that are not treated will eventually succumb to EAB and will need to be removed if and when they become hazardous. Some communities already have a diseased tree ordinance in place for managing Dutch elm disease and oak wilt that can be amended for EAB management. It will be up to managers to decide if there are enough resources to take action when private trees are identified as infested.

Training/Outreach/Education

Having citizens and forestry staff who are informed about EAB and its symptoms will assist in identifying EAB populations within your community. Supplying education and outreach to residents will allow homeowners to start thinking about what to do with their own ash trees when EAB arrives and be aware of the management options available. Some residents may want to begin insecticide treatments or remove and replace trees in advance of EAB which can benefit the overall tree canopy.

Detection Methods

In order to effectively manage EAB, you will need to know where it is. Opportunities for management decrease over time as trees begin to die. It is beneficial to be proactive and detect EAB in the early stages of infestation. There are multiple methods to do this and each method requires different labor inputs and yields different information. The method chosen will depend on specific management goals.

VISUAL SURVEY

When trees are lightly infested with emerald ash borer, it's unlikely there will be any visible signs of infestation on the exterior of the tree. In contrast, trees that are heavily infested with emerald ash borer are likely to display many signs of infestation including canopy thinning, damage caused by woodpecker foraging, and loose, splitting bark.

Impacts to the canopy of a tree from EAB will not be apparent until the density of larvae within the tree is relatively high with many tunnels in the stem of the tree. At this point, it may be too late to save the tree with insecticide treatments. However, other visual symptoms such as woodpecker foraging and loose, splitting bark can often be found well before EAB levels are high enough to impact the canopy.

EAB infestations tend to begin in branches, and as more larvae infest branches they are more likely to be discovered as a food source by foraging woodpeckers. This provides an opportunity to spot the damage left when EAB levels in a tree are still relatively light and generally limited to branches and upper stems. Likewise, loose bark splits may also form during this time, providing another sign that a tree may be infested with EAB.

While neither of these symptoms is diagnostic for EAB, there are characteristics particular to each that may increase suspicion that the damage is related to EAB.

The MDA has a "How To" video on visual survey techniques available at: **https://youtu.be/Bq9mZKy-3Ao**

What to look for when conducting a visual survey:

**While these symptoms are present year round, it is best to conduct visual surveys in the late winter or early spring when leaves are absent from the trees. Woodpecker activity also increases in the early spring so there is likely to be more visual signs at this time of year.*

Woodpecker damage – When woodpeckers forage on ash trees they generally knock some of the outer bark off of the area they are pecking, thereby exposing the lighter colored inner bark. These areas of lighter bark are noticeable from the ground and indicate areas where closer inspection is needed. However, it is good to note that black and white ash trees tend to display less contrast for the lighter colored inner bark compared to green ash trees due to the differing bark texture. This can lead to woodpecker damage being less noticeable at earlier stages in black and white ash trees.

When woodpeckers forage on EAB, they peck a dime to quarter-sized hole through the bark and to the surface of the sapwood. If these holes are not present, it is unlikely that woodpeckers are foraging on EAB or other insects beneath the bark of the tree. Sometimes trees have areas of outer bark

that appear to have been knocked away by woodpeckers but there are no holes through the bark. There are a number of possible reasons why this could happen including woodpeckers exploring trees for insects, squirrel activity, smooth bark pathogen, weather, or other unknown causes. The important point for EAB monitoring is that woodpecker foraging on EAB should leave behind light colored holes that go through the bark and to the surface of the wood.

Once it has been determined that woodpecker foraging with holes created through the bark is present, the only certain way to identify whether it is EAB is to view the tunneling left by the insect. This can be done by finding an area where enough bark has been removed already or removing some bark to enlarge the hole left by a woodpecker (see How to Confirm EAB for more information on insect tunneling in ash).

Some characteristics make it apparent that the woodpeckers were foraging on native insects and not EAB. Native insects typically infest trees that are in obvious decline, or they may infest discrete areas of trees in decline such as dead branches, areas around wounds or near large pruning cuts. The occurrence of one of these factors is an indicator that the insects being predated are native insects and not EAB. Another indicator is the appearance of the holes left behind by woodpeckers. Wood in areas where native insects have been active is often stained dark in color, either from the decline of the tree or from organisms introduced by the insects. As a result, the woodpecker holes over these galleries will also appear dark. In contrast, EAB can generally be found tunneling in healthy trees and in wood that is not stained dark. As a result, woodpecker holes over EAB galleries will often appear light in color with the white wood visible through the woodpecker hole. EAB does not tunnel deeply into the wood of a tree like some native insects do, so large, deep holes in the wood can be excluded as indicators of EAB.

Bark Cracks – Another early EAB visual symptom in the canopy of ash trees are bark cracks. As the tree is initially attacked, the tree tries to heal around the larval gallery area and keep growing. As the branch continues to grow it forms callus tissue around the gallery and the bark will begin to crack open. When the crack becomes large enough you may be able to see the gallery with a pair of binoculars.

***Note on removing bark**

Removing bark from a healthy area of a tree destroys food and possibly water conducting cells (if the outer wood is also damaged) in that area of the tree and also provides an entry point for pathogens. Areas in trees where insects have tunneled and woodpeckers have created holes through the bark have already sustained this injury and removing an additional small amount of bark will probably not add significant injury. However, bark missing from trees will attract the attention of other people who may not appreciate this argument and so you should never remove bark from a tree that you do not have authority or permission to sample in this way.

If an EAB gallery is present, bark should come off the tree relatively easy when pried up. This is due to how EAB feeds under the bark. If you are having to struggle to remove the bark, the damage is likely not caused by EAB

Note on Binoculars

While the light colored patches of inner bark are generally noticeable to the naked eye, determining whether or not woodpecker-created holes are present may require binoculars. Binoculars with greater magnifying power work better, but keep in mind that as viewing power increases the sensitivity of the view to movement also increases (it's hard to hold the binoculars steady enough). The MDA has had good success with binoculars offering 16 power (images magnified 16 times). The light gathering ability of binoculars is important as well, and generally the more light the better. Binoculars are generally labeled with both values, for instance, 10 x 20. This means that the binoculars will magnify images 10x and the diameter of the objective lens is 20 mm (wider lens = more light). The trade-off is that binoculars with greater power and light gathering ability will generally be bigger and heavier and more difficult to use.

There are characteristics associated with EAB in addition to woodpecker feeding damage and bark cracks, which can be seen while conducting a visual survey. While these things may in fact be present, they are not valuable indicators of EAB as they may be caused by many different things or are extremely difficult to see.

Loose splitting bark

Canopy Thinning – Canopy thinning is typically a symptom that occurs after woodpecker damage and bark cracks can be seen, usually around the fourth year a tree is infested. The top canopy will have a general thinning to it, not a leafless branch.

Epicormic Sprouting – Epicormic sprouting is often seen on ash trees that are stressed in general. However, sprouting within the lower canopy of the tree is often seen with EAB infestations. This is the least reliable visual symptom for EAB.

"D"-shaped Exit Holes – Unless you are working in the canopy of the trees, you will not see "D"-shaped holes until much later in the infestation. There are also many native insects attacking ash trees that make oval shaped holes of similar size. Looking for "D"-shaped exit holes is not a good use of your time when conducting visual survey.

How visual survey can be beneficial to managing urban environments:

Visual survey is an efficient way to detect EAB before impact to the canopy occurs. This is also the most economical method to find EAB. The MDA has observed that visual survey takes about 20 percent of the time it takes to branch sample a given area. The MDA has also noted that the difference of EAB detection between branch sampling and visual survey is rather small. Branch sampling can detect EAB at a lower density when no outward symptoms are present; however, in most cases trees infested with EAB will have some visual symptoms. It is also important to note that trees in an infested area will have varying degrees of EAB density, meaning that some trees are likely be at the level where woodpeckers have begun to forage and feed on EAB. Depending on the management goals, the value of knowing where EAB is may outweigh knowing exactly how many trees are infested in that area. For these reasons, if the goal is to detect EAB before canopy decline with the least amount of resources and time, visual survey is the best method to use.

How visual survey can be beneficial to managing woodlots and forested environments:

Management options are limited in woodlots and forest stands. Outside of biological control of EAB and cold mortality, there is no practical way to protect trees in these environments as EAB gradually spreads. As a result, the main goal for these areas will be to remove or harvest ash trees before they succumb to EAB and become hazardous. Visual survey will allow for the detection of EAB before this happens so that infested trees can be removed earlier and labor costs can be spread out over time.

BRANCH SAMPLING

Branch sampling is a technique that can be used to identify EAB infestations in trees that are free from external symptoms - making it the most sensitive method for EAB detection. This detection method involves removing two healthy limbs from ash trees and removing the bark to look for the presence of EAB larvae or feeding galleries. While branch sampling is sensitive and capable of early detection, it is very labor intensive and the results may not justify the added labor over other methods. Branch sampling can also be used to aid in estimating the density of an EAB infestation; however, this information may not be pertinent to managing the infestation.

How to process a branch sample:

Bark needs to be removed carefully down to the sapwood where EAB feeds. The best way to do this is by peeling the bark off in thin layers from the outer bark through the inner bark. The most common mistake when removing the bark from a branch sample with a draw knife is to not go deep enough. If the sample was recently cut this can be distinguished by a thin layer of moisture that is present when you reach the correct depth, as well as a change in texture.

A tree can be identified as positive when an EAB gallery or larva is uncovered. Depending on one's management goals, determining the density of EAB in a sample could be important. This is done by calculating the surface area of each sample and the amount of EAB galleries present. If the goal is to simply determine if a tree is infested, peeling can stop once one gallery is found. This can save time. It is important to note that other insects can leave feeding galleries, but the serpentine "s" gallery is unique to EAB in ash trees.

Things to consider before implementing:

Is there enough staff time available for such work? Is there storage space available for the samples? Are there potential student worker/intern resources available?

Keep in mind that sampling 50 trees will create 100 branches that will need to be peeled and documented for presence of EAB.

Estimate of labor hours needed to sample 50 trees and peel 100 branches = 50 hours

Intensity level of EAB Infestation in area (low, moderate or high)?

If known, is it worthwhile in terms of potential management outcomes? If infestation levels are already moderate to high in the surrounding area, then the potential to positively impact management may be too late or the resources may be better used on future management rather than detection.

Will results lead to targeted management?

Are the results going to be used to influence the way a specific location is managed?

Targeted removals or insecticide treatments? If no, then branch sampling may not be worth the time and resources as it won't impact forest management objectives.

Define area to be sampled:

To begin preparing your branch sampling plan, decide the following:

Define the geographic area being targeted for sampling:

- Entire city – EAB is not known to be in area or adjacent communities.
- High risk neighborhood(s) based on – proximity to nearby infestations, ash density, or types of businesses (areas with wood products, land clearing and firewood industry).
- High value areas – areas where ash is highly valuable to canopy coverage.
- County level – Parks, campgrounds, main travel corridors, high ash density, proximity to nearby infestations, etc.

Define the intensity of sampling:

Example: Grid based approach – create a grid using ArcGIS based on the intensity of sampling to be completed. (ex: place ½ mile x ½ mile grid over entire city) modify it until desired level of sampling is reached based on available staff resources.

Other Options:

Spot sample ash trees while performing other work such as trimming or removals. Have employees take a closer look while doing other work in the canopy of ash trees. This can be accomplished by peeling away bark if woodpecker damage or bark splits are noticed while pruning or removing a tree. Take a picture or collect a representative sample of the damage.

Recommended characteristics when selecting trees to sample:

- Open grown, semi-mature trees
- 8-20 inch DBH
- Two branches per tree from mid-crown (cut branch at the base)
- Branches are minimum of 2-3 inches diameter (4-5 inch diameter preferred)
- Branches have rough bark opposed to smooth bark
- Branches are taken from the south/southwest facing side of tree if possible (part of tree that receives the most sunlight)
- Branches are a minimum of 20 inches in length (30-40 inch lengths are best size for handling when peeling)

*Remember that the goal of branch sampling is to detect EAB, not to prune the ash tree. Take the best branches possible based on the criteria listed above and consider the tree being sampled as sacrificial to the goal.

Timing of branch sampling:

October 1 through April 1

- not recommended to fell, trim or sample ash trees during the summer due to risk of spreading EAB through movement of infested materials.

Tools/Equipment needed for this method:

- Bucket truck/pole saw/rope saw
- Chainsaw/ hand saw
- Drawknife
- Pocket knife
- Table vice/other with ability to hold branch in place

How branch sampling can be beneficial to urban environments

Branch sampling can be a valuable tool if finding EAB early will direct how the infestation is managed. For example, a management plan may involve insecticide treatments of healthy ash in an area once EAB is discovered. Branch sampling has the potential to detect EAB before the canopy is impacted resulting in a greater number of trees where treatments are viable.

* It is important to note that while branch sampling is the most sensitive tool available for detecting EAB, it is only 75% accurate. There is still a 25% chance that the sampling results will produce a false negative if the branches sampled happen to not contain EAB galleries even though the tree is infested

How branch sampling can be beneficial to woodlots and forests

Due to the large labor costs compared to visual survey and the management goals associated with these environments, branch sampling is not often the most practical method of detection. Resources would be better spent on planning for tree replacement and tree removal once EAB is detected with visual survey.

BIOSURVEILLANCE

Smoky winged beetle bandit wasp, Cerceris fumipennis, is a native, stingless wasp that preys on EAB and other similar beetles. The University of Minnesota Extension is working to use this wasp to detect EAB by monitoring wasp colonies and collecting beetle prey from the wasps. Beetles are intercepted from the wasps or found near nests by volunteers during the summer months.

For more information on this program visit: **www.myminnesotawoods.umn.edu/eab/waspwatchers/**

PURPLE TRAPS

Trapping for EAB involves placing prism traps in the canopies of ash trees during the EAB flight season. Traps contain a lure to attract EAB and are coated in a sticky substance. Adult EAB flying around the canopy get stuck to the outer surface of the trap. The US Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) coordinates the placement of traps in counties that are not infested with EAB. These traps are useful on a state or county level but are not designed to detect EAB in a way that will help manage the insect and forest.

EAB AND ASH MANAGEMENT

Management Tactics for Municipalities

Minnesota municipalities on average have 20.3% ash in their urban forest, with percentages ranging from 0.2 to 59.6 based on a 2010 MN DNR Community Tree Survey. There is no stopping EAB from spreading to every municipality in Minnesota; however, actions can be taken to slow EAB's spread through a city and manage the ash resource. There are a variety of management options available which can be combined to cater to each individual municipality with or without EAB infestations. Management options include best management practices, surveys, removals, chemical treatments, outreach, and reforestation. The MDA encourages municipalities to manage EAB; however, it is not a requirement.

Best Management Practices (BMPs)

The MDA has prepared Best Management Practice (BMP) recommendations for when to perform work on ash trees. It is recommended that no work be completed on ash trees during the EAB Active Period: May 2 – September 30. This helps reduce the risk of EAB spreading during transportation, and will provide habitat for EAB adults to lay eggs that will be destroyed during the dormant period. Note that trees damaged in storms or hazardous trees can be removed at any time to prevent damage to property or persons.

If possible, perform maintenance on or remove ash trees during the EAB Dormant Period: October 1 – May 1.

For more information on EAB BMPs visit www.mda.state.mn.us/eab

Ordinances

The Shade Tree Pest Control Ordinance can be applied to EAB infested trees. Please remember that the MDA does not require municipalities to enforce any ordinance. More information on preparing a Shade Tree Pest Ordinance can be found on the League of Minnesota Cities website www.lmc.org.

Municipalities that enforce a Shade Tree Pest Ordinance will condemn trees that have a visible EAB gallery, an EAB larvae, or an EAB exit hole. Some municipalities allow private property owners to treat condemned trees if they are lightly infested and still have a healthy canopy.

Visual Survey

The MDA and the University of Minnesota (U of M) have determined through a three year study that visual survey is the most time and cost efficient way to find EAB infested trees at varying population densities is through visual survey in the late winter and early spring. The study compared three survey techniques used in the field; visual survey for woodpecker damage, purple prism traps, and branch

sampling. They found that visual survey took 12-24 minutes to find a positive tree compared to 3.5-3.6 hours by branch sample and 4.3-5.4 hours by purple prism trap. With basic training, municipality staff can easily identify EAB infested trees using a pair of binoculars to look for woodpecker damage. (See Detection Methods: Visual Survey for more information)

Removals

The MDA and the U of M also determined that removing trees with EAB woodpecker damage showed a larger decrease in the beetle production per removed tree in a four year study in the Twin Cities Metro. By removing ~ 63% of the total ash trees in the study area over four years, there was a ~54% reduction of the cumulative number of beetles produced. Only removing EAB woodpecked trees will allow fewer removals over a longer time period which can buy time for other management strategies to be implemented and place less strain on budgets.

Examples of removal options: poor quality ash trees, EAB woodpecked public ash trees, EAB woodpecked private ash trees, ash trees regardless of quality or EAB, hazardous/dead ash trees.

Insecticide Treatment

Insecticide treatments can be started before EAB is in the area, after an initial detection in the municipality or after a tree is lightly infested. When treatments are applied correctly they will protect the tree from EAB and they will need to be repeated. Trees that have 50% or more of the canopy in good health are candidates for chemical treatment. Any ash tree that is not treated can be infested by emerald ash borer and die.

There are many options available to chemically treat trees which are described in the Insecticide Options for Protecting Ash Trees from EAB produced by the North Central IPM Center. Note that certain chemicals require a Pesticide Applicator License from the MDA.
www.extension.umn.edu/garden/insects/find/emerald-ash-borer/docs/ncbipm_eab_insecticide_bulletin_2nd_ed_may_2014.pdf

A homeowner version of treatment options is available at **www.mda.state.mn.us/eab**.

Municipalities can perform insecticide treatments in–house or contract with a private company. Municipalities working with a contractor have the potential to offer private property owners the municipality's discounted rate. A free permit is typically issued by municipalities when private residents pay for the treatment of public ash trees on their property. In some cases, in-house treatment rates can be lower than contracted rates. One municipality was able to get their in-house treatment rate to $4.77 per diameter inch, which included licensing, wages, benefits and equipment costs. Contracted treatment rates vary but are typically around $6.00 per diameter inch.

Insecticide treatments can be used to maintain the current tree canopy while waiting for reforested tree species to grow or removals can be planned. This prevents widespread ash mortality that may overwhelm the municipality's available resources.

Examples of treatment options: public boulevard trees, public park trees not in forested areas, private treatment of public trees, private property trees at contracted rate.

Combinations

Many municipalities are combining management tactics by removing unhealthy (non-EAB infested) ash, removing EAB infested ash showing woodpecker damage, and chemically treating healthy mature trees. Below are examples of management activities at cities in Minnesota. Again, the MDA does not require municipalities to perform any management of EAB.

MANAGEMENT ACTIVITY EXAMPLES			
REMOVAL	City A	City B	City C
Poor quality public trees	Yes	Yes	Yes
Public woodpecked boulevard trees	Yes	Yes	Yes
Public woodpecked park landscape trees	Yes	Yes	Yes
Public woodpecked forestland trees	Only hazards	Only hazards	Only hazards
Private woodpecked trees	Within a specific		
(Shade Tree Pest Ordinance)	distance of adjacent property		Contract, high-value
CHEMICAL TREATMENT	City A	City B	City C
Mature public boulevard trees	In-house		Contract, high-value
Mature public park landscape trees	In-house		Contract, high-value
Mature forestland trees			
Private mature trees			Contract rate
Privately funded public boulevard trees	Yes		Yes
Private mature trees lightly infested	Yes		Yes

Do Nothing

Municipalities do have the option to do nothing; however, dead ash trees become hazardous and will eventually require removal to ensure public safety.

Outreach Efforts

Educating citizens should be considered by every municipality even if they are not actively managing EAB to prevent spread. Movement of infested wood is a leading cause of EAB traveling long distances in short periods of time. EAB adult beetles do not travel a significant distance each year on their own, but a person can easily move infested firewood hundreds of miles in a day.

Examples of outreach efforts: tree signs/wraps, water bill inserts, postcard mailings, press releases, posters, educational tables at municipal functions, or presentations at public meetings.

Reforestation

Species diversity is essential in reforestation efforts to prevent widespread mortality from future pests. A guide to recommended trees for Minnesota by region can be found on the My Minnesota Woods website.
www.myminnesotawoods.umn.edu/2008/11/recommended-trees-for-minnesota-by-region/

Tree sales are another way to reforest the urban canopy through private residents purchasing wholesale priced trees and shrubs. Tree sales are run by counties, cities, non-profits, gardening groups, soil and water conservation districts or other entities. The sales typically take place in the spring and can be comprised of bare root, container or air pot trees and shrubs. Trees purchased through the sales are typically planted on private property; however, some cities allow plantings in the public boulevards. Depending on the entity holding the sale, residents may also purchase trees and donate them to a municipal park.

Management Tactics for Woodlots and Forested Areas

Minnesota has a vast number of ash trees outside of urban environments located in woodlots and forested regions of the state. Biological control is one practical landscape-level management option. There is no way to stop EAB from spreading throughout the state or a way to protect all of these trees. Although it may take many years for EAB to spread, if you have ash trees on your property, it is time to start planning for a future with fewer ash trees. However, planning ahead and managing the ash resource before EAB arrives will help keep your forest healthy and resilient.

For more information on managing ash in a forested setting visit:
www.myminnesotawoods.umn.edu/2011/07/emerald-ash-borer-and-your-minnesota-woodlands/

Biological Control

Biological control of EAB was initiated in Minnesota in 2010 and remains the most practical landscape-level management option. Three parasitoid wasp species are being released in Minnesota. Two species attacks the larval stage of EAB under the ash bark. The other species kills EAB eggs that are laid in bark crevices. These wasps are small like gnats and do not harm humans. They were selected by the US Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) and Forest Service and tested extensively to ensure that they will not negatively impact other species or the environment. APHIS rears these biological control agents at a specialized facility in Brighton, MI and provides them to states with EAB infestations. Program implementation includes EAB detection, site assessment, and parasitoid release and recovery.

Assessment of EAB Infestation:

Not all sites fit the criteria for biological control. Once an EAB infestation is positively identified, several activities need to be completed to determine if biological control is viable:

Perform a delimit survey of the infestation to identify the perimeter of where symptoms are visible.

Gauge the intensity or pest pressure in the area based on severity of EAB symptoms throughout the identified visibly infested area. Low to moderate EAB densities are recommended for potential sites. It is important that there are enough EAB for the parasitoids to feed on and there are enough living ash trees to sustain the populations over time.

Identify forested areas on public or private land within the visibly infested area where removal and/or treatment of infested ash trees will not be feasible. Size and composition of forest should be at least 40 acres and at a minimum include 20% ash of varying size class. Ideally, the site would be greater than 25% ash and connected to other woodlots.

Coordination:

After a viable biological control site is identified, coordination by the MDA with local natural resource managers, property owners and the USDA EAB Parasitoid Rearing Facility are necessary. At each site, one has to obtain permission, guarantee access and ensure other management objectives won't interfere with implementation. Special permits may be necessary depending on the ownership and designation of land. Long-term site access is important for follow-up monitoring of ash health and documenting parasitoid establishment.

Parasitoid Recovery:

After parasitoids have been released, it is important to recover some to confirm that populations are overwintering and reproducing. There are multiple ways to recover parasitoids from release sites.

For more information on biological control of EAB in Minnesota; including parasitoids, release sites and recovery locations, visit MDA's biocontrol webpage: http://www.mda.state.mn.us/plants/pestmanagement/eab/eabbiocontrol.aspx

EAB Cold Hardiness

Condensed No Snow Day for EAB

Have as PDF/Word-need to insert in this document(formatting is off)

PDF link

Word Link

Emerald Ash Borer Regional Meeting

May 17, 2017

DEPARTMENT OF AGRICULTURE

Agenda

Time	Topic
9:00-9:20	EAB Biology
9:20-9:40	EAB Regional Status
9:40-10:00	Strategic Removal Of Host Trees In Isolated, Satellite Infestations Of EAB Can Reduce Population Growth
10:00-10:05	BREAK
10:05-10:20	Biocontrol & Biosurveillance
10:20-10:50	Using Monitoring Data to Optimize EAB Management
10:50-11:00	UMN Past & Present Projects
11:00-11:05	BREAK
11:05-11:25	EAB Cold Tolerance
11:00-noon	Participant Discussion

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EAB Biology

Angie Ambourn | Entomologist

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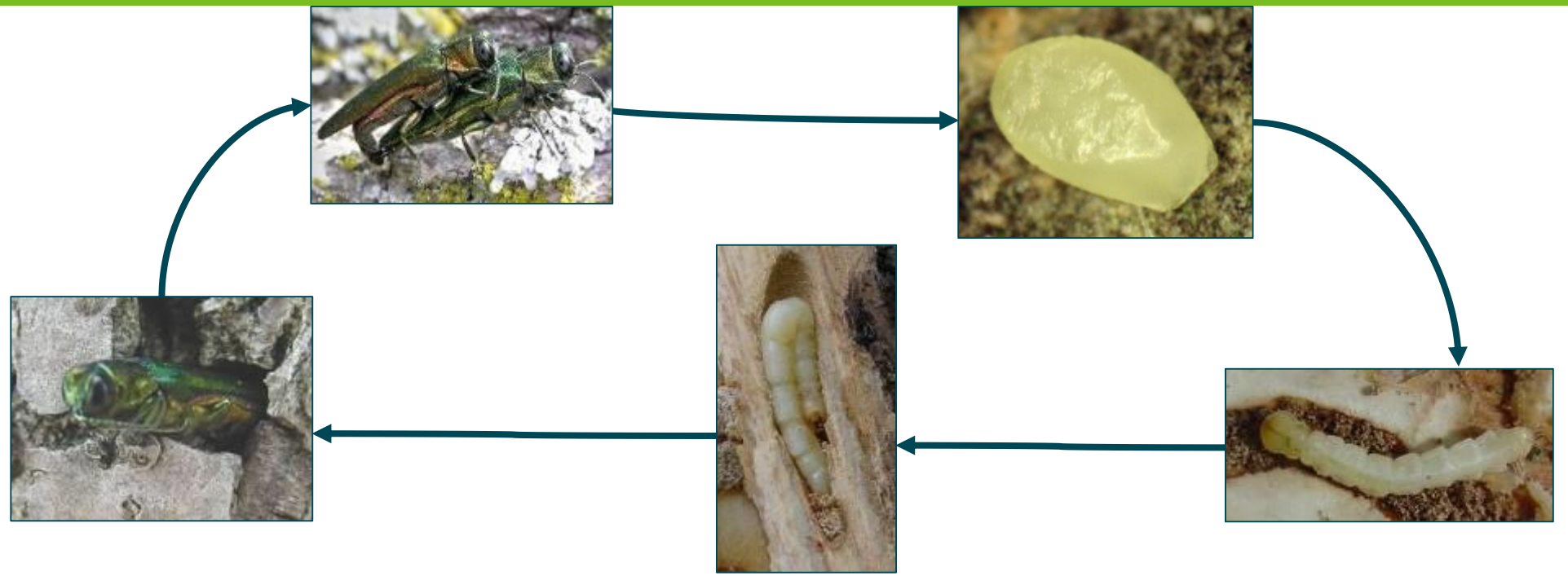
Life Cycle

Life Cycle



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Immature (under bark)	■	■	■	■	■	■	■	■	■	■	■	■
Adult (free living)					■	■	■	■	■			

How Does EAB Kill Trees?

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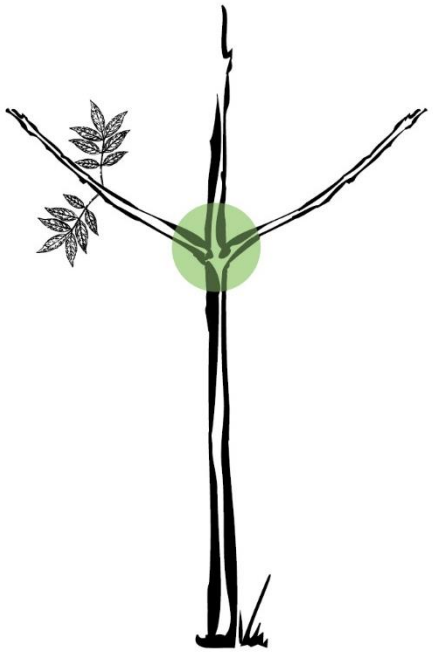
Host Trees

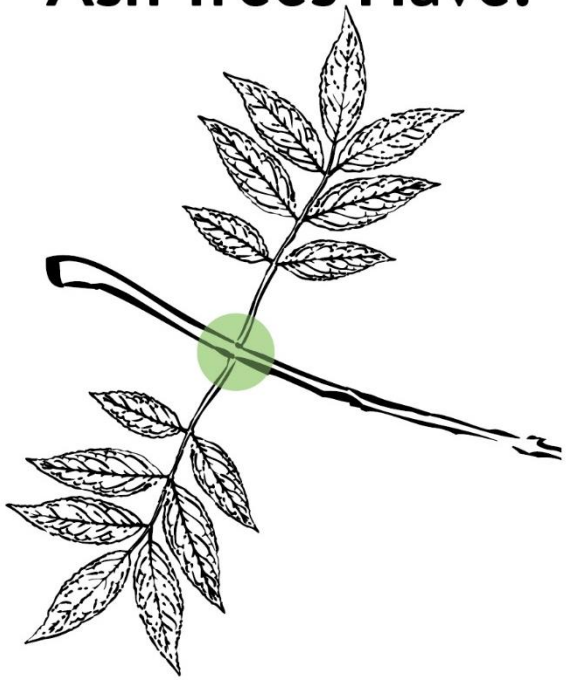
Ash Tree ID

Ash Trees Have:



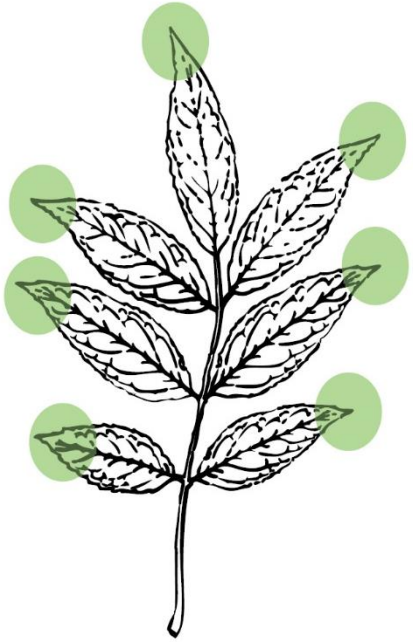
Opposite Branching

Ash Trees Have:



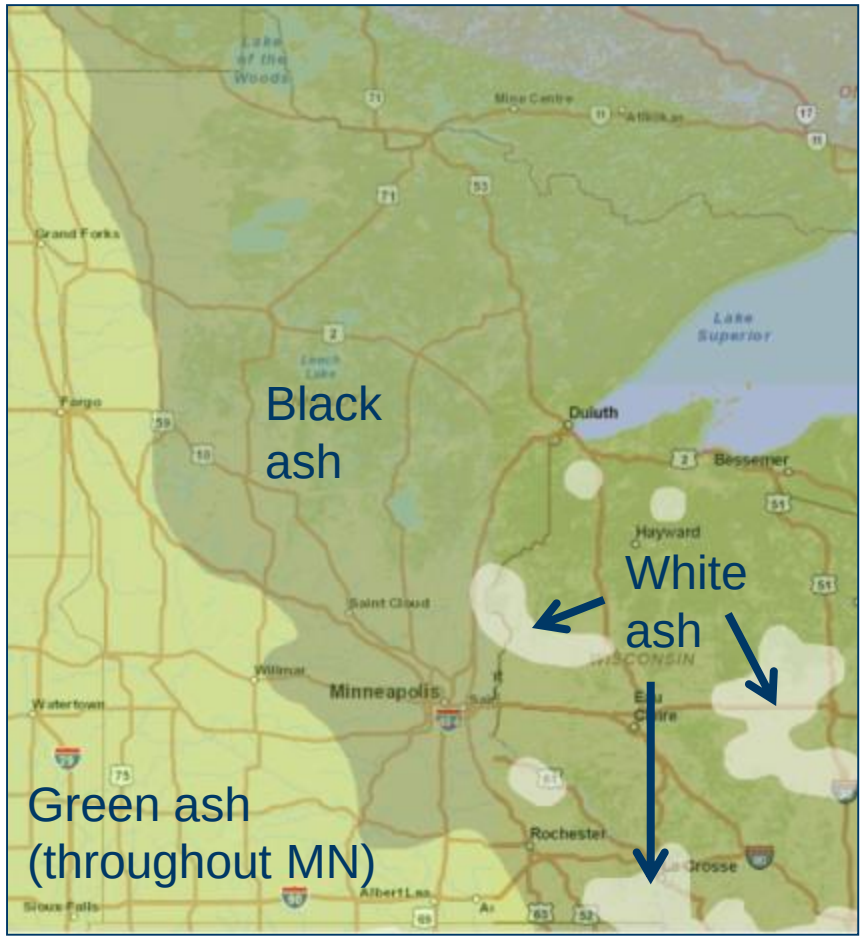
Compound Leaves

Ash Trees Have:



5 to Many Leaflets

Host Trees



Susceptibility

high

Black ash

Green ash

White ash

Blue ash

Manchurian ash

low

Black Ash Cultivars

- Fallgold

Green Ash Cultivars

- Bergeson
- Cimmaron
- Marshall
- Patmore
- Summit

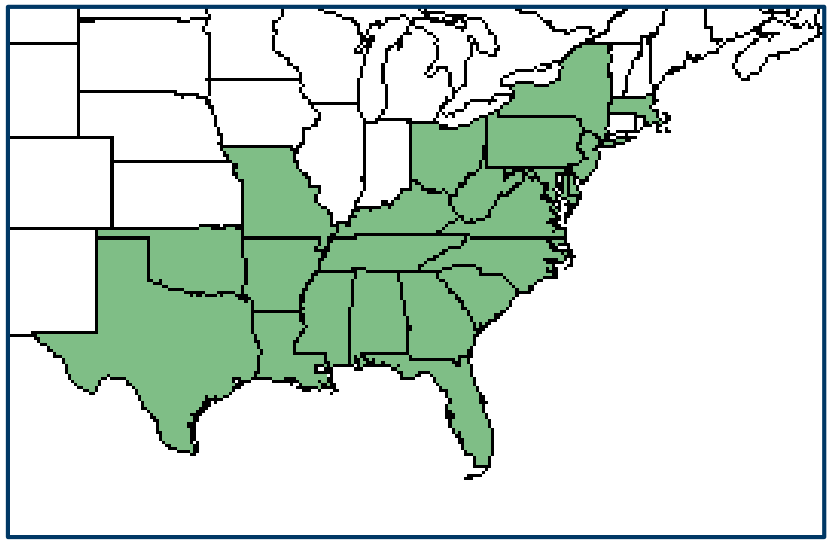
White Ash Cultivars

- Autumn Applause
- Autumn Blaze
- Autumn Purple
- Baltimore
- Greenspire
- Northern Blaze
- Rosehill
- Skyline

Secondary Host Tree

- Olive Family - Oleaceae
- White Fringetree

  Chionanthus virginicus



Fringetree Risk

- Not a preferred host but EAB can complete its life cycle
- Sold in nurseries as an ornamental shrub

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Recognizing EAB

Confirmation

"S" shaped galleries

EAB Larva

Confirmation

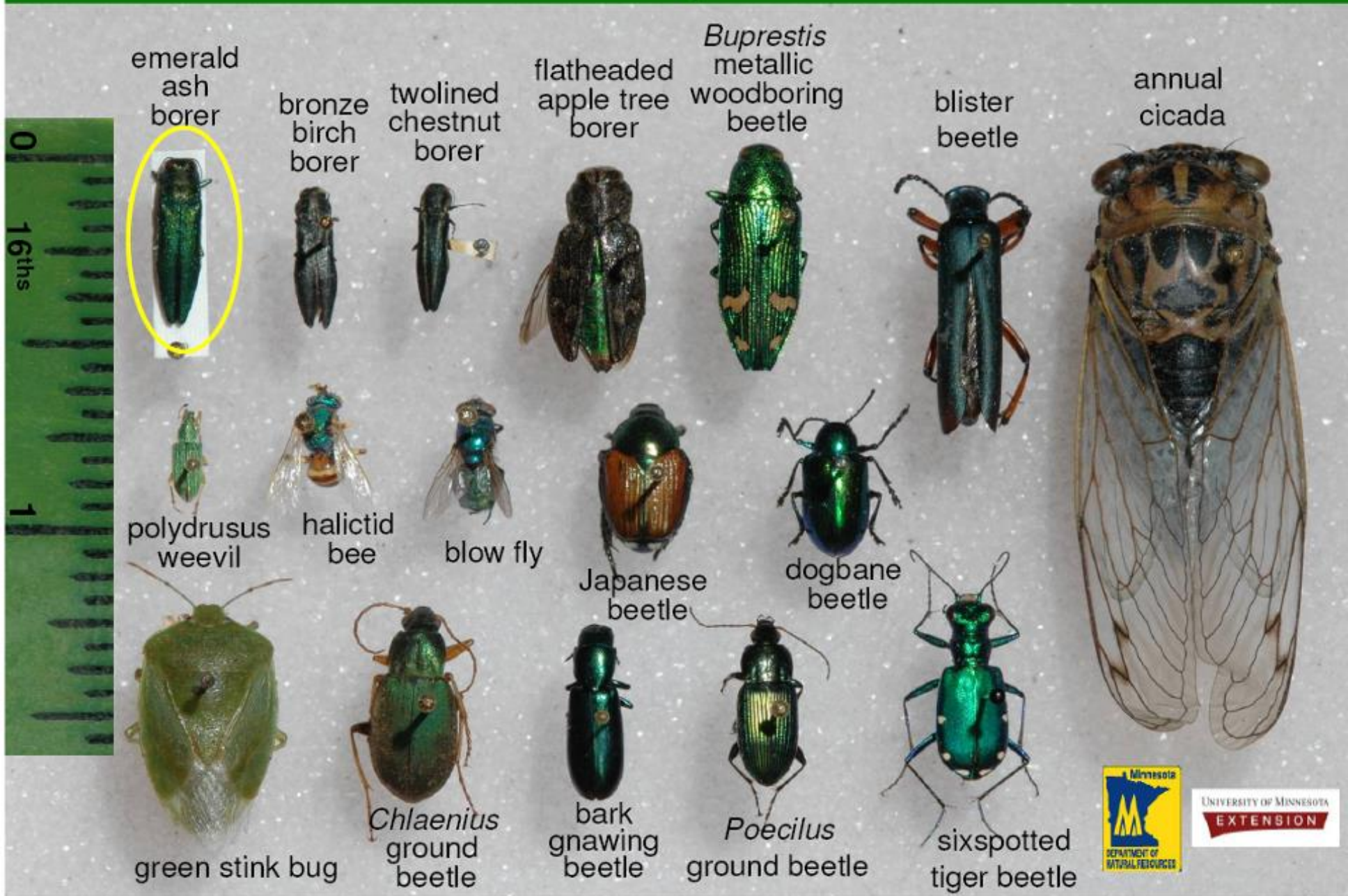
1/8” width

“D” shaped exit holes

EAB Adult

Insects in Minnesota That May Be Confused with Emerald Ash Borer

Jeff Hahn, University of Minnesota Extension
Val Cervenka Minnesota Dept. of Natural Resources



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Signs & Symptoms

Symptom Progression

EAB Status	Symptoms	Years Infested
Small larvae present	None	1
Large larvae present / Emerging adults	Woodpecking possible	2
Increasing larvae numbers 	Woodpecking likely Bark splits possible	3
	Canopy impacts visible	4
	Dead trees present	5-6

Woodpecker Damage

- Mid / Top canopy
- Branches 3-6” in diameter
- Bark transitions to rough
- Bark blonding / flaking
- Dime sized woodpecker holes
- Light colored woodpecker holes
- Oval shaped

Woodpecker Damage

Bark Splits

Native Damage

- Trunk
- Lower canopy
- Dead limbs

Emerald Ash Borer Regional Meeting

May 17, 2017

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EAB Regional Status

Jennifer Burington | EAB Community Liaison

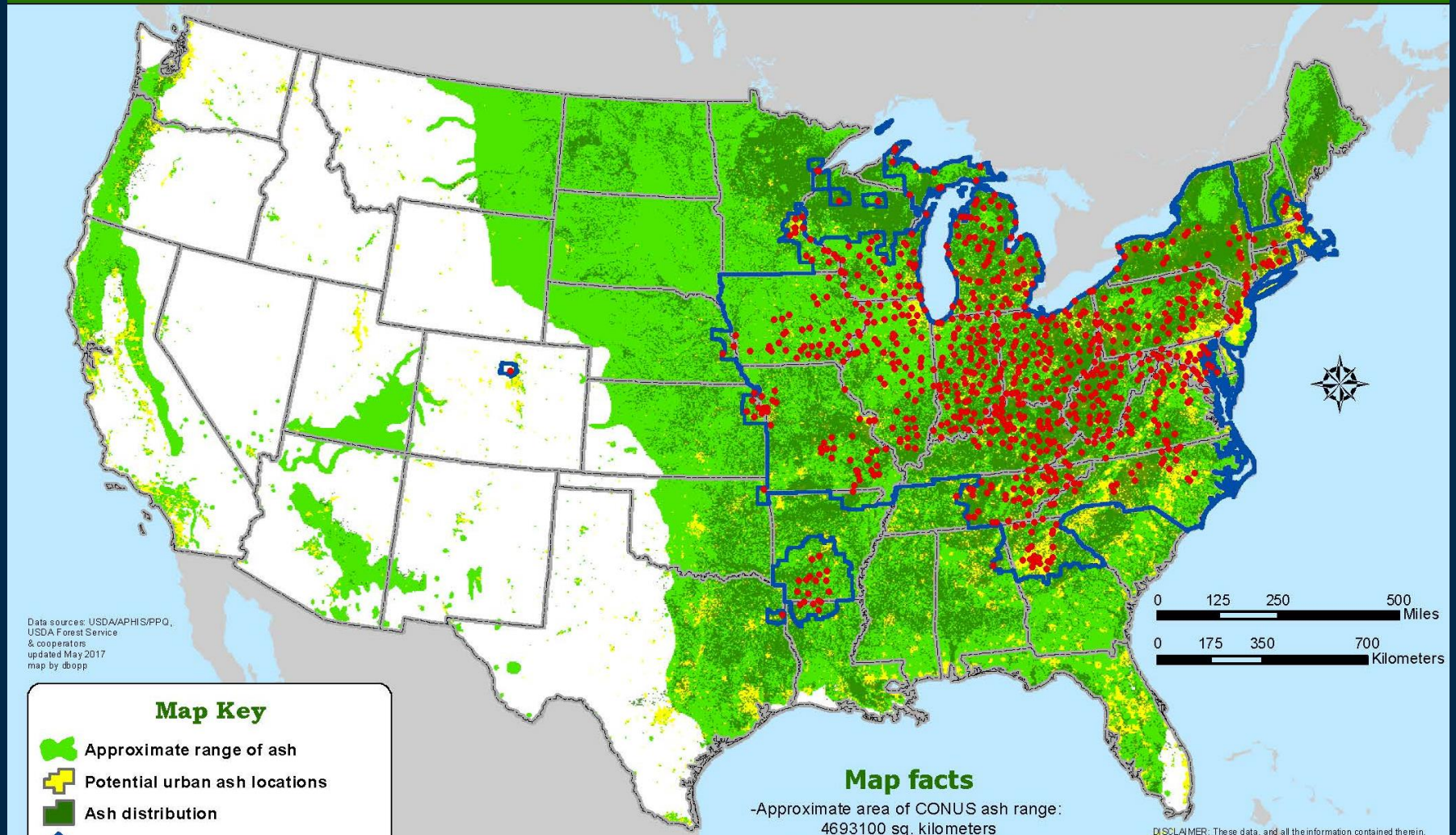
Distribution

USDA United States Department of Agriculture

Cooperative Emerald Ash Borer Project

Approximate range of ash species in the Contiguous U.S.
with EAB positives and Federal quarantines

May 1, 2017



Data sources: USDA/APHIS/PPQ, USDA Forest Service & cooperators
updated May 2017
map by dbopp

Map Key

- Approximate range of ash
- Potential urban ash locations
- Ash distribution
- Federal EAB quarantine boundaries
- Initial county EAB detection

Ash species distribution map source:
USDA, Forest Service, Forest Health Technology Enterprise Team (FHTET).

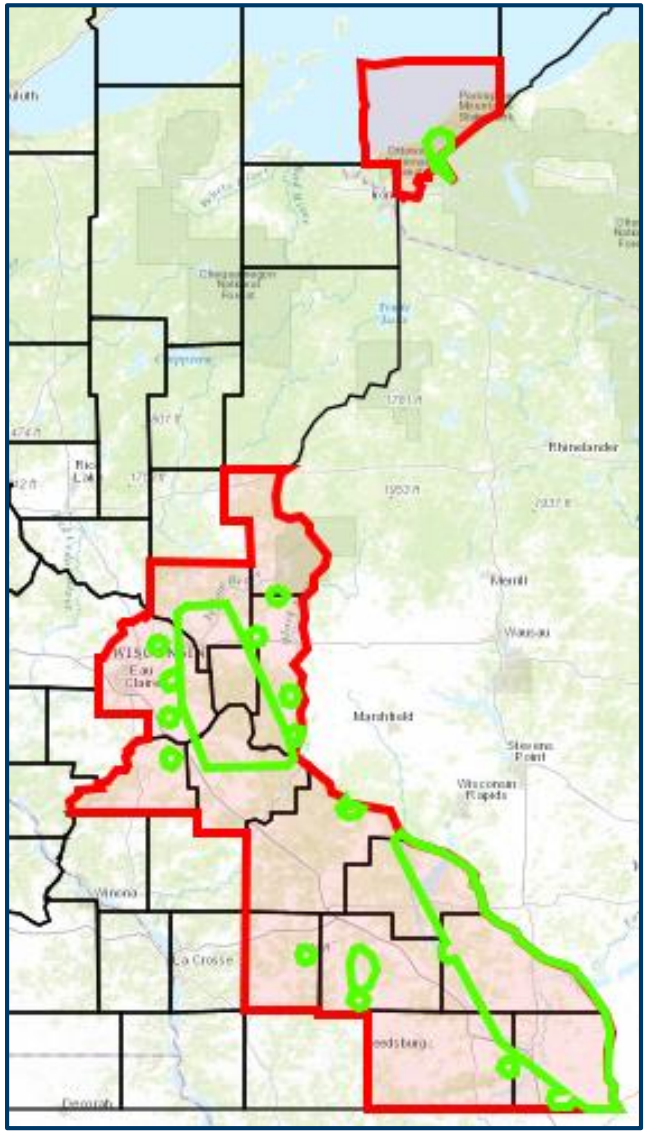
Link to FHTET species distribution maps:
http://foresthealth.fs.usda.gov/host/

Map facts

-Approximate area of CONUS ash range:
4693100 sq. kilometers
-Area of U.S. Federal quarantine:
1850714 sq. kilometers
-Total area of counties where EAB is present:
1220538 sq. kilometers

Minnesota Distribution

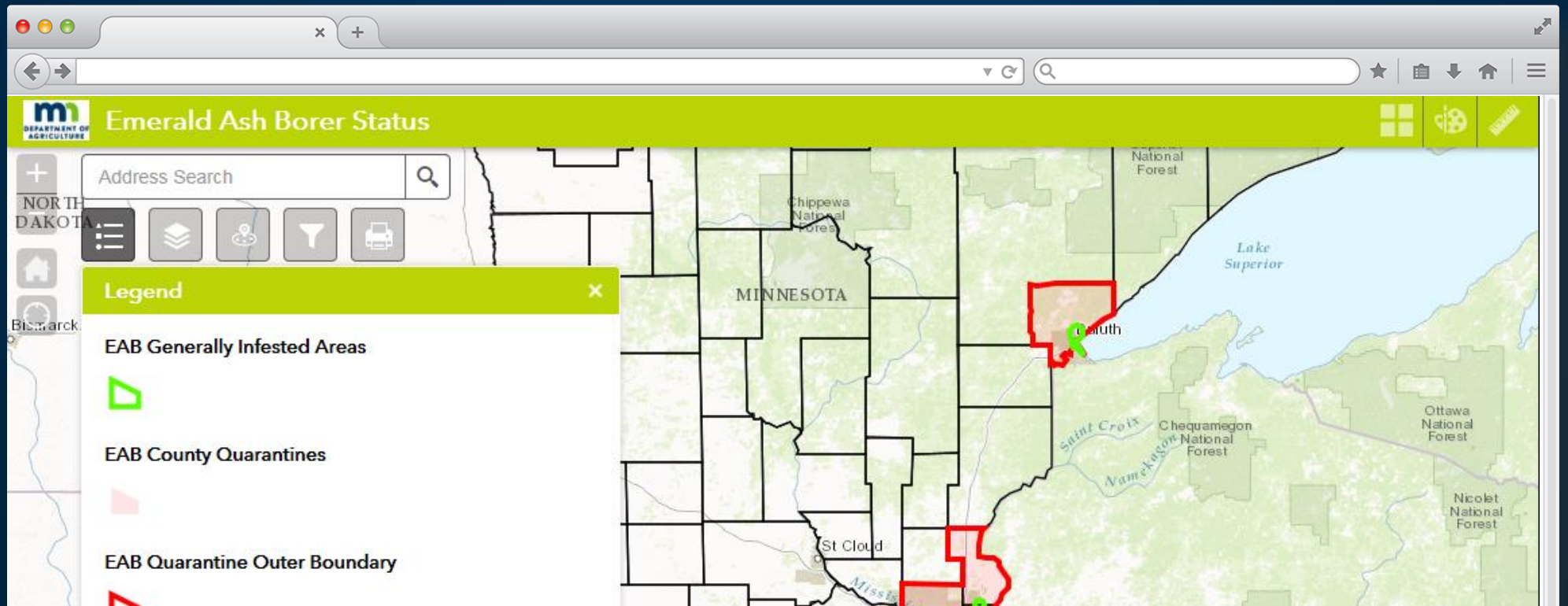
- Generally infested area in green within red EAB quarantined counties
- Quarantined Counties
  - Ash
  - EAB
  - Hardwood Firewood (<4 feet in length)



mda.state.mn.us/eab

Interactive Map

- mda.state.mn.us/eabstatus
- Closest known infested ash tree



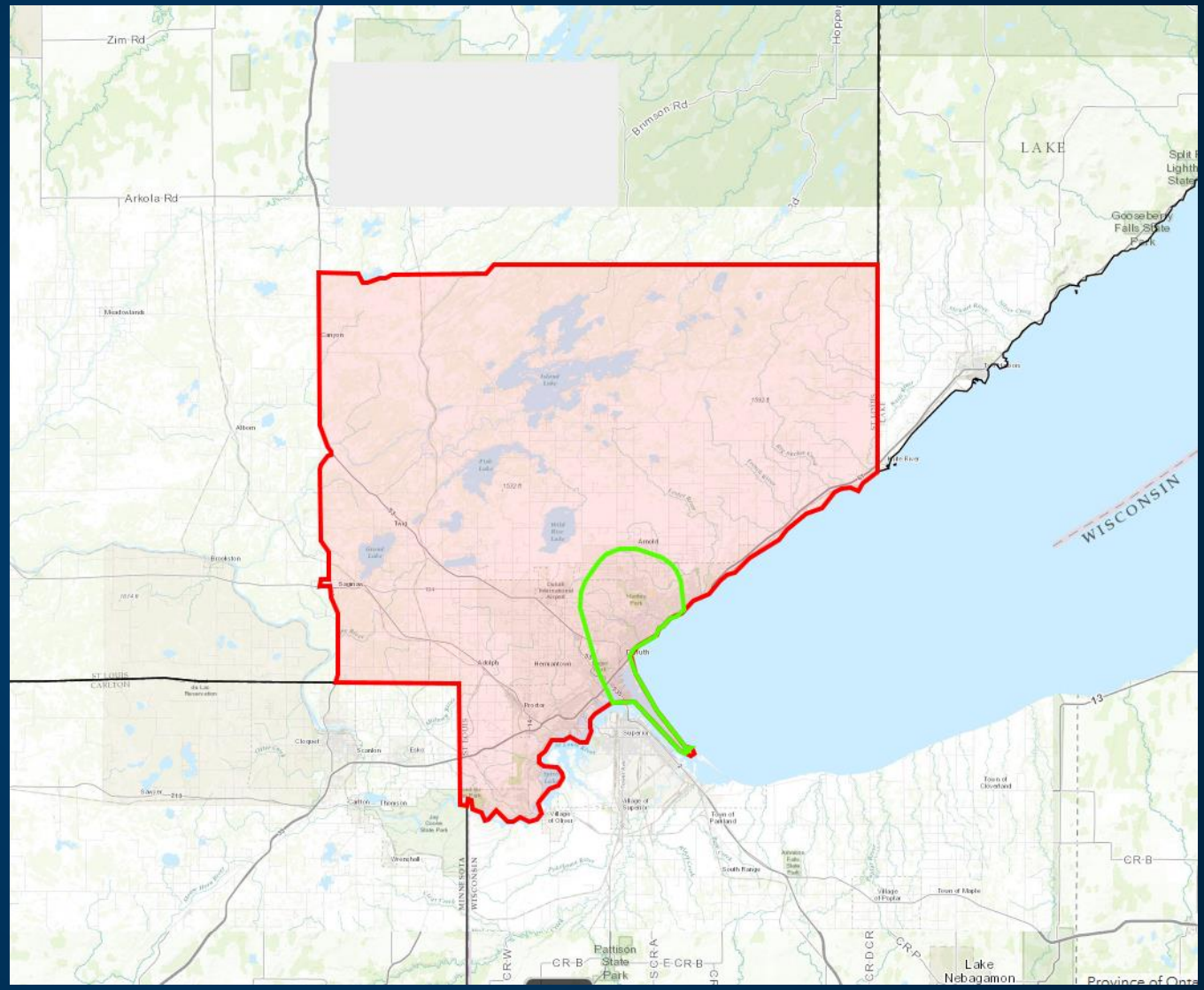
August 2013
- Superior, WI

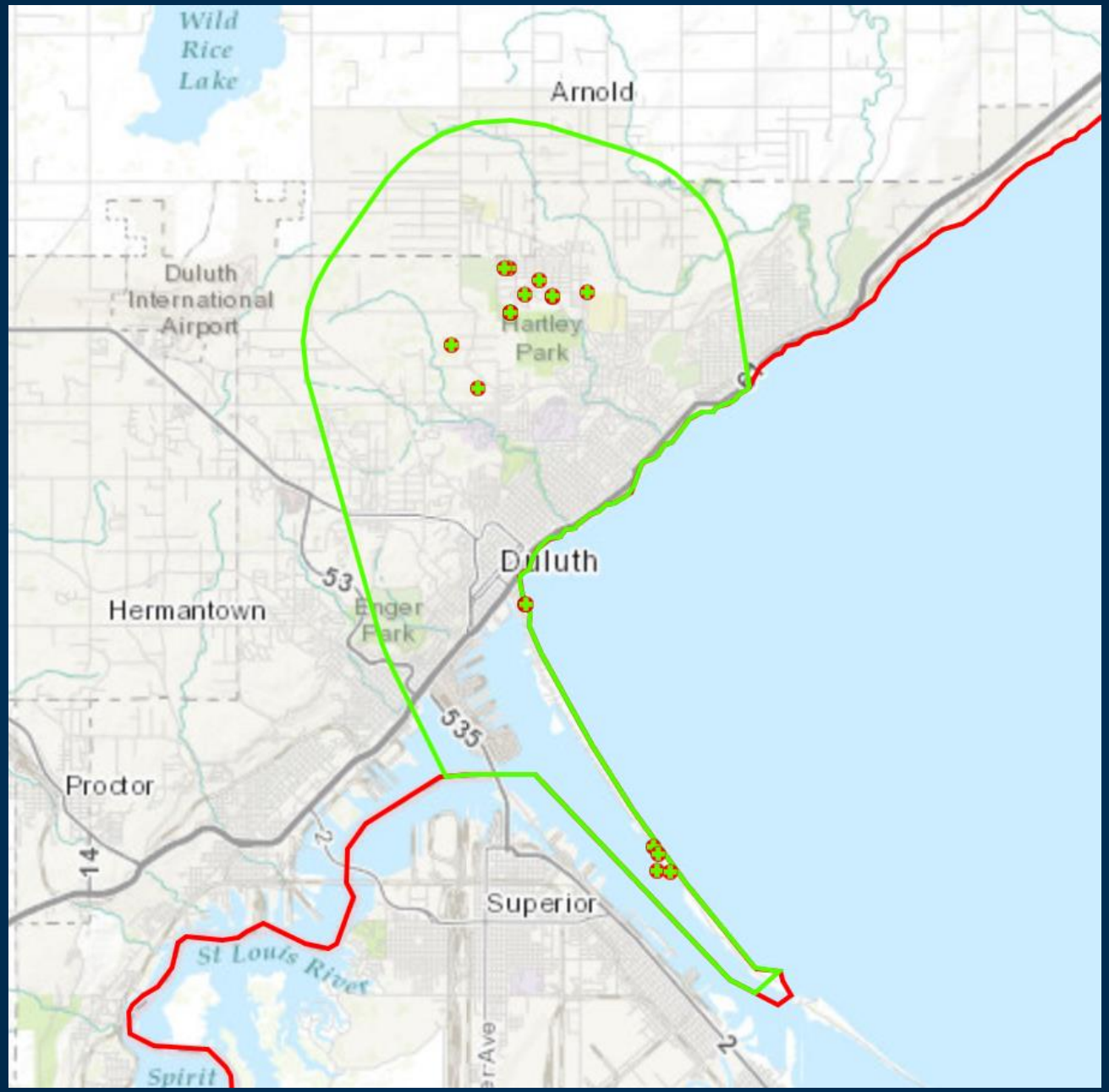
October 2015
- Park Point

June 2016
- Thunder Bay, Ontario

September 2016
- Duluth mainland

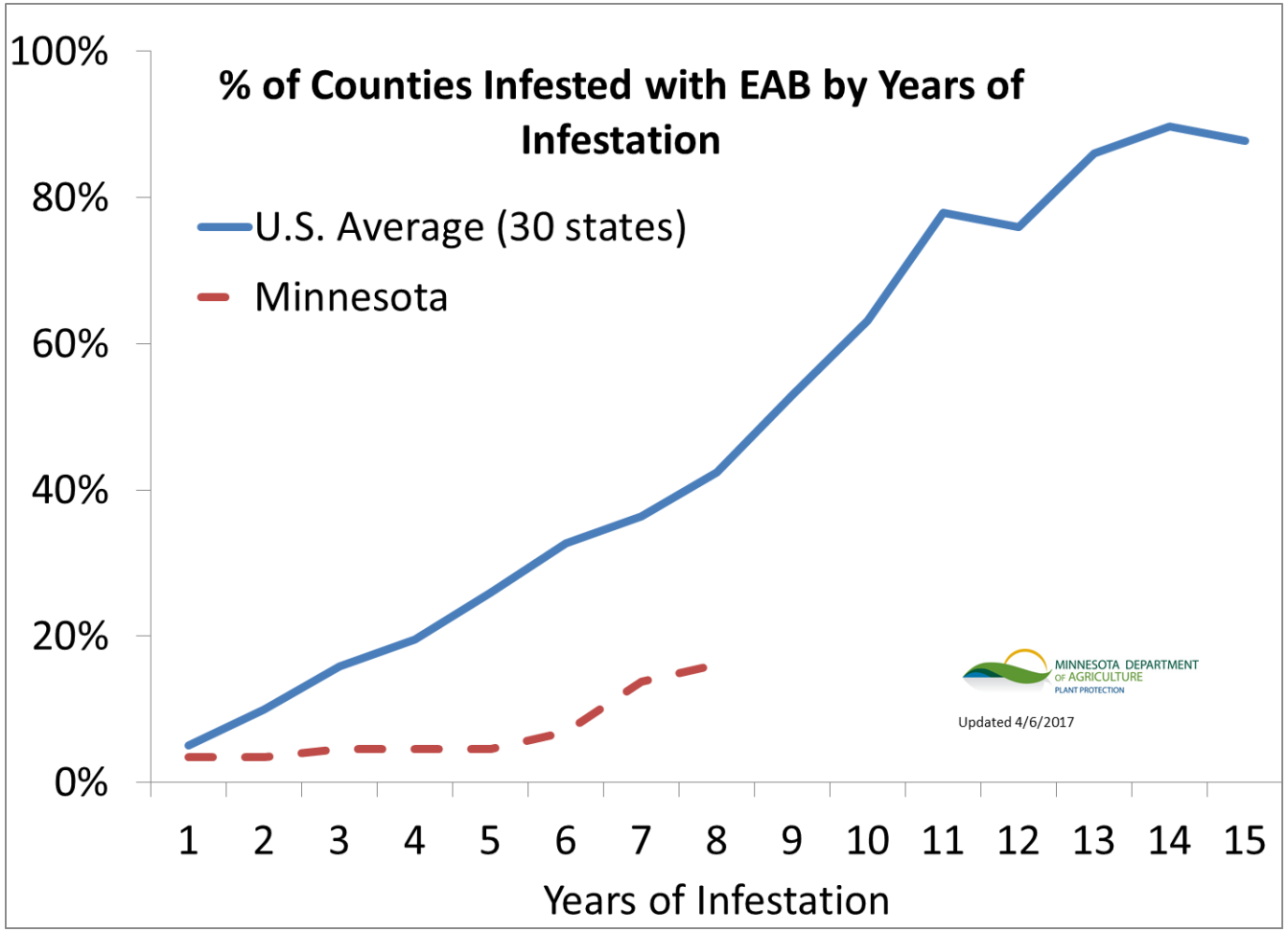
March 2017
- Hartley Park




Wild Rice Lake
Arnold
Duluth International Airport
Hartley Park
Duluth
Hermantown
53
Enger Park
535
Proctor
14
2
Superior
St Louis River
Spirit

Slow Spread

- Cold weather
- Education
- Outreach
- Aggressive management
- Quarantines
- Sanitation



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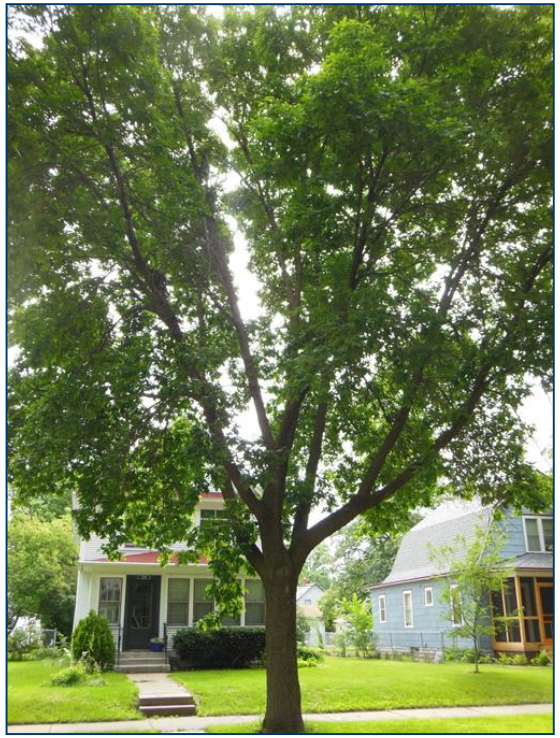
Management

Treatment Plans

- Free permit for private treatment of public trees
- In-house treatments of public trees, $4.77/Diameter inch
- City contract rate extended to private residents, ~$6/D inch
- Treat trees to remove at a later date while waiting for diverse plantings to grow or funds become available



mda.state.mn.us/eab

Removal Plans

- Pre-EAB remove poor quality
- Remove woodpecked trees
- Remove private infested trees (Diseased Tree Ordinance)
- Remove all trees regardless of infestation
- Remove hazard trees

Outreach Efforts

- City Water Bill Insert
- Tree Wraps
- Press Releases
- Postcard Mailings
- Don’t Move Firewood Poster

City A

- Remove poor quality trees
- Remove public infested trees
- Remove private infested trees within a specific distance of adjacent property
- Treat public mature trees in-house, park and boulevard

City B

- Remove poor quality trees
- Remove public infested trees
- No treatments
- No removal of private infested trees

City C

- Remove poor quality trees
- Remove public infested trees
- Remove private infested trees
- Treat mature public park trees, contract
- Treat private trees, offer contract rate

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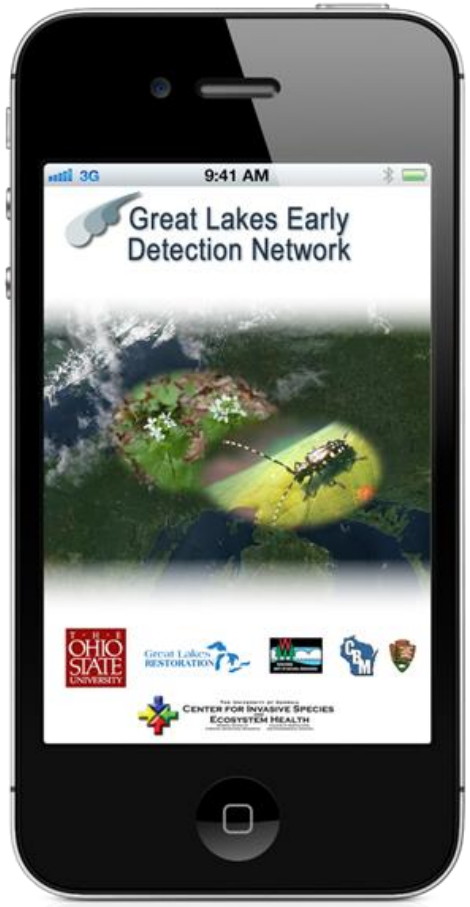
Reporting

Arrest the Pest

- Take pictures and notes
- Capture the insect or remove bark to see gallery/larvae
- Report
  - GLEDN app (Great Lakes Early Detection Network)
  - mda.state.mn.us/arrestthepest
  - Arrest.the.pest@state.mn.us
  - Call 888-545-6684 and leave a detailed message



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Biocontrol & Biosurveillance

Jonathan Osthus| EAB BioControl Coordinator

Biological Control Agents

- Egg Parasitoid
  - *Oobius agrili*
- Larval Parasitoid
  - *Tetrastichus planipennisi*
- Larval Parasitoid
  - *Spathius galinae*

EAB Biological Control - Implementation

Over 449,000 parasitoid wasps released at 35 sites since September 2010

Biocontrol Agent	2010	2011	2012	2013	2014	2015	2016	All
Tetrastichus planipennisi	2,154	19,480	19,822	42,579	34,434	151,022	45,288	314,779
Oobius agrili	0	3,641	10,241	8,597	12,062	31,490	42,600	108,631
Spathius agrili	1,172	7,596	15,258	0	0	0	0	24,026
Spathius galinae	0	0	0	0	0	0	1,613	1,613
Totals	3,326	30,717	45,321	51,176	46,496	182,512	89,501	449,049

EAB Biological Control - Assessment

- Recovery Methods
  - Tree Debarking
  - Bark Sifting
  - Yellow Pan Trapping

BioSurveillance

- Smoky winged beetle bandit wasp
  - *Cerceris fumipennis*
- Citizen Engagement – Wasp Watchers

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Using Monitoring Data to Optimize EAB Management

Mark Abrahamson, Assistant Director, Plant Protection Division

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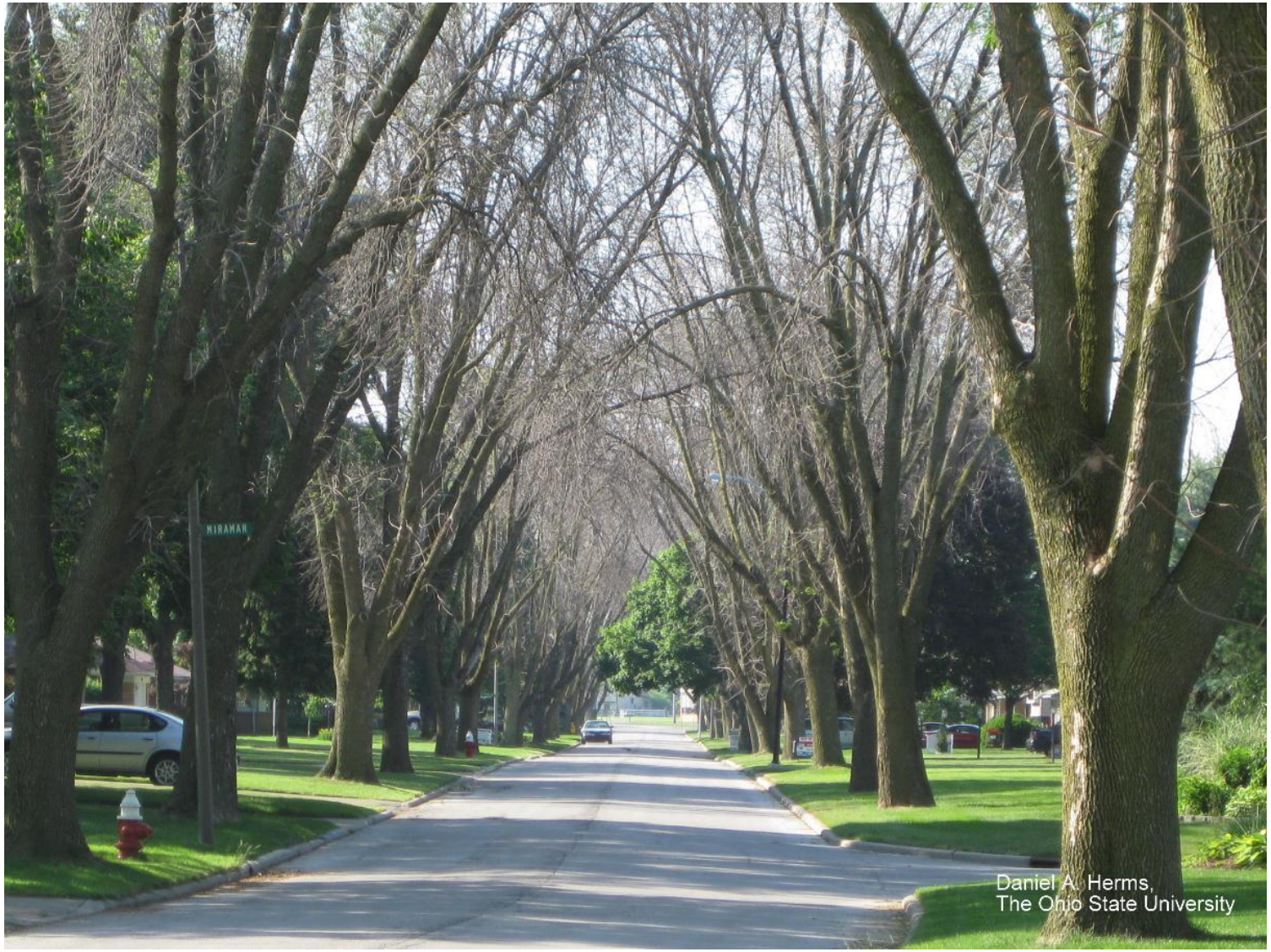
EAB is Bad



Trees are Good!

Environmental Science & Technology

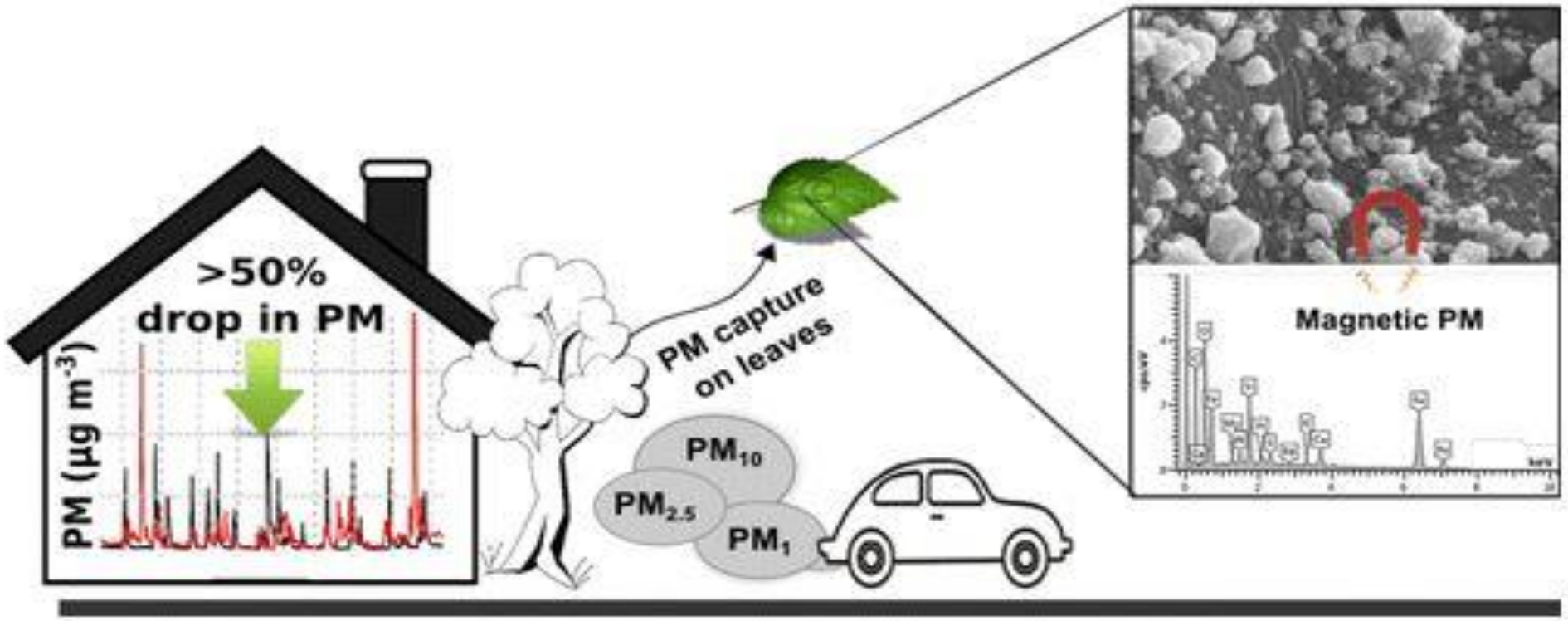
Article

pubs.acs.org/est

Impact of Roadside Tree Lines on Indoor Concentrations of Traffic-Derived Particulate Matter

Barbara A. Maher,* Imad A. M. Ahmed, Brian Davison, Vassil Karloukovski, and Robert Clarke

Centre for Environmental Magnetism & Palaeomagnetism, Lancaster Environment Centre, Lancaster University, Lancaster LA1 4YQ, United Kingdom



The Relationship Between Trees and Human Health

Evidence from the Spread of the Emerald Ash Borer

Geoffrey H. Donovan, PhD, David T. Butry, PhD, Yvonne L. Michael, ScD, Jeffrey P. Prestemon, PhD, Andrew M. Liebhold, PhD, Demetrios Gatziolis, PhD, Megan Y. Mao

Background: Several recent studies have identified a relationship between the natural environment and improved health outcomes. However, for practical reasons, most have been observational, cross-sectional studies.

Purpose: A natural experiment, which provides stronger evidence of causality, was used to test whether a major change to the natural environment—the loss of 100 million trees to the emerald ash borer, an invasive forest pest—has influenced mortality related to cardiovascular and lower-respiratory diseases.

Methods: Two fixed-effects regression models were used to estimate the relationship between emerald ash borer presence and county-level mortality from 1990 to 2007 in 15 U.S. states, while controlling for a wide range of demographic covariates. Data were collected from 1990 to 2007, and the analyses were conducted in 2011 and 2012.

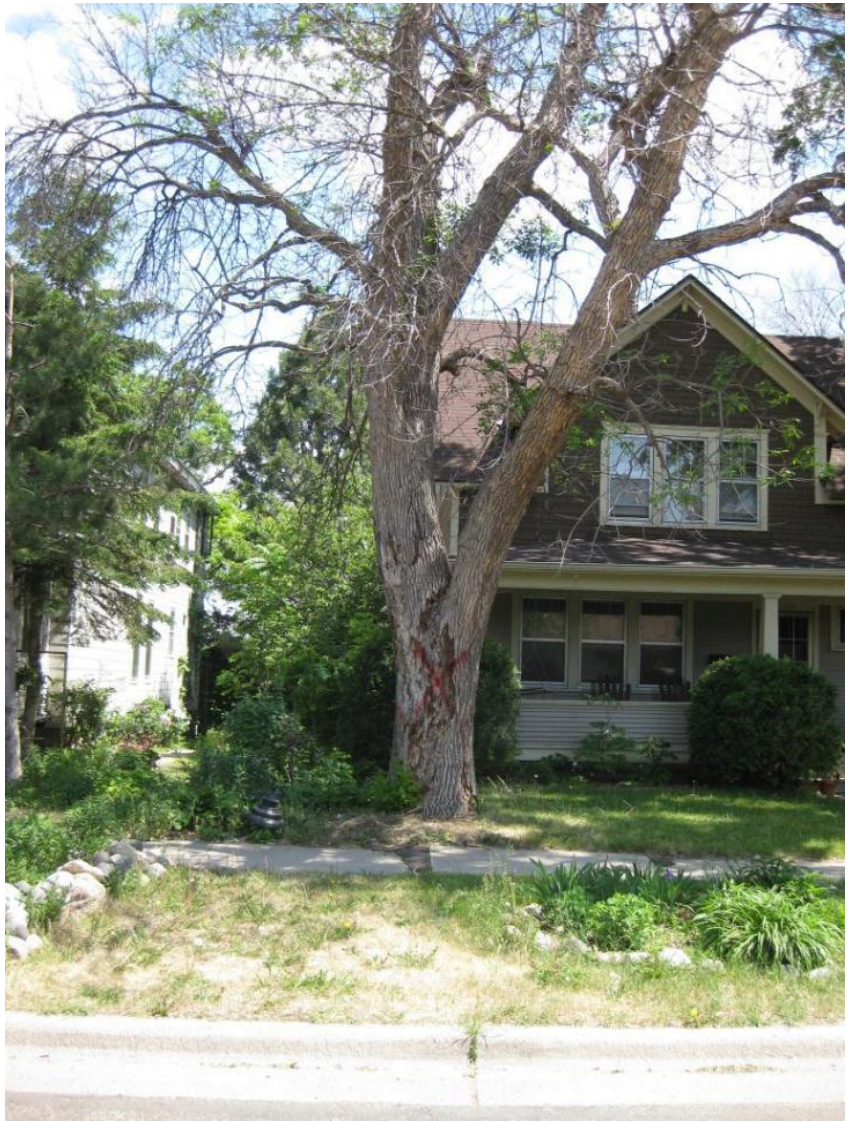
Results: There was an increase in mortality related to cardiovascular and lower-respiratory-tract illness in counties infested with the emerald ash borer. The magnitude of this effect was greater as infestation progressed and in counties with above-average median household income. Across the 15 states in the study area, the borer was associated with an additional 6113 deaths related to illness of the lower respiratory system, and 15,080 cardiovascular-related deaths.

Conclusions: Results suggest that loss of trees to the emerald ash borer increased mortality related to cardiovascular and lower-respiratory-tract illness. This finding adds to the growing evidence that the natural environment provides major public health benefits.

(Am J Prev Med 2013;44(2):139–145) Published by Elsevier Inc. on behalf of American Journal of Preventive Medicine

Fate of EAB Infested Trees

1. Removed (before or after death)
2. Treated with insecticide
3. Die and fall apart



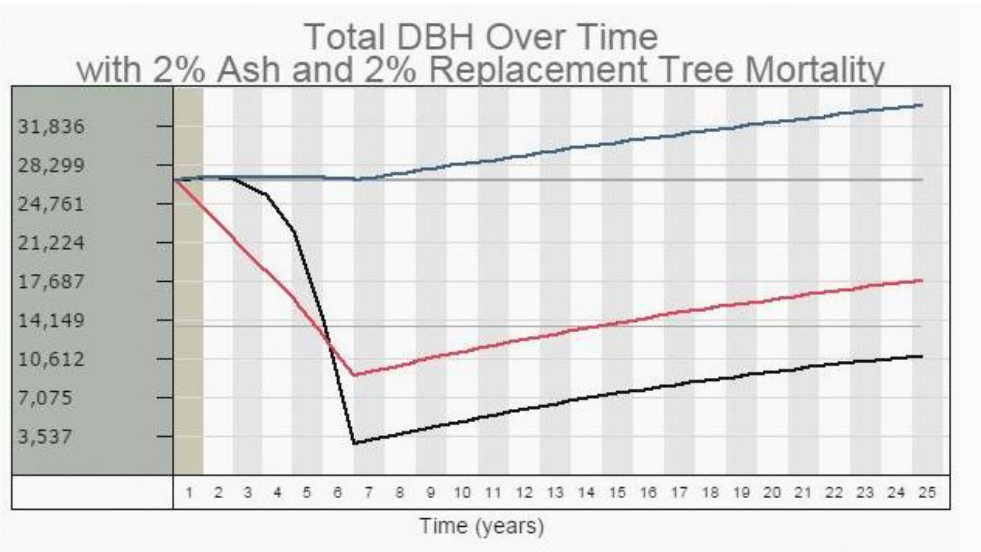
EXTENSION ENTOMOLOGY | EAB IN INDIANA

Emerald Ash Borer Cost Calculator

PURDUE UNIVERSITY

Welcome to the Emerald Ash Borer Cost Calculator 2.1

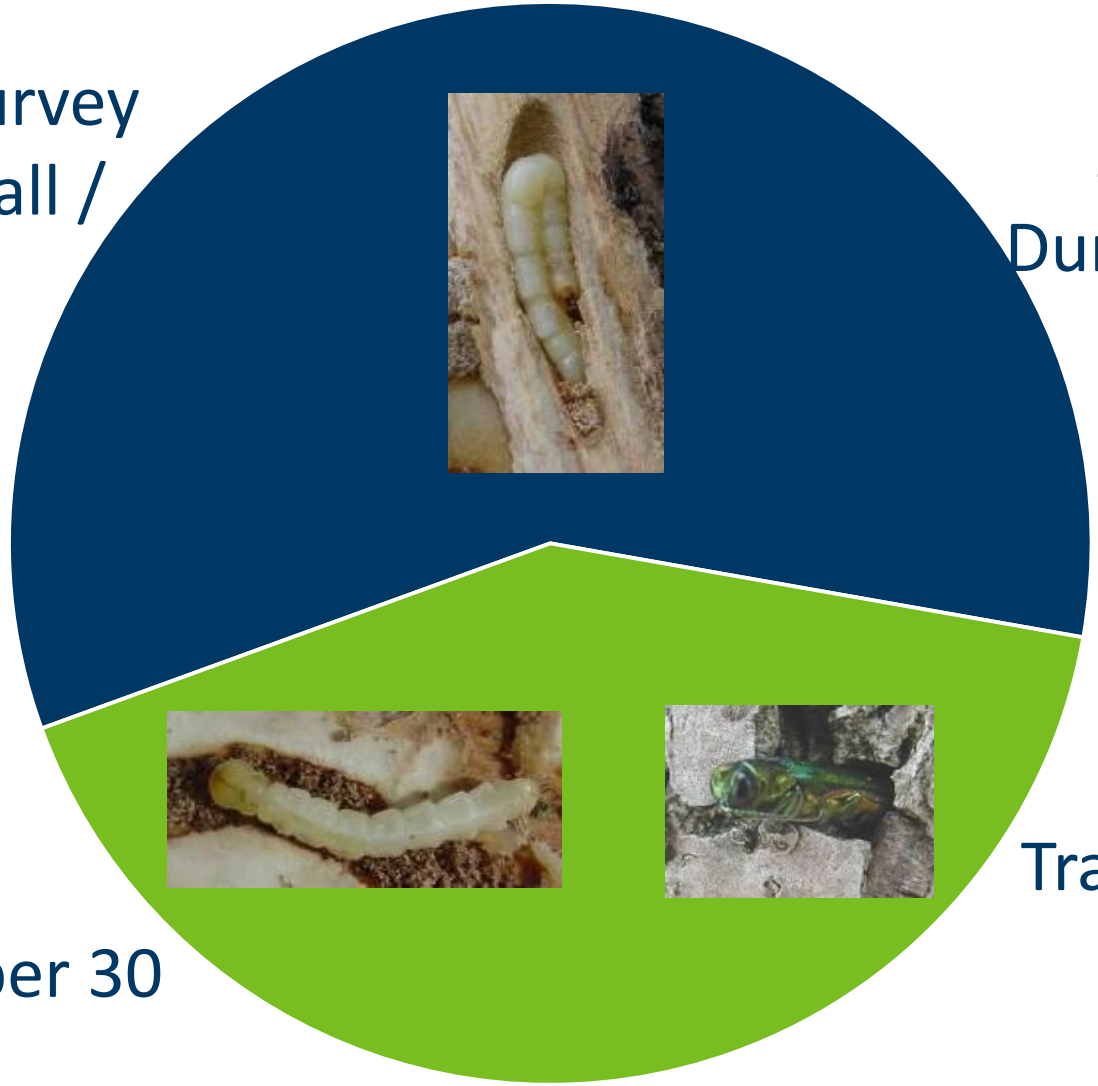
Option 1	Option 2	Option 3
Remove All	Remove All	Remove All
Replace All	Replace All	Replace All
Treat All	Treat All	Treat All
Remove Unsafe Ash	Remove Unsafe Ash	Remove Unsafe Ash
Replace Unsafe Ash	Replace Unsafe Ash	Replace Unsafe Ash
Save 80%	Save 80%	Save 80%
Replace <12	Replace <12	Replace <12
Save 50%	Save 50%	Save 50%
URBAN SLAM	URBAN SLAM	URBAN SLAM



Use of Monitoring to Inform Management

EAB Lifecyle

Visual Survey During Fall / Winter / Spring



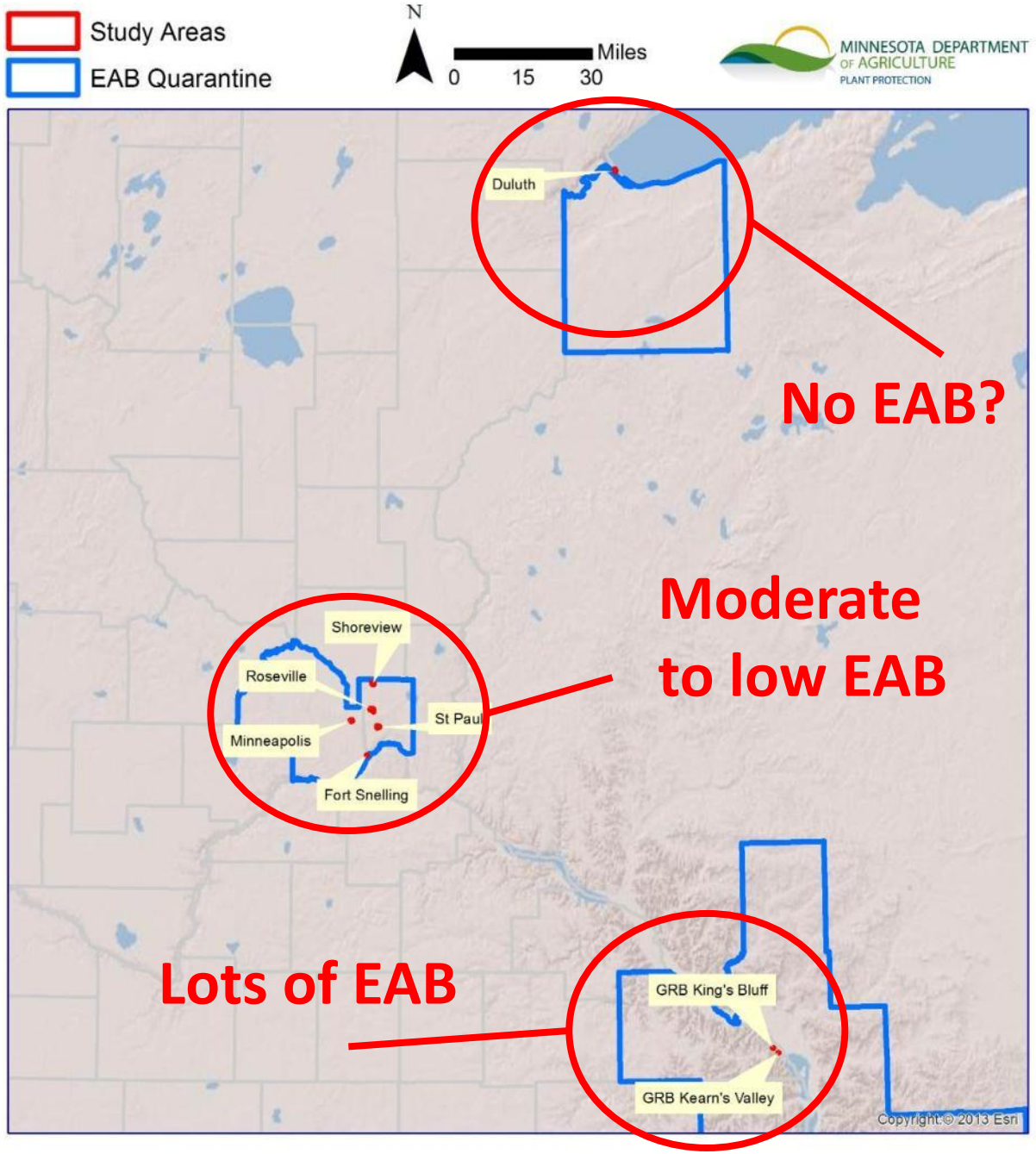
Branch Sampling During Fall / Winter / Spring

May 1

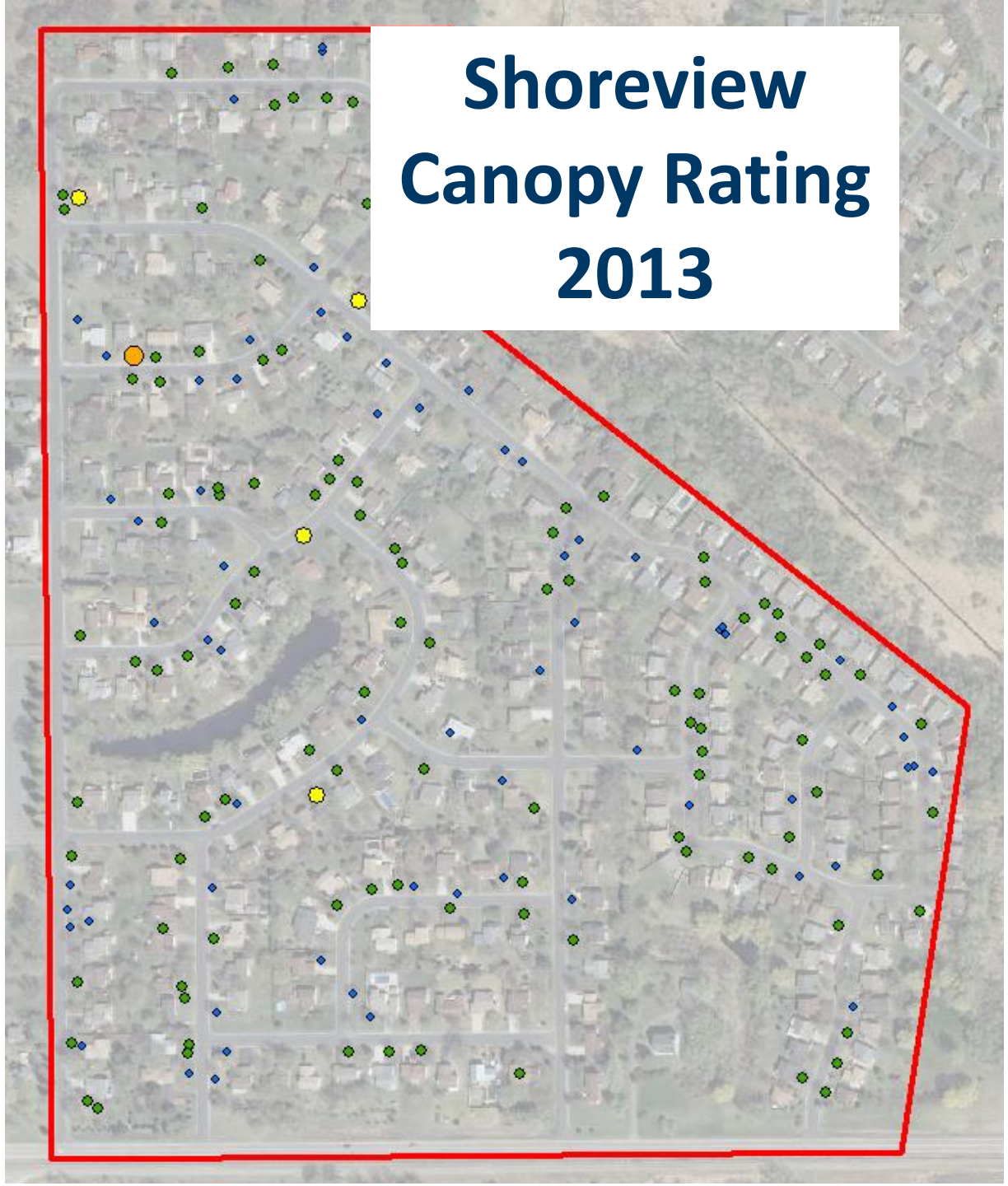
Trap Survey During Summer

September 30

EAB Detection Study Sites



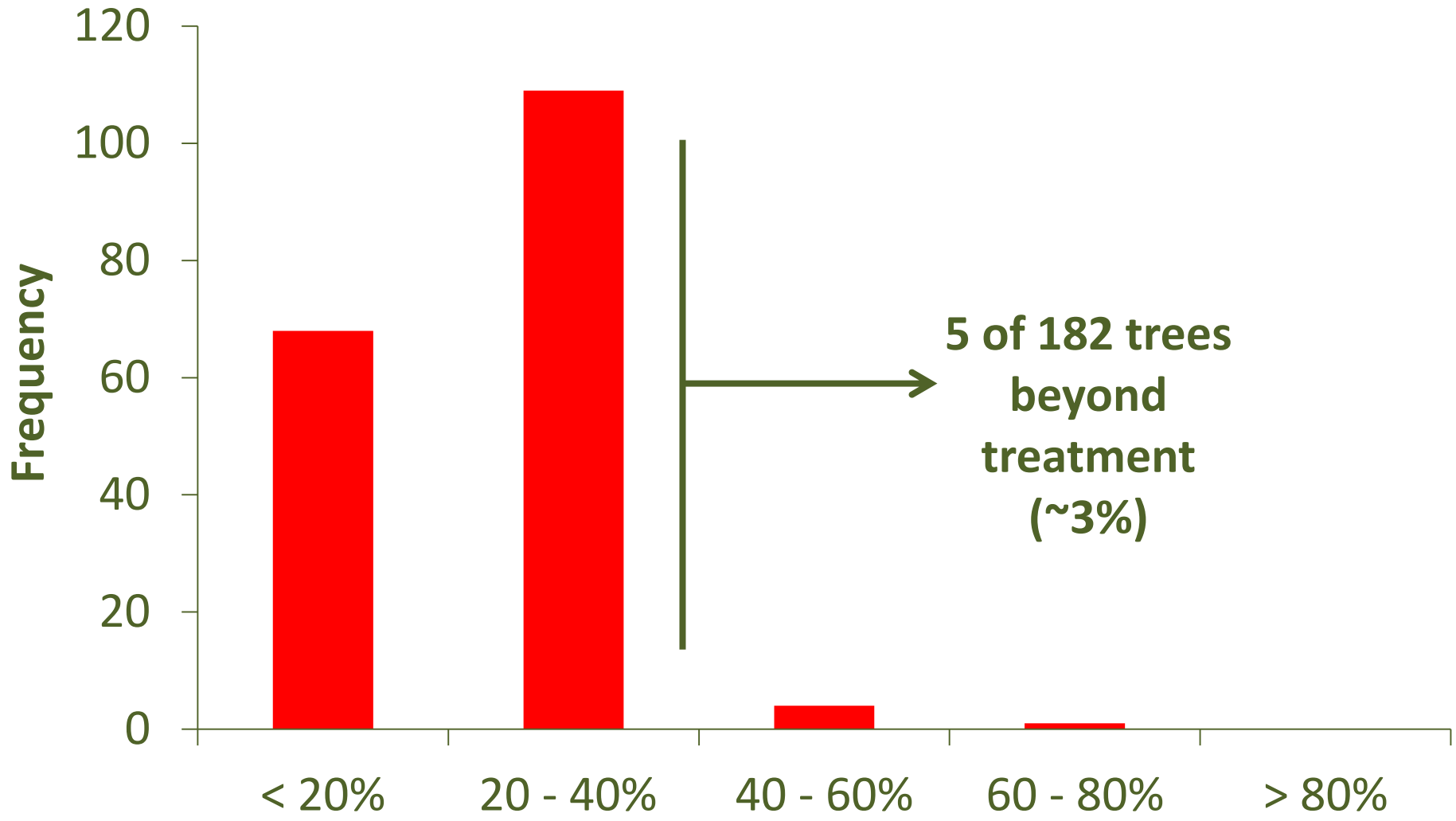
Shoreview Canopy Rating 2013



Canopy Rating

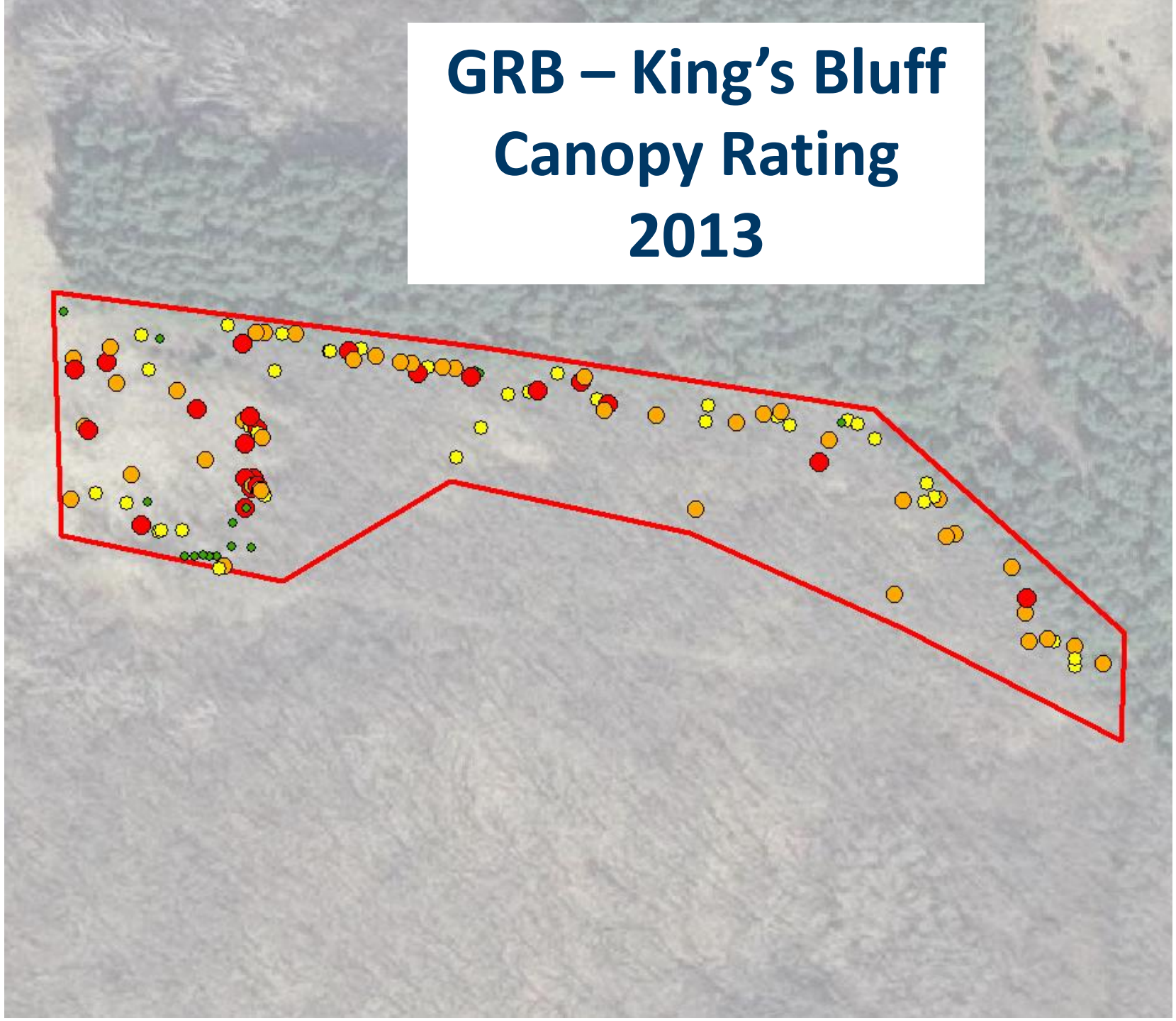
- < 20% loss
- 20-40%
- 40-60%
- 60-80%
- > 80%

Shoreview 2013



EAB Regional meeting/https://www.mda.state.mn.us/emeraldashborer

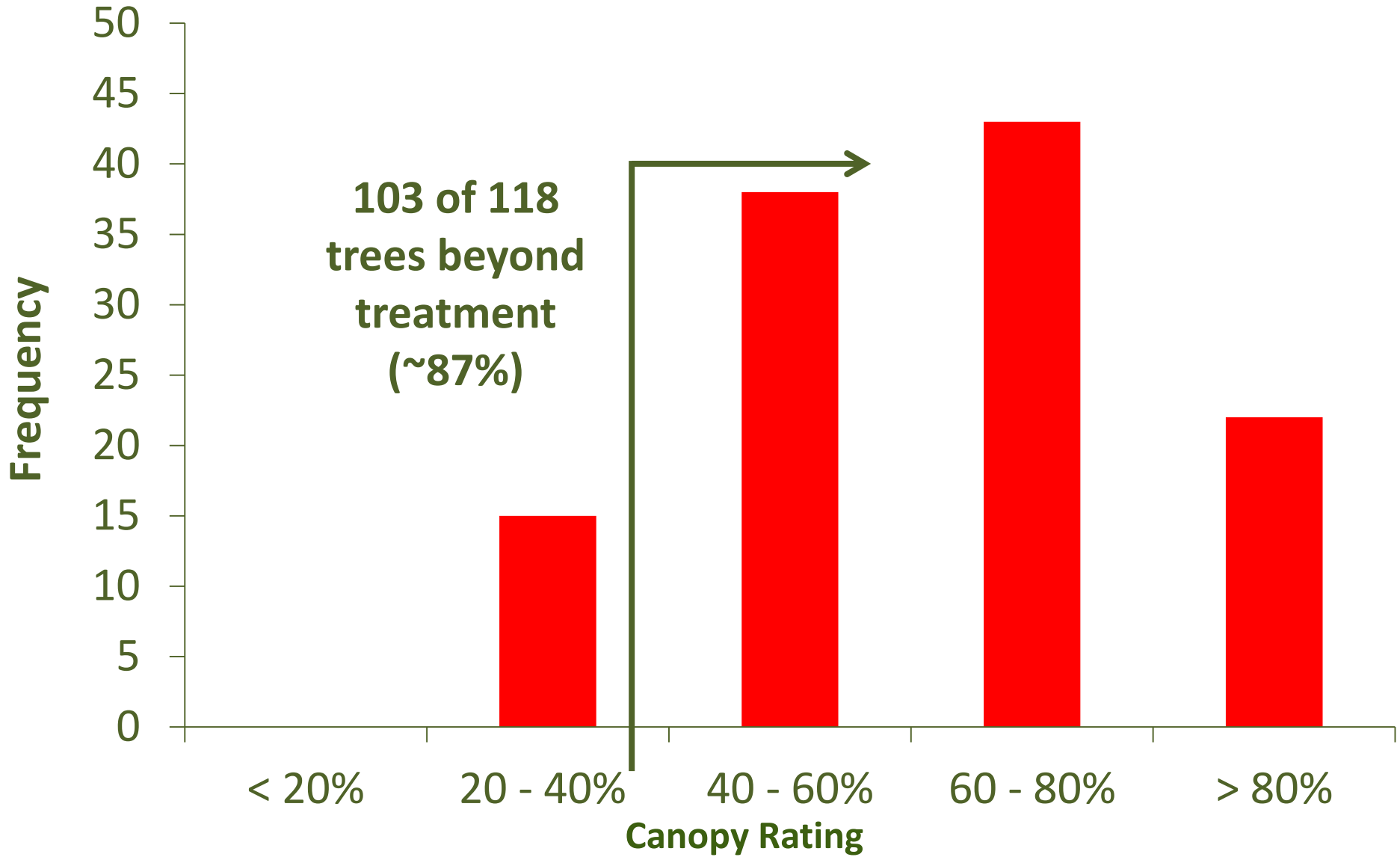
GRB – King's Bluff Canopy Rating 2013



Canopy Rating

- < 20% loss
- 20-40%
- 40-60%
- 60-80%
- > 80%

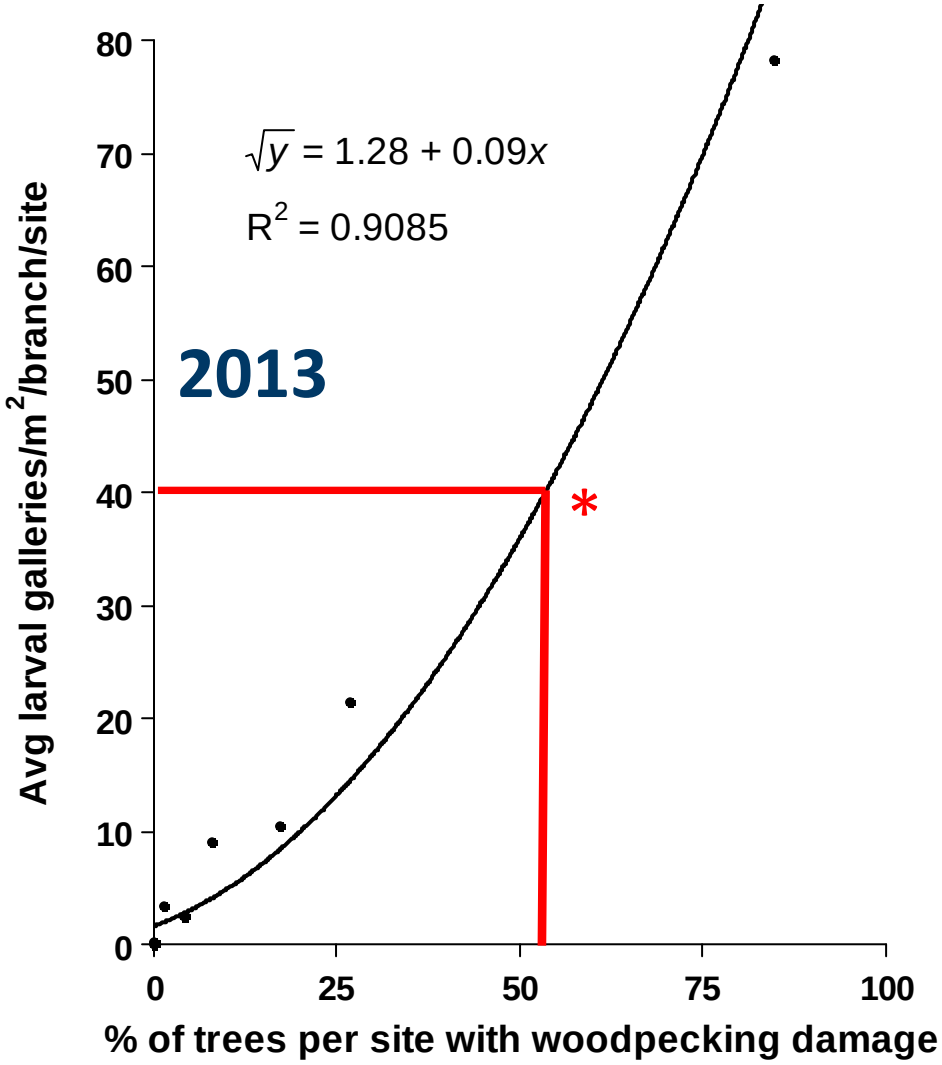
GRB Kings Bluff 2013

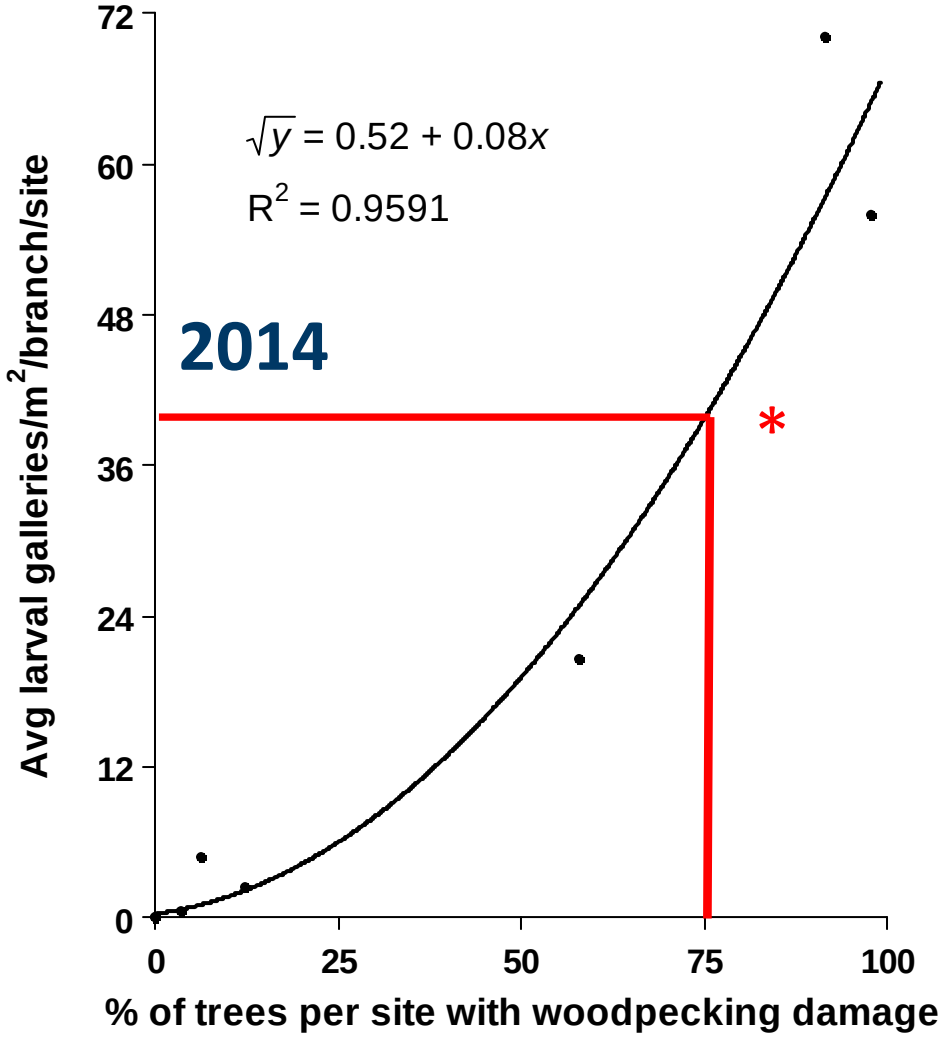


Value of Monitoring-Woodpecking (Branch Sampling)

* From Flower, et al. 2013. The relationship between the emerald ash borer and ash tree decline…

Analysis by Wilke and Aukema, University of Minnesota





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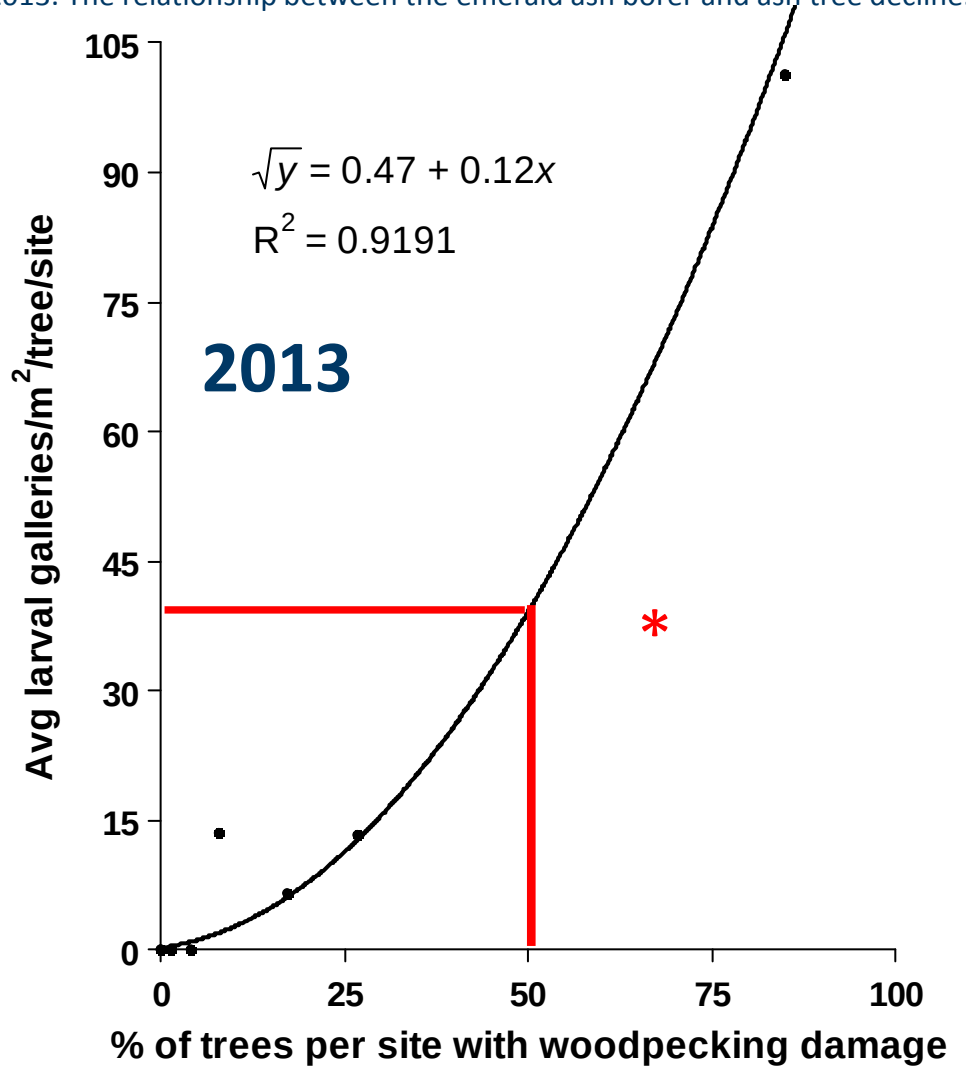
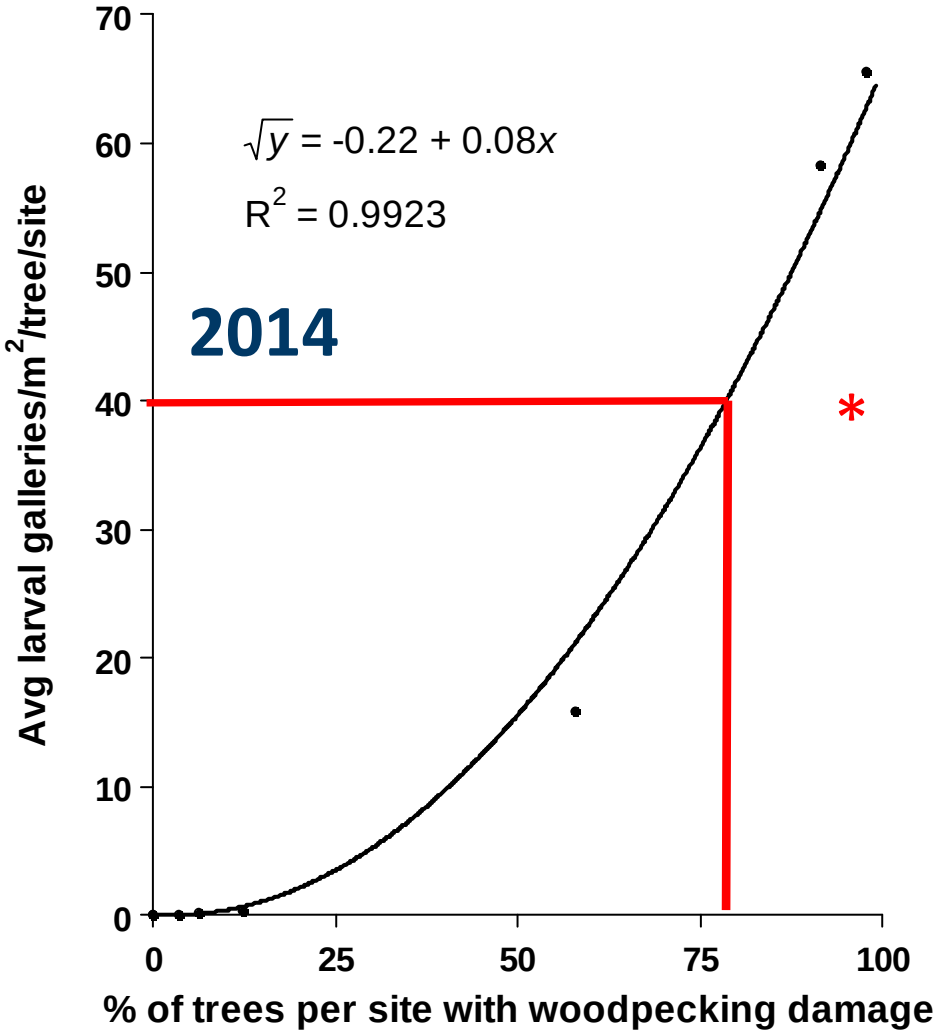
Value of Monitoring- Woodpecking (Whole Tree)

* From Flower, et al. 2013. The relationship between the emerald ash borer and ash tree decline…

Analysis by Wilke and Aukema, University of Minnesota





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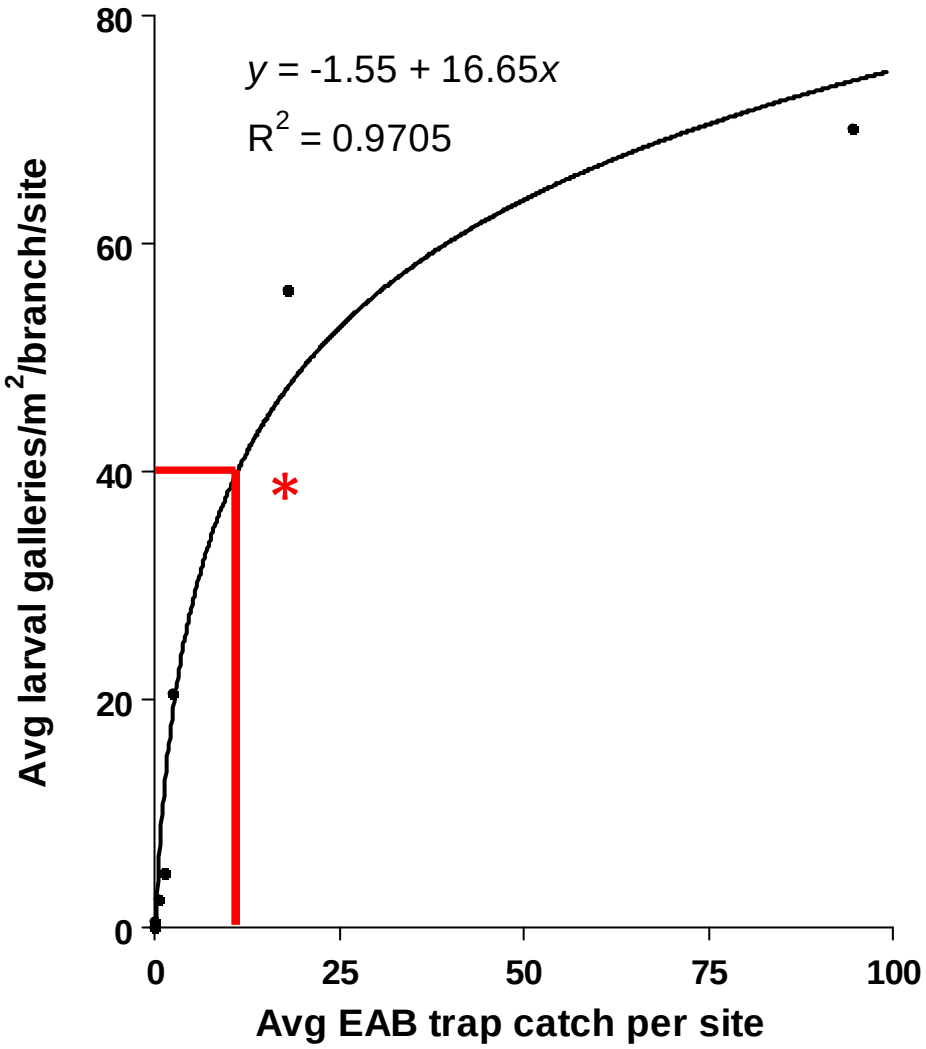
Value of Monitoring- Trapping

Analysis by Wilke and Aukema, University of Minnesota



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* From Flower, et al. 2013. The relationship between the emerald ash borer and ash tree decline…

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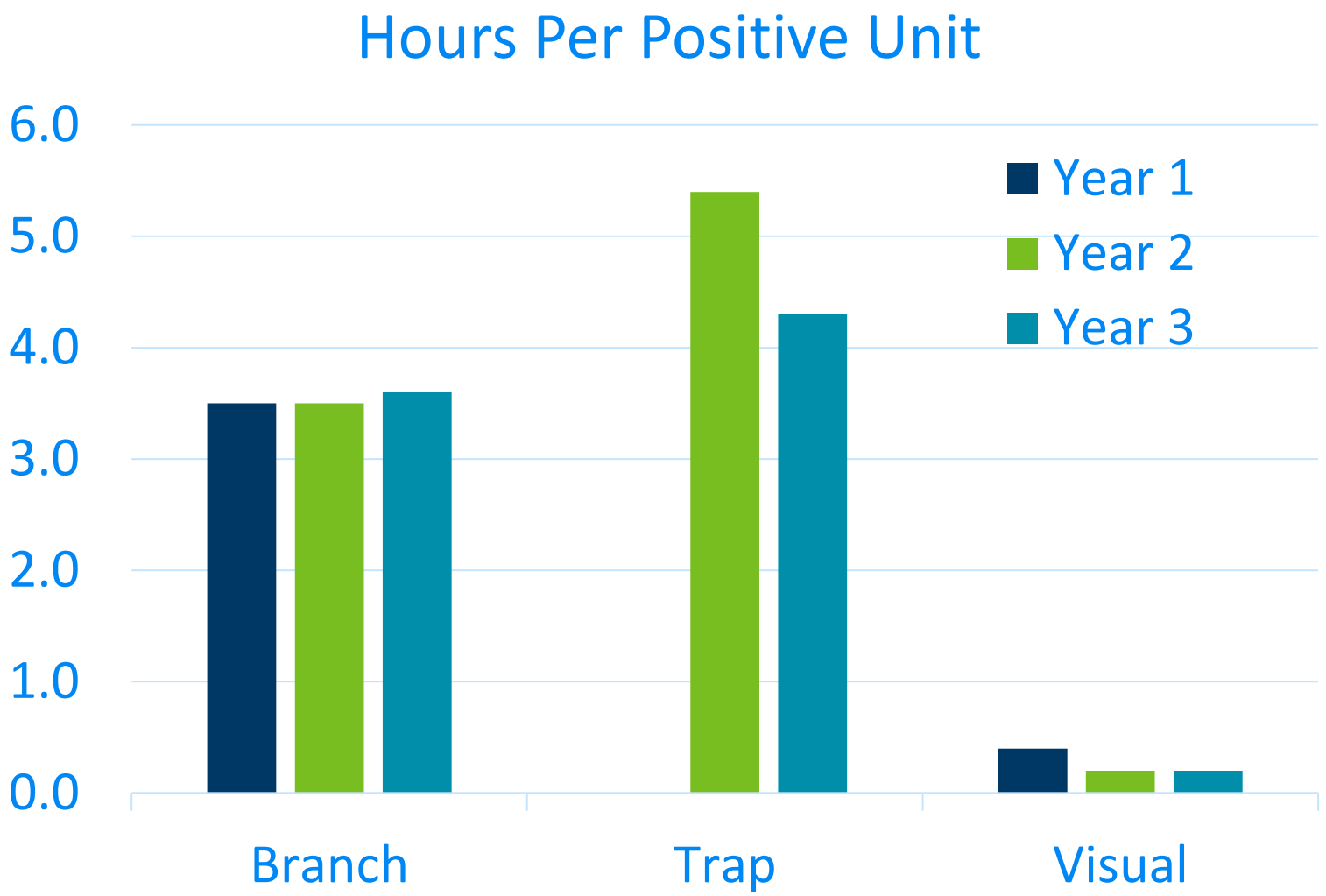
Value of Monitoring- Time Management



ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

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U of M – Brian Aukema, Rob Venette, Aubree Wilke, Sam Fahrner

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Thank you!

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Thank you!

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