2014 Project Abstract

For the Period Ending June 30, 2017

PROJECT TITLE: Biosurveillance and Biocontrol of Emerald Ash Borer – Phase 2
PROJECT MANAGER: Monika Chandler
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FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2014, Chp. 226, Sec. 2, Subd. 04d

APPROPRIATION AMOUNT: $447,000
AMOUNT SPENT: $446,810
AMOUNT REMAINING: $190

Overall Project Outcomes and Results

Emerald ash borer (EAB) populations have grown slower than expected in the Twin Cities metro region. To date, the insect has not spread as quickly in Minnesota as in other states. We were able to characterize this growth phase well with the continuing study on the infestation core commenced in Phase I of this project. Using annual branch sampling, we showed that after a decade of EAB presence in the Twin Cities metro region, half of the trees in the core area still did not exhibit easily-detectable levels of EAB, and canopy conditions remained quite good. We expect that EAB mortality due to extreme cold during the winter of 2013-2014 helped slow population growth. This slow growth continued to buy the state valuable time for implementing biological control and engaging the public in the fight against this insect, two other important strategies funded by this project. An astounding total of 450,000 larval and egg parasitoids were released at 33 sites during Phases 1 and 2 of this project. We are pleased that we documented established, reproducing populations of biological control agents at 5 sites in 2 counties. To document this, both larval parasitoids and the egg parasitoids were recovered with methods involving debarking ash branches and trunks, bark sifting, yellow pan traps and larval dissection. We also documented a native parasitoid, *Atanycolus simplex*, which can also attack EAB. We engaged a total of 128 citizen scientists using the biosurveillance program with smokey winged beetle bandit wasps, and collected more than two dozen species of buprestid beetles brought back to the nests by these wasps. We recovered ten species of *Agrilus* (in addition to EAB), providing important survey information on what other potential damaging wood borers in this family are present in the state. *Agrilus coxalis* is killing oaks in California, for example, but we have not found it in Minnesota to date.

Project Results Use and Dissemination

Our newly updated EAB management guidelines will be a valuable resource for people planning for or actively managing EAB. We incorporated findings from the project titled Improving EAB Detection in addition to Phase 1 and Phase 2 of our project. These guidelines provide information regarding EAB identification and reporting, detection methods and their relative efficiencies, recommended management tactics, including biocontrol, based on the infestation and site specifics. The guidelines will soon be available on MDA's EAB webpages (https://www.mda.state.mn.us/emeraldashborer).

We will build upon our accomplishments and learning with Phase 3: Assessment and Citizen Engagement.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2014 Work Plan

Date of Report: November 30, 2016

Date of Final Report: August 1, 2017

Date of Work Plan Approval: June 4, 2014

Project Completion Date: June 30, 2017

Does this submission include an amendment request? Yes

PROJECT TITLE: Biosurveillance and Biocontrol of Emerald Ash Borer – Phase 2

Project Manager: Monika Chandler

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Location: Statewide

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$ 447,000**
	Amount Spent:	**$ 446,810**
	Balance:	**$ 190**

Legal Citation: M.L. 2014, Chp. 226, Sec. 2, Subd. 04d

Appropriation Language:
$447,000 the second year is from the trust fund to the commissioner of agriculture in cooperation with the University of Minnesota to continue to monitor ash tree and emerald ash borer populations and expand the biological control implementation for emerald ash borer management. This appropriation is available until June 30, 2017, by which time the project must be completed and final products delivered.

I. PROJECT TITLE: Biosurveillance and Biocontrol of Emerald Ash Borer – Phase 2

II. PROJECT STATEMENT:

Our project focuses on best management strategy implementation for the emerald ash borer (EAB), one of the most destructive non-native pests in North America. Minnesota has an estimated 1 billion ash trees at risk – more than any other state – and all of our native ash species are susceptible. Loss of our ash trees would result in ecosystem change, financial losses estimated in the hundreds of millions and the possible extinction of many species dependent on ash trees such as the banded ash clearwing moth.

In Michigan and Ohio, EAB infestations have killed 99% of all ash trees within six years after initial infestation resulting in the death of over 50 million ash trees to date. In Minnesota, we have seen very few trees killed by EAB and EAB seems to be spreading more slowly than in Michigan. EAB infestations have been aggressively managed in the Twin Cities and trees at southeast Minnesota biological control sites remain in visibly better condition than surrounding natural stands of infested ash. Still, there are many challenges that we must continue to address. EAB continues to spread. We do not know the full extent of existing infestations and it is too early to determine the long-term efficacy of biological control.

EAB biological control uses parasitoid wasps to reduce EAB populations and is still experimental in practice. However, biological control is the only practical EAB management strategy for natural forest ash and is a component of urban EAB management. We will improve biological control implementation with:

Biosurveillance of EAB: Engage citizen scientist volunteers to monitor EAB populations statewide using a native predatory wasp, the smoky winged beetle bandit. Our goals are to better delimit EAB populations and educate the public about EAB. Additionally, biosurveillance will monitor for similar high risk wood-boring beetles that are not documented in Minnesota such as the European oak borer that threatens our oaks and was detected with biosurveillance in Ontario and picked up on a trap in Michigan.

Track EAB infestation core: Continue monitoring ash health, EAB and EAB biological control agents in the core infested area of the Twin Cities. This study was initiated in 2011 with ENRTF funds and will provide answers about the importance of multiple management activities. This unique long-term study receives attention from national researchers.

Expand biological control implementation: Biological control was initiated in 2010 and biological control agents released at all known infestations. EAB is spreading so new detections are inevitable. The biological control effort will be expanded to address new EAB finds and continue existing site monitoring.

III. PROJECT STATUS UPDATES:

Amendment Request September 11, 2014: The requested work plan change pertains to the Research Scientist 1 position in Activity 3, Expand biological control implementation. The position is currently unclassified and filled by Jonathan Osthus. The Minnesota Department of Agriculture (MDA) plans to create a new, classified position for Jonathan Osthus. The working title is EAB Biocontrol Coordinator. The change in status would be effective 10/08/14. This classified position does not currently exist.

Amendment was approved on September 17, 2014.

Project Status as of November 26, 2014: This project smoothly transitioned from Phase 1 that was completed 06/30/14 to Phase 2 starting 07/01/14. Biosurveillance for EAB is a new activity in Phase 2. To begin our activity over the summer of 2014, the ENRTF appropriation was leveraged to secure bridge funds from the Renewable Resources Extension Act funding (RREA). University of Minnesota (U of M) received $11,930 to cover expenses for a part-time Wasp Watchers coordinator to begin in May 2014, prior to the availability of ENRTF dollars. A Wasp Watchers Program Coordinator, Jennifer Schultz, was hired and initiated biosurveillance. Biological control agent releases continued and ash health data were collected for Activities 2 and 3. Branch sampling to monitor for EAB and biological control agents (Activity 2) will begin after contracts with the Minneapolis Parks

and Recreation Board and the City of St. Paul are executed. MDA is in the process of hiring a student worker for Activities 2 and 3.

Contracts for branch sampling are in process. A contract with the U of M for Activity 1 and 2 funds was executed. Because it took some time to set up funding strings at the U of M, actual amounts spent during the project period are not available yet. The amounts spent by the U of M will be included in future status reports.

We plan to update our webpage www.mda.state.mn.us/plants/pestmanagement/eab/eabbiocontrol.aspx with a summary of Phase 1 and activities in progress for Phase 2.

Project Status as of May 29, 2015:
Our project is making good progress. The Wasp Watchers program (Activity 1) is ramping up for a large beetle bandit monitoring effort with 93 volunteers in 17 counties. Winter and spring branch sampling for Activity 2 was completed. An extensive survey of southeastern Minnesota was completed to define EAB infestations and search for potential new biocontrol release sites. There was a new EAB find in Rushford as a result of this survey. Bioagent releases for the 2015 season have started for Activity 3 and the egg parasitoid was documented in EAB eggs for the first time in Minnesota. In addition, we redesigned and updated our project webpage at www.mda.state.mn.us/plants/pestmanagement/eab/eabbiocontrol.aspx.

Project Status as of November 30, 2015:
Wasp Watchers completed its first full field season with a trained team of volunteers checking sites for beetle bandit colonies and monitoring colonies. Summer field season data were collected for Activities 2 and 3. Releases of biological control agents continued from late spring to early fall. Recoveries of biological control agents went very well. We found many more larval parasitoids in the fall of 2015 compared to the fall of 2014. This indicates that their population is established and growing at the site in southeastern Minnesota that was sampled.

Amendment Approved December 8, 2015
We have some salary savings from lower insurance costs than originally budgeted (single vs. dependent care coverage). This presents an opportunity to do more than originally planned. Starting in May 2016, we propose to hire an additional Research Scientist 1 to work on Activity 3. This position would do the following.

1. Activity 1: Intensively monitor a biosurveillance site during the 2016 field season. We are disappointed that volunteers have not collected EAB with biosurveillance. We attribute this to volunteers monitoring sites with low to no EAB in the area. We propose to select a site in a heavily infested area and monitor it at least twice per week. We would better understand EAB levels as they relate to biosurveillance.
2. Activity 3: Test a parasitoid recovery method using yellow pan traps. Traps would be placed and trap contents collected at three sites during the 2016 field season. The trap contents would be examined for parasitoids during the winter of 2016/2017. Researchers have had some success with this method, but it has not been used extensively.
3. Activity 3: Update guidelines for EAB management in Minnesota, including biological control. These guidelines would incorporate findings from the project titled Improving EAB Detection in addition to our project. Both projects are funded by ENRTF and have taught us much about EAB management. After guidelines are written, they will be reviewed by a multi-agency team of experts. Then a presentation with the information will be put on the MDA EAB webpage. This will make the information readily accessible for municipalities, counties and the public.

Activity budgetary changes:

- Add an approximately 80% time Research Scientist 1 position to Activities 1 and 3 from May 2016 to June 2017 (14 months).
- Activity 2 salary funds would be decreased by $27,860. $3,000 would go to Activity 1 salary and $24,860 would go to Activity 3.

- Activity 3 travel funds would be decreased by $3,460 with $800 going to MDA Activity 1 travel and $2,660 moved to Activity 3 personnel.
- Activity 3 supply funds would be decreased by $1,000 and moved to Activity 3 shipping ($500) and Activity 3 personnel ($500).

Project Status as of May 31, 2016:
Our project is progressing well. For biosurveillance (Activity 1), most of the beetles from the 2015 season were identified and we are geared up for the 2016 season. There was an emphasis on outreach and volunteer recruitment during the winter and spring. Field training for the volunteers is scheduled for summer 2016. We secured a DNR permit to conduct biosurveillance at specific parks and scientific and natural areas. Tracking the infestation core (Activity 2) continues to pleasantly surprise us. Predictions based upon experiences in Ohio and Michigan were that 99% study trees would have been infested by 2015. Instead, only 21% of study trees have been infested to date. Four new release sites were selected for bioagent releases starting in 2016 (Activity 3). Additionally, our website was enhanced and updated to provide more information with interactive mapping and a presentation on the bark sifting technique for detecting parasitized EAB eggs.

Project Status as of November 30, 2016:
We had a productive field season with a substantial increase in biosurveillance activities and sustained parasitoid releases and recoveries. We tested yellow pan trapping as a parasitoid recovery method and consider it to be a reasonable method. Continued parasitoid recoveries indicated an increased number of established populations. This was the first year that we released *Spathius galinae*, a newly approved larval parasitoid. We will be wrapping up Phase 2 of this project with final branch sampling and data collection followed by analysis of our long-term study of the EAB infestation core in the Twin Cities.

Amendment Request August 1, 2017
Activity 1: We overspent on personnel by $6,422. This included the addition of two summer student workers to monitor beetle bandit nests. The subcontract was underspent by $41 so would be reduced from $6,500 to $6,459. Equipment/tools/supplies were underspent by $1,715 so would be reduced from $2,900 to $1,185. Printing was underspent by $435so would be reduced from $4,500 to $4,065. Travel was underspent by $4,125 so would be reduced from $9,700 to $5,575. There were no shipping charges because volunteers handed in rather than shipped samples so shipping would be reduced from $1,000 to $0. Of the original Activity 1 budget of $107,000 only $106,810 was spent so $90 remains unspent.

Activity 3: Personnel was underspent by $798 so would be reduced from $164,560 to $163,762. We overspent $53 on supplies so supplies would be increased from $500 to $553. We overspent travel by $895 so it would be increased from $14,000 to $14,895. We underspent shipping by $151 so shipping would be reduced from $500 to $349.

Overall Project Outcomes and Results:
Emerald ash borer (EAB) populations have grown slower than expected in the Twin Cities metro region. To date, the insect has not spread as quickly in Minnesota as in other states. We were able to characterize this growth phase well with the continuing study on the infestation core commenced in Phase I of this project. Using annual branch sampling, we showed that after a decade of EAB presence in the Twin Cities metro region, half of the trees in the core area still did not exhibit easily-detectable levels of EAB, and canopy conditions remained quite good. We expect that EAB mortality due to extreme cold during the winter of 2013-2014 helped slow population growth. This slow growth continued to buy the state valuable time for implementing biological control and engaging the public in the fight against this insect, two other important strategies funded by this project. An astounding total of 450,000 larval and egg parasitoids were released at 33 sites during Phases 1 and 2 of this project. We are pleased that we documented established, reproducing populations of biological control agents at 5 sites in 2 counties. To document this, both larval parasitoids and the egg parasitoids were recovered with methods involving debarking ash branches and trunks, bark sifting, yellow pan traps and larval dissection.

We also documented a native parasitoid, *Atanycolus simplex*, which can also attack EAB. We engaged a total of 128 citizen scientists using the biosurveillance program with smokey winged beetle bandit wasps, and collected more than two dozen species of buprestid beetles brought back to the nests by these wasps. We recovered ten species of *Agrilus* (in addition to EAB), providing important survey information on what other potential damaging wood borers in this family are present in the state. *Agrilus coxalis* is killing oaks in California, for example, but we have not found it in Minnesota to date.

Our newly updated EAB management guidelines will be a valuable resource for people planning for or actively managing EAB. We incorporated findings from the project titled Improving EAB Detection in addition to Phase 1 and Phase 2 of our project. These guidelines provide information regarding EAB identification and reporting, detection methods and their relative efficiencies, recommended management tactics, including biocontrol, based on the infestation and site specifics. The guidelines will soon be available on MDA's EAB webpages.

We will build upon our accomplishments and learning with Phase 3: Assessment and Citizen Engagement.

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Biosurveillance of EAB
Description:
The smoky winged beetle bandit, *Cerceris fumipennis*, can teach us which species of wood-boring beetles, including EAB, are in an area. This is a form of biosurveillance – using one organism, the beetle bandit wasp, to monitor for another organism - in this case EAB and related beetles. Monitoring beetle bandits in Connecticut yielded the first EAB find in the state. Additionally, beetle bandit biosurveillance will monitor for similar high risk wood-boring beetles that are not documented in Minnesota such as the European oak borer that threatens our oaks and was detected with biosurveillance in Ontario and picked up on a trap in Michigan.

The smoky winged beetle bandit is a native, ground nesting wasp. Females collect wood-boring beetles from wooded and forested areas then bring the beetles back to their nests to feed their young. Beetles from these wasps can be collected with the following methods. Beetle bandit wasps drop beetles they think were attacked by parasitic flies. Consuming parasitized beetles would kill developing beetle bandit wasps. Therefore, the adult wasps abandon suspect beetles outside of their nests. These abandoned beetles can be easily collected. Another way to collect beetles is to net the beetle bandit as it returns to its nest with a beetle. The wasps are docile and do not sting humans. They will immediately drop the beetle then the wasp can be released from the net.

University of Minnesota Extension (Extension) will lead the joint effort with MDA and USDA Forest Service (USFS) to monitor beetle bandit colonies in Minnesota. Citizen scientist volunteers proved in 2013 that they could find beetle bandit colonies in multiple areas of the state. A preferred habit of the ground nesting beetle bandit is minimally maintained baseball fields. The wasps like the sandy soils for nest building and the relatively undisturbed setting. Citizen scientists can be directed to search ball fields in high risk areas and report their finds. See www.myminnesotawoods.umn.edu/cerceris/ for more information. These same citizen scientists will be trained to monitor beetle bandit colonies. Collected beetles will be identified by a taxonomist and data will be entered into a Forest Service database. A Community Program Specialist will coordinate volunteers, process beetle samples and enter data.

Summary Budget Information for Activity 1:	~~**ENRTF Budget:**~~	~~**$ 107,000**~~
	ENRTF Budget	**$ 106,810**
	Amount Spent:	**$ 106,810**
	Balance:	**$ 0**

Activity Completion Date: 06/10/2017

Outcome	Completion Date	Budget
1. First Detector and other volunteer training and colony monitoring completed	09/30/2016	$ 95,700
2. Beetles identified and data entered into a Forest Service database	06/10/2017	$ 7,500
3. Intensively monitor a site with a high EAB population	11/01/2016	$ 3,800

Project Status as of November 26, 2014: To begin our activity over the summer of 2014, the ENRTF appropriation was leveraged to secure bridge funds from the Renewable Resources Extension Act funding (RREA). U of M Extension received $11,930 to cover expenses for a part-time Wasp Watchers coordinator to begin in May 2014. A Wasp Watchers Program Coordinator, Jennifer Schultz, was hired and working on biosurveillance prior to the availability of ENRTF dollars. Bridge funds were used for the following.

- A validation dataset for beetle bandit emergence in Minnesota was collected. An additional dataset will be collected in 2015 and provided to Dr. Claire Rutledge with the Connecticut Agricultural Experiment Station. Dr. Rutledge and her colleagues developed and are refining a degree day model to predict beetle bandit emergence. An accurate degree day model will enable us to efficiently utilize volunteers for monitoring colonies.
- The presence of beetle bandit colonies was checked at over 40 potential sites and confirmed at 10 sites. Over 60 buprestid beetles were collected and will be identified. None of the beetles appear to be EAB.
- A protocol was developed for beetle collection and submission. Many potential methods were tested.

Current and future project activities will be supported by ENRTF. The following activities will occur over the winter.

- Beetles collected during summer 2014 will be pinned, labelled and grouped by like types prior to identification.
- A taxonomist will be selected and contracted with for beetle identification.
- Beetles will be identified and data recorded.
- Kits containing beetle collection tools, supplies and educational materials will be assembled. They will be distributed to volunteers at training sessions.
- Training materials including a presentation and instructional handouts are being created.
- Volunteer recruitment is in process.

Activity Status as of May 29, 2015:

A taxonomist, Wayne Steffens, was contracted to identify beetles. Beetles collected summer 2014 were pinned and all were identified to genus and some to species. Work to identify the remaining Agrilus to species will continue. None of the beetles collected were EAB. The table below lists the collected beetles.

Species	Common Name	Total
Actenodes acornis	No common name	3
Agrilus bilineatus	Twolined chestnut borer	1
Agrilus politus	Willow gall limb	2
Agrilus quadriguttatus	No common name	16
Agrilus sp	(not identified to species yet)	17
Chrysobothris femorata	Flatheaded appletree borer	3
Chrysobothris sexsignata	No common name	4
Dicerca divaricata	Flatheaded hardwood borer	3
Dicerca tenebrica	Flatheaded poplar borer	8
Poecilonota cyanipes	Eastern poplar buprestid	7
	Total	**66**

Ten outreach presentations to over 500 people resulted in rapid growth of our Minnesota Wasp Watchers program. There are currently 93 volunteers in 17 counties. These volunteers will provide a valuable network for monitoring EAB and other buprestid beetles in 2015.

Summer plans include checking additional sites for beetle bandit colonies, managing volunteers and collecting a validation data set for a beetle bandit emergence model that is in development. Volunteers will check over 300 sites for the presence of beetle bandit colonies. These sites were identified with habitat favorable to beetle bandits.

Activity Status as of November 30, 2015:
This was the first full field season with a trained team of volunteers checking sites for beetle bandit colonies and monitoring colonies. Volunteers who check sites are called scouts and those who monitor are called surveyors. Surveyors collected 95 beetles. None of the beetles are EAB. Seven outreach presentation were given to a total audience of 246 people.

- 84 sites were checked in 27 different cities found in 11 different counties
- 13 new or confirmed beetle bandit sites found in Lakeville, Eden Praie, Wyoming, St. Paul, Afton, Frontenac, Red Wing, St. Cloud, Eagan, Wayzata, and Aitkin.
- There are now 31 confirmed to have beetle bandits and there are 15 additional sites of interest (sites that were not confirmed this summer or sites that have had beetle bandits in the past, but not this year). Confirmed sites are in the following 11 counties: Aitkin, Anoka, Benton, Chisago, Dakota, Goodhue, Hennepin, Le Sueur, Olmstead, Ramsey and Washington.
- 50 volunteers comprised of 23 adults and 27 youth conducted biosurveillance at 17 sites.
- 95 beetles captured (none EAB) from 14 different sites found in 9 different counties. These beetles are pinned and labeled and being identified by the project taxonomist.

We will try recruit volunteers in southeastern Minnesota to monitor sites where EAB densities are higher than at sites currently monitored. This will help us understand the sensitivity of this method.

<u>Beetle Bandit Emergence Tracking for Degree Day Modeling</u>
After consulting Claire Rutledge (CT Ag Exp Station) regarding the collected degree day data for beetle bandit emergence, it was determined that for the 2015 season, beetle bandit emergence occurred around **950-975F DD** in Minnesota. Claire's values for the New England/East Coast was around 865F DD. Wasp Watchers will continue to track emergence and gather more degree day data in 2016.

Activity Status as of May 31, 2016:
Outreach and volunteer recruitment was the focus of the last six months. There were 16 outreach events with 515 participants. Two events included two events were focused on park maintenance staff. Park maintenance staff groom the ball fields where many beetle bandit colonies are found. There will be an attempt in 2016 to groom the fields early in the morning, before the wasps are active. This should minimize disturbance to the beetle bandits. The online map of potential sites with beetle bandit colonies was updated to include hundreds of potential new sites.

Beetles collected summer 2015 were pinned and all were identified to genus and some to species. None of the beetles collected were EAB. A greater diversity of beetle species were collected in 2015 than 2014, probably because the beetles came from more sites in 2015. The table below lists the collected beetles.

Species	**Amount**
Actenodes acornis	3
Actenodes simi	1
Agrilus anxius	16
Agrilus arcuatus	1

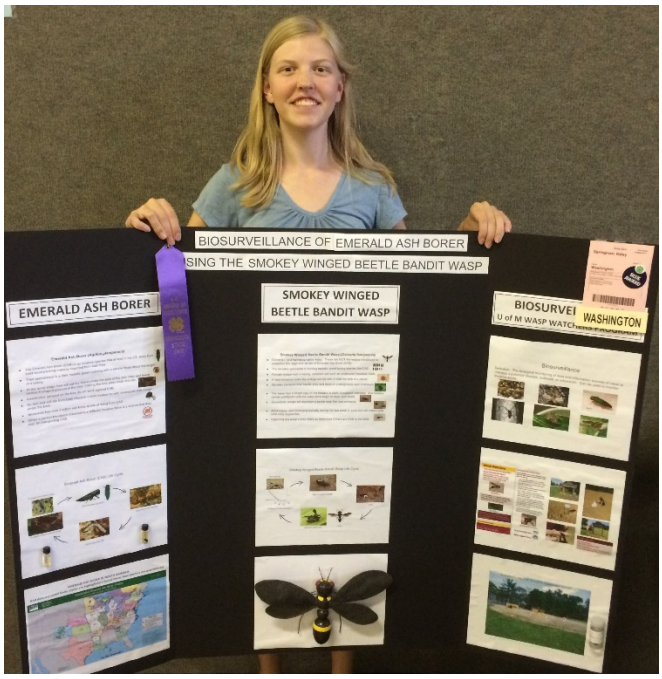
Species	Amount
Agrilus bilineatus	1
Agrilus difficilis	8
Agrilus obsoletoguttatus	2
Agrilus politus	1
Agrilus quadriguttatus	9
Agrilus sp. (politus group)	4
Buprestis consularis	2
Bupestis maculativentris	1
Chrysobothris femorata	1
Chrysobothris sexsignata	6
Chrysobothris rugosiceps	2
Chrysobothris sp.	1
Dicerca tenebrica	14
Dicerca tenebros	1
Dicerca sp	1
Poecilonota cyanipes	13
Total	**88**

Biosurveillance Plans for 2016:

- Collect emergence data beginning mid-June.
- U of MN student worker will be added to support biosurveillance efforts.
- Chris Mallet joined the project and will search for a beetle bandit colony in an area heavily infested with EAB. Once found, Chris will monitor the colony intensively to help us understand EAB levels as they relate to biosurveillance.
- Sites with more than 10 nest holes will be adopted and monitored by volunteers and/or staff.
    - Heights Park, Edina
    - Pinger's Plaza Park, Ham Lake
    - Purgatory Park, Minnetonka
    - Northdale Park, Oakdale
    - Battle Creek Middle School, St. Paul
    - Banta Park, Wyoming
    - Tolzmann Park, Wyoming
- Volunteers will be searching for new, large beetle bandit colonies to monitor, targeting areas near newer EAB finds (Plymouth, Prior Lake, Apple Valley, Duluth, Washington County, Wabasha County). Under-searched communities with EAB will also be searched more thoroughly (Rochester, Winona). Other areas of interest are along the following transportation corridors: Hwy 169North, I-94North, and I-35North.
- We received DNR permit 2016-8R for biosurveillance activities in select parks and scientific and natural areas during the 2016 field season.

Activity Status as of November 30, 2016:

We are pleased to report that four EAB were captured at Riverside Park in Minneapolis, demonstrating that biosurveillance is a valid EAB detection method in Minnesota. We expected this based upon experiences in other states but it was important to confirm our expectations. Biosurveillance won a championship ribbon at the Washington County Fair and a purple ribbon at the State Fair thanks to Kaley, a talented and dedicated 4H youth volunteer.



Award winning biosurveillance project that was displayed at the State Fair.

During this reporting period, there were five field trainings and three presentations. All of the outreach has paid off to substantially increase the biosurveillance effort in summer 2016. One super volunteer, Anna, from Rochester searched 35 sites in Olmsted, Fillmore and Winona Counties volunteering over 60 hours of her time.

Quantified	**2016**	**2015**
Buprestid beetles captured	183	95
Number of volunteers	65	50
Volunteer hours spent on beetle bandit scouting and monitoring	453	160
New sites checked for beetle bandit presence	219	87
New nesting sites found	29	13

A total of 20 sites were actively monitored in Aitkin, Anoka, Chisago, Crow Wing, Dakota, Hennepin, Ramsey, Washington and Winona Counties. Chris Mallet with MDA intensively monitored two sites near known EAB infestations three times per week during peak activity of the beetle bandits. These sites were Autumn Grove Park in Roseville and Riverside Park in Minneapolis.


Volunteers inspect a beetle bandit catch during a field training in Wyoming, MN.

Minnesota appears to have many small beetle bandit colonies. Of our 59 known sites, approximately 10% have more than 30 nests (large colonies), 20% have between 10-30 nests (medium colony), and 70% have between 1-9 nests (small colony). Because most colonies are small, we do not rule out monitoring small colonies in Minnesota as has happened in states that routinely find medium and large colonies.

Additionally, there are 53 sites of interest. The site may have had a colony previously but no colony was confirmed in 2016 or nests were found but it was not determined whether they were beetle bandit nests.

We theorize that heavy rainfall during peak beetle bandit activity may have had an impact. Many nests were washed out and not excavated by the wasps again. Here is a comparison of precipitation level by year in Minnesota.

Date	Statewide Average Precipitation	Statewide Average Precipitation Departure from Normal*
6/15/14-8/15/15	8.45 inches	+0.27 inches
6/15/15-8/15/15	7.89 inches	-0.21 inches
6/15/16-8/15/16	11.49 inches	+ 3.30 inches

http://www.dnr.state.mn.us/climate/historical/summary.html

* Climate Normals are three-decade averages of climatological variables including temperature and precipitation. (NOAA)

Final Report Summary:

Biosurveillance Activities from December 1 2016-June 30, 2017:

The winter and spring activities focused on buprestid beetle curation and identification as well as outreach, education, and volunteer management.

- There were 8 outreach events (trainings, presentations, educational exhibitions) with 362 participants.
- The University of Minnesota Entomology Department also hosted a volunteer appreciation event in March 2017. Volunteers were invited to tour the U of MN Insect Collection and meet outreach arthropods and their graduate student handlers.
- The database and map of known and negative beetle bandit sites were updated.
- Beetles collected summer 2016 were pinned and all were identified to genus and most of them to species. A total of 183 beetles were captured in the summer of 2016. Four of the beetles collected were EAB. These specimens were captured at Riverview Park in Minneapolis. There were a total of 183 beetles captured with 26 different buprestid species. Two new genera were found this year (*Eupristocerus and Spectralia).*

Species and quantity of beetles collected by Wasp Watchers

Species	Amount
Actenodes acornis	1
Agrilus anxius	4
Agrilus arcuatus	13
Agrilus bilineatus	8
Agrilus carpini	1
Agrilus difficilis	4
Agrilus liragus	27
Agrilus obsoletoguttatus	2
Agrilus olivaceoniger	1
Agrilus politus	1

Species	Amount
Agrilus planipennis	4
Agrilus quadriguttatus	3
Agrilus sp.	10
Buprestis consularis	2
Bupestis maculativentris	1
Chrysobothris femorata	2
Chrysobothris sexsignata	15
Chrysobothris viridiceps	2
Chrysobothris sp.	2
Dicerca asperata	1
Dicerca caudata	15
Dicerca divaricata	10
Dicerca tenebrica	31
Dicerca tenebrosa	3
Dicerca tuberculata	1
Dicerca sp	1
Eupristocerus cogitans	7
Poecilonota cyanipes	7
Spectralia gracilipes	4
Total	**183**

Wasp Watchers Program Summary:
The Wasp Watchers Program engaged citizen scientist volunteers in EAB biosurveillance from 2014-2017. During this period, there were 49 outreach and education events (trainings, presentations, educational exhibitions) with 1,720 participants. These events served to educate the general public about EAB and also recruit and train citizen scientist volunteers. The biosurveillance program from 2014-2017 has built a solid foundation for future EAB detection. Just two weeks after this grant ended (July 2017), Wasp Watchers captured EAB at three biosurveillance sites indicating new pockets of EAB infestations in Roseville, Shoreview, and Rochester. The Wasp Watchers Program is poised to mobilize a cadre of citizen scientist volunteers to continue to detect new EAB infestations with the help of the smoky winged beetle bandit in Phase 3 of our project. The tables below indicate the growth and accomplishments of the Wasp Watchers Program over the past three years.

Volunteer Efforts:
This grant began in July 2014 so the first field season was focused on establishing field protocols with a few volunteers. Volunteer recruitment and training increased in the following years.

Year	# of Volunteers	# of Volunteer Hours
2014	12	26
2015	51	160
2016	65	458

Beetle bandit search: Volunteers searched ballfields throughout Minnesota for the presence of the smoky winged beetle bandit wasp. Once discovered, a nesting site can be monitored for the presence of EAB in that area.

Year	# of sites searched	Accumulated positive beetle bandit nesting sites
2014	45 sites	15 positive sites
2015	88 sites	31 positive sites
2016	219 sites	59 positive sites

Biosurveillance sites and Buprestid beetles collected: As the number of known beetle bandit nesting sites increased, the number of biosurveillance sites and beetles increased as well. Each biosurveillance site is a location where volunteers captured Buprestid beetles to survey for the presence of EAB.

Beetle bandit prey species diversity: When the Buprestids (metallic wood-boring beetles) are captured from beetle bandit wasps, they are preserved, curated, and identified. Over the past three years, as the number of survey sites increased and expanded around the state, the diversity of Buprestid species increased and diversified as well.

Year	# of biosurveillance sites	# of beetles collected	# of different beetle species captured
2014	6 sites	65 beetles	11 beetle species
2015	17 sites	95 beetles	17 beetle species
2016	21 sites	183 beetles	26 beetle species

ACTIVITY 2: Track EAB infestation core
Description:
To track dispersal of EAB and biological control agents, project partners initiated long-term monitoring of ash health, EAB, and EAB biological control agents in the Twin Cities in 2011. This is a large, collaborative project with multiple partners including USDA Forest Service, University of Minnesota, Department of Natural Resources, and the cities of Falcon Heights, Minneapolis, Lauderdale, Roseville, and St. Paul. Three hundred ash trees were selected in the late summer of 2011. The selected trees were in the original EAB infestation area (the core infestation) and the surrounding area up to four kilometers from the core. Each tree is monitored for six years. We collect data on tree size and health. We are using branch sampling methodology to subsample ash trees for evidence of EAB and EAB biological control agents. Two branches per year are removed from each tree each year. A length is cut from each branch then peeled. Detailed information is collected on each EAB gallery, EAB larvae, biological control agent parasitoids, and native parasitoids. All study tree removals are noted in the database. Data collection for this study is coordinated by a Research Scientist 1 at MDA and will be analyzed by Drs. Aukema (U of M) and Venette (USFS).

Summary Budget Information for Activity 2:

ENRTF Budget:	**$ 160,440**
Amount Spent:	**$ 160,440**
Balance:	**$ 0**

Activity Completion Date: 06/10/2017

Outcome	Completion Date	Budget
1. Ash health and sample branches for EAB and biological control agents data collected	03/30/2017	$ 126,540
2. Data analyzed	06/10/2017	$ 33,900

Project Status as of November 26, 2014:
Ash health data were collected by Jonathan Osthus during summer 2014 for the remaining 155 study trees. In order to gain an understanding of the density and health of ash near study trees, Jonathan Osthus and Angela Gupta recruited and trained volunteers about ash health data collection. Volunteers collected data on 48 area ash trees. Track EAB Infestation Core Study results are available online and are shown in the map below.

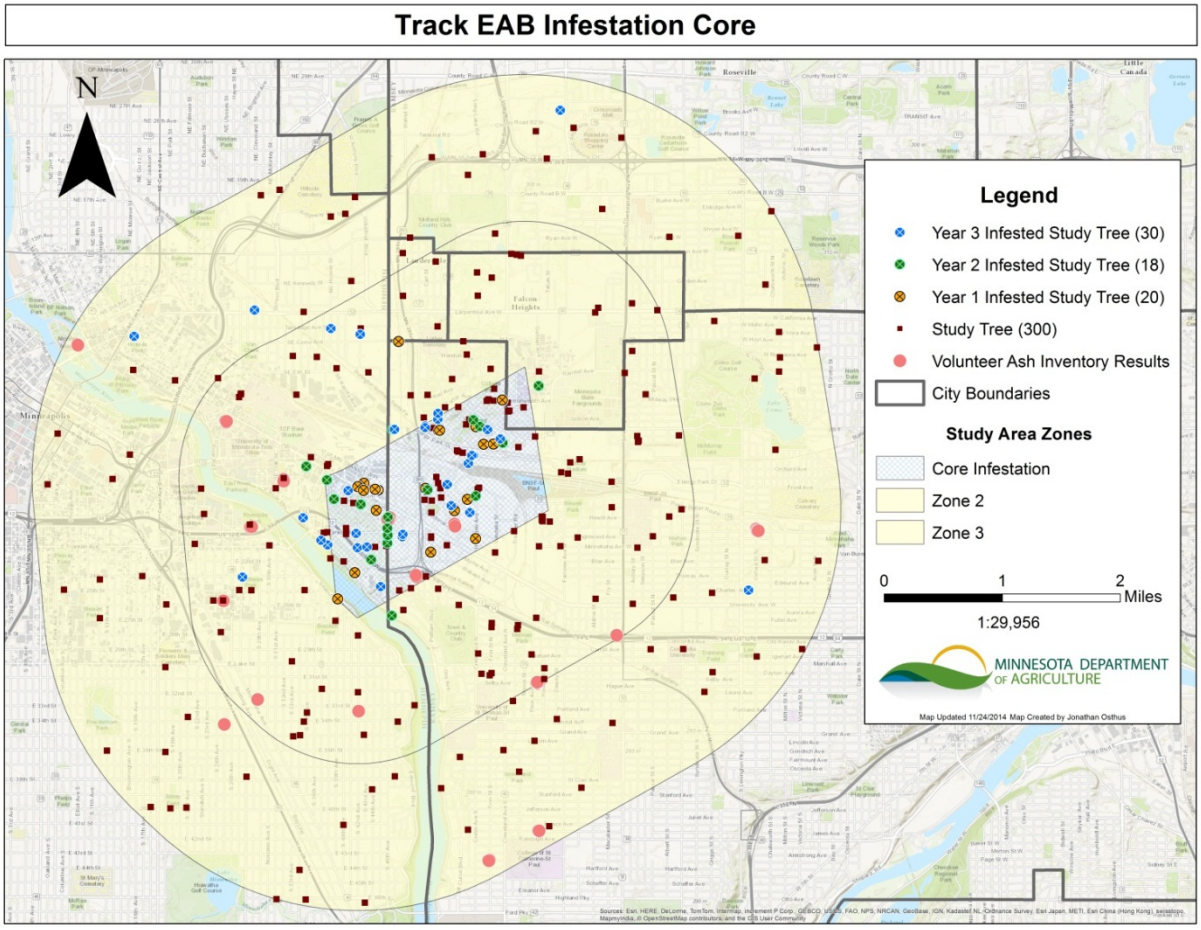
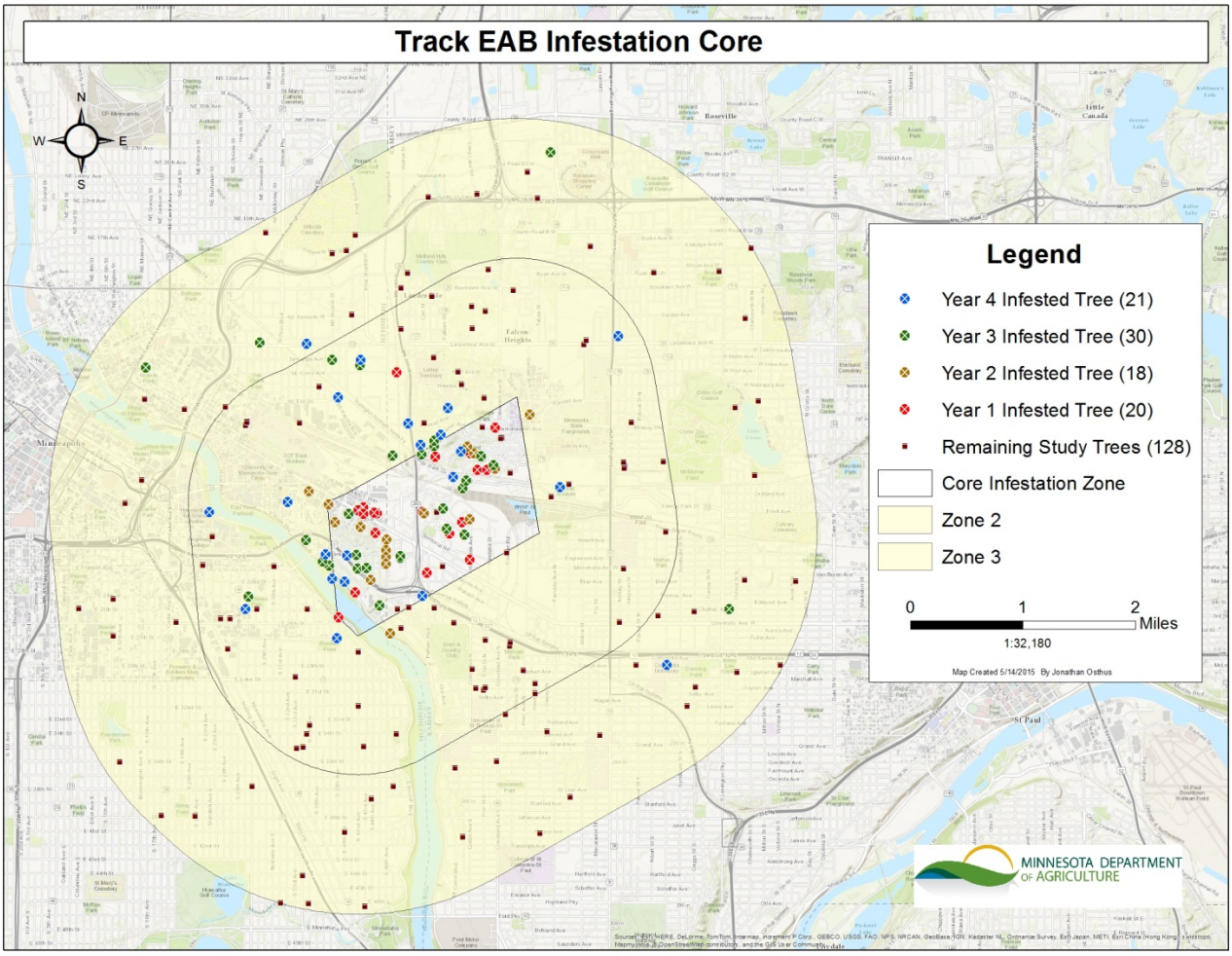


Figure 1: Map of study trees including trees that were found to be infested then removed.

Branch sampling is planned for fall and winter. Contracts with the City of St. Paul and the Minneapolis Parks and Recreation Board for branch sampling are in process. Branches will be peeled and data collected over the winter.

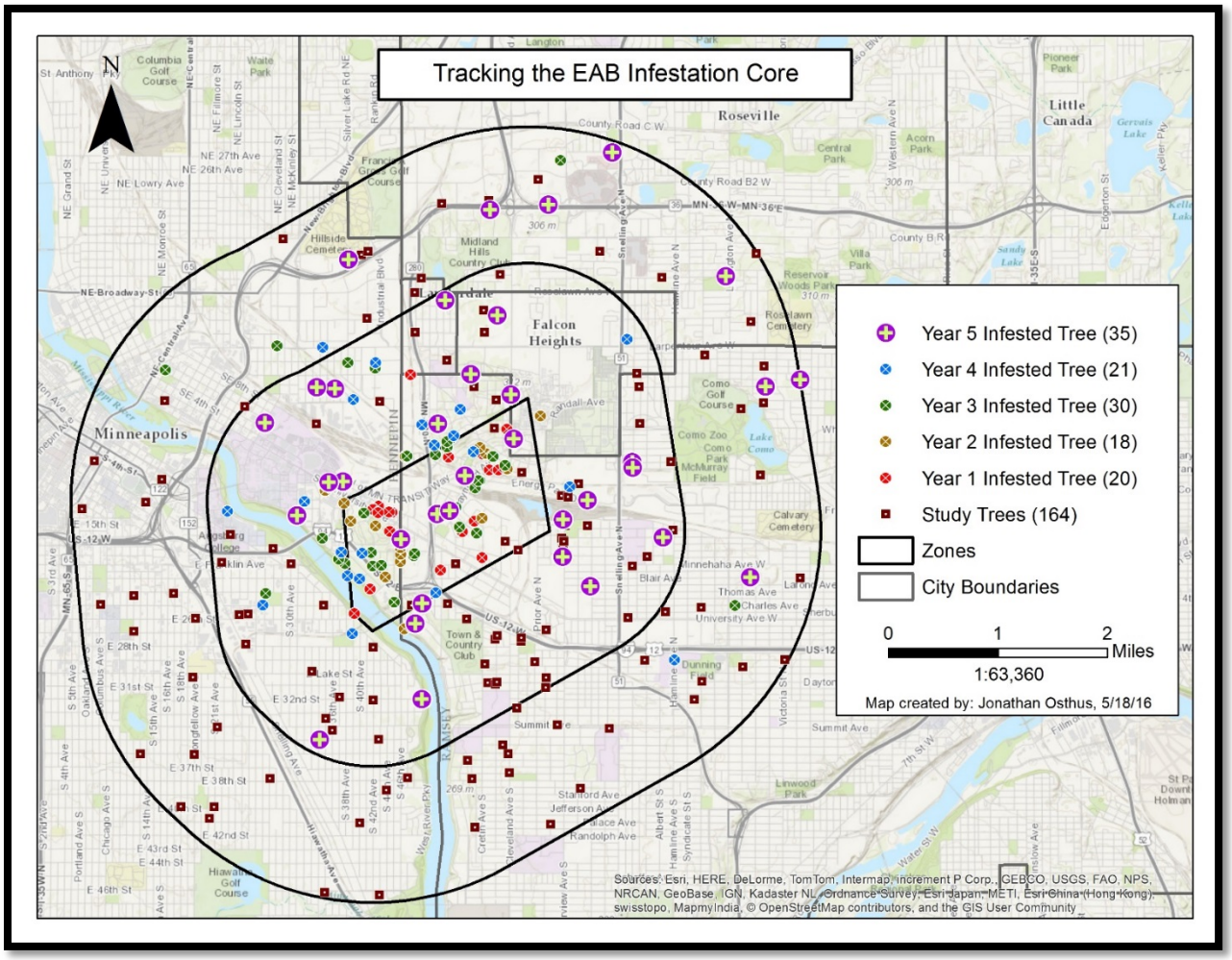
Activity Status as of May 29, 2015:
All remaining 149 study trees were branch sampled and the samples peeled for evidence of EAB and EAB bioagents. A total of 21 trees were identified as positive for EAB and no bioagents were recovered through the sampling process. Track EAB Infestation Core Study results are available online and shown in the map below. An additional 49 trees will be selected in zones 2 and 3 during the summer of 2015 to maintain the robust monitoring network within the study area. An ash inventory for zones 2 and 3 will be taken during the summer to look at potential total infested ash within each zone to reference with city management records and compare outcomes.



Activity Status as of November 30, 2015:
An additional 58 trees were selected in zones 2 and 3 in order to maintain the monitoring network within the study area. Ash health data were collected on all remaining and newly selected study trees. The total number of trees to be branch sampled this winter is 173. An ash inventory for zones 2 and 3 was completed over the summer by using 100 randomly generated polygons and assessing the presence of ash within those polygons. Data are being analyzed by Dr. Venette.

Branch sampling is scheduled to begin in early December 2015.

Activity Status as of May 31, 2016:
The remaining 164 study trees were branch sampled over the winter with the samples processed and debarked to look for evidence of EAB and EAB bioagents. A total of 35/164 study trees were identified as infested with EAB and no biaogents were recovered through the process. The proportion of infested study trees for each zone is as follows: Zone 1 = 50%, Zone 2 = 25% and Zone 3 = 11%. Overall, 21% of the study trees were found to be infested within the study area. The overall rate of infestation, especially in the core area, is still far lower than was expected this far along in the study.



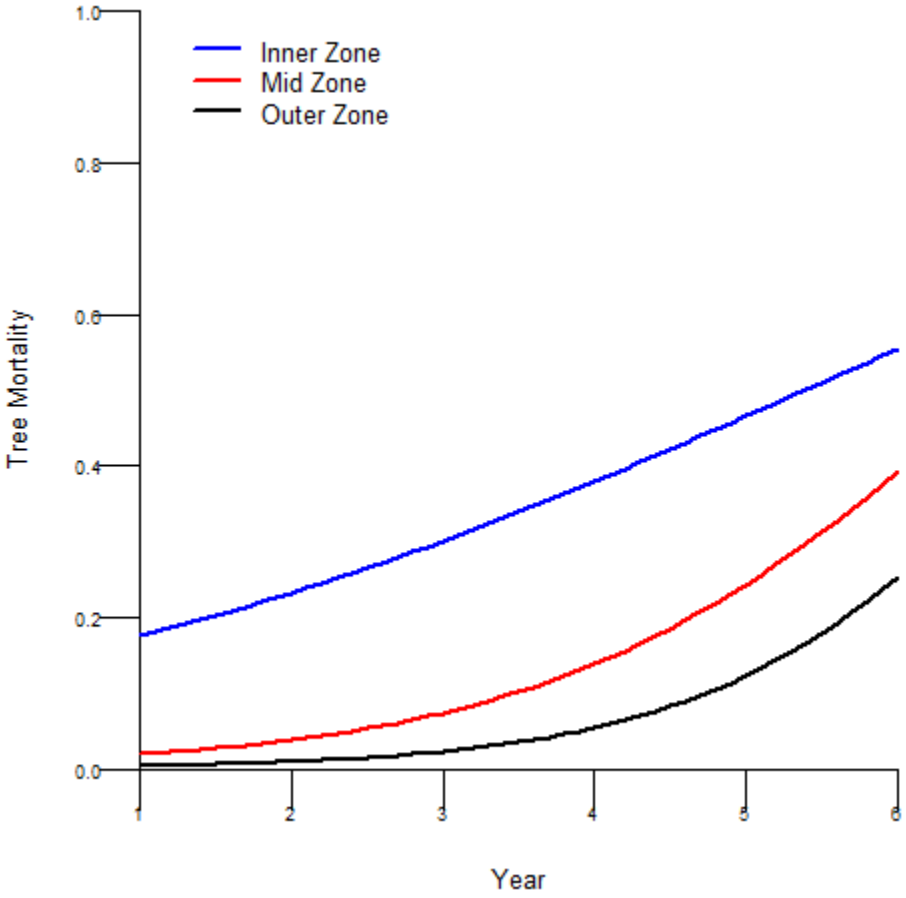
Activity Status as of November 30, 2016:
We are beginning to wrap up this activity with the final round of branch sampling this winter. There are 109 remaining study trees and none of these are in the core infested area. There are 51 in zone 2 and 58 in zone 3. Analysis will begin after final data collection.

Final Report Summary:
Emerald ash borer was first detected in the Twin Cities in 2009, although it likely arrived in the area at least three years prior to that date. As such, we expect that we are now entering the second decade with emerald ash borer present in the Twin Cities metro area. Substantial mortality across the metro area was expected by now.

Instead, populations of emerald ash borer – while increasing – have remained at low or undetectable levels in the majority of study trees after six years of study. The remaining study trees were branch sampled and processed during the winter of 2017. The final year of sampling results produced 32 infested trees out of the 109 trees remaining. No parasitoids were found through the branch sampling process and densities of EAB remained very low throughout the duration of the study. As shown in the graph below, only approximately 20% of trees in the outer zone, 30% of trees in the mid zone, and 50% of trees in the inner zone had detectable levels of emerald ash borer using annual branch sampling techniques by the end of the sixth year of this study. Statistically, we found that over this three mile radius, the rates of infestation through time were different in each of the three zones (χ^2_2=7.17, *P*=0.0277). We had expected to find, if not complete mortality, a uniform rate of increase over this relatively small area.

We suspect that cold weather during the winter of 2013-2014 slowed population growth considerably, and the insects are still rebounding.

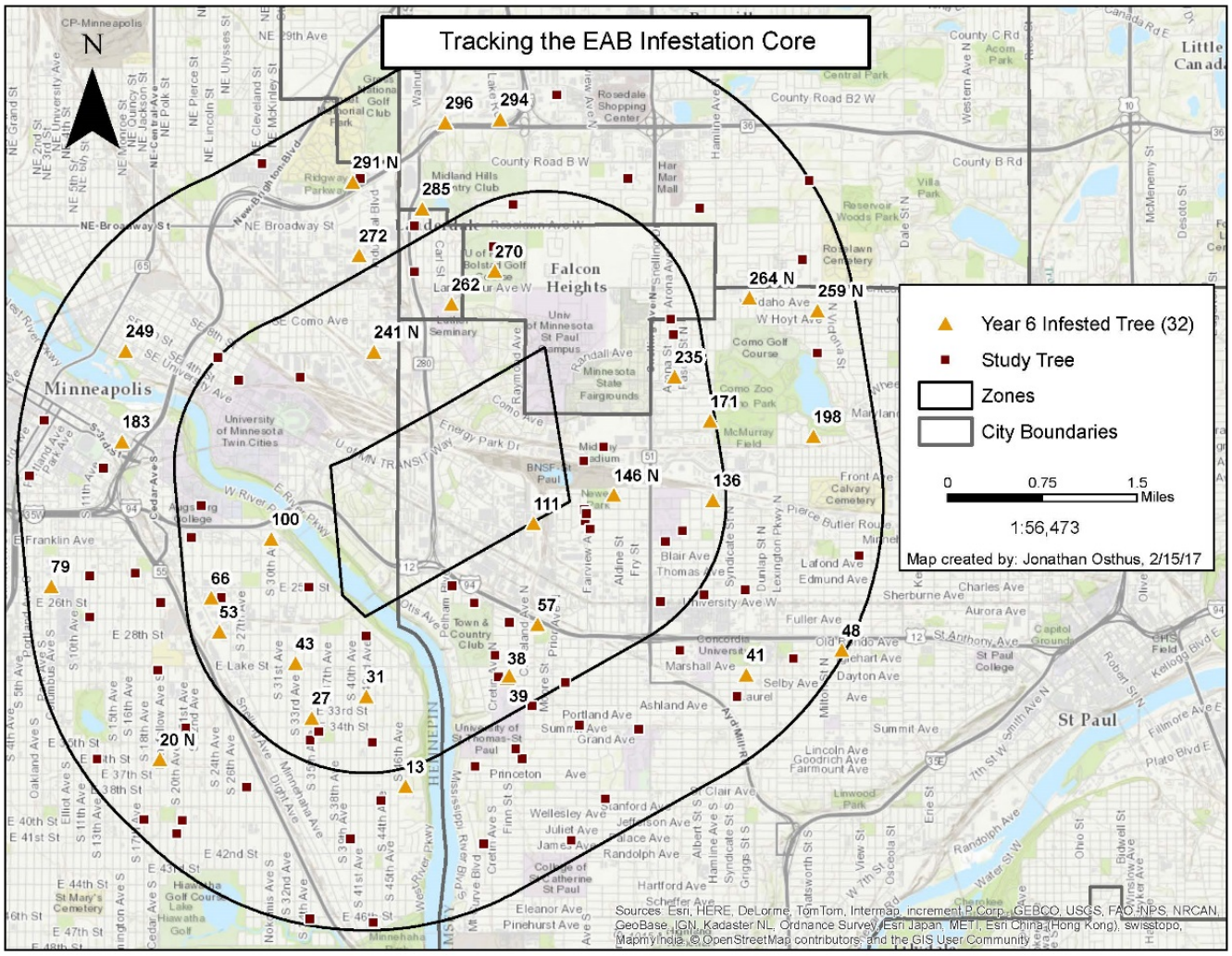
These results suggest that population growth in Minnesota – at the northwestern edge of populations of emerald ash borer nationally – may be slower than in other states. This may buy resource managers valuable time to plan an appropriate response to this insect, and allow critical time for further research efforts into biological control and resistance breeding by ourselves and colleagues nationally.



Caption: Infestation through time in each of the zones of the 300 tree study. Year one is 2011-12. All remaining trees were removed in the inner core zone in 2016-17.

Ash Health Rating (1 = Healthy and 5 = Dead) by Year and Zone

Year	Zone	# Trees	Mean	Std Error
2011	1	98	1.296	0.06487
2011	2	123	1.203	0.04735
2011	3	79	1.228	0.06686
2011	Combined	300	1.24	0.03378
2012	1	77	1.247	0.05853
2012	2	112	1.268	0.06311
2012	3	76	1.12	0.05607
2012	Combined	265	1.22	0.03572
2013	1	54	1.593	0.09629
2013	2	105	1.423	0.06725
2013	3	68	1.188	0.05172
2013	Combined	227	1.392	0.04273
2014	1	27	1.444	0.12096
2014	2	89	1.382	0.0584
2014	3	61	1.328	0.06847
2014	Combined	177	1.373	0.04205
2015	1	10	1.2	0.18974
2015	2	91	1.275	0.0517
2015	3	72	1.264	0.06512
2015	Combined	173	1.266	0.03995
2016	2	52	1.423	0.07857
2016	3	59	1.441	0.09669
2016	Combined	111	1.432	0.06322



ACTIVITY 3: Expand biological control implementation

Description:

The goal of EAB biological control is to use natural enemies to bring EAB populations into balance and reduce damage. In this case, two larval parasitoid species (wasps that attack EAB larvae under ash bark) and one egg parasitoid species (wasps that attack EAB eggs) have been released in Minnesota. These three species were tested to ensure that they will not negatively impact other species or the environment. USDA rears these biological control agents at a specialized facility and provides them to states with EAB infestations. Biological control implementation is a collaborative effort by local governments and state and federal agencies. MDA coordinates the statewide EAB biological control program. ENRTF funding has enabled Minnesota EAB biological control activities to date.

The larval parasitoid species are *Spathius agrili* and *Tetrastichus planipennisi*. Both species were released 2010 – 2012 in Minnesota. USDA decided in 2013 that they would continue releases of *S. agrili* south of the 40th parallel trying to better synchronize EAB and *S. agrili* lifecycles. Minnesota did not receive *S. agrili* for release in 2013 and there are no plans to release this species again north of the 40th parallel. Releases of *T. planipennisi* continued in 2013 and we anticipate continuing to release this species. We learned from cold tolerance studies of this species in Phase 1 of this project that spring releases are preferable. They allow the most time for multiple generations to reproduce over the summer season so that overwintering populations are sufficiently large to withstand some cold-induced mortality. The egg parasitoid, *Oobius agrili*, was released 2011-2013 and we anticipate continuing to release this species. Over 130,000 wasps were released at 20 sites with confirmed EAB infestations since 2010. *Tetrastichus planipennisi* larvae were recovered on two occasions at Great River

Bluffs State Park in southeastern Minnesota in the fall of 2013. These finds confirm that *T. planipennisi* is attacking EAB and reproducing in the field in Minnesota. Also, we know that the parasitoids are dispersing well. These larvae were found approximately 0.5 miles from the nearest release site.

Data are collected for all bioagent releases and recoveries. Ash health and EAB activity are monitored at release sites. These data are maintained in a MDA database and entered into a USDA database annually.

EAB is expected to continue to spread in Minnesota. We plan to expand the EAB biological control effort with new release sites to address EAB spread while continuing to monitor existing release sites. Biosurveillance (Activity 1) will inform biological control. A MDA Research Scientist 1 will expand biological control releases to new EAB finds and monitor existing sites.

Summary Budget Information for Activity 3:

ENRTF Budget:	**$ 179,560**
Amount Spent:	**$ 179,560**
Balance:	**$ 0**

Activity Completion Date: 06/10/2017

Outcome	Completion Date	Budget
1. New release sites established and existing sites monitored	10/31/2016	$ 130,000
2. Data entered into MDA database and channeled into a national database	06/10/2017	$ 2,500
3. Test parasitoid recovery method with yellow pan traps	06/10/2017	$ 27,060
4. Update Minnesota's EAB management guidelines to include latest information from three ENRTF EAB related projects.	06/30/2017	$ 20,000

Project Status as of November 26, 2014:
EAB was detected at sites in Bloomington, Houston, Rochester and Rushford. We anticipate biological control releases in these areas in 2015. EAB was found in and near Caledonia as well. We scouted the area and found insufficiently low quantities of ash stands for a biological control release at this time. Biological control agents were released at the following sites.

Summary of biological control agent releases from 07/01/14 to 09/10/14

Site Name	Location		*Tetrastichus planipennisi*	*Oobius agrili*	Total Released
	Latitude	Longitude			
Como Park	44.97898	-93.14738	1,377	750	2,127
E. River Pkwy 3	44.9519	-93.20251	3,676	1,700	5,376
Ft. Snelling Hwy 5 Hillside	44.88491	-93.18779	7,836	2,550	10,386
Hwy 26	43.53996	-91.28052	4,249	1,879	6,128
Lake Winona	44.038721	-91.652942	5,421	2,483	7,904
Northwestern College	45.03636	-93.16732	682	300	982
W. River Pkwy 2	44.95102	-93.20656	3,915	1,400	5,315
Shepard's Road	44.912613	-93.140291	744	200	944

A total of 39,162 parasitoids were released seven sites in the Twin Cities and southeastern Minnesota. *Tetrastichus planipennisi* is a larval parasitoid and *Oobius agrili* is an egg parasitoid of EAB.

Biological control releases were initiated at one site in the fall of 2010. Since then, a total of 177,000 parasitoids were released at 22 sites. Parasitoids are released at a site for two complete summer field seasons to establish parasitoid populations. Ash health is monitored at all sites, including sites where parasitoids are no longer released. Ash health is declining at sites in southeastern Minnesota as EAB increases in density and distribution. Ash health is relatively constant at release sites in the Twin Cities. Removal of EAB infested trees is likely to be a factor for ash health in the Twin Cities.

Monitoring biological control releases is very challenging because the parasitoids are concealed by ash bark for part of their lifecycles and cannot be efficiently trapped during the mobile adult phase of their lifecycles. The parasitoids are very small and difficult to see. Also, the parasitoid populations are small at this time so there is a low probability of recovering parasitoids with most attempts. To increase the efficiency and efficacy of monitoring, Jonathan Osthus and Monika Chandler worked with experts in Michigan on monitoring methods that are in development. Working with Dr. Leah Bauer and her technician, Jonathan and Monika learned how to collect, prepare and inspect bark samples for evidence of the egg parasitoid. Dr. Bauer is with the USDA Forest Service and her lab is at Michigan State University in East Lansing. At a USDA APHIS lab in Brighton, Dr. Bauer taught Jonathan, Monika and their APHIS colleagues to dissect EAB larvae and look for both *Tetrastichus planipennisi* and native parasitoids. Parasitized EAB larvae may not display symptoms in the early stages of parasitoid development. It is essential to dissect each collected larva to understand the parasitism rate. In addition, Jonathan and Monika toured the USDA APHIS biological control agent rearing facility in Brighton. People at this facility provide all of the EAB parasitoids released in the United States. We exchanged information at the facility and decided that Minnesota will pioneer a new method of releasing *Oobius agrili* to increase its distribution. No ENRTF funds were used for the October 2014 travel in Michigan. A total of $1,128 ($850 meals and lodging, $218 car rental and $60 fuel) MDA general funds were used.

The parasitoid, *Tetrastichus planipennisi*, is reared on EAB larvae in sections of ash wood at a specialized USDA APHIS facility in Brighton, MI.

In November 2014 the larval parasitoid, *T. planipennisi*, was recovered at two sites in southeastern Minnesota. Both sites are at Great River Bluffs State Park. The parasitoids were found one year after they were released at the park. This demonstrated that populations of this species are establishing in the EAB population and the parasitoids successfully overwintered through the extreme cold winter of 2014. This finding is consistent with cold tolerance research on this species that was completed in Phase 1 of this project.

Bark samples were collected at Great River Bluffs State Park to monitor *O. agrili*. The samples are drying and will be processed by a student worker over the winter. MDA's seed lab is providing a high quality dissecting microscope station for this work.

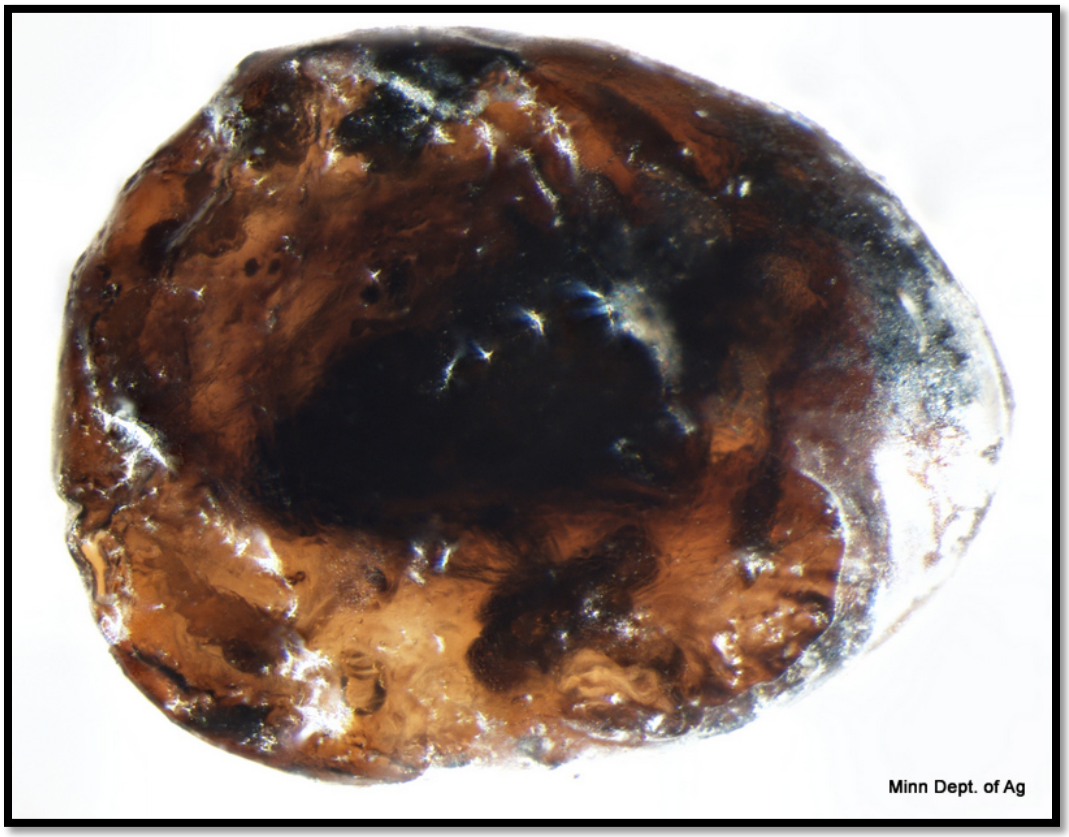
Activity Status as of May 29, 2015:
Multiple surveys were conducted to inform our biocontrol effort. An extensive survey for EAB in southeastern Minnesota with nine MDA experts on 04/22/15 and 04/23/15 defined a leading edge of EAB just north of Winona, found EAB in Rushford where it had not been previously detected and identified promising new sites for biocontrol releases. Since December of 2014, EAB was detected at two new locations in the cities of Ham Lake and Eagan. Areas were scouted for potential biological control release sites with one new site identified in Ham Lake. Sites in forested natural areas in Bloomington and Rochester were identified for future releases once EAB has spread from the street trees to these natural areas. Urban sites containing only boulevard and landscape ash are less than ideal due to other management activity that takes precedence resulting in those trees either being treated with insecticide or removed. Biological control agents were released at the following sites. Releases will continue over the summer field season.

Summary of biological control agent releases from 05/19/15 to 05/29/15

Site Name	Location		*Tetrastichus planipennisi*	*Oobius agrili*	Total Released
	Latitude	Longitude			
Lake Winona	44.038721	-91.652942	3,135	0	3,135
Prairie Island	44.080734	-91.690985	3,135	0	3,135
Reno to LaCrescent	43.604195	-91.271197	3,135	0	3,135
Ft Snelling Hwy 5 Hillside	44.88491	-93.18779	1,656	0	1,656
Shepard's Rd	44.912613	-93.140291	1,656	0	1,656
Hidden Falls Park	44.90956	-93.19195	1,656	0	1,656
Minnehaha Park	44.91806	-93.2065	1,656	0	1,656
Lake Harriet	44.929285	-93.299044	1,656	0	1,656
W. River Pkwy (2)	44.95102	-93.20656	1,656	0	1,656
Patricia's Wilderness Estates Park	45.230884	-93.169617	1,656	0	1,656

A total of 20,997 parasitoids were released at 10 sites in the Twin Cities and southeastern Minnesota. *Tetrastichus planipennisi* is a larval parasitoid and *Oobius agrili* is an egg parasitoid of EAB.

Since November 2014, bioagent recovery work for the egg parasitoid, *Oobius agrili*, has been underway. Using the bark sampling process learned from researchers in Michigan, MDA successfully recovered the egg parasitoid from sites in the southeast and Twin Cities. A total of four separate egg parasitoid recoveries were made since December of 2015. Initial samples were sent to Dr. Leah Bauer's Forest Service lab in East Lansing, MI for official confirmation. Recoveries of the larval parasitoid, *Tetrastichus planipennisi*, continued with branch sampling activities in southeast Minnesota. An additional four larval parasitoid recoveries were made from branch sampling and larval dissection at Great River Bluffs State Park.



The egg parasitoid, *Oobius agrili*, was found inside of this EAB egg recovered from Great River Bluffs State Park. The dark spot in the center of the egg is an adult *Oobius agrili*.

Activity Status as of November 30, 2015:

Bioagent releases continued through summer with the last releases taking place on 9/23/2015 in southeast Minnesota. The 2015 field season marked the biggest season of releases to date, completely eclipsing the number of bioagents released in the last four years combined. A total of eight new sites were initiated at locations in the Twin Cities and southeast Minnesota.

Summary of biological control agent releases from 5/30/2015 to 9/23/2015 *****New Site

Site Name	Latitude	Longitude	*Tetrastichus planipennisi*	*Oobius agrili*	Total Released
Lake Winona	44.038721	-91.652942	13,415	3,350	16,765
Homer, MN*	44.021025	-91.5448534	10,730	1,950	12,680
Prairie Island*	44.080734	-91.690985	15,482	4,650	20,132
Reno to LaCrescent*	43.604195	-91.271197	15,728	3,750	19,478
Ft Snelling Hwy 5 Hillside	44.88491	-93.18779	11,381	2,940	14,321
Shepard's Rd	44.912613	-93.140291	10,278	2,650	12,928
Minnehaha Park*	44.91806	-93.2065	12,279	2,750	15,029
Hidden Falls Park*	44.90956	-93.2065	12,024	2,750	14,774
Lake Harriet*	44.92985	-93.299044	11,470	2,650	14,120
W. River Pkwy (2)	44.95102	-93.20656	6,688	1,300	7,988
Patricia's Wilderness Estates Park*	45.230884	-93.169617	4,701	850	5,551
Wheelock Pkwy*	44.982776	-93.118431	5,849	1,900	7,749

A total of 161,515 parasitoids were released at 11 sites in the Twin Cities and southeast Minnesota.

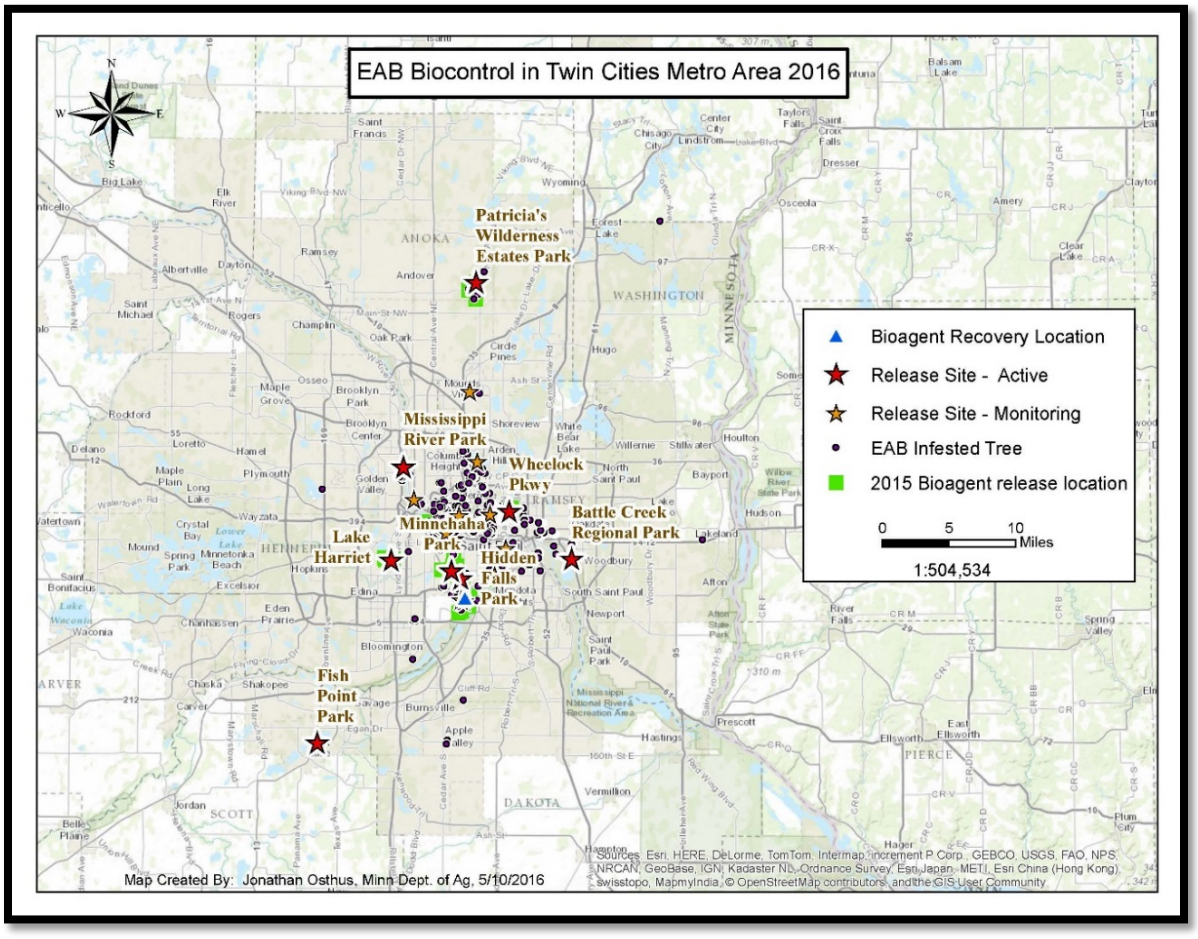
Bioagent recovery work resumed at the beginning of November at sites in southeast Minnesota. Branch sampling work at Great River Bluffs State Park was completed resulting in 29 recoveries of the larval parasitoid *Tetrastichus planipennisi*. This is a large and significant increase from the previous two years of sampling at the park. These results indicate a well-established parasitoid population that is sufficiently cold hardy and increasing in numbers. Bark samples have begun to be collected and processed from multiple sites in the Twin Cities and southeast Minnesota to continue recovery efforts of the egg parasitoid *Oobius agrili*.

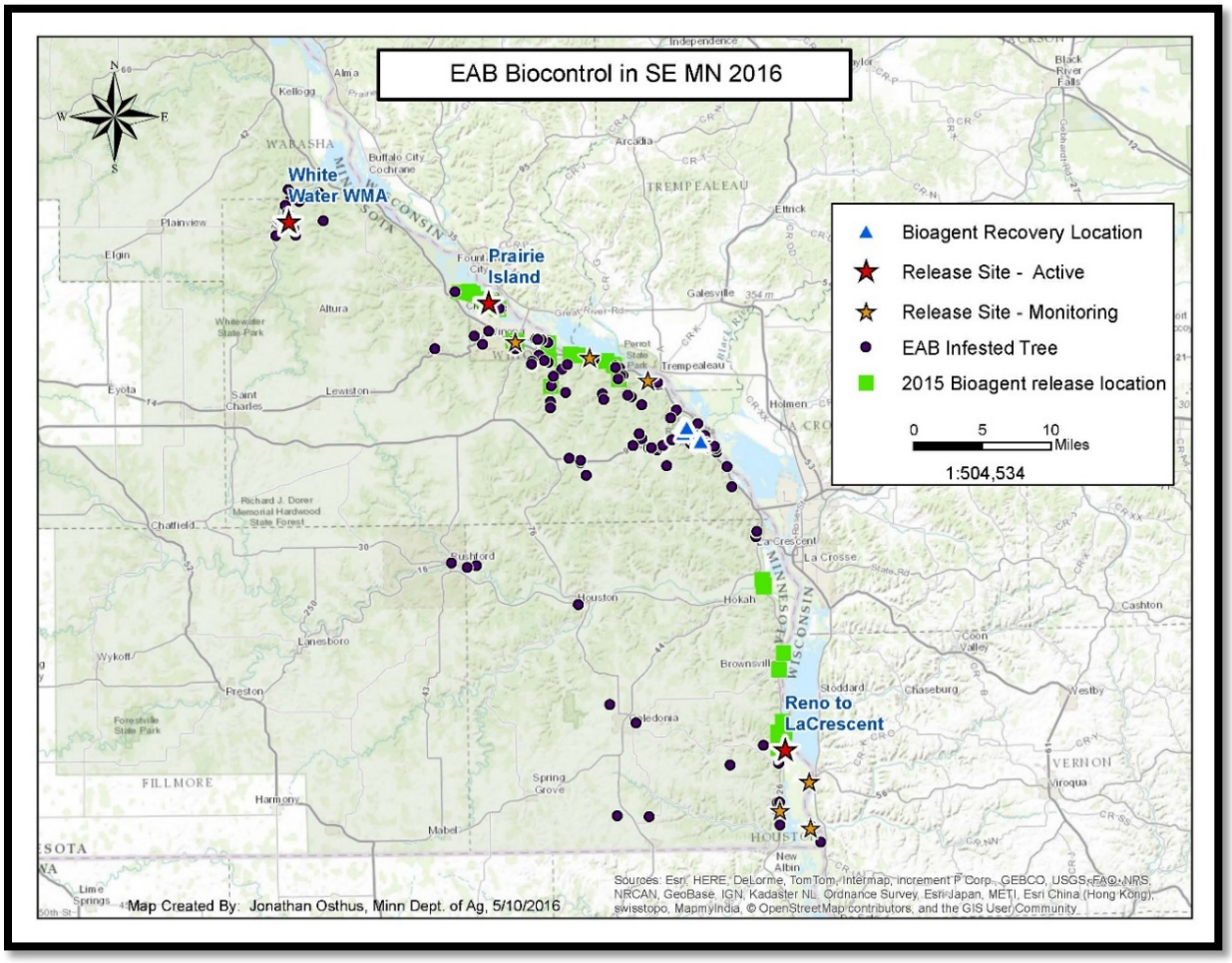
We are assessing sites and planning 2016 releases in response to the following new EAB finds.

- Two new EAB finds were discovered by trap survey in Chisago and Washington Counties. EAB was not previously confirmed in these counties.
- EAB was found in the cities of Prior Lake and Plymouth. EAB was confirmed in these previously but not in these cities.
- We conducted a joint MDA/DNR survey at Whitewater Wildlife Management Area (WMA) in the northwestern part of Winona County and infested trees were identified.

Activity Status as of May 31, 2016:

Bark samples were collected through the winter months from Great River Bluffs State Park 1, Hwy 26, Lake Winona and Lamoille release sites. Samples were collected from a total of 24 trees and are being stored in paper bags that allows the bark material to dry out making it easy to sift and sort once ready to be processed in the fall. New EAB biocontrol release sites were selected during the spring to continue implementation along the leading edges of EAB infestation in the state. Four new release sites were selected in Hennepin, Ramsey, Scott and Wabasha Counties. An interactive map of EAB biocontrol activities in Minnesota can be viewed at http://arcg.is/25hRRet.





We will begin testing yellow pan traps as a monitoring method for parasitoid recovery during the 2016 summer season.

Activity Status as of November 30, 2016:

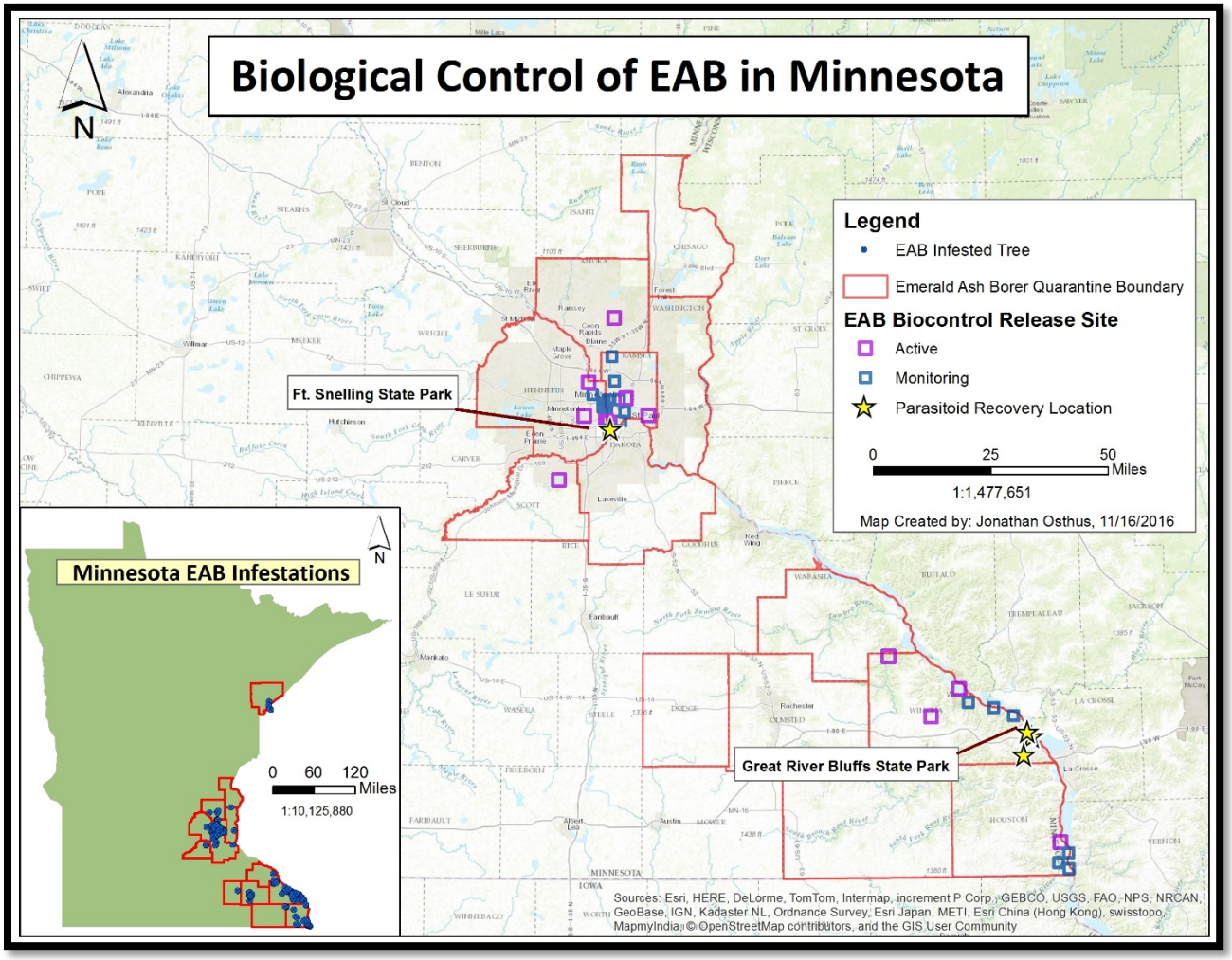
Parasitoid Releases

Parasitoid releases wrapped up for the season on 09/22/16. A total of 89,501 wasps were released at 12 sites in Minnesota. The 2016 field season marked the first time *Spathius galinae* was released in Minnesota. *Spathius galinae* is a newly approved larval parasitoid originating from the Russian Far East and was released at 3 sites located along the Mississippi River in the Twin Cities. Numbers of *S. galinae* releases are expected to increase in future seasons as production ramps up at the USDA EAB Parasitoid Rearing Facility in Brighton, MI. We did not receive as many *Tetrastichus planipennisi* as in 2015, possibly due to increased demand from other states.

EAB larval parasitoid, *Spathius galinae*

Biocontrol Release Summary by Year

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**



Parasitoid Recovery

We tested yellow pan trapping and consider it a reasonable method of parasitoid recovery. Our methods were to install 30 yellow pan traps at Ft. Snelling State Park on 05/31/16. Pans were filled with propylene glycol to trap insects. The traps were sampled weekly from 06/03/16 to 09/09/16. Sampling involved pouring the propylene glycol through a filter then bagging and freezing the contents on the filter. Pans were refilled with new propylene glycol. A total of 870 samples were collected, frozen then examined in October and November.

Our preliminary identification is 14 *T. planipennisi* and 9 *Atanycolus*, a native parasitoid that we cannot identify to species. These recovered parasitoids were sent to Dr. Juli Gould with APHIS for expert identification.



Yellow pan trap on tree (left) and collecting contents from trap (right).

Sampling bark for the egg parasitoid, *Oobius agrili*, yielded one parasitized EAB egg from Ft. Snelling State Park. This was the second time parasitized EAB eggs were recovered from this park demonstrating that *O. agrili* is established at this site. To date in 2016, 28 samples have been processed from 6 release sites.

A clutch of *Tetrastichus planipennisi* was detected in an EAB gallery by a Forest Health Specialist with the MNDNR. It was found when ground-truthing aerial survey locations of potential ash mortality in southeast Minnesota. The detection is important as it was found 4.5 miles from the nearest parasitoid release location and continues to demonstrate the establishment and dispersal of the larval parasitoid *T. planipennisi.*

Final Report Summary:

Parasitoid Release

Minnesota continues to be one of the most active states in the nation implementing EAB biological control. A total of 21,368 wasps were released at 8 sites from May 16th to June 28th in 2017. Three new release sites were added in 2017 based on new detections of EAB. The addition of Hartley Park in Duluth marks the furthest north releases have been done to date. Hartley Park is also the first site dominated by black ash to receive biocontrol releases in the state. The total number of wasps released throughout the project period from July 1st, 2014 to June 30th, 2017 is 332,543 wasps at 25 sites statewide. Through discussions with colleagues in other states, it has become abundantly clear that having dedicated staff for implementing EAB biocontrol has been a huge advantage and benefit for the state of Minnesota. It has allowed for increased access to finite resources from the USDA EAB Parasitoid Rearing Facility in Brighton, MI and the ability to aggressively apply this management method throughout the known extent of EAB at early stages of infestation.

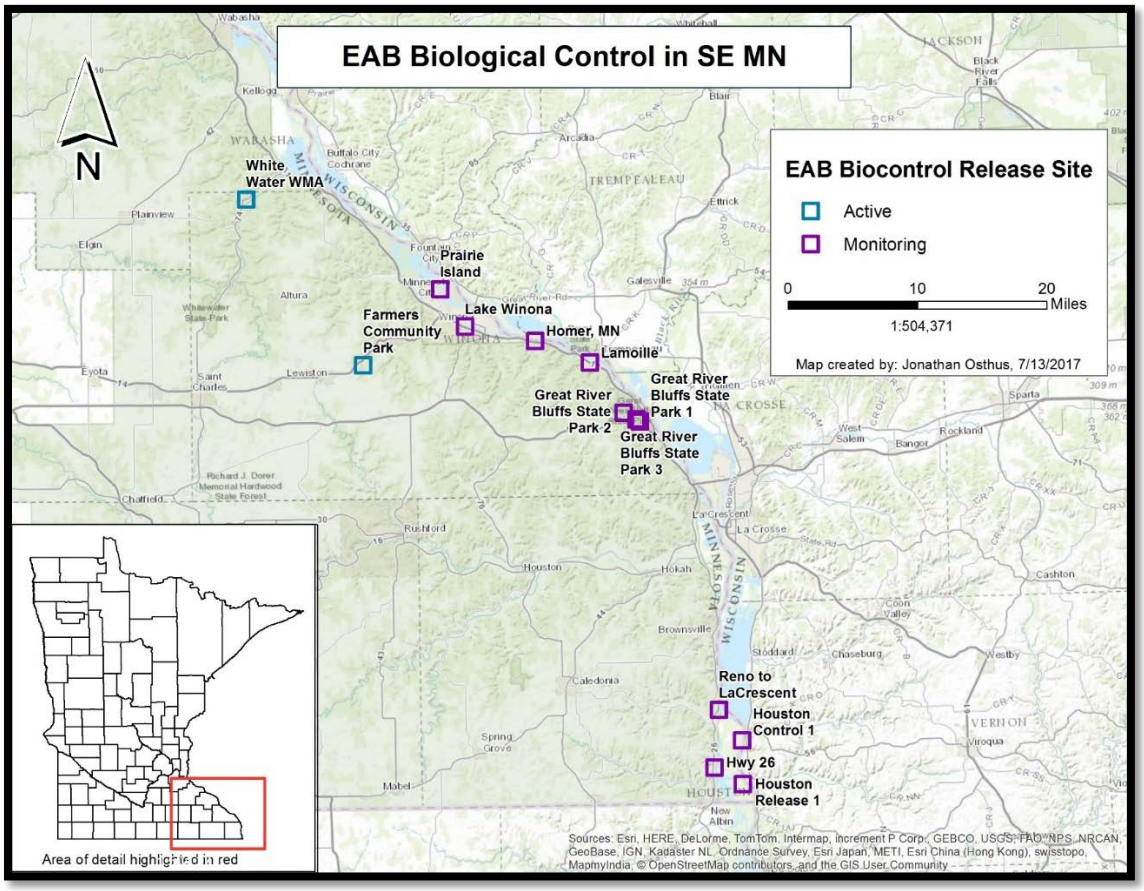
Biocontrol Release Summary by Year

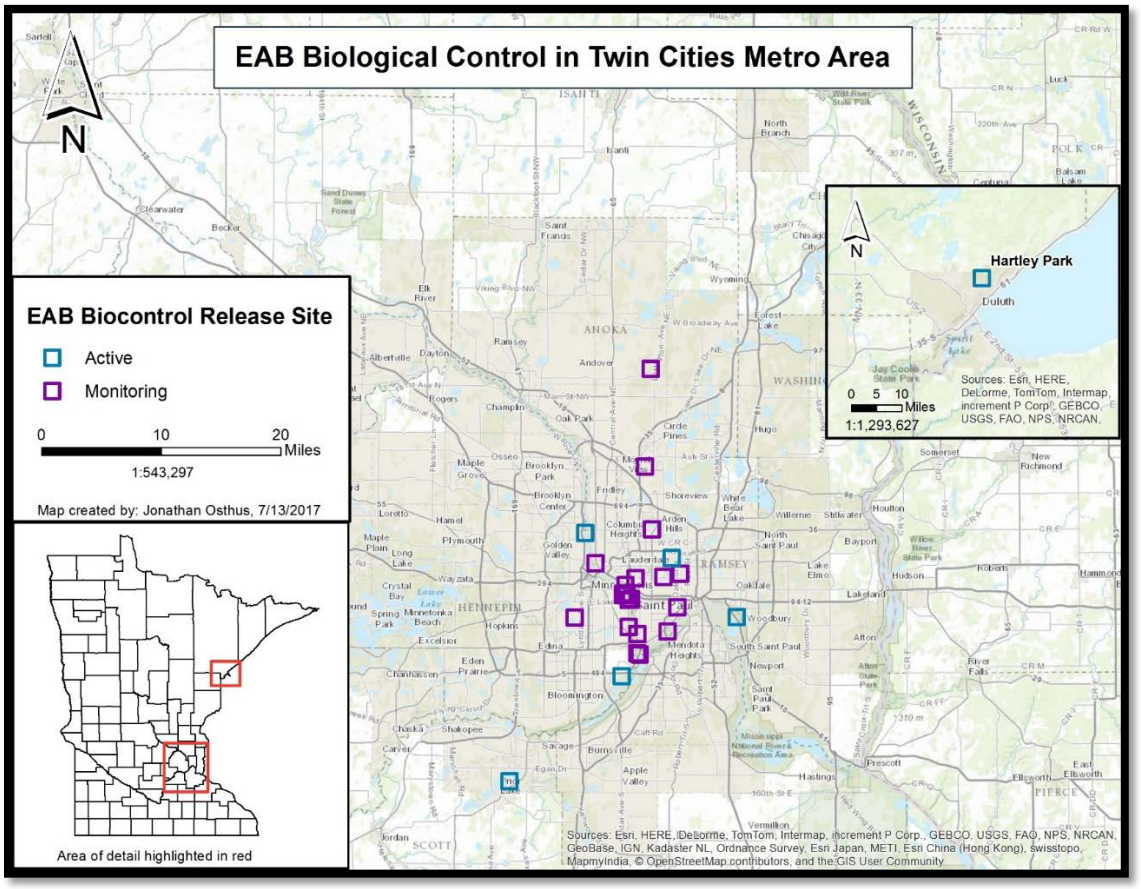
Biocontrol Agent	2010	2011	2012	2013	2014	2015	2016	2017 (up to June 30th)	All
Tetrastichus planipennisi	2,154	19,480	19,822	42,579	34,434	151,022	45,288	16,676	331,455
Oobius agrili	0	3,641	10,241	8,597	12,062	31,490	42,600	3,800	112,431
Spathius agrili	1,172	7,596	15,258	0	0	0	0	0	24,026
Spathius galinae	0	0	0	0	0	0	1,613	892	2,505
Totals	3,326	30,717	45,321	51,176	46,496	182,512	89,501	21,368	470,417

Even with bioagent releases, ash health declined at sites with high levels of EAB. Although we lost many ash trees at release sites, we remain hopeful that the establishment of biological control agents will help to protect future generations of ash trees.

Mean Ash Health at Biocontrol Sites (1=Healthy, 5=Dead)

Site	2010	Error	2011	Error	2012	Error	2013	Error	2014	Error	2015	Error	2016	Error
2nd Street NE	0	0	0	0	0	0	1.3	0.18	1.6	0.24	1.7	0.24	1.3	0.21
Battle Creek Reg. Park	0	0	0	0	0	0	0	0	0	0	0	0	1.5	0.15
Como Park	0	0	0	0	0	0	1.4	0.17	1.7	0.24	2.3	0.33	1.8	0.37
E. River Pkwy 1	0	0	1.6	0.26	1.4	0.31	2.1	0.35	2	0.37	2.1	0.31	2.6	0.31
E. River Pkwy 2	0	0	1.7	0.22	1.3	0.21	1.9	0.13	1.8	0.25	2.2	0.17	2.5	0.29
E. River Pkwy 3	0	0	0	0	0	0	1.6	0.24	1.6	0.18	2	0.29	2	0.29
Farmers Com. Park	0	0	0	0	0	0	0	0	0	0	0	0	1.1	0.08
Fish Point Park	0	0	0	0	0	0	0	0	0	0	0	0	1.1	0.08
Ft. Snelling Upper Post	0	0	0	0	1	0	1.2	0.15	2.2	0.32	3.3	0.29	4.1	0.26
Ft. Snelling Hwy 5	0	0	0	0	0	0	1.2	0.11	1.3	0.19	2.1	0.31	3	0.33
GRBSP1	0	0	1.6	0.29	1	0	1.7	0.19	2.9	0.34	3.6	0.29	4.8	0.11
GRBSP2	0	0	1.2	0.11	1.2	0.11	1.8	0.18	3	0.3	3.9	0.19	5	0
GRBSP3	0	0	0	0	1.7	0.12	2.2	0.17	3.3	0.23	3.1	0.52	4.6	0.2
Hidden Falls	0	0	0	0	0	0	0	0	0	0	2	0.28	2.6	0.26
Houston Release 1	1	0	1.4	0.26	1.3	0.14	2.4	0.45	3.2	0.36	4.1	0.17	0	0
Hwy 26	0	0	0	0	0	0	1.4	0.19	1.8	0.25	2.3	0.33	4	0.25
Lake harriet	0	0	0	0	0	0	0	0	0	0	1.8	0.24	1.6	0.15
Lake Winona	0	0	0	0	0	0	0	0	1.3	0.13	3.2	0.27	4.3	0.35
Lamoile	0	0	1	0	1	0	1	0	1.5	0.15	2.3	0.45	4	0.52
Langford Park	0	0	1.6	0.19	1.2	0.11	1.3	0.21	2	1	3	0	0	0
Minnehaha Park	0	0	0	0	0	0	0	0	0	0	1.8	0.25	2.1	0.29
Miss. River Park	0	0	0	0	0	0	0	0	0	0	0	0	1.9	0.23
Northwestern College	0	0	0	0	0	0	1.6	0.23	1.8	0.25	1.8	0.27	2.2	0.32
Prairie Island	0	0	0	0	0	0	0	0	0	0	1.2	0.11	1.3	0.14
Reno to LaCrescent	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Shepards Rd	0	0	0	0	0	0	0	0	0	0	3	0.33	4.2	0.37
Shoreview 1	0	0	1.3	0.13	1	0	1	0	1	0	1.2	0.11	1.2	0.17
Summit & Dale	0	0	1	0	1	0	1.5	0.19	1.8	0.25	2	0.27	2	0.27
Tower Hill Park	0	0	2.3	0.3	1.3	0.25	0	0	0	0	0	0	0	0
W. River Pkwy 1	0	0	2.5	0.19	2.4	0.26	0	0	0	0	0	0	0	0
W. River Pkwy 2	0	0	0	0	0	0	1.2	0.22	1.4	0.15	2	0.29	2	0.44
Wheelock Pkwy	0	0	0	0	0	0	0	0	0	0	0	0	2	0.25
Whitewater WMA	0	0	0	0	0	0	0	0	0	0	0	0	1.8	0.22


EAB Biological Control in SE MN
N
White Water WMA
Prairie Island
Lake Winona
Farmers Community Park
Homer, MN
Lamoille
Great River Bluffs State Park 1
Great River Bluffs State Park 2
Great River Bluffs State Park 3
Reno to LaCrescent
Houston Control 1
Hwy 26
Houston Release 1
EAB Biocontrol Release Site
Active
Monitoring
0 10 20 Miles
1:504,371
Map created by: Jonathan Osthus, 7/13/2017
Area of detail highlighted in red
Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

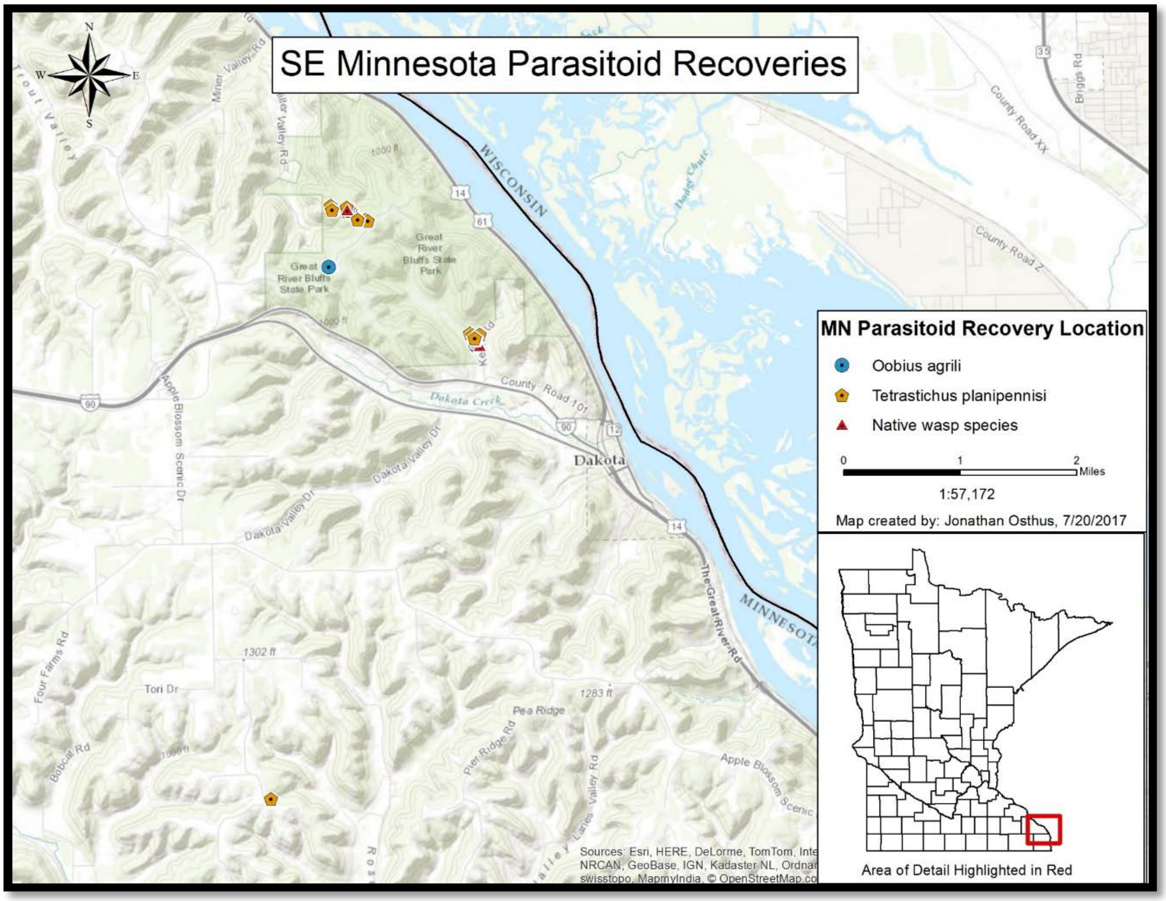

EAB Biological Control in Twin Cities Metro Area
N
Hartley Park
Duluth
EAB Biocontrol Release Site
Active
Monitoring
0 10 20 Miles
1:543,297
Map created by: Jonathan Osthus, 7/13/2017
0 5 10 Miles
1:1,293,627
Area of detail highlighted in red
Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

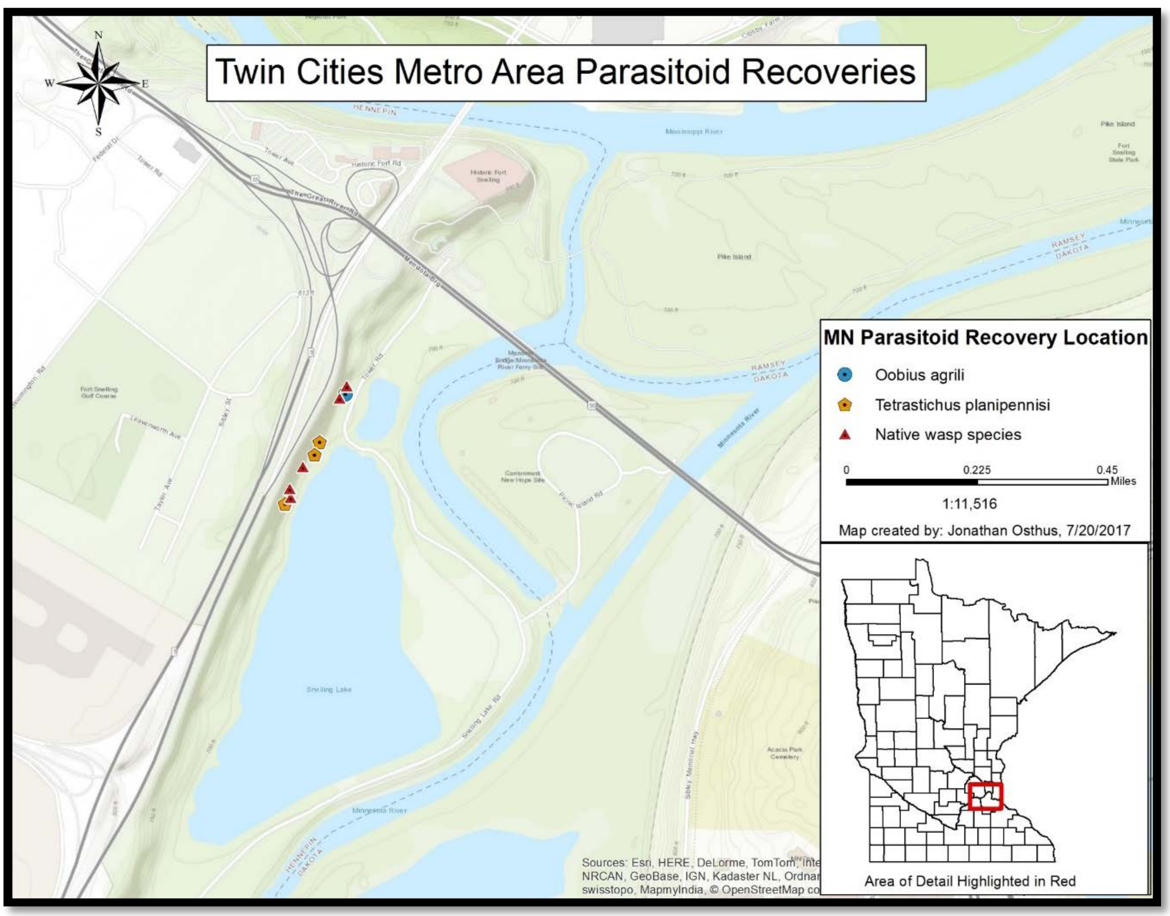
Parasitoid Recovery

Efforts to recover and document establishment of the parasitoid wasps released to combat EAB continues to move forward with each passing year. Several techniques have been implemented including branch sampling, larval dissection, bark sifting and yellow pan trapping. All have been successful in recovering parasitoid wasps throughout the project. In the winter of 2017, bark samples that were collected in fall of 2016 to look for the egg parasitoid *Oobius agrili* were processed with one parasitized egg confirmed. The confirmation of a parasitized egg again at Ft. Snelling State Park provided further evidence that it has established a reproducing population at the site. The recovery of *Tetrastichus planipennisi* at Ft. Snelling State Park through the use of yellow pan traps in the summer of 2016 was very important as well. The recovery marked the first time *T. planipennisi* had been recovered in the Twin Cities and demonstrated an established reproducing population at the site because releases were completed in 2015. Recovery efforts are continuing through the summer of 2017 with 30 yellow pan traps each deployed at two sites (Phase 3).

Parasitoid Recovery Summary

Year	*Tetrastichus planipennisi* (Recoveries)	Sampling Type	*Oobius agrili* (Recoveries)	Sampling Type	*Atanycolus simplex* - native wasp (Recoveries)	Sampling Type	Total by Year
2013	2	Tree debarking	-	-	-	-	2
2014	4	Tree debarking	-	-	-	-	4
2015	24	Tree debarking, larval dissection	3	Bark sifting	-	-	27
2016	6	Tree debarking, Yellow Pan Traps	-	-	9	Yellow Pan Traps	15
2017	-	-	1	Bark sifting	-	-	1
Total All Years	36	-	4	-	9	-	49

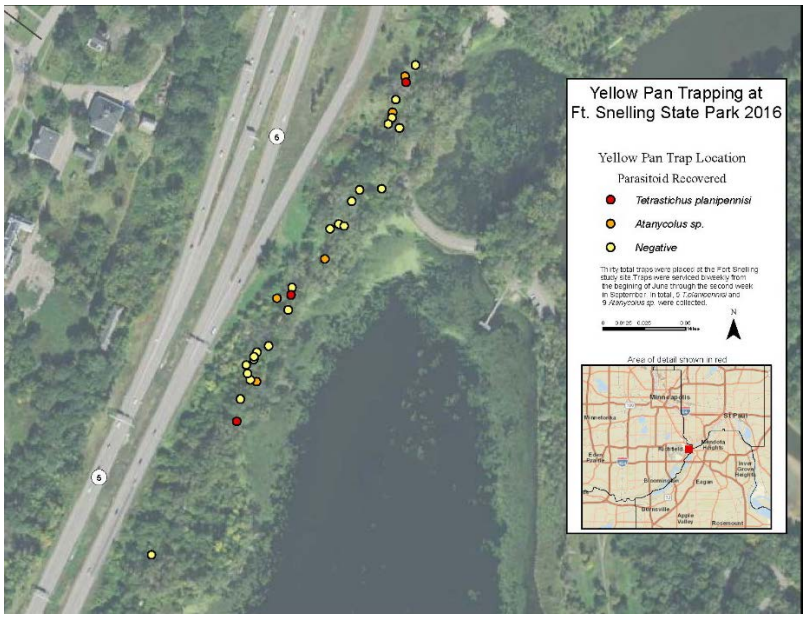

SE Minnesota Parasitoid Recoveries
MN Parasitoid Recovery Location
Oobius agrili
Tetrastichus planipennisi
Native wasp species
0
1
2
Miles
1:57,172
Map created by: Jonathan Osthus, 7/20/2017
Area of Detail Highlighted in Red
Great River Bluffs State Park
Dakota
WISCONSIN
MINNESOTA
County Road 101
Dakota Creek
Sources: Esri, HERE, DeLorme, TomTom, Inte
NRCAN, GeoBase, IGN, Kadaster NL, Ordnar
swisstopo, MapmyIndia, © OpenStreetMap co

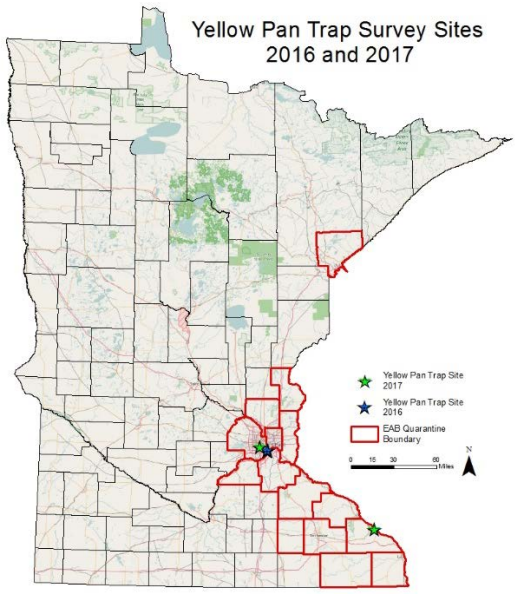

Twin Cities Metro Area Parasitoid Recoveries
MN Parasitoid Recovery Location
Oobius agrili
Tetrastichus planipennisi
Native wasp species
0
0.225
0.45
Miles
1:11,516
Map created by: Jonathan Osthus, 7/20/2017
Area of Detail Highlighted in Red
Sources: Esri, HERE, DeLorme, TomTom, Inte
NRCAN, GeoBase, IGN, Kadaster NL, Ordnar
swisstopo, MapmyIndia, © OpenStreetMap co

Yellow Pan Trapping Summary for Parasitoid Recovery
2016 Final Results
The Minnesota Department of Agriculture and Natural Resources partnered to test yellow pan trapping methods for parasitoid recovery over the summer of 2016. A protocol and pan traps were provided by USDA AHPIS. Yellow plastic bowls were attached to the stems of living ash trees using shelving brackets. The bowls were filled with a solution of clear propylene glycol to trap insects that were attracted to the yellow color. Samples were collected from the traps twice a week from 06/03/16 to 09/09/16. Sampling involved pouring the propylene glycol through a filter and then bagging and freezing contents. Pans were then cleaned and filled with new propylene glycol. A total of 870 samples were collected, frozen then examined in October and November. Samples were screened under a dissection scope for suspected parasitoids which were sent to USDA APHIS for identification

Yellow pan trap sample submissions were identified by Dr. Juli Gould with APHIS. This sampling method resulted in the positive identification of 5 *Tetrastichus planipennisi* and 9 *Atanycolus simplex* (a native parasitoid of EAB). The recovery of *T. planipennisi* was the first in the Twin Cities region.

2017 Traps
Yellow pan trapping was repeated for the summer of 2017 at two locations. Our methods were to place 30 traps at Roberts Bird Sanctuary near Lake Harriet in Minneapolis and at Prairie Island in Winona. Traps were placed in the beginning of June and will be sampled once a week until mid-September. Pans are filled with a propylene glycol solution to trap insects attracted to the yellow color. Sampling involves pouring the propylene glycol through a filter then bagging and freezing the contents on the filter. Samples will be screened in the fall under a dissection scope and suspected parasitoids will be sent off for identification by APHIS.





Management Guidelines
MDA staff updated and expanded guidelines for EAB management in Minnesota, including procedures for biological control. Over the course of this project, as well as the project titled Improving EAB Detection, we have learned much about EAB management. These guidelines incorporated information regarding EAB identification and reporting, detection methods and their relative efficiencies, recommended management tactics based on the infestation and site specifics. Associated costs were also included in the guidelines. The guidelines will be available on MDA's EAB webpages for municipalities, counties, the public and others.

V. DISSEMINATION:

Description: We will communicate about the biosurveillance and biocontrol of EAB with the public, land managers, and researchers. The web will be used for communication http://www.mda.state.mn.us/en/plants/pestmanagement/eab/eabbiocontrol.aspx and will be updated annually. Communication with the public will be via news media (print, television, and radio) and social media such as Facebook and Twitter. We will communicate updates with land managers at the multi-agency EAB Forum (meets 4 times/year) and in trade publications such as "The Scoop" published by the Minnesota Nursery Landscape Association. Updates and findings will be presented at a University of Minnesota seminar, the 2014 Upper Midwest Invasive Species Conference, and other meetings (LCCMR funding will not be used for meetings).

Project Status as of November 26, 2014:

Presentations

- EAB and EAB biocontrol were included in Invasive Blitz workshops at Spicer, MN on 09/13/14 (8 participants), Rochester, MN on 09/20/14 (11 participants) and Duluth, MN on 10/04/14 (7 participants).
- Extension Conference Lightening Talk by A. Gupta on EAB biosurveillance titled *Surprise!* on 10/06/14 (150 Extension educators).
- Gupta, A., J. Schultz, J. Hahn, and M. Chandler. 2014. Wasp Watchers: Minnesota's efforts to use citizen scientists to do EAB biosurveillance. University of Minnesota Extension Program Conference. Bloomington, MN October 8-10, 2014.
- Gupta, A. 2014. Communicating forestry through citizen science and invasive species. National Society of American Foresters Convention and Canadian Institute of Forestry/Instiut forestier du Canada Conference in Salt Lake City, UT, October 8-11, 2014.
- Forest Pest First Detector workshop in Rochester, MN on 11/05/14 (30 participants)
- Ash management workshop in Rochester, MN on 11/12/14 (15 participants)
- Gupta, A. 2014. Using volunteers for emerald ash borer and terrestrial invasive species early detection and management. Canadian Institute of Forestry webinar, November 19, 2014. (575 Canadian participants)

The following presentations were given at the Upper Midwest Invasive Species Conference in Duluth, MN, October 20-22, 2014. There were over 650 conference participants.

- Aukema, B., R. Venette, J. Hahn, M. Chandler, and M. Abrahamson. Mythbusters: Ten ideas about emerald ash borer that may not be true.
- Gupta, A. Engaging volunteers in early detection and management.
- Gupta, A., J. Schultz, J. Hahn, and M. Chandler. Wasp Watchers: Minnesota's efforts to use citizen scientists to do EAB biosurveillance.
- Osthus, J. Biological control of emerald ash borer (*Agrilus planipennis*) in Minnesota: A state update on parasitoid release, recovery and observations from the field.
- Venette, R., M. Abrahamson, and J. Osthus. Winter mortality of emerald ash borer in Minnesota: Lessons for managers.

Events

- Minnesota State Fair – MDA exhibit hosted information on EAB and EAB biocontrol at the Northwoods campground display 08/21/14 – 09/02/14.

Media

- The University of Minnesota's Urban Forestry program interviewed Jonathan Osthus for a short informational video on EAB biocontrol implementation in the Twin Cities.

Status as of May 29, 2015:

Presentations

- Osthus, J. Biological Control of EAB in Minnesota. Presented to Dakota County natural resource managers and staff on 01/08/15.
- Osthus, J. Tracking the EAB Infestation Core. Presented to the Minneapolis Tree Advisory Commission on 01/08/15.

- Osthus, J. Emerald Ash Borer Biological Control: Evolving strategies and observations from the field. Presented at South Dakota State University EAB workshop on 03/10/15. (Travel costs were paid by USDA.)
- **Wasp watcher outreach presentations**
  Brainerd Area Master Naturalists on 03/30/15 (25 participants), Stearns County Master Gardeners on 04/06/15 (35 participants), Scott and Carver Counties Master Gardeners on 04/13/15 (50 participants), Chisago County Master Gardeners on 04/14/15 (25 participants), Mower County Master Gardeners on 04/15/15 (15 participants), Steele County Master Gardeners on 04/20/15 (20 participants), Ramsey County Master Gardeners on 04/21/15 (75 participants), Hennepin County Master Gardeners on 05/04/15 (200+ participants), Master Naturalist Conference on 05/16/15 in Grand Rapids (20 participants), Winona County Master Gardeners on 05/19/15 (20 participants)
- Four Forest Pest First Detector workshops were held in Hutchinson on 02/19/15 (16 participants), Alexandria on 02/26/15 (9 participants), Cloquet on 03/03/15 (29 participants) and Shoreview on 03/04/15 (46 participants).

Training about EAB and EAB biocontrol

- City of Bloomington on 12/03/2015 (65 participants)
- City of Duluth on 01/22/2015 (20 participants)
- Dakota County sessions 01/29/15 – 02/16/15 (96 participants)
- City of Rochester on 02/04/15 (12 participants)
- Sherburne County volunteer training on 02/23/2015 (39 participants)
- EAB volunteer survey - held at Lebanon Hills Regional Park in Dakota County on 03/03/15 and Stewartville in Olmsted County on 03/05/15.
- Dakota County EAB meeting on 03/05/2015 (60 participants)
- EAB workshops (open to public) 04/13/15 – 04/17/15 (160 participants)
- Dakota County Master Naturalist on 04/27/2015 (16 participants)
- Anoka County EAB meeting on 04/30/2015 (30 participants)
- Anoka County training/scouting on 05/06/2015 (30 participants)
- Chanhassen EAB open house on 05/07/15 (6 participants)

Events

- MDA forest pest outreach (includes EAB biocontrol) had a booth at the following events. Farm Bill (federal) grant funds were used for these events.
  DaVinci Fest on 01/10/2015 (310 visitors), Northern Green Expo 01/14/15 – 01/16/16 (402 visitors), Explore Minnesota Tourism 02/03/15 – 02/04/15 (169 visitors), RV, Vacation & Camping Show 02/12/15 – 02/14/15 (1,335 visitors), Wabasha County Forestry Day on 02/13/15 (53 visitors), Home & Garden Show 02/25/15 – 03/01/15 (2,155 visitors), Shade Tree Short Course 03/17/15 – 03/19/15 (410 visitors), Lakeville Watershed Clean Up Day on 04/25/15 (300 visitors), Cinco De Mayo on 05/02/15 (600 visitors), Gathering Partners Natural Resources Conference 05/15/15 – 05/17/15 (260 visitors), Garlough Elementary Environmental Fair on 05/15/15 (185 visitors) and Mille Lacs County SWCD Conservation Day on 05/20/15 (300 visitors).

Media

Minnesota Public Radio interviewed Jennifer Schultz and ran a story on the Wasp Watchers program on 05/26/15.

Other

- Our project webpage at www.mda.state.mn.us/plants/pestmanagement/eab/eabbiocontrol.aspx was redesigned and updated.
- Biosurveillance will be featured in the 2016 Minnesota Invasive Species Advisory Council calendar. The calendar text and images were submitted.
- EAB forum meetings were held at MDA which included city, county, state and federal participants from around the state of Minnesota on 12/04/14, 02/12/15 and 04/09/15. Biocontrol updates were presented at each meeting.
- Gave updates on EAB biocontrol at the County Agricultural Inspector Board meeting on 12/10/15 and at the annual Camp Ripley and Arden Hills Army Training Site natural resources meeting on 03/26/15.

Status as of November 30, 2015:

Wasp watcher outreach presentations

Master Naturalist Conference on 05/16/15 (14 participants), Winona County Master Gardeners on 05/19/15 (20 participants), Arbor Day Event in St. Paul on 05/19/15 (25 participants), Dakota County Master Gardeners on 06/01/15 (90 participants), Goodhue County Master Gardeners on 06/02/15 (22 participants), Minnesota Zoo staff on 06/16/15 (15 participants), Cascade Meadows Environmental Learning Center in Rochester on 07/28/15 (15 participants), State Fair EcoExperience Sustainability Stage on 08/31/15 (30 participants) and Houston County Master Gardeners on 11/10/15 (15 participants). The total number of participants is 246.

EAB biocontrol presentation

- A coordinated multi-state approach to EAB biocontrol was presented to the Upper Mississippi River Basin Association on 11/17/15.

Events

- University of Minnesota Extension hosted an invasive species tour on 8/12/2015 for extension staff and made several stops at sites around the Twin Cities covering different invasive species and educational efforts. EAB biocontrol and biosurveillance were presented at one of the tour stops.

Media

- An article on biosurveillance were published on 07/14/15in the Rochester Post Bulletin
- A media event was held at Northdale Park in Oakdale, MN highlighting biosurveillance activities on 07/20/2015. Four local news stations covered the event with interviews of Jennifer Schultz and Jonathan Osthus airing on the six and ten o'clock news. Articles on biosurveillance were published in the Start Tribune (07/20/15) and Winona Daily News (07/30/15).
- An update on EAB biocontrol activities was sent out as part of the MDA's Plant Pest Insider October issue. The monthly publication goes out to state cooperators and stakeholders highlighting pest management updates around the state.
- A press release on EAB biocontrol efforts in the state was done on 11/17/2015 highlighting increased parasitoid recoveries in southeast Minnesota. It was picked up by numerous media sources around the state as well as news agencies in LaCrosse, WI, Sioux Falls, SD and Mason City, IA.

Status as of May 31, 2016:

Wasp watcher outreach presentations

Fillmore County Master Gardeners on 01/11/16 (6 participants), Blue Earth County/Minnesota Valley Master Gardeners on 01/18/16 (20 participants), Carlton County Master Gardeners and general public on 01/21/16 (19 participants), Pine County Master Gardeners on 02/09/16 (20 participants), Bloomington Home Improvement Fair on 02/20/16 (spoke with 25 people), Park maintenance staff in St. Louis Park on 03/30/16 (15 participants), Kanabec County Master Gardeners and general community on 03/31/16 (30 participants), Pine County Horticulture Day on 04/02/16 (35 participants), city of Chanhassen community members on 04/07/16 (40 participants), Houston County Horticulture Education Event on 04/09/16 (100 participants), Douglas County Master Gardeners on 04/22/16 (20 participants), Anoka County 4H (35 participants), Washington County Master Gardeners on 04/28/16 (80 participants), Edina Parks Maintenance Staff on 05/02/16 (20 participants), Otter Tail County Master Gardeners (webinar) on 05/03/16 (20 participants)

EAB biocontrol presentations

- Chandler, M. Regional Management of Riparian Ecosystems to Minimize Invasive Threats. Presented to the Upper Mississippi River Basin Association on 11/17/15 and addressed EAB, Japanese hops, Japanese knotweed and Oriental bittersweet.
- Osthus, J. How to report EAB using the Great Lakes Early Detection Application. Presented to the Minneapolis Parks and Recreation Forestry Department on 3/30/16.

Events

- Exhibitor: RV Show (2/11 – 2/14/16) and the Home and Garden Show (2/26 – 2/28/16 and 3/4 – 3/6/16) at the Minneapolis Convention Center.
- EAB workshops organized by Jennifer Burrington with the MDA were held in Apple Valley, Duluth and Winona in February and March of 2016. EAB management options including biocontrol were discussed in detail.
- Exhibitor: St. Louis Park Organic Living Workshop on 04/16/16 (spoke with 20 people)
- U of M Extension and MDA organized and held a volunteer survey for EAB in the Stillwater area on 4/18/2016. Trained volunteers looked for EAB infested trees in the area surrounding the rest stop location where EAB was found in 2015 along I-94 near the Minnesota/Wisconsin border. 10 volunteers covered over 100 miles of roadway during the one day survey.
- Exhibitor: U of M Ag Awareness Day in the Northrup Plaza on 4/19/2016. MDA's table contained information on invasive insect pests threatening Minnesota's forests and agriculture.
- Exhibitor: Bloomington Arbor Day Tree Sale on 05/07/16 (spoke with 10 people)
- Gathering Partners in Natural Resources Conference Field tour on 5/21/2016 in Winona, MN. EAB and EAB biocontrol activities were presented to the group of master woodland owners.

Media

- Kanabec County Times: Wasp Watchers monitor ash borer spread, April 10, 2016
- Pine City Pioneer: Naturalists prepare for invading Emerald Ash Borer, April 22, 2016
- Alexandria Echo Press: Slowing the spread of emerald ash borer, April 27, 2016
- Longfellow Messenger interviewed Jonathan Osthus about EAB biocontrol activities along the Mississippi River in Minneapolis on 5/4/2016. www.longfellownokomismessenger.com/good-bugs-face-off-bad-bugs-in-minneapolis-to-slow-eab-advance/
- WIZ Radio in LaCrosse, WI interviewed Jonathan Osthus about EAB biocontrol activities in southeast Minnesota on 5/25/16.

Other

- MDA's EAB biocontrol website was reformatted to provide a better user experience. Updates include more pictures of project activities, a drop-down tool bar for easier navigation and a summary table of statewide EAB biocontrol activities to date. A presentation Biological Control of Emerald Ash Borer: Bark sifting for Oobuis agrili was added to our website.
- Interactive maps have been created for both EAB biocontrol and Track EAB infestation core activities. The maps provide an easy way to communicate project results to all cooperators. EAB biocontrol map and Track EAB infestation core map.

Status as of November 30, 2016:

Presentations

- Anoka County Master Gardeners on 07/28/16 (60 participants)
- Schultz, J. 2016. Minnesota Wasp Watchers: An update on EAB Biosurveillance. Upper Midwest Invasive Species Conference, October 18, 2016 (40 participants).
- Minnesota Naturalist Association Conference in Finland, MN, November 13, 2016 (25 participants).
- Osthus, J., M. Chandler, A. Ambourn, B. Aukema, R. Venette. Implementation of EAB Biological Control in Minnesota. Poster presented at the Upper Midwest Invasive Species Conference, La Crosse, WI, October 16-19, 2016.

Events

- Five field trainings in July in Ham Lake, Oakdale, Wyoming and St. Paul (45 participants total)

Media

- Presentation recording about biosurveillance at QCTV cable station in Champlin, August 9, 2016
- Jon Osthus was interviewed by reporter Kevin Doran with KSTP News (Channels 5 & 45) on EAB biocontrol activities in Minnesota on 6/13/2016. The segment aired on 6/21/16 and can be viewed at http://kstp.com/news/parasitic-stingless-wasps-released-in-fight-against-emerald-ash-borer/4175999/?cat=12196

Final Report Summary:

Wasp watcher outreach presentations

There were 4 Wasp Watchers presentations (60-90 minutes) given during this period:

- Wargo Nature Center Staff on December 14, 2016 (10 participants)
- National Wildlife Refuge Citizen Science Day (Bloomington) on March 4, 2017 (10 participants)
- Minnesota Master Naturalist Class at Fort Snelling State Park on March 29, 2017 (21 participants)
- Volunteer Appreciation Event on March 7, 2017 (11 participants)

EAB Biocontrol Presentations

- Osthus, J. 3/15/17. Minnesota Shade Tree Short Course mini session.
- Ambourn, A. 4/6/17. Metro Mosquito Control District Conference.
- Osthus, J. 5/1817, 5/19/17 & 5/23/17. EAB Regional Meetings.
- Burrington, J. 1/12/17, 2/9/17, 4/6/17, 4/17/17, 4/21/17, 4/26/17, 5/3/17 & 5/11/17. EAB Municipal Staff trainings.

Events

- Wabasha County Forestry Day on February 10, 2017 (60 attendees)
- EAB detection and management workshops held in Twin Cities (2/27/17 - 3/3/17), Rochester (2/20/17 – 2/24/17) & Duluth/Superior, WI (3/7/17 – 3/9/17).
- Wright County Spring Days on March 4, 2017 (100 attendees)
- Rice County Horticulture Day on March 11, 2017 (75 attendees)
- U of MN CFANS Alumni Event: Classes Without Quizzes on April 1, 2017 (75 attendees)

Other

- A one page fact sheet on EAB biocontrol in Minnesota was created for dissemination at events and as a downloadable PDF for MDA's EAB biocontrol website.

VI. PROJECT BUDGET SUMMARY:

A. ENRTF Budget Overview:

Budget Category	$ Amount	Explanation
Personnel:	$ 360,900	**MDA** One 3 yr FTE Research Scientist 1 salary $44,500/yr & 48% fringe for Activity 3 **MDA** One 3 yr PTE-FTE undergrad student wages $13.70/hr & 7.65% fringe for Activity 3 **U of M** One 3 yr PTE-FTE Community Program Specialist wages $18/hr & 39.6% fringe for Activity 1 (40 weks @ 15-20 hrs/wk & 12 wks @ 40 hrs/wk) **U of M** One 3 yr PTE Insect Taxonomist wages $25/hr & 7.65% fringe for Activity 1

		U of M One 3 yr PTE technician salary $33,000/yr & 39.6% finge for Activity 2 **U of M** One 0.5 mo faculty summer salary $10,600/mo & 20% fringe for Activity 2
Professional/Technical/Service Contracts:	$ 45,000	**MDA** One 3 year contract with Minneapolis and St. Paul for branch sampling for Activity 2
Equipment/Tools/Supplies:	$ 5,900	**MDA** Supplies include draw knives, gloves, etc. **U of M** Supplies include nets, vials, insect collection supplies, etc. for Activity 1
Printing:	$ 4,500	**U of M** Printing manuals, id guides, signage and promotional patches for Activity 1
Travel Expenses in MN:	$ 29,400	**MDA** Milage for Activities 2 & 3 at 56.5 cents/mile **MDA** Meals and lodging for Activity 4 (approx. 20 days of travel/yr for 3 yr for the student worker and EAB biocontrol coordinator and 10 days of travel/yr for 3 yr for the PI and EAB Project Manager) **U of M** Milage at 56.5 cents/miles for Activity 1 **U of M** Meals and lodging for Activity 1 (approx. 10 days of travel/yr for program specialist and PIs)
Other:	$ 1,300	**MDA** Shipping bioagent transport coolers for Activity 3 **U of M** Shipping beetle samples overnight for Activity 1
TOTAL ENRTF BUDGET:	**$ 447,000**	

Explanation of Use of Classified Staff: Jonathan Osthus is the Research Scientist 1 on the project (Activity 3). His position is unclassified from 07/01/14 – 10/08/14. His position will be classified from 10/08/14 - 06/30/17. The working title is EAB Biocontrol Coordinator. This is a new, classified position at MDA.

Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation:
One 3 yr full-time Research Scientist 1 = 2080*3 = 6,240 hrs
One 14 mo part-time Research Scientist 1 = 1,885 hrs
One 3 yr part-time undergrad student = 1000*3 = 3,000 hrs
One 3 yr part-time Community Program Specialist = 1040 * 3 = 3,120 hrs
One 3 yr part-time Insect Taxonomist = 80*3 = 240 hrs
One 3 yr part-time technician = 416*3 = 1,248 hrs
One 0.5 mo faculty(summer) = 80*3 = 240 hrs
Total hours = 15,973
Total FTEs = 14,088/2080 = 7.68

Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:
MDA will contract with Minneapolis and St. Paul for branch sampling. Sampling and related work is estimated to require 500 hours over 3 years = 1,500 hours. Total FTE's = 1,500 hours/2080 per year = 0.72

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
	$	$	
State (in-kind)			
MDA: Field equipment, computing/software, GIS and data management and project management ($40,000); U of M: Waived indirect costs ($17,628 at U of M), project coordination and computing ($10,000 at Extension); Minneapolis Parks & Rec and St. Paul Parks & Rec: Difference between actual branch sampling cost of $60,000 and contract total of $45,000 is $15,000; Volunteer participation estimated at $15,000	$ 97,630	$ 97,630	
TOTAL OTHER FUNDS:	**$ 97,630**	**$ 97,630**	

VII. PROJECT STRATEGY:

A. Project Partners:

Receiving funds: Angela Gupta, Jeffrey Hahn and Dr. Karen Oberhauser with Extension will lead EAB biosurveillance. Drs. Robert Venette and Brian Aukema with the U of M will lead the data analysis from tracking the EAB infestation core. Monika Chandler with MDA will lead biological control implementation and data collection for tracking the EAB infestation core. Minneapolis Parks and Recreation Board Forestry Division and St. Paul Parks and Recreation Forestry Unit will receive funds for collecting branch samples for tracking the EAB infestation core. All organizations will provide in-kind equipment, facilities, and GIS/technical support.

Not receiving funds: For EAB biosurveillance, we will draw volunteers from the Forest Pest First Detector and the Minnesota Master Naturalist programs, which have over 1,000 active volunteers. For all activities, we will collaborate with USDA APHIS and Forest Service EAB biocontrol researchers, DNR, Mn/DOT, other federal and state agencies, counties, municipalities, and private landowners.

B. Project Impact and Long-term Strategy:

EAB biocontrol is in the second phase of implementation. Management recommendations from Phase 1 research on parasitoid cold tolerance and dispersal will be incorporated in our Phase 2 plans. Biological control agent releases were initiated in Phase 1 at 20 sites. We plan to continue monitoring these sites to document the landscape level impact of biological control on EAB at these sites. We anticipate that EAB populations will increase in density and spread in Phase 2. We plan to utilize biosurveillance to better understand EAB population spread and density to guide biological control releases. We will release bioagents on leading edges of EAB populations with the aim of establishing bioagent populations that move and spread with EAB. In addition, we will continue to track the EAB infestation core of the Twin Cities. This will inform us about EAB and bioagent movement and spread and their resulting impact on ash trees. The information gained from this project will enable us to hone EAB biological control and increase the feasibility of successful EAB management.

It will likely take decades to fully determine whether EAB can be sufficiently managed with biological control at a national level. We have an advantage in Minnesota that we initiated biological control while EAB populations were relatively small. New biological control candidate species currently in testing may become available for future releases. We have the difficult challenge of learning whether and how we can effectively manage EAB before we lose our ash resources. We expect to continue to learn and improve our tactics over the coming decade. The stakes are high. Minnesota has approximately 1 billion ash trees. Urban ash trees provide oxygen, reduce pollution and erosion, lower air conditioning costs and contribute to an aesthetically pleasing environment. Increased human mortality from cardiovascular and lower respiratory tract illness was documented after the large-scale loss of ash trees in EAB impacted US counties. Woodland ash trees provide oxygen, sequester carbon, filter water, reduce floods, support wildlife, provide timber and are important for recreation and human culture such as tribal black ash basket making. Loss of Minnesota's ash trees would be catastrophic. Our project aims to mitigate EAB damage with biological control to prevent catastrophic loss. Unfortunately, we do not know at this time if biological control will be successful.

C. Spending History:

Funding Source	**M.L. 2008 or FY09**	**M.L. 2009 or FY10**	**M.L. 2010 or FY11**	**M.L. 2011 or FY12-13**	**M.L. 2013 or FY14**
Forest Service supplies and salary to initiate Phase 1			8,000		
U of M salary to initiate Phase 1			2,500		
MDA salary to initiate Phase 1			3,000		
LCCMR Emerald Ash Borer Biocontrol Research and Implementation project $500,000 from ENRTF				500,000	
USDA APHIS CPHST				70,160	
MDA in kind				15,000	
U of M waived indirect				162,550	
Minneapolis and St. Paul branch sampling				22,000	
LCCMR Improving Emerald Ash Borer Detection Efficacy for Control $600,000 from ENRTF					600,000

VIII. ACQUISITION/RESTORATION LIST: N/A

IX. VISUAL ELEMENT or MAP(S): See final page

X. ACQUISITION/RESTORATION REQUIREMENTS WORKSHEET: N/A
XI. RESEARCH ADDENDUM: N/A

XII. REPORTING REQUIREMENTS:
Periodic work plan status update reports will be submitted no later than 05/29/2015, 11/30/2015, 05/31/2016 and 11/30/2016. A final report and associated products will be submitted between June 30 and August 15, 2017.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2014 Work Plan

Biosurveillance and Biocontrol of the Emerald Ash Borer

Activities inform biological control implementation

Adult EAB beetle

Biosurveillance for EAB detection and monitoring

Track EAB infestation core

Biological Control for EAB Management

The smoky winged beetle bandit wasp captures EAB and similar beetles (pictured above). Citizen scientist volunteers net the wasps. The wasps drop the beetles then the wasps are let go and the beetles collected. These wasps have been used for successful EAB detection and monitoring in 17 states and 3 Canadian provinces.

Biological Control Agents = Parasitoid Wasps

The egg parasitoid, *Oobius agrili*, (A) attacks EAB eggs. The larval parasitoids, *Tetrastichus planipennisi* (B) and *Spathius agrili* (C) attack EAB larvae under ash bark.

Monitoring for EAB larvae and EAB parasitoids

Partners

University of Minnesota Extension

University of Minnesota

Minnesota Department of Agriculture

Forest Service U.S. Department of Agriculture

Saint Paul — The Most Livable City in America

Minneapolis Park & Recreation Board

Environment and Natural Resources Trust Fund
M.L. 2014 Project Budget

Project Title: Biosurveillance and Biocontrol of Emerald Ash Borer - Phase 2
Legal Citation: M.L. 2014, Chp. 226, Sec. 2, Subd. 04d
Project Manager: Monika Chandler
Organization: Minnesota Department of Agriculture
M.L. 2014 ENRTF Appropriation: $ 447,000 but $190 was not spent
Project Length and Completion Date: This is a 3 year project to be completed June 30, 2017
Date of Report: November 30, 2015

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Revised Activity 1 Budget 08/11/17	Amount Spent	Activity 1 Balance	Activity 2 Budget	Amount Spent	Activity 2 Balance	Activity 3 Budget	Revised Activity 3 Budget 08/01/17	Amount Spent	Activity 3 Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM													
Personnel (Wages and Benefits) MDA	$3,000	$3,000	$3,000	$0	$77,800	$77,800	$0	~~$164,560~~	$163,762	$163,762	$0	$244,562	$0
Research Scientist 1: $150,000 (77% salary, 33% fringe); 100% FTE for 3 years													
Research Scientist 1: $50,860 (77% salary, 33% fringe); approximately 80% PTE for 14 months													
Student worker: $44,500 (92.35% salary, 7.65% fringe); 48% FTE for 3 years													
Equipment/Tools/Supplies													
Supplies include draw knives, gloves, etc.					$1,500	$1,500	$0	~~$500~~	$553	$553	$0	$2,053	$0
Travel expenses in Minnesota													
Milage, lodging, and meals for travel to EAB infestation and biological control sites	$800	$800	$800	$0	$2,240	$2,240	$0	~~$14,000~~	$14,895	$14,895	$0	$17,935	$0
Other - Shipping													
Shipping bioagent transport coolers								~~$500~~	$349	$349	$0	$349	$0
Professional/Technical/Service Contracts													
Contract with Minneapolis and St. Paul Total is $45,000													
Branch sampling for 3 years					$45,000	$45,000	$0					$45,000	$0
Contract with U of M Total is $137,100													
Personnel (Wages and Benefits) U of M	~~$78,600~~	$85,212	$85,022	$190	$33,900	$33,900	$0					$119,112	$190
Community Program Specialist: $78,600 (60.4% salary, 39.6% fringe), 50% FTE for 3 years													
Technician: $27,540 (60.4% salary, 39.6% fringe); 20% FTE for 3 years													
Faculty summer salary: $6,360 (80% salary, 20% fringe); 11.5% FTE for 1 year													
Two part-time summer student workers on project in 2016													
U of M Subcontract													

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Revised Activity 1 Budget 08/11/17	Amount Spent	Activity 1 Balance	Activity 2 Budget	Amount Spent	Activity 2 Balance	Activity 3 Budget	Revised Activity 3 Budget 08/01/17	Amount Spent	Activity 3 Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM													
Insect Taxonomist: $6,500 (92.35% salary, 7.65% fringe); 4% FTE for 3 years	$6,500	$6,459	$6,459	$0								$6,459	$0
Equipment/Tools/Supplies U of M													
Supplies include nets, vials, insect collection and rearing supplies	$2,900	$1,889	$1,889	$0								$1,889	$0
Printing U of M													
Printing manuals, id guides, signage and promotional patches	$4,500	$4,065	$4,065	$0								$4,065	$0
Travel expenses in Minnesota U of M													
Milage, lodging and meals for travel to volunteer training sessions and Cerceris monitoring sites	$9,700	$5,575	$5,575	$0								$5,575	$0
Other - Shipping U of M													
Shipping beetle samples overnight	$1,000	$0	$0	$0								$0	$0
COLUMN TOTAL	**$107,000**	**$107,000**	**$106,810**	**$190**	**$160,440**	**$160,440**	**$0**	**$179,560**	**$179,560**	**$179,560**	**$0**	**$447,000**	**$190**