

**M.L. 2017, Chp. 96, Sec. 2, Subd. 06b** as extended by M.L. 2020, First Special Session, Chp. 4, Sec. 2  
**Project Abstract** for the Period Ending June 30, 2021

**PROJECT TITLE:** Emerald Ash Borer Biocontrol – Phase III

**PROJECT MANAGER:** Jonathan Osthus

**AFFILIATION:** Minnesota Department of Agriculture

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**WEBSITE:** <http://www.mda.state.mn.us/plants/pestmanagement/eab/eabbiocontrol.aspx>

**FUNDING SOURCE:** Environment and Natural Resources Trust Fund

**LEGAL CITATION:** **M.L. 2017, Chp. 96, Sec. 2, Subd. 06b** as extended by M.L. 2020, First Special Session, Chp. 4, Sec. 2

**APPROPRIATION AMOUNT:** \$729,000

**AMOUNT SPENT:** \$729,000

**AMOUNT REMAINING:** \$0

#### **Sound bite of Project Outcomes and Results**

Biological control has been effectively implemented, which has led to increasing recoveries of parasitoids over time. Cold tolerance testing of *Spathius galinae* resulted in a forecasting model of survival in North America. The Buprestidae of Minnesota guide was created and provides baseline data on jewel beetles present in Minnesota.

#### **Overall Project Outcome and Results**

We have successfully completed all activities. We are pleased to report that the effective implementation of EAB biocontrol has led to increasing recoveries of the larval parasitoid *Tetrastichus planipennis* and the egg parasitoid *Oobius agrili* through time based on data analysis in Activity 2. We produced several peer-reviewed scientific publications (with full credit to LCCMR) on Activities 3 and 4. For Activity 3, we evaluated the cold hardiness of the larval parasitoid *Spathius galinae* and published a study forecasting its survival in North America (Wittman, Aukema, Duan, and Venette (2021) Forecasting overwintering mortality of *Spathius galinae* in North America. *Biological Control*. 160: 104694). The insect will survive best in areas where winter temperatures remain above -20 Fahrenheit. For Activity 4, we published two journal articles detailing a checklist of buprestids found in Minnesota (Hallinen, Steffens, Schultz, Aukema (2021) The Buprestidae (Coleoptera) of Minnesota, with a discussion of the emerald ash borer, *Agrilus planipennis* Fairmaire. *The Coleopterists Bulletin* 75: 173-190) as well as a study on their habitat features (Hallinen, Wittman, Aukema (2020) Factors associated with diversity and distribution of buprestid prey captured by foraging *Cerceris fumipennis* (Hymenoptera: Crabronidae) (*Environmental Entomology* 49: 1363-13763). These works provide critical information on what is here, now, so we have a basis of comparison for when a new invasive wood-boring beetle in the same family as emerald ash borer arrives in the future. We then published, from the scientific checklist, a free and accessible guide (The Buprestidae of Minnesota) that can be downloaded from permalink <https://hdl.handle.net/11299/218928>. This latter guide contains not only specimen photos but also maps of the distribution record and dates of last collection by decade. All four publications are submitted with this final report.

#### **Project Results Use and Dissemination**

Throughout the duration of the project, results were disseminated through a variety of venues. A wide and diverse audience was reached through interviews with local press, informational webinars, outdoor training sessions held throughout the state, and at academic and natural resource professional conferences and meetings. Parasitoid release and recovery results from activity 1 and 2 can be viewed through an interactive online map at <https://www.mda.state.mn.us/plants/pestmanagement/eab/eabbiocontrol>. Through the work on

activity 3 of this project, models have been created and published forecasting the expected overwintering mortality of the introduced larval parasitoid *Spathius galinae*. This information is of vital importance to the successful implementation of EAB biological control throughout North America (Wittman, Aukema, Duan, and Venette (2021) Forecasting overwintering mortality of *Spathius galinae* in North America. *Biological Control*. 160: 104694). Activity 4 of this project produced tremendously valuable baseline data on the buprestids found in Minnesota. Two journal articles were published detailing a checklist of buprestids found in Minnesota (Hallinen, Steffens, Schultz, Aukema (2021) The Buprestidae (Coleoptera) of Minnesota, with a discussion of the emerald ash borer, *Agrilus planipennis* Fairmaire. *The Coleopterists Bulletin* 75: 173-190) as well as a study on their habitat features (Hallinen, Wittman, Aukema (2020) Factors associated with diversity and distribution of buprestid prey captured by foraging *Cerceris fumipennis* (Hymenoptera: Crabronidae) (*Environmental Entomology* 49: 1363-13763). A free and accessible guide was created from these publications called The Buprestidae of Minnesota and can be downloaded from the permalink <https://hdl.handle.net/11299/218928>.



# Environment and Natural Resources Trust Fund (ENRTF) M.L. 2017 LCCMR Work Plan Final Report

**Date of Submission:** August 11, 2021

**Date of Next Status Update Report:** Final Report

**Date of Work Plan Approval:** 06/07/2017

**Project Completion Date:** June 30, 2021

**PROJECT TITLE:** Emerald Ash Borer Biocontrol – Phase III

**Project Manager:** Jonathan Osthus

**Organization:** Minnesota Department of Agriculture

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**City/State/Zip Code:** St. Paul, MN 55155

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**Web Address:** <http://www.mda.state.mn.us/plants/pestmanagement/eab/eabbiocontrol.aspx>

**Location:** Statewide

**Total ENRTF Project Budget:**

**ENRTF Appropriation:** \$729,000

**Amount Spent:** \$729,000

**Balance:** \$0

**Legal Citation:** M.L. 2017, Chp. 96, Sec. 2, Subd. 06b as extended by M.L. 2020, First Special Session, Chp. 4, Sec. 2

**Appropriation Language:**

\$729,000 the first year is from the trust fund to the commissioner of agriculture in cooperation with the Board of Regents of the University of Minnesota to implement biocontrol of emerald ash borer using a newly approved parasitic wasp, assess the impact of the statewide program, and engage citizen volunteers. This appropriation is available until June 30, 2020, by which time the project must be completed and final products delivered.

M.L. 2020 - Sec. 2. ENVIRONMENT AND NATURAL RESOURCES TRUST FUND; EXTENSIONS. [to June 30, 2021]

## I. PROJECT TITLE: EAB Biocontrol Phase 3: Assessment & Citizen Engagement

### II. PROJECT STATEMENT:

Emerald ash borer (EAB) continues to be one of the most destructive non-native pests in North America with over 1 billion ash trees at risk in Minnesota. Although Minnesota has had some success with slower than national average spread of EAB, the number of counties infested more than doubled from 2015-2016. Several effective methods to combat EAB exist, but biological control remains the most promising long-term management strategy at the landscape level. Along with biocontrol, citizen volunteers can detect new EAB infestations and gather data about other wood-boring beetles in Minnesota by conducting EAB biosurveillance using the native smoky winged beetle bandit wasp. Our project focuses on expanded implementation and assessment of the statewide impact biological control is having on EAB populations.

#### Accomplishments from Phases 1 & 2 (2011-2014) & (2014-2017)

- Total release of 359,548 wasps! at 30 EAB infested sites.
- 37 distinct wasp recoveries from parasitized EAB larvae and eggs have been recorded across the state.
- Determined cold tolerance for EAB and parasitic wasps.
- Determined flight capacity of parasitic wasp, *Tetrastichus planipennis*.
- 50 citizen volunteers checked and monitored 84 sites. The smoky winged beetle bandit wasp was confirmed at 31 sites in 11 counties.

**The Next Step:** As EAB spreads to more northern and forested areas of the state, biocontrol will be the most practical management option available. The newly approved parasitic wasp, *Spathius galinae*, is from the Russian Far East and may be better suited to northern climates. (Unfortunately, one of the early approved species, *Spathius agrili*, has been found to be incapable of establishing in Minnesota). This new species offers Minnesota yet another tool for natural reduction of EAB populations.

#### Objectives for Phase 3:

**Expand EAB biocontrol:** The biocontrol effort will be expanded to address new EAB finds, release EAB biological control agents and continue existing site monitoring.

**Assess EAB biocontrol establishment and impact:** Measure numbers of stingless wasp recoveries. Annual data will allow us to examine how densities of biological control agents are changing through time (i.e., impacting population growth and mortality rates of EAB).

**Determine cold tolerance – *Spathius galinae* (\*new parasitic wasp):** Measure the cold hardiness of this new stingless wasp with techniques that our team successfully applied to two other biological control agents for EAB. This information refined MDA's strategy to implement biocontrol for EAB.

**Citizen engagement and Biosurveillance of EAB:** Engage and educate the public about EAB and involve citizens in the detection and data collection process. 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. That borer was recently detected with biosurveillance in Ontario, Canada.

Our project will build on other LCCMR projects: Emerald Ash Borer Biocontrol Research and Implementation (2011-2014), Biosurveillance and Biocontrol of Emerald Ash Borer – Phase 2 (2014-2017).

### III. OVERALL PROJECT STATUS UPDATES:

**September 13, 2017:** The Research Scientist 1 for MDA, Chris Mallet, reached the time limit for working in his current temporary position with the State of Minnesota. As a temporary unclassified Research Scientist 1, Chris has worked on LCCMR projects for emerald ash borer detection and biological control for the last three years. However, in order to retain Chris in his current position the MDA was required to transition him to permanent classified status. No amendment request was deemed necessary per phone correspondence with LCCMR staff and no budgetary changes were required for the transition from unclassified to classified status.

**Amendment Request November 20, 2017:**

The Student Worker Para-Professional Senior position for Activities 1 & 2 has been difficult to fill dating back to the last year of Phase 2 of this project due to a lack of interest by qualified candidates applying for the position. We request the ability to fill the position instead with MDA's current permanent intermittent staff in the Plant Industry Inspector 1 classification that have valuable experience in EAB detection and sampling. Work would be split between two Plant Industry Inspectors as necessary based on their location and who would otherwise not be working without this project. No budgetary changes are necessary as the work would be performed within the current budget parameters.

**Amendment Request November 27, 2017:**

We would like to move \$44K of the \$100K allocated graduate student salary under Activity 2 (biological control agent establishment and impact) to Activity 4 (biosurveillance) for two reasons. First, populations of EAB have been rising slower in Minnesota than other states (measured in % of counties infested through time). As such, we are concerned that there is insufficient data at this time for a graduate student to begin developing parasitoid recovery curves. Second, we recruited a graduate student, Ms. Marie Hallinen, who received a prestigious first year University of Minnesota Department of Entomology MGK fellowship (i.e., no cost to the project). She has been helping with Activity 4, which has more than doubled state captures of wood-boring beetles to date using biosurveillance techniques. Given how little we know about potential threats to Minnesota's resources from woodboring beetles related to EAB, and Marie's previous entomological expertise with emerald ash borer gained in Michigan, we enthusiastically support her involvement. The salary reallocation of \$44K would fund the second year of her studies on Activity 4 rather than Activity 2, for which we will recruit a different student at the appropriate time.

Amendments Approved by LCCMR 12/11/2017

**Project Status as of November 30, 2017:**

This project transitioned from Phase 2 that was completed 6/30/17 to Phase 3 starting 7/1/17. A contract with the U of M for Activities 2, 3 and 4 was executed. Biological control agent releases continued with 68,496 parasitoid wasps released at 8 sites. Ash health data was collected from 24 sites and monitoring for establishment of biological control agents at two sites through the use of yellow pan traps all occurred throughout the summer for Activity 1. Biosurveillance activities engaged 58 volunteers who contributed 460 hours and searched almost 200 potential new sites for Activity 4. Smoky winged beetle bandit wasps were found at 30 new sites, and volunteers collected a total of 288 wood boring beetles brought back to the nests by the smoky winged beetle bandit wasps. Captures were up more than 50% from 2016.

We plan to update our webpage [www.mda.state.mn.us/plants/pestmanagement/eab/eabbiocontrol.aspx](http://www.mda.state.mn.us/plants/pestmanagement/eab/eabbiocontrol.aspx) with a summary of Phase 2 and activities in progress for Phase 3.

**May 16, 2018:**

After reviewing budget projections and speaking with Michael McDonough over the phone, we decided to hire an additional Plant Health Specialist 1 (PHS1) as a temporary intermittent employee to increase our work on parasitoid recovery efforts over the next two summers. The extra \$24,000 in salary is available due to savings on fringe benefits (single vs. dependent care) for Chris Mallet, the Research Scientist 1 for this project. Through verbal contact with LCCMR, an amendment was determined to not be necessary. Marissa Bendickson, hired as the temporary intermittent PHS1, began work on May 16, 2018. No budgetary changes were necessary.

**Project Status as of May 31, 2018:**

EAB biocontrol release site monitoring and parasitoid recovery efforts are off to a strong start with the first round of sampling complete for Activities 1 & 2. A total of thirteen sites were sampled. Eleven were looked at for general parasitoid establishment by using yellow pan trapping and bark sampling methods for Activity 1. The other two sites were selected for intensive sampling efforts in order to begin determining levels of parasitism

and their impact on EAB populations for Activity 2. Whole tree debarking and bark sampling methods were used at these sites. In addition, yellow pan traps will be placed at both intensive sampling sites during the summers of 2018 and 2019. The egg parasitoid, *Oobius agrili*, was confirmed at four sites with no previous parasitoid recoveries. These finds continue to highlight that parasitoid populations are successfully establishing in central and southeast Minnesota.

Progress has been made on Activity 3 for cold hardiness testing for the EAB parasitoid *Spathius galinae*. Arrangements have been made with a federal researcher that maintains a colony of the insect to supply the necessary specimens. Lab work is set to begin this fall with an in-coming PhD student in the Department of Entomology. Much of the winter was spent identifying the 288 Buprestid beetles that were captured during the summer 2017 field season for Activity 4. A total of 39 different species were identified including EAB. Of special note, Marie Hallinen, the graduate student amended to Activity 4 was able to present some of her initial biosurveillance research at the national scientific meeting of the Entomological Society of America in December of 2017. Marie won a President's Prize (first place) in the Invasive Species division, highlighting the quality of this work and LCCMR's investment in biological control and biosurveillance.

**Amendment Request (11/30/2018):**

We would like to move \$2k of the \$74k salary dollars allocated to the Plant Industry Inspector 1 position for Activities 1 & 2 to the Equipment/Supplies budget for Activity 2. The reason for this is due the increased work on parasitoid recovery efforts. Yellow pan trapping for parasitoid recovery doubled in its effort, therefore doubling the amount of money necessary for supplies.

Amendment Approved by LCCMR **12/10/2018**

**Project Status as of November 30, 2018:**

The EAB biocontrol summer field season had another successful year of parasitoid releases at seven sites located in SE, Central and NE Minnesota for Activity 1. A total of 44,546 parasitoids were released from June to September. This brings the total number of parasitoids released in the state to a whopping 561,633 since the first releases in SE Minnesota in September 2010. Monitoring for establishment of parasitoids with use of yellow pan traps at former releases sites was completed once again at two sites and was also used at our two intensive sampling sites for Activity 2. A total of 1,489 samples were collected throughout the summer and then screened in October and November. All suspect parasitoid specimens have been sent to the USDA for official identification.

Progress continues to be made in the assessing of biological control establishment and impact for Activity 2. For the first time in Minnesota, we are seeing \*non-zero\* rates of parasitism and recovery. While this is great news, percent parasitism has still only reached a fraction of a percent highlighting the long-term nature of implementation and evaluation. Plans for winter parasitoid sampling have been set and will begin in earnest in January 2019. Cold hardiness testing of the larval parasitoid *Spathius galinae* for Activity 3 has begun after receiving the first shipment from Dr. Duan's lab. A combination of lab assays and field mortality experiments have been outlined and work is now moving forward.

Biosurveillance and citizen engagement for Activity 4 had a very successfully field season with volunteer participation at an all-time high. A total of 71 volunteers participated with 585 hours of volunteer time contributed. The increased participation led to 659 buprestid beetles being collected compared to 288 in 2017. Of the 659 beetles collected, 36 were emerald ash borer. Volunteers also searched 196 new sites in 88 different communities throughout the state. Work has now begun on identifying the beetles collected during the summer.

**Amendment Request (May 30, 2019):**

Graduate student salary is currently allocated across Activities 2, 3, and 4 as \$56K, \$100K, and \$44K (= \$200K). We would like to reallocate these amounts as \$22K, \$60K, and \$36K (= \$118K). These revised amounts best reflect timing of graduate student recruitments/graduations projected through the end of the project. We would like to reallocate the \$82K in graduate student funds to technician support where extra help has been needed accordingly (e.g., handling shipments of parasitoids for chilling assays, identification of higher-than-expected volume of Wasp Watcher material due to program's success). We would also like to move \$2000 travel from Activity 2 (projected savings generated through use of laboratory truck when available rather than UMN rentals) to printing for Activity 4 as we would like to publish the list of woodboring beetles present in the state of Minnesota – important baseline data before the arrival of any new exotic pests.

Amendment Approved by LCCMR **6/19/2019**

**Project Status as of May 31, 2019:**

Monitoring for parasitoid establishment and impact for Activities 1 and 2 kicked into high gear over the winter and spring months. The recovery work took place at 9 separate sites as part of this effort. The egg parasitoid *Oobius agrili* has likely been recovered at 2 new locations (pending official confirmation) and the number of recoveries of the larval parasitoid *Tetrastichus planipennis* at Ft. Snelling State Park more than tripled from the previous year. Heading into the summer field season, the number of sites receiving yellow pan traps to monitor parasitoid establishment has doubled from 4 to 8 and a total of 3 new sites have been added to the list to receive parasitoid releases in 2019.

At UMN, work over the past six months has primarily focused on Activities 3 (cold tolerance) and 4 (biosurveillance). We have continued cold hardiness testing of the larval parasitoid *Spathius galinae* for Activity 3 after a brief delay due to the federal government shutdown, which interfered with our ability to receive insects from collaborator Dr. Jian Duan. We continue to focus on how chilling rates affect cold hardiness. For Activity 4, identification work continues last year's captures in the citizen science Wasp Watchers biosurveillance program after the program more than doubled the number of specimens from 2017 to 2018. Some specimens appear quite unique, which has presented some challenges as the buprestid wood-boring beetle family (of which EAB is a member) is well-known in the entomological community as having specimens that can be very difficult taxonomy. The Wasp Watcher coordinator produced a 2018 newsletter for all volunteers and has organized trainings for this coming summer.

**Amendment Request (Nov 27, 2019):**

(MDA) Increased parasitoid recovery work was initiated beginning 2018 due to extra salary dollars available in Activities 1 & 2. Due to the increased parasitoid recovery work and increases in costs for travel, MDA has overspent on travel costs by \$4,000 and supplies by \$700 for Activity 1. MDA would like to reallocate \$4,700 from remaining salary \$ to cover the additional travel and supply expenses.

(UofM) In our best attempt to project expenses to the end of the project at UMN, we anticipate savings of approximately \$5,200 from supplies, \$3,500 from travel, \$525 from shipping, and \$5,160 from printing (total \$20,500) across Activities 2,3,4 to June 30, 2020. Savings in supplies have arisen as repeat volunteers have not required new collecting gear for citizen science activities, or through the ability to allocate supplies from other projects in the forest entomology lab to this LCCMR project. Travel savings have accrued by continued use of the laboratory truck when available rather than UMN rentals. Printing has been overestimated due to digital dissemination of material such as newsletters whenever possible as well as re-use of manuals by repeat volunteers. We would like to reallocate the projected \$20,500 in savings to technician support as we finish project curation now that the graduate student in Activity 4 has graduated and joined the Peace Corps (e.g., handling shipments of parasitoids for chilling assays, identification of higher-than-expected volume of Wasp Watcher material due to program's success, final preparation of the list of woodboring beetles present in the state of Minnesota for publication).

Amendment Approved by LCCMR **2/13/20**

**Project Status as of November 30, 2019:**

MDA's parasitoid release numbers stayed consistent with the past few years allowing for weekly releases at sites from June through mid-September. Yellow pan trapping at older release sites to confirm establishment of parasitoids increased from 2 to 6 sites. The larval parasitoid *T. planipennisi* was recovered at 2 new sites (pending official confirmation), with one of those sites being the furthest north and a new county detection (St. Louis County). Overall parasitoid recovery using yellow pan traps was down at the intensive sampling sites for Activity 2. The final round of parasitoid recovery sampling for Activities 1 & 2 are now in the process of being completed as we work through the final months of the project.

At UMN, we chilled several hundred parasitoids in Activity 3 and determined that chilling rates do not affect survival. We are repeating some of these experiments due to low eclosion rates overall – we think conditions within a growth chamber may have been at fault. We are also preparing to field validate results this winter at Research and Outreach Centers associated with the University of Minnesota where snowfall is measured. The Wasp Watchers program had its most successful summer yet. Volunteer hours increased 30%, and 145 sites across 80 communities were searched. The number of specimens increased from 676 buprestids at 56 sites to 1,063 specimens at 65 sites! Graduate student Marie Hallinen helped with difficult identifications while completing her MS degree. Her work was presented at two scientific conferences this fall and two data chapters are being prepared for scientific publication. Work in the remaining six months is focusing on proper curation and databasing of specimens as the project concludes.

**Project extended to June 30, 2021 by LCCMR 6/18/20** as a result of M.L. 2020, First Special Session, Chp. 4, Sec. 2, legislative extension criteria being met.

**Project Status as of November 30, 2020:**

Parasitoid release and recovery work at the MDA were mostly completed for the project by the time COVID-19 restriction set in across the state. Intensive sampling efforts at Fort Snelling State Park and White Water WMA were able to be completed but recovered far fewer parasitoids than the two previous years of the project. This result wasn't totally unanticipated due to the extreme cold the previous winter (2018-2019). Biological control releases continued once again during the summer of 2020 with a noticeable decline in numbers of parasitoids received from the USDA Rearing Facility in Brighton, MI. The decline in available parasitoids was caused by the facility having to operate at half capacity due to COVID-19 staffing restrictions. However, over 16,000 parasitoids were still able to be released at seven sites across the state from June through September.

At UMN, we deployed parasitoids in infested sticks to three, secure overwintering sites in the state. The sticks with parasitoids were retrieved in the spring and brought back into the laboratory. The no-cost extension allowed us to wait until all parasitoids emerged from the sticks instead of needing to dissect them early to determine viability. We compared temperature profiles experienced by the sticks to the laboratory insect survival experiments at different temperatures and used these survival curves to construct maps to determine potential overwintering survival for *Spathius galinae* in Minnesota and neighboring states, based on climate. This work is now being prepared for scientific publication in conjunction with federal collaborators at USDA Animal Plant Health Inspection Service. Meanwhile, the two thesis chapters being prepared for scientific publication on jewel-beetle biodiversity in Minnesota as part of the Wasp Watchers program were both accepted for publication. We expect they will appear in December 2020 and March 2021 with current press schedules. The works detail our native buprestid biodiversity with associated notes on host plants, collection methods, and maps. Moreover, we detail new state records collected with this project. The works provide critical baseline information on our arboreal insect communities, and we look forward to sharing them when they appear.

**Project Status as of May 31, 2021:** LCCMR combined May 2021 updates with final report 06/18/21

**Amendment Request (8/31/21):**

### Activity 2

Personnel: \$200 left due to minor variations in daily schedules.

Supplies: \$23 left due to inability to estimate exact needs at previous amendment when projecting closeout (Feb 2020).

Travel: \$30 left due to inability to estimate exact needs at previous amendment when projecting closeout (Feb 2020).

A total of \$253 remaining in Activity 2

### Activity 3

Personnel: overspent \$2,713 on personnel due to wrapping up activities during no-cost extension in pandemic.

Supplies: overspent \$109 due to inability to estimate exact needs at previous amendment when projecting closeout (Feb 2020).

Travel: \$195 left due to inability to estimate exact travel needs/rates at previous amendment when projecting closeout (Feb 2020).

A total shortfall of \$2,627 in Activity 3

### Activity 4

Personnel: overspent \$1130 on personnel due to wrapping up activities during no-cost extension in pandemic.

Contracting: \$41 left due to minor variation in pay rates across years.

Supplies: \$1,013 left due to pandemic canceling planned volunteer activities

Printing: \$1,836 left due to decision to print and bind fewer copies of buprestid guides after publishing online in freely available repository.

Travel: \$465 left due to inability to estimate exact travel needs/rates at previous amendment when projecting closeout (Feb 2020).

Shipping: \$150 left due to fewer shipments to experts required than initial expected.

A total of \$2,375 remaining in Activity 4

All remaining funds from Activity 2 and Activity 4 were used to address the shortfall in personnel funds for both Activity 3 and Activity 4, leaving a total balance of \$0.

## Amendment approved by LCCMR 9/24/21

### Overall Project Outcomes and Results:

We have successfully completed all activities. We are pleased to report that the effective implementation of EAB biocontrol has led to increasing recoveries of the larval parasitoid *Tetrastichus planipennisi* and the egg parasitoid *Oobius agrili* through time based on data analysis in Activity 2. We produced several peer-reviewed scientific publications (with full credit to LCCMR) on Activities 3 and 4. For Activity 3, we evaluated the cold hardiness of the larval parasitoid *Spathius galinae* and published a study forecasting its survival in North America (Wittman, Aukema, Duan, and Venette (2021) Forecasting overwintering mortality of *Spathius galinae* in North America. *Biological Control*. 160: 104694). The insect will survive best in areas where winter temperatures remain above -20 Fahrenheit. For Activity 4, we published two journal articles detailing a checklist of buprestids found in Minnesota (Hallinen, Steffens, Schultz, Aukema (2021) The Buprestidae (Coleoptera) of Minnesota, with a discussion of the emerald ash borer, *Agrilus planipennis* Fairmaire. *The Coleopterists Bulletin* 75: 173-190) as well as a study on their habitat features (Hallinen, Wittman, Aukema (2020) Factors associated with diversity and distribution of buprestid prey captured by foraging *Cerceris fumipennis* (Hymenoptera: Crabronidae) (*Environmental Entomology* 49: 1363-13763). These works provide critical information on what is here, now, so we have a basis of comparison for when a new invasive wood-boring beetle in the same family as emerald ash borer arrives in the future. We then published, from the scientific checklist, a free and accessible guide (The Buprestidae of Minnesota) that can be downloaded from permalink <https://hdl.handle.net/11299/218928>. This latter guide contains not only specimen photos but also maps of the distribution record and dates of last collection by decade. All four publications are submitted with this final report.

## IV. PROJECT ACTIVITIES AND OUTCOMES:

**ACTIVITY 1:**

**Description: Expand biological control implementation**

EAB biological control has been implemented with the goal of using natural enemies to reduce EAB populations and damage to ash trees. Initial biological control agent releases in Minnesota began in 2010 with the release of two larval parasitoid species (wasps that attack EAB larvae underneath the bark) and the addition of an egg parasitoid species (wasps that attack EAB eggs) beginning in 2011. These three species were tested to ensure that they will not negatively impact other species or the environment. USDA rears these stingless wasps at a facility in Brighton, MI and provides them to states with EAB infestations.

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 40<sup>th</sup> parallel trying to better synchronize EAB and *S. agrili* lifecycles. Minnesota has not received *S. agrili* for release since 2012 and there are no plans to release this species again north of the 40<sup>th</sup> parallel. *T. planipennisi* continues to be released and has showed the greatest success thus far with an annual increase of recoveries in southeast Minnesota. The egg parasitoid, *Oobius agrili*, continues to be released each season and has now been recovered from sites in Hennepin and Winona Counties.

A new larval parasitoid species, *Spathius galinae*, was discovered in the Russian Far East and has undergone testing and has been approved for release by the USDA. Due to the origin of *S. galinae*, it is hypothesized that its life cycle will be more synchronized with northern latitudes and thus more suited for success in places such as Minnesota. Results from Activity 3 in this project will help inform implementation of this newly approved biological control agent, especially for locations like Duluth, MN.

MDA coordinates statewide implementation of the EAB biological control program and collaborates with local governments and state and federal agencies. ENRTF funding has enabled EAB biological control activities to date. Data are collected for all insect releases and recoveries. All release sites are monitored for ash health and EAB activity. Results are entered into MDA and USDA databases annually. Based upon results of our first two projects, we will continue weekly parasitoid releases throughout each field season. An MDA Research Scientist 1 will expand biological control releases to new EAB finds and continue monitoring older sites.

**Summary Budget Information for Activity 1:**

**ENRTF Budget: \$ 195,900**  
**Amount Spent: \$ 195,900**  
**Balance: \$ 0**

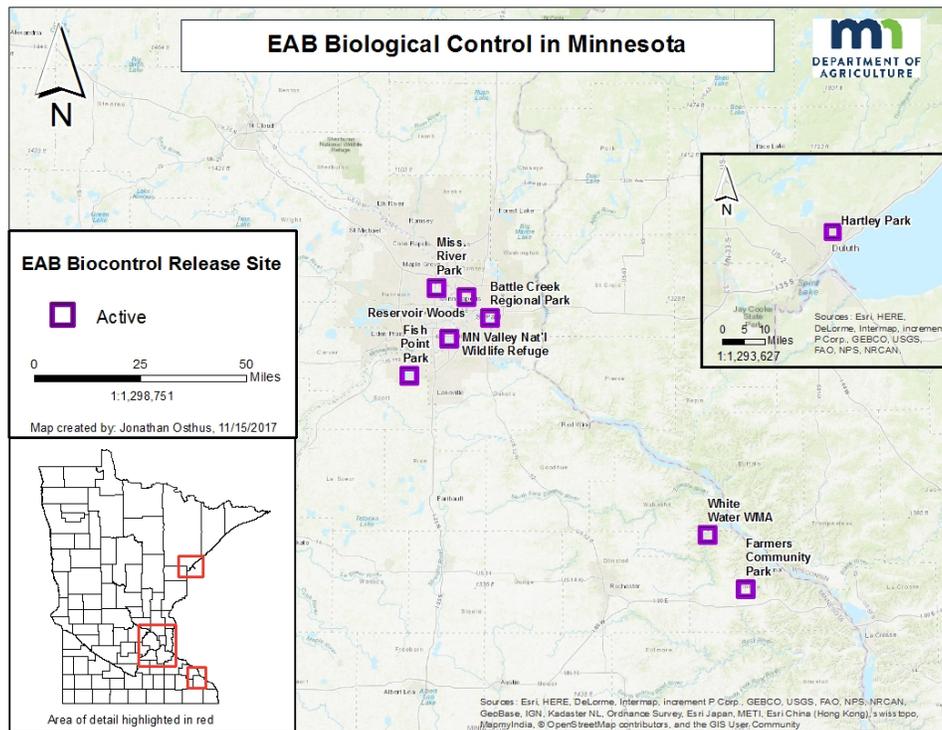
<b>Outcome</b>	<b>Completion Date</b>
1. New release sites established and existing ones monitored (MDA)	10/31/2019
2. Data entered into MDA database and into national database (MDA)	06/10/2020

**Activity 1 Status as of November 30, 2017:**

Parasitoid releases for the 2017 field season concluded on 9/14/2017. A total of 68,496 parasitoids were released between 8 sites. Parasitoids are released at a site for two field seasons to establish parasitoid populations. Of these 8 sites, 5 were in the second year of releases and will not receive parasitoids in 2018. MDA will monitor these sites for parasitoid establishment in the future. Annual ash health monitoring at 24 current and former release sites was completed during July and August of 2017. Ash health has greatly declined in southeastern Minnesota compared to the Twin Cities metro area.

<b>Site</b>	<b>Location</b>		<b><i>Tetrastichus planipennisi</i></b>	<b><i>Oobius agrili</i></b>	<b><i>Spathius galinae</i></b>	<b>Total Released</b>
	<b>Latitude</b>	<b>Longitude</b>				
Battle Creek Regional Park	44.93037	-93.02206	5,488	3,200	116	8,804
Farmers Community Park	43.99704	-91.81222	6,217	2,800	404	9,421

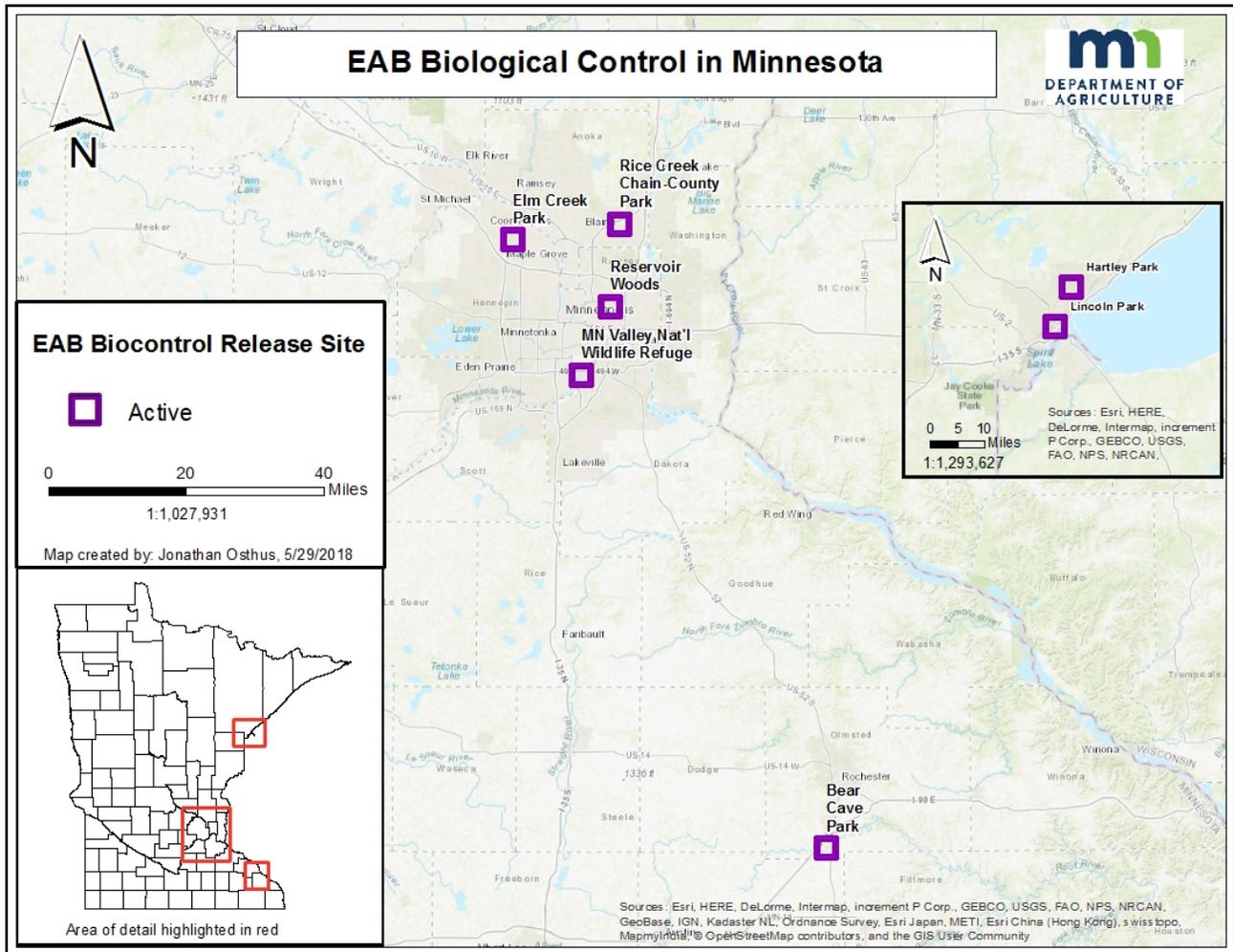
Fish Point Park	44.73078	-93.40847	2,179	1,000	0	3,179
Hartley Park	46.83917	-92.09568	6,384	2,800	621	9,805
Mississippi River Park	45.03151	-93.28125	5,275	3,300	103	8,678
MN Valley Nat'l Wildlife Refuge	44.85824	-93.21815	5,009	3,500	0	8,509
Reservoir Woods	45.00171	-93.13357	5,782	3,700	416	9,898
White Water WMA	44.18450	-91.99079	6,911	2,800	491	10,202
<b>All Sites</b>			<b>43,245</b>	<b>23,100</b>	<b>2,151</b>	<b>68,496</b>



Yellow pan traps were placed at two locations from early June through mid-September to monitor for parasitoid establishment at two former release sites in Minneapolis and Winona. Our methods consisted of placing 30 traps each at both Roberts Bird Sanctuary near Lake Harriet in Minneapolis and at Prairie Island in Winona. Pan traps were filled with a propylene glycol solution to trap insects attracted to the yellow color. Sampling involved pouring the propylene glycol through a filter then bagging and freezing the contents in the filter. Traps were sampled weekly throughout the summer with samples now being screened for parasitoids at MDA. Screening will be completed by the end of December at which time suspected parasitoids will be sent off for official identification by Dr. Juli Gould with the USDA.

#### **Activity 1 Status as of May 31, 2018:**

Over the winter and spring new release sites were selected based on new detections of EAB and natural spread into areas suitable for EAB biocontrol releases. A total of four new sites were selected at the following locations: Lincoln/Central Park in Duluth, Bear Cave Park in Stewartville, Elm Creek Park Reserve in Maple Grove, and Rice Creek Chain County Park in Lino Lakes. This brings the total number of active release sites receiving parasitoid releases to seven for the 2018 summer field season. Additional sites may be added throughout the summer depending on new detections of EAB.



Monitoring efforts at sites no longer receiving parasitoid releases continued through the winter and spring with bark sampling occurring at nine sites located in the Twin Cities metro area and southeastern Minnesota. Four new sites had their first recovery of the egg parasitoid, *Oobius agrili*. Providing further evidence of establishing populations in the Twin Cities and southeastern Minnesota.

Site	Latitude	Longitude	Number of EAB Eggs Recovered	Number of Parasitized Eggs
Hidden Falls	44.909166	-93.193194	23	1
Wheelock Parkway	44.986989	-93.114122	69	1
Shepard Road	44.914340	-93.135757	93	1
Lake Winona	44.039037	-91.653745	22	3
Minnehaha Park	44.91868	-93.20456	26	0
Shoreview	45.11464	-93.17979	26	0
Lamoille	44.00183	-91.47143	7	0
Millstone Landing	43.53959	-91.27798	15	0
Reno to LaCrescent	43.60306	-91.272	16	0

Results from the yellow pan traps placed at Robert's Bird Sanctuary in Minneapolis and McNally Landing on Prairie Island in Winona for the 2017 summer field season came back negative for any larval parasitoids.

Yellow pan trapping will take place at four locations for the 2018 summer field season. Traps will be placed along Wheelock Pkwy in St. Paul and at Prairie Island Park in Winona with the goal of recovering *Tetrastichus planipennisi* for the first time at both locations. Fort Snelling and Great River Bluffs State Parks will also have yellow pan traps as part of the intensive monitoring of parasitoid populations for Activity 2. Thirty traps will be placed at each site with a sample collected weekly for a total of fifteen weeks. Samples will be screened throughout the summer and fall with all suspect specimens sent to Dr. Juli Gould for official identification.

**Activity 1 Status as of November 30, 2018:**

Parasitoid releases for the 2018 field season concluded on 9/12/2018. A total of 44,656 parasitoids were released among seven sites. Parasitoids are released at a site for two field seasons to establish parasitoid populations. Of the 7 release sites, 4 sites will receive parasitoids in 2019 as well. Annual ash health assessments took place at 23 past and present release sites between July and August. Ash health has greatly declined in southeastern Minnesota compared to the Twin Cities metro area and we are beginning to see more decline at Hartley Park in Duluth.

Site	Location		<i>Tetrastichus planipennisi</i>	<i>Oobius agrili</i>	<i>Spathius galinae</i>	Total Released
	Latitude	Longitude				
Bear Cave Park	43.857973	-92.500159	4975	3400	918	9293
Elm Creek Park	45.142149	-93.424193	2813	1000	237	4050
Hartley Park	46.839172	-92.095684	3828	1800	633	6261
Lincoln Park	46.767666	-92.138548	4588	1800	606	6994
MN Valley Nat'l Wildlife Refuge	44.858243	-93.218146	3785	1600	877	6262
Reservoir Woods	45.001709	-93.133568	4065	1600	968	6633
Rice Creek Chain-County Park	45.175278	-93.105373	3256	1400	397	5053
All sites			27,310	12,600	4,636	44546

Releases in 2018 brings the total amount of parasitoids released to 561,633. This year marked the most *Spathius galinae* released since its initial release in MN during the summer of 2016.

Year	<i>Spathius galinae</i>	<i>Tetrastichus planipennisi</i>	<i>Oobius agrili</i>	<i>Spathius agrili</i>	Total per year
2010	0	2154	0	1172	3326
2011	0	19480	3641	7596	30717
2012	0	19822	10241	15258	45321
2013	0	42579	8597	0	51176
2014	0	34434	12062	0	46496
2015	0	151022	31490	0	182512
2016	1613	45130	42300	0	89043
2017	2151	43245	23100	0	68496
2018	4636	27310	12600	0	44546
Total	8,400	385,176	144,031	24,026	561,633

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for *Tetrastichus planipennisi*. Traps were placed at Wheelock Parkway and Prairie Island to try to confirm parasitoid establishment. Traps were also placed at Fort Snelling and Great River Bluffs State Park where parasitoids are known to be established as part of the intensive sampling efforts being conducted at these sites. Thirty pan traps were placed at each site with the exception of Great River Bluffs due to lack of accessible living ash trees. Marissa Bendickson sampled the yellow pan traps once a week which resulted in 1,489 samples collected over the summer. Suspected parasitoids have been screened and 58 samples will be sent for official identification by Dr. Juli Gould with the USDA.

Site	Location		Traps Set
	Latitude	Longitude	
Fort Snelling	44.886509	-93.18404	30
Great River Bluffs	43.946326	-91.40624	17
Prairie Island	44.076801	-91.682671	30
Wheelock Parkway	44.988560	-93.112828	30

Plans for winter sampling and monitoring for parasitoid establishment at former release sites are nearly complete. MDA will conduct bark sampling for EAB eggs and *Oobius agrili* at former release sites across the state no longer receiving parasitoids. Whole tree and selective branch sampling will also be used in attempt to recover both larval parasitoids *Tetrastichus planipennisi* and *Spathius galinae*.

**Activity 1 Status as of May 31, 2019:**

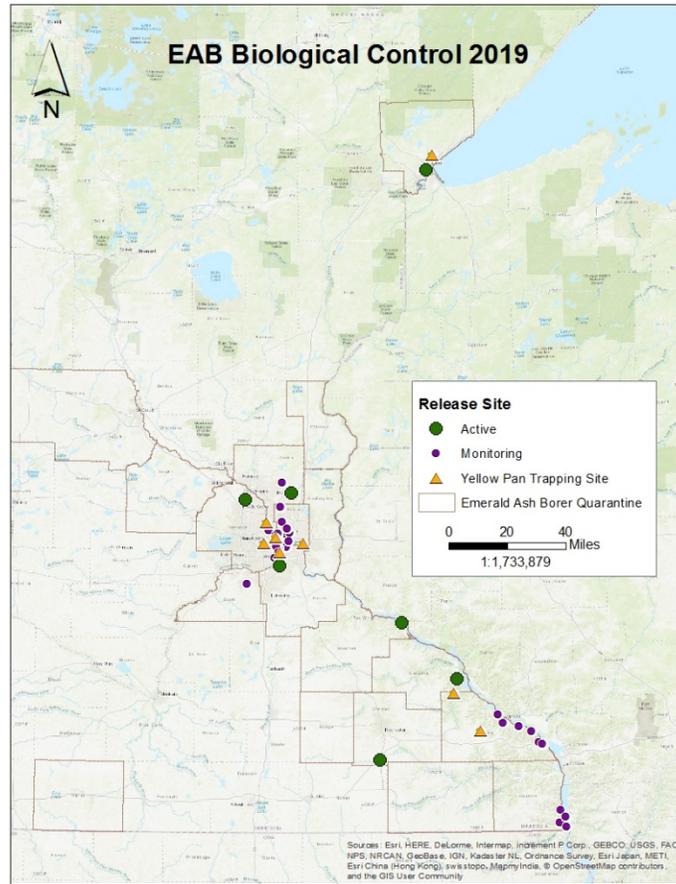
Monitoring for parasitoid establishment at sites no longer receiving parasitoids took place throughout the winter and spring with bark sampling occurring at seven sites located in the Twin Cities metro area and southeastern Minnesota. Stems of EAB infested ash trees were scraped with a draw knife and the bark shavings were collected then dried. Bark shavings were then sieved and examined for EAB eggs and eggs parasitized by *Oobius agrili*. A total of 56 bark samples have been screened and eggs suspected of parasitism were mailed to Leah Bauer with the U.S. Forest Service for identification on 5/28/2019.

Site	Latitude	Longitude	Number of EAB Eggs Recovered	Number of Suspected Parasitized Eggs
Farmer's Park	43.997184	-91.812601	107	52
West River Pkwy	44.945834	-93.203252	27	1
Lake Harriet	44.929069	-93.306186	70	0
Prairie Island	44.074187	-91.679435	96	0
East River Pkwy	44.955339	-93.209331	35	0
Battle Creek	44.929971	-93.022027	49	0
Miss. River Park	45.030770	-93.281099	7	0

During the 2019 spring, new release sites were selected based on new detections of EAB. Three new release sites were selected at the following locations: McCarthy Lake State WMA/Pool 4 WMA in SE Wabasha County, Frontenac State Park in Goodhue County and Blackhawk Park in Dakota County.

This brings the total number of active release sites receiving parasitoid releases to seven for the 2019 summer field season. Additional sites may be added throughout the summer depending on new detections of EAB.

Yellow pan trapping at sites no longer receiving parasitoids and sites under intensive sampling will take place at 8 locations this summer. USDA APHIS has advised on setting 15 traps per site as that number will be sufficient to detect parasitoids. Last year 30 traps were placed at 4 locations thus the same amount of samples will be collected and screened from the field. Pan traps will be deployed at Fort Snelling State Park in Minneapolis and Whitewater WMA in Altura as part of the intensive sampling for Activity 2. Traps will also be placed at Battle Creek Regional Park in St. Paul, Farmer's Community Park in Lewiston, Hartley Nature Center in Duluth and three sites in Minneapolis: Mississippi River Park, the Roberts Bird Sanctuary and along West River Parkway. Trap set will begin the week of May 27<sup>th</sup> in SE MN. Trap set may be delayed at Fort Snelling State Park due to flooding.



**Activity 1 Status as of November 30, 2019:**

Parasitoid releases for the 2019 field season concluded on 9/12/2019. A total of 47,616 parasitoids were released among eight sites. Dodge Nature Center in Dakota County was added as a release location in mid-June. Parasitoids are released at a site for two field seasons to establish parasitoid populations. Annual ash health assessments took place at 23 past and present release sites between July and early September. Ash health has greatly declined in southeastern Minnesota compared to Twin Cities metro area and we are beginning to see steady decline at Hartley Park in Duluth.

Site	Location		<i>Tetrastichus planipennisi</i>	<i>Oobius agrili</i>	<i>Spathius galinae</i>	Total Released
	Latitude	Longitude				
Bear Cave Park	43.85797	-92.5002	5248	900	564	6712
Elm Creek Park	45.14215	-93.4242	3646	1200	328	5174
Dodge Nature Center	44.89137	-93.0993	2018	1200	468	3686
Lincoln Park	46.76767	-92.1386	3685	900	601	5186
Frontenac State Park	44.5367	-92.3412	6045	900	863	7808
McCarthy Lake State WMA	44.25693	-91.968	5648	900	936	7484

Blackhawk Park	44.81625	-93.1864	4394	1200	342	5936
Rice Creek Chain-County Park	45.17528	-93.1054	3923	1200	507	5630
All sites			34,607	8,400	4,609	47,616

Releases in 2019 brings the total amount of parasitoids released to 609,249.

Year	<i>Spathius galinae</i>	<i>Tetrastichus planipennisi</i>	<i>Oobius agrili</i>	<i>Spathius agrili</i>	Total per year
2010	0	2154	0	1172	3326
2011	0	19480	3641	7596	30717
2012	0	19822	10241	15258	45321
2013	0	42579	8597	0	51176
2014	0	34434	12062	0	46496
2015	0	151022	31490	0	182512
2016	1613	45130	42300	0	89043
2017	2151	43245	23100	0	68496
2018	4636	27310	12600	0	44546
2019	4609	34607	8400	0	47616
Total	13,009	419,783	152,431	24,026	609,249

Yellow pan trapping took place at 8 sites this summer. Fifteen traps were placed at each site as opposed to 30 in prior years. This was done at the discretion of USDA APHIS and allowed MDA to place traps at more locations. Traps were placed with the goal of recovering adult parasitoids and confirming establishment. West River Parkway had 12 traps placed due to lack of accessible living ash trees. An extra trap was set at White Water WMA during trap set and was checked throughout the summer. Marissa Bendickson collected samples each week from the beginning of June through mid-September resulting in 1,714 samples. Suspected parasitoids were recovered from Battle Creek, Duluth, Whitewater, Fort Snelling, Farmers Park, and Roberts Bird Sanctuary. Suspect parasitoids were shipped to Juli Gould at APHIS for identification and we are awaiting results.

Site Name	Latitude	Longitude	Traps Set
Whitewater WMA	44.184495	-91.990792	16
Hartley Park	46.839172	-92.095684	15
Miss. River Park	45.03151	-93.28125	15
Fort Snelling	44.88491	-93.18779	15

Farmer's Comm. Park	43.99703	-91.81221	15
W. River Pkwy	44.95102	-93.20656	12
Battle Creek	44.93037	-93.02206	15
Robert's Bird Sanctuary at Lake Harriet	44.929285	-93.299044	15

Minnesota Department of Agriculture and University of Minnesota staff visited the state's initial release site and control plot in SE MN during the summer with the help of the Army Corps of Engineers and U.S. Fish & Wildlife, who piloted the boats necessary to access the sites. Most of the ash trees have died at each location. Eight bark samples were collected at the control site and one at the release site from the remaining living ash trees. Samples are currently being screened at MDA.

Winter sampling activities have begun for this season. Bark samples have been collected from sites around the metro that have not had a recovery of *Oobius agrili* to date. Samples will be dried and screened for EAB eggs and eggs suspected of parasitism in the coming months. Whole tree and selective branch sampling will also be used in attempt to recover both larval parasitoids *Tetrastichus planipennisi* and *Spathius galinae* from sites without recoveries to date.

**Activity 1 Status as of November 30, 2020:**

Monitoring results for parasitoid establishment have been completed and finalized for the project. The final round of yellow pan trapping that occurred in the summer of 2019 resulted in the recovery of the larval parasitoid *Tetrastichus planipennisi* from one new site, Farmers Park in Winona County. The native parasitoid, *Atanycolus* spp., was also recovered from Battle Creek, Farmers Park, Fort Snelling and Mississippi River Park located in central and southeastern Minnesota. Winter parasitoid recovery activities were completed with whole tree, branch and bark samples collected from eight locations including Fort Snelling State Park and White Water WMA for the intensive sampling included in Activity 2. Whole tree and branch sampling activities were impacted by COVID-19 and was only completed for the intensive sampling portion of Activity 2.

**Bark sampling results for *Oobius agrili*.**

Site Name	Latitude	Longitude	Number of Samples Collected	Number of EAB Eggs Recovered	Confirmed <i>Oobius agrili</i>
Fort Snelling	44.88491	-93.18779	26	340	0
White Water WMA	44.184495	-91.990792	27	63	0
Battle Creek	44.93037	-93.02206	10	28	0
MN Valley National Wildlife Refuge	44.85824	-93.21815	10	13	0
Reservoir Woods	45.00171	-93.13357	10	2	1
Houston Control	43.56971	-91.23684	8	0	0
Houston Release	43.52080	-91.23666	1	0	0
Hartley Park	46.76767	-92.13855	1	3	0

Biological control releases for the 2020 season began on June 5, 2020 and continued through the end of September. Total release numbers were down for the season due to the USDA rearing facility operating at half capacity due to COVID-19 and the scaling back production of *Tetrastichus planipennisi* to focus on increased production of *Spathius galinae*. MDA released a total of 16,847 parasitoids. This included 4,465 *Spathius galinae*, 4,062 *Tetrastichus planipennisi* and 8,320 *Oobius agrili*. Beginning in 2020 and moving forward, release sites will receive primarily *Tetrastichus planipennisi* in the first year of releases and the other parasitoids in year two. Rice

Creek Chain-County Park and Elm Creek Park are receiving parasitoid releases beyond the typical two-year recommendation of releases to reach the threshold of *Spathius galinae* required for establishment.

2020 Active Release Sites

Site	Latitude	Longitude
Dodge Nature Center	44.89137	-93.09928
Blackhawk Park	44.81625	-93.18637
Frontenac State Park	44.53670	-92.34116
McCarthy Lake WMA	44.25693	-91.96795
Grand Lake	45.44626	-94.32870
Rice Creek Chain-County Park	45.17528	-93.10537
Elm Creek Park	45.14215	-93.42419

Total number of parasitoids released in Minnesota.

Year	<i>Spathius galinae</i>	<i>Tetrastichus planipennisi</i>	<i>Oobius agrili</i>	<i>Spathius agrili</i>	Total per year
2010	0	2154	0	1172	3326
2011	0	19480	3641	7596	30717
2012	0	19822	10241	15258	45321
2013	0	42579	8597	0	51176
2014	0	34434	12062	0	46496
2015	0	151022	31490	0	182512
2016	1613	45130	42300	0	89043
2017	2151	43245	23100	0	68496
2018	4636	27310	12600	0	44546
2019	4609	34607	8400	0	47616
2020	4465	4062	8320	0	16,847
<b>Total</b>	<b>17,474</b>	<b>423,845</b>	<b>160,751</b>	<b>24,026</b>	<b>626,096</b>

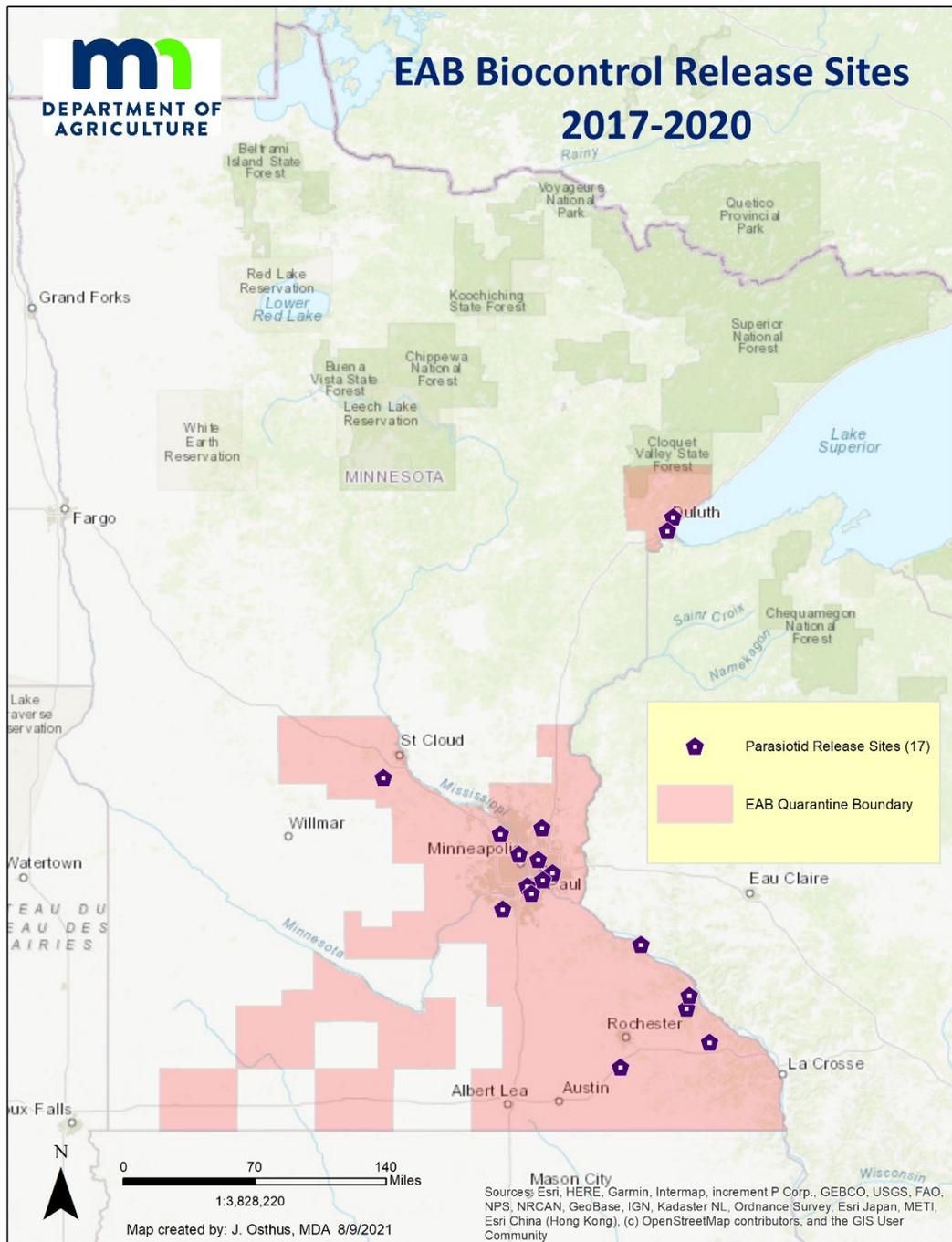
Activity 1 Status as of May 31, 2021: N/A

**Final Report Summary:**

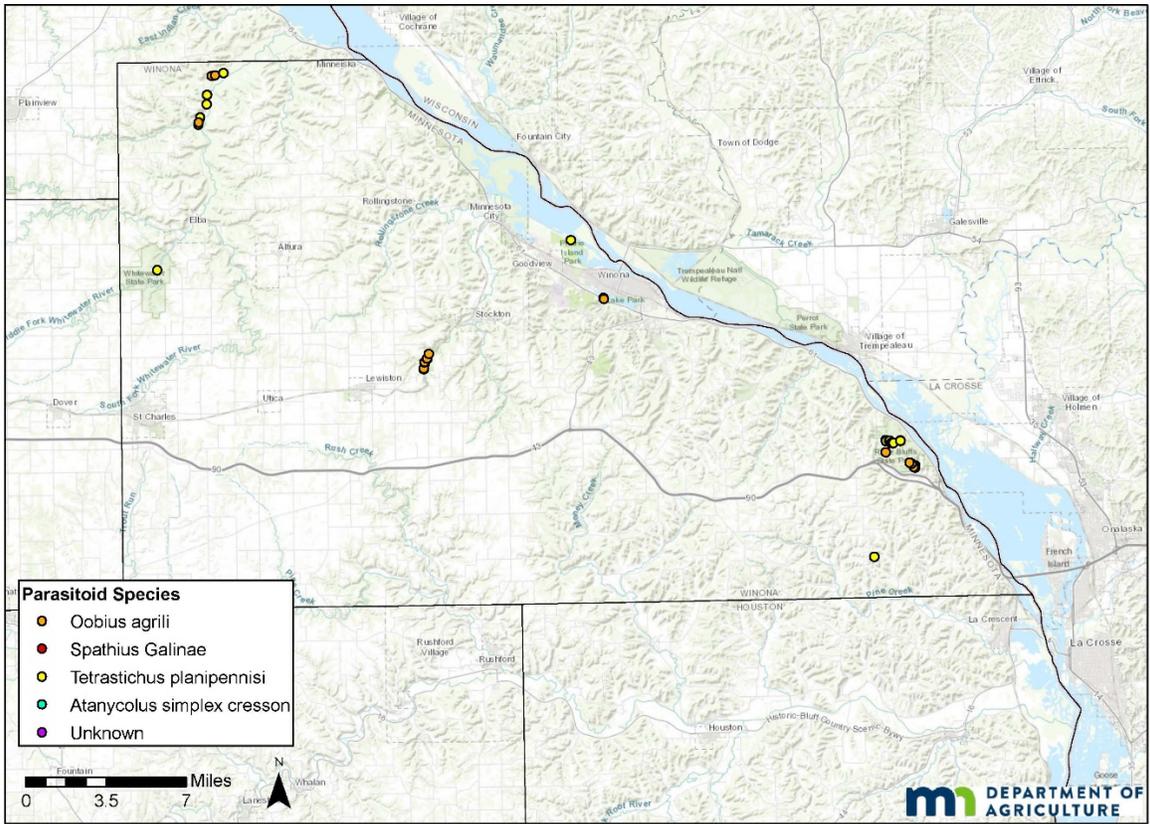
Emerald ash borer biological control implementation has been a very successful endeavor with the support from the Environment and Natural Resources Trust Fund. Minnesota has been a leading state in the early implementation, monitoring, and research due to the funds received during each phase of this project. The dedicated funds have allowed the state of Minnesota to take advantage of the limited resources available from the USDA EAB biocontrol rearing facility and set a path for success in managing EAB at a forest landscape level. A total of 177,505 parasitoids were released at 17 different sites in 10 counties (Dakota, Goodhue, Hennepin, Olmsted, Ramsey, Scott, St. Louis, Stearns, Wabasha, and Winona) throughout the duration of the project. A total of 626,096 parasitoids have been released at 47 sites since implementation began in September 2010. The consistent implementation and recovery work has led to increasing recoveries of the larval parasitoid *Tetrastichus planipennisi* and the egg parasitoid *Oobius agrili* through time. The larval parasitoid *Spathius galinae* was not recovered during the monitoring work performed during this project but has recently been recovered along with *Tetrastichus planipennisi* for the first time in Duluth, MN. Sampling occurred in March 2021 with state match funds for an EAB suppression grant received from the U.S. Forest Service. Over the course of the project, monitoring methods have been revised to recover parasitoids more efficiently. The number of yellow pan traps set per location was reduced based on USDA recommendations which allowed for more sites to be monitored with the resources and staff time available. An interactive map of parasitoid release and recovery locations is viewable at <https://www.mda.state.mn.us/plants/pestmanagement/eab/eabbiocontrol>.

**Parasitoid Recoveries 2017-2019**

Species	# of Recoveries	# of Sites	Counties
<i>Oobius agrili</i>	30	10	Hennepin, Ramsey, Winona
<i>Tetrastichus planipennis</i>	90	7	Hennepin, Ramsey, Winona
<i>Spathius galinae</i>	0	0	
<i>Atanycolus simplex</i> cresson (Native Species)	23	6	Hennepin, Ramsey, Winona
All Species	143	14	Hennepin, Ramsey, Winona



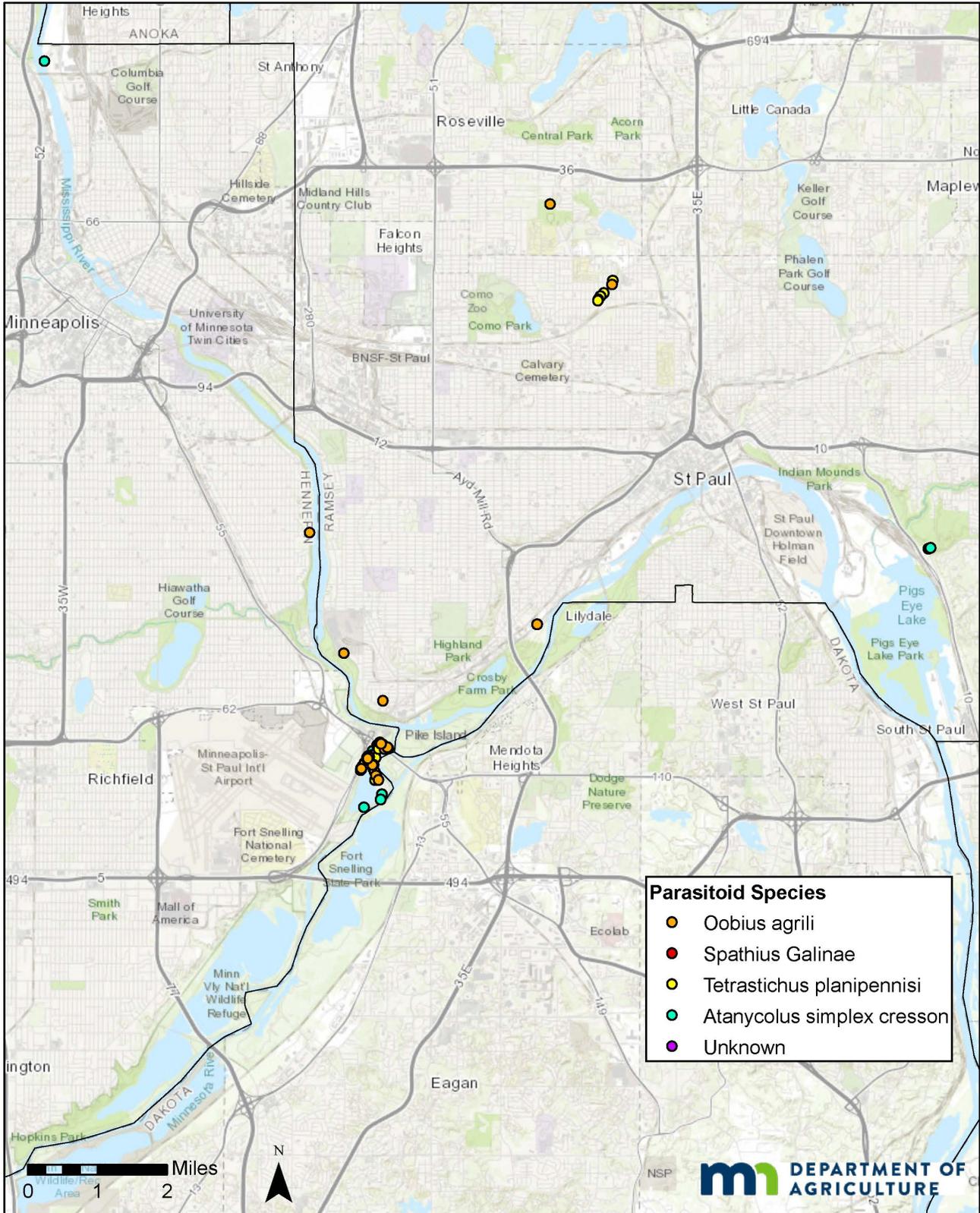
### Biological Control Recoveries SE MN



### Biological Control Recoveries Duluth



# Biological Control Recoveries Twin Cities



**ACTIVITY 2:**

**Description: Assessing biological control establishment and impact**

Two release sites will be selected for in-depth assessment of parasitism rates by EAB biological control agents. These stingless wasps are very small, so documenting recoveries and detections of reproducing populations in subsequent years are non-trivial. MDA will implement several different recovery techniques including yellow pan trapping and bark and branch sampling to collect data on the impact of the stingless wasps on EAB populations. Two sites will be selected in geographically separate areas of the state. The U of M will analyze biological control agent recovery data and calculate the percent parasitism by species per site. We hope to see that parasitism rates increase through time as species become established and spread. Any impacts by native wasps that begin to respond numerically to EAB populations will also be noted. Efficacy curves for parasitoid recovery methods will be developed to better understand strengths and limitations of detection tools. This work will be completed by one technician, one graduate student and one undergraduate student advised by Dr. Brian Aukema at the University of Minnesota.

**Summary Budget Information for Activity 2:**

**ENRTF Budget: \$203,690**  
**\$203,437**  
**Amount Spent: \$203,437**  
**Balance: \$ 0**

Outcome	Completion Date
1. Two former release sites assessed for impact of parasitism by EAB bioagents (MDA)	06/30/2020
2. Data analyzed, percent parasitism by species per site calculated (U of M)	06/30/2020
3. Develop efficacy curve for utilized bioagent recovery techniques (U of M)	06/30/2020
Research recommendations will be implemented and published after completion	

**Activity 2 Status as of November 30, 2017:**

Two former release sites have been selected and are awaiting approval of a special use permit from the DNR. Great River Bluffs State Park in Winona County and Ft. Snelling State Park in Hennepin and Ramsey Counties are the sites selected. Both sites have previously had multiple recoveries of two of the EAB biological control agents *Oobius agrili* and *Tetrastichus planipennisi*. Sampling is planned to begin at both sites in January, 2018. U of M work will begin in summer of 2018.

**Activity 2 Status as of May 31, 2018:**

After discussions with a national expert in biological control of emerald ash borer, we have been exploring additional sites along the expanding front of emerald ash borer in the eastern side of the state. Our goal is to be able to compare the efficacy of biological control agents in new infestations where parasitoids have been released by our partners at the MDA vs. areas where EAB has been recently discovered but no mass-reared agents have been released. This will shed some further insight into whether established parasitoids are moving at the same rate as emerald ash borer to new areas, as well as whether our native parasitoids are responding numerically. To date, for example, we know very little about natural populations of parasitoids such as *Atanycolus* spp. that have been found in good numbers in Michigan. We have been working with resource managers to select candidate sites from SE Minnesota to Duluth area.

The first year of intensive parasitoid sampling efforts began in January 2018. Whole tree debarking and bark sampling was completed at Fort Snelling State Park in Hennepin County and Great River Bluffs State Park in Winona County. These former release sites were selected for sampling due to having multiple recoveries of two of the EAB biological control agents *Oobius agrili* and *Tetrastichus planipennisi*.

Whole tree debarking - A minimum of 10 whole trees with a diameter at breast height (DBH) of 2 to 4 inches were felled and debarked at each location. EAB larval gallery conditions were recorded and inspected for *T. planipennisi* larvae. Clutches of *T. planipennisi* larvae were recovered from both sites.

Site	Latitude	Longitude	Number of Trees Sampled	Number of Trees with <i>T. planipennisi</i>	Number of <i>T. planipennisi</i> clutches
Fort Snelling	44.888060	-93.185214	17	3	8
Great River Bluffs	43.939280	-91.409170	10	2	6

Bark sampling - Our goal was to collect at least 100 EAB eggs at each site to determine what percent of eggs are being parasitized by *Oobius agrili*. A minimum of 25 trees were sampled at each park due to previous bark samples yielding an average of 4 EAB eggs per sample depending on the density of EAB.

Site	Number of Bark Samples	Number of EAB Eggs	Number of Parasitized Eggs	Percent of eggs Parasitized
Fort Snelling	27	111	5	4.50
Great River Bluffs	28	297	7	2.36

**Activity 2 Status as of November 30, 2018:**

Work continues to build a long term dataset on parasitoid recovery and establishment as year over year growth curves will identify rates of mortality. For the first time in Minnesota, we are seeing \*non-zero\* rates of parasitism and recovery; to this point, percent parasitism has only reached a fraction of a percent as egg and larval parasitoids are released and establish. Parasitism especially by the egg parasitoid approaching 5% at this early stage leaves us ecstatic, but also highlights the long term nature of implementation and evaluation of biological control strategies.

In discussions with national biological control experts, we had hoped to conduct an additional experiment this last year identifying what proportion of emerald ash borers in a new site exhibit a two-year vs. one year life cycle. There is anecdotal evidence that when single emerald ash borers colonize new trees in areas devoid of any other EAB pressure (e.g., a few insects emerging from firewood to attack surrounding trees), the trees have a small wound response where callous tissue or the like can reduce insect growth rates. As such, a proportion of new colonizers may be forced into a two year life cycle, but as more insects attack the tree, any minimal resistance is quickly overcome and insects rapidly shift to a one year life cycle.

This phenomenon may be partially responsible for the long lag phase in growth of new infestations, but also has serious implications for biological control success in new sites (i.e., timing life stage availability for parasitoids). Unfortunately, we were not able to secure sites to establish EAB under very controlled conditions, given the sensitive nature of such an experiment, but we have filed the idea for future thought should a value-added opportunity arise.

Preparations for winter parasitoid recovery sampling are taking place. Intensive sampling will occur again at Fort Snelling State Park and SE MN. These sites were selected last year due to having multiple recoveries of *Oobius agrili* and *Tetrastichus planipennisi*. MDA has applied for special use permits and sampling activities are planned to begin in January, 2019.

**Activity 2 Status as of May 31, 2019:**

Intensive sampling for parasitoids occurred for the second year. Whole tree and bark sampling was conducted at Fort Snelling State Park in Hennepin County and Whitewater WMA in Winona County. Whitewater WMA was selected for intensive sampling this year instead of Great River Bluffs State Park as most of the small living ash trees that were accessible in Great River Bluffs State Park had been sampled in previous years. Whitewater WMA was selected as it has a similarly large EAB population in southeastern Minnesota near Great River Bluffs and we had suspected that parasitoids established at this release site.

Whole tree sampling - A minimum of ten small trees with a diameter at breast height of 2 to 5 inches were felled and debarked at each site. EAB larvae and galleries were recorded and inspected for larval stages of *Tetrastichus planipennisi* or adults that failed to emerge.

Site	Number of Trees Felled	Number of Trees Containing <i>T. planipennisi</i>	Clutches of <i>T. planipennisi</i> recovered
Fort Snelling State Park	15	7	29
Whitewater WMA	10	6	15

\*Fort Snelling State Park had one tree that contained 17 clutches of *Tetrastichus planipennisi*.

*Tetrastichus planipennisi* was also recovered from the campground at Whitewater State Park. Material was sampled from infested ash trees that were removed by Conservation Corps Minnesota crew members during chainsaw training. This location is 5 miles away from the Whitewater WMA release site and is a positive indicator of natural dispersal of parasitoids.

Bark Sampling - Bark samples were collected from 30 ash trees within each site. Our goal again was to recover at least 100 EAB eggs to determine what percent are being parasitized by *Oobius agrili*.

Site	Latitude	Longitude	Number of EAB Eggs Recovered	Number of Suspected Parasitized Eggs
Fort Snelling	44.882630	-93.182330	311	19
Whitewater WMA	44.175352	-91.998719	202	9

MDA also conducted extra whole tree sampling to determine what impact this winter's cold temperatures had on EAB. Trees and branches were sampled from Fort Snelling, Duluth and Sauk Centre. EAB was discovered in Sauk Centre in April and MDA was able to get samples from the trees removed by the city. Branches were debarked and EAB larvae were inspected for signs of cold mortality. Larvae killed by the cold tend to become dark in color. Larvae that still appeared healthy were stored in growth chambers in the MDA lab and allowed to acclimate to room temperatures. Larvae were prodded and examined under a scope to see if they moved up to several days after sampling.

Site	Recovered Larvae	Visibly Dead Larvae	Unmoving Larvae	Moving Larvae	Parasitized Larvae
Duluth	260	175 (0.67)	57 (0.21)	28 (0.10)	0
Fort Snelling State Park	133	45 (0.33)	52 (0.39)	16 (0.12)	20 (0.15)
Sauk Centre	210	173 (0.82)	34 (0.16)	3 (0.01)	0

\*Recovered larvae denotes larvae that were not damaged or destroyed during debarking. More EAB were present in the samples.

**Activity 2 Status as of November 30, 2019:**

Yellow pan traps were set at Fort Snelling and Whitewater WMA to monitor parasitoid abundance from June through mid-September. Samples have been screened with suspect parasitoids sent off for official identification.

Bark samples have been collected from Fort Snelling State Park as part of intensive sampling being conducted at that site along with White Water WMA. Whole tree sampling will be conducted in December at both intensive sampling sites to complete the final parasitoid sampling for this activity.

**Activity 2 Status as of November 30, 2020:**

Intensive parasitoid sampling efforts were completed and finalized for the project, while final analysis was data was delayed due to COVID-19. Yellow pan trapping, whole tree debarking and bark sampling were completed once again during the summer of 2019 and winter of 2019-2020. A total of 31 yellow pan traps were set at Ft. Snelling State Park and White Water WMA during the summer of 2019. No parasitoids were recovered at either site. Whole tree sampling was completed at both park locations to try and recover both larval parasitoids *Tetrastichus planipennisi* and *Spathius galinae*. A minimum of 10 trees with signs of EAB infestation and diameter of at least 3-4 inches at breast height were felled and debarked. Larval conditions were recorded and inspected for signs of parasitism and mortality. No *Spathius galinae* was recovered from either site. Sampling results showed a marked decrease in parasitoid recovery and EAB larvae in general. The decrease in parasitoid recoveries as well as EAB larvae may be attributed to the impact of the extremely cold temperatures experienced in the previous winter (2018-2019).

Intensive bark sampling results for *Oobius agrili* (2019-2020).

Site Name	Latitude	Longitude	Number of Samples Collected	Number of EAB Eggs Recovered	Confirmed <i>Oobius agrili</i>
Fort Snelling	44.88491	-93.18779	26	340	0
White Water WMA	44.184495	-91.990792	27	63	0

Intensive whole tree debarking results (2019-2020)

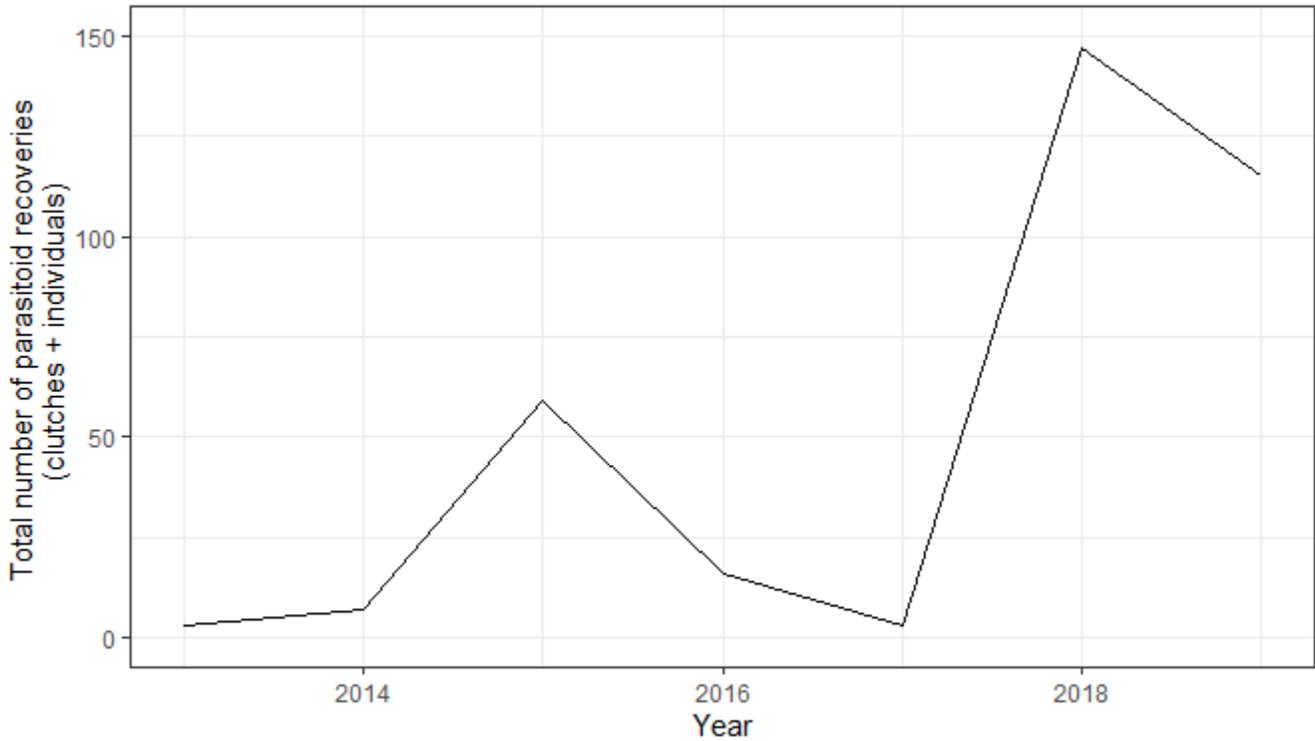
Site	Latitude	Longitude	Number of Trees Sampled	Number of Trees with <i>T. planipennisi</i>	Number of <i>T. planipennisi</i> clutches
Fort Snelling	44.88491	-93.18779	18	2	3
White Water WMA	44.184495	-91.990792	15	0	0

**Activity 2 Status as of May 31, 2021:** N/A

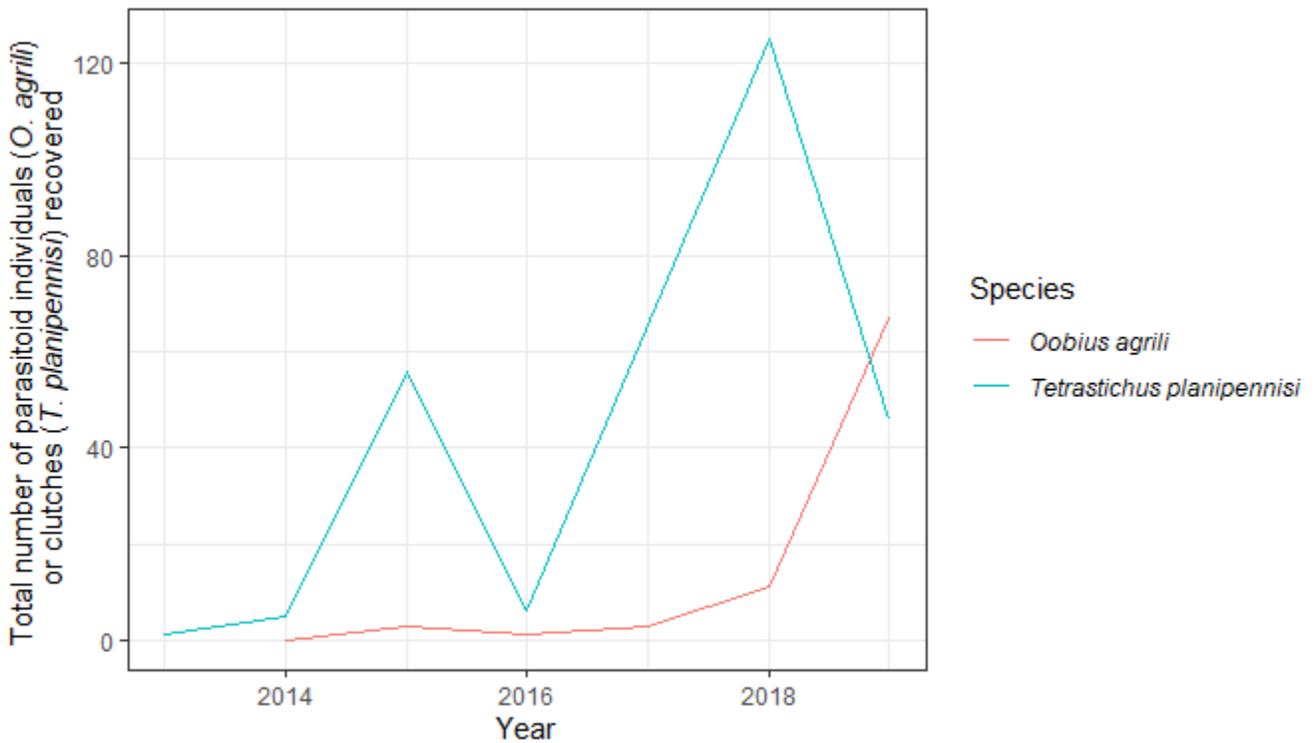
**Final Report Summary:**

We incorporate earlier sampling data into the final report summary here in the interest of providing the best context through time. Across all trapping methods (tree debarking, bark sifting, and yellow pan traps), parasitoids sampled from 2013 to 2019 continue to increase. The biological control agent *Tetrastichus planipennisi* was recovered in every year of surveying except for 2017, while another biological control agent, *Oobius agrili*, was recovered in every year except for 2013 and 2014. The native generalist parasitoid *Atanycolus simplex cresson* was recovered in small numbers in 2016 and 2018.

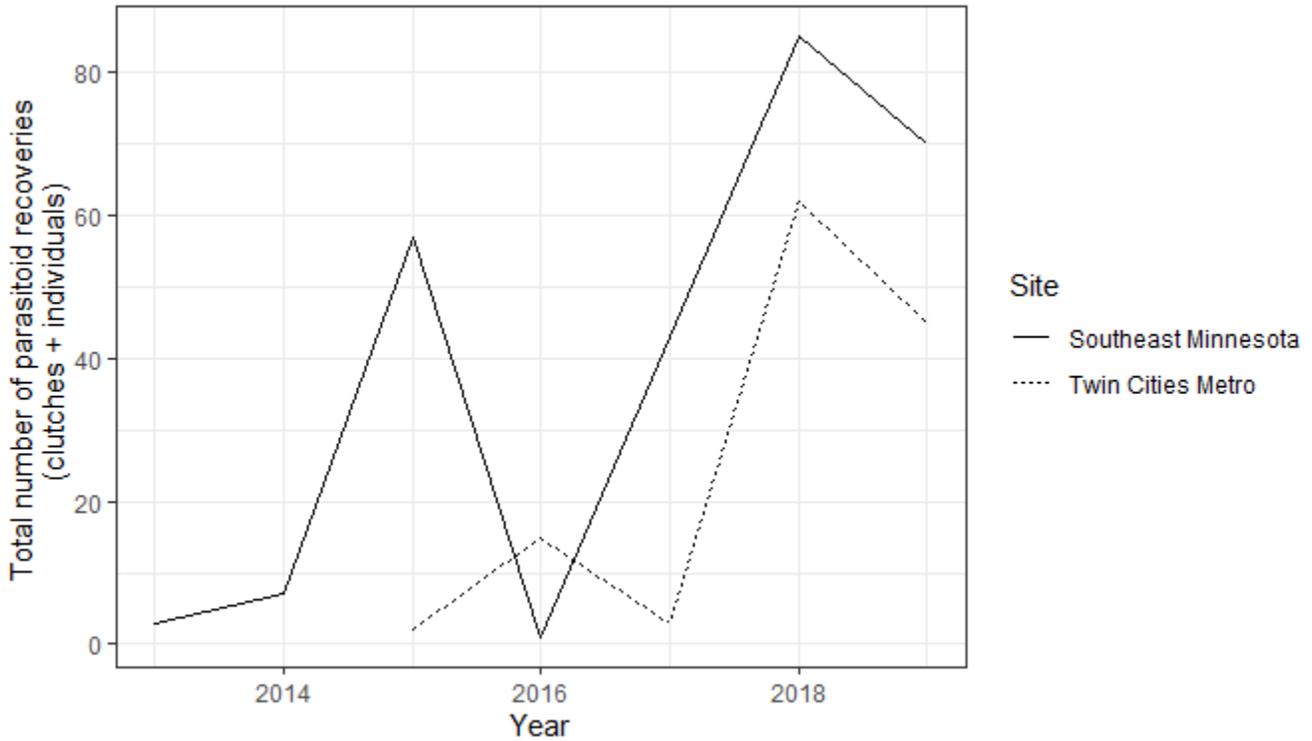
*In general, overall parasitoid recoveries are increasing overtime.*



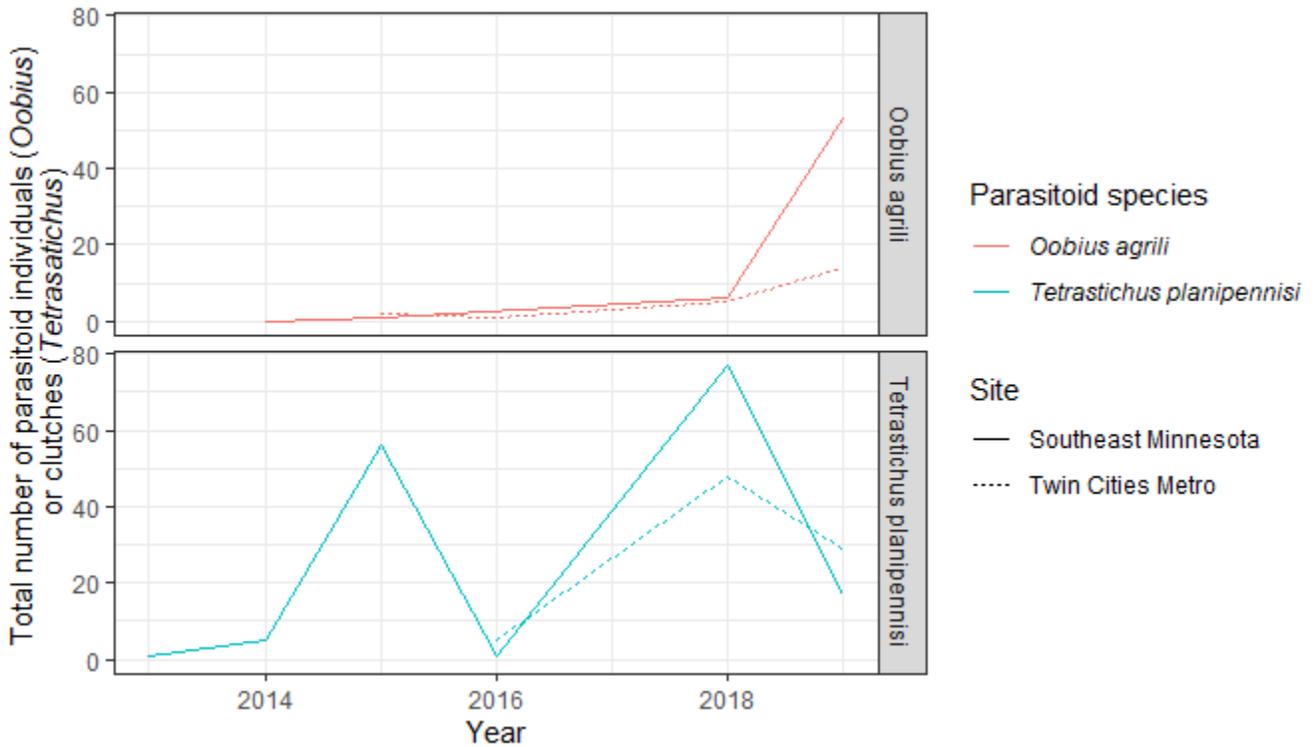
Recoveries of *Tetrastichus planipennisi* clutches fluctuated up and down, but appear to be generally increasing. In contrast, the recoveries of individual *Oobius agrili* remained relatively low, but started to increase in 2017.



The sites sampled can largely be grouped into two locations: the Twin Cities metropolitan area and southeastern Minnesota. Grouping recoveries at these sites, we can see that recoveries are increasing in both locations.



In general, recoveries of both parasitoids increased over time at each of the two broader site locations. *Tetrastichus planipennisi* populations appear to also fluctuate in both the Twin Cities metropolitan area and southeastern Minnesota.



**ACTIVITY 3:**

Description: Assess new bioagent cold hardiness – *Spathius galinae*

Cold hardiness of the new EAB biological control agent, *Spathius galinae*, will be assessed using established laboratory methods to measure the insect supercooling point, lower lethal temperature, and lower lethal times. Climate analysis maps will be developed for the state of Minnesota projecting where *S. galinae* may not be able to establish based on cold hardiness testing results. This work will be completed by one graduate student and one undergraduate student advised by Dr. Robert Venette with the U.S. Forest Service and University of Minnesota. This project complements previous ENRTF funded work assessing cold hardiness of EAB and EAB biological control agents.

**Summary Budget Information for Activity 3:**

ENRTF Budget: ~~\$138,985~~  
**\$141,692**  
 Amount Spent: \$141,692  
 Balance: \$ 0

Outcome	Completion Date
1. Measure bioagent cold hardiness of <i>Spathius galinae</i> (U of M)	05/15/2019
2. Develop climate analysis maps for Minnesota to determine the establishment potential for <i>Spathius galinae</i> .	06/10/2020
Research recommendations will be implemented and published after completion	

**Activity 3 Status as of November 30, 2017:**

We have not begun work in this objective yet.

**Activity 3 Status as of May 31, 2018:**

We have contacted Dr. Jian Duan, a scientist with the US Department of Agriculture, Agricultural Research Service, to collaborate on this project. Dr. Duan has studied the behavior and efficacy of *Spathius galinae* to control emerald ash borer. He maintains *S. galinae* in his laboratory and is willing to provide us with these insects in a condition that would be ready for field release (not cold hardy) and after individuals have been prepared for winter storage (presumably more cold hardy). He agrees that detailed studies of the cold tolerance of this biological control agent would be extremely worthwhile. An incoming PhD student in the Department of Entomology at the University of Minnesota has agreed to begin working on the project in the fall of 2018.

We have successfully renewed a federal permit to receive biological control agents to the University of Minnesota for study. The permit was approved in under two months.

**Activity 3 Status as of November 30, 2018:**

We received the first shipment of *S. galinae* this fall and conducted our first cold tolerance tests. We have very much appreciated Dr. Duan’s support and advice, as these insects arrive in sticks and must be tediously and carefully peeled out before we can work with them. It is very difficult to remove the parasitoids for cold tolerance testing without killing them.

We have developed a research plan in conjunction with Dr. Duan as follows:

Goals: Assess the cold tolerance of *Spathius galinae* by measuring lower lethal temperatures (LLtemp) at different cooling rates. If enough specimens are available, we would also like to use our cold tolerance assays to predict field survival to estimate the accuracy of our lab results. We will use this information to produce maps with estimated proportion of mortality based on relevant winter climate information to help guide the biocontrol program. If specimens are also available from different rearing regimens, we can test for differences in cold hardiness based on rearing regimen.

Hypotheses:

- *S. galinae* will be chill tolerant and freeze tolerant.
- *S. galinae* will have lower LLtemp when cooled at slower, more ecologically relevant cooling rates.

## Methods:

- Cold tolerance assays
  - *S. galinae* prepupae will be removed from ash twigs and chilled inside a test tube using a silicon-chilling bath.
  - Prepupae will be chilled to temperatures between 5 °C and -40 °C, which reflect temperatures they may experience in North America. Upon reaching those temperatures, the insect will be removed and placed in a refrigerator at 4 °C. This holding period in the refrigerator is meant to replicate more ecologically relevant conditions. Insects are unlikely to experience extreme cold followed by “room temperature” in the wild.
  - Mortality will be assessed 24 hours, 48 hours, 5 days, 14 days after cold assays. After 14 days in a refrigerator at 4 °C, the insects will be placed in a growth chamber under ideal growth conditions to further assess their ability to complete development.
  - Prepupae will be chilled at rates of 1 °C/min, 0.5 °C/min, or 0.1 °C/min to their target temperature to assess the effect of cooling rate on cold mortality.
  - Based on power simulations, we would like to have 450 prepupae to use in these assays (25 different temperatures x 6 insects per temperature x 3 cooling rate treatments). This should give us enough power to detect effects of temperature and cooling rate and more accurately characterize the mortality curve.
  - To test for a difference in rearing regimen, we can perform an additional set of cold tolerance assays at one cooling rate to compare SCP and lower lethal temperatures.
- Field mortality experiments
  - Prepupae in ash sticks will be placed outside at different locations in Minnesota.
  - Mortality will be assessed periodically and compared to values predicted from cold tolerance assays
- Maps
  - Potential range/mortality maps in North America based on minimum winter temperatures will be produced from the results of the LLtemp cold tolerance assays.
  - Using the minimum winter temperatures experienced in an area, we will predict what proportion of *S. galinae* will survive based on lower lethal temperatures calculated from our cold assays. Assuming there is a difference in survival at a given temperature for different cooling rates, we will use survival estimates from the lowest cooling rate experiments.

### Contribution to the larger biocontrol program:

Survival maps and field verified estimates of mortality produced from these experiments can help managers by identifying where *Spathius galinae* will likely suffer low levels of winter mortality. Additionally, if prepupae provided are reared and stored under different temperature regimens, we can use our cold tolerance assays to assess which method may provide more cold hardy parasitoids, which may help increase the likelihood of establishment.

### Activity 3 Status as of May 31, 2019:

Following the methods outlined above, we have put approximately 280 parasitoids through the chilling assay. We have been exceptionally pleased to get this many insects from federal cooperators given the 1) amount of work it takes to rear this particular insect (prior to shipping, each parasitoid must be recovered by hand through careful bark scraping, a laborious process) and 2) the impact of the federal government shutdown, which hampered rearing efforts.

Preliminary data to date suggests that the supercooling point for lab-reared *S. galinae* parasitoids is around -27°C. Interestingly, and contrary to what has been hypothesized, parasitoids chilled at the faster rate of 1°C/min

are exhibiting higher rates of survival and lower temperatures than those chilled at 0.5°C/min or slower at 0.1°C/min. These experiments are ongoing, so it is too soon to determine the statistical significance of these results. Future work will include measuring mortality of *S. galinae* outdoors to field validate our laboratory results and model survival of the parasitoid in Minnesota.

### **Activity 3 Status as of November 30, 2019**

We continued collaborating with Dr. Jian Duan, a research scientist and expert on emerald ash borer biological control with the United States Department of Agriculture, to investigate the cold tolerance of mature *S. galinae* larvae, the overwintering stage of the insect. We used a silicon chiller bath in the laboratory. We collected data on the supercooling points and estimates of the lowest temperature at which 50% of larvae survived to quantify cold tolerance. Additionally, we compared these cold tolerance measures across different chilling rates, which is how quickly the insect is chilled to a target temperature. We chilled parasitoids at 1 °C/min, 0.5 °C/min, and 0.1 °C/min to temperatures ranging from 0 °C to -40 °C. This was to determine if slower, more ecologically relevant chilling rates produce different results than the traditional, faster chilling rates historically used in the cold tolerance literature. Much of the cold tolerance work to-date on other parasitoids of emerald ash borer has been done using a 1 °C/min chilling rate.

We chilled 427 parasitoids total. We found an average super cooling point of approximately -24 °C. We found that the chill rate had no significant effect on the survival of the insects. Most of the insects that were chilled showed no signs of discoloration three days after chilling was complete. However, we saw very few larvae emerge as adults, with less than 15% of larvae completing eclosion. We believe this low eclosion rate is due, at least in part, to issues with the incubator in which we placed insects after cooling. Interestingly, we did have specimens that survived freezing, suggesting that *S. galinae* may be tolerant of freezing. We plan to field validate our cold tolerance results this winter and hope to repeat the laboratory assays to confirm the results we found last winter.

### **Activity 3 Status as of November 30, 2020:**

We continued to collaborate with Dr. Jian Duan, a research scientist and expert on emerald ash borer biological control with the United States Department of Agriculture. He graciously supplied us with mature larvae of *S. galinae* larvae, the overwintering stage of the insect, in trunk segments that we placed outside in secure locations at the University of Minnesota (St. Paul campus), the University's Southern Research and Outreach Center in Morris, MN, and the Western Research and Outreach Center in Waseca, MN. At each location, half of the trunk segments were tied around the circumference of a tree trunk at approximately breast height using twine. Trees were chosen on the interior of the stands to limit the effect of direct sunlight. The other half of the trunk segments were placed nearby on the ground. If snow was already present at the site it was removed to expose the ground, the trunk segments were placed on the ground, and then covered with snow. Each group of trunk segments also had a HOBO data-logger (Onset Computer Corporation, Bourne, Massachusetts) placed nearby to record ambient temperature.

We planned to collect trunk segments from their outdoor locations in the spring just before temperatures were regularly warm enough for the insects to continue their development to adults (approximately 15 °C). However, trunk segments were removed from the outdoors in Minnesota on March 25th, 2020. This was done as the University of Minnesota was preparing to shut down and restrict employee travel due to the COVID-19 pandemic. We retrieved the trunk segments ahead of schedule to prevent the loss of data if the travel restrictions were in place past the emergence of *S. galinae* adults. Once removed from the outdoors, all log segments were placed in emergence cages in incubators held at 25 °C and 12:8H L:D cycle. Additionally, we placed a saturated sodium nitrite (NaNO<sub>2</sub>) solution in the base of incubators in Minnesota to aid holding relative humidity between 60 – 70%. We think that low humidity was the reason for poor emergence in the past (see past status reports) so consulted with experts who advised the purchase of special salts to make solutions that would humidify the chambers to appropriate levels. As such, we are slightly over in the supply budget for this part of the project, but still within the total budget overall.

Cages were monitored and emerging adults counted. Several weeks after the last emergence, the bark was peeled off the trunk segments to tally any larvae that failed to develop and any adults that failed to emerge. Some insects showed partial adult morphology and these insects were recorded as failing to eclose.

The parasitoids that overwintered outdoors showed that 50% can survive temperatures down to approximately -6 degrees Fahrenheit, with increasing numbers dying at under-bark temperatures colder than that level. Based on these levels and past climate data, we have been making maps to forecast survival in Minnesota. Our results and maps to date show that 50% will survive in mild winters even up to the northern part of the state, while severe winters like the one of 2013-2014 results in 75%+ survival south of the Twin Cities but almost 100% mortality in International Falls. We have written a draft publication that is being submitted to a scientific journal that we expect to include as a final published product with the final report.

**Activity 3 Status as of May 31, 2021:** N/A

**Final Report Summary:**

The publication detailing the above results was accepted and published and is attached to this report. Most *S. galinae* larvae died after reaching their supercooling point, which occurred at -13F on average. Several larvae, however, initiated freezing but later eclosed, suggesting *S. galinae* may be partially freeze tolerant. Supercooling points were not affected by chilling rate. In the winter of 2019 – 2020, we monitored development of mature *S. galinae* larvae in ash segments above and beneath the snow in three locations in Minnesota. Nearly 100% of *S. galinae* larvae died after air temperatures reached -20F. Using models developed from our data, we forecast eclosion rates of *S. galinae* based on minimum winter temperatures across the range of ash (*Fraxinus* spp.) in North America. Our results indicate that *S. galinae* populations may suffer high overwintering mortality in areas where winter temperatures regularly decrease below -20F, but a small portion of the population may be able to survive lower temperatures.

**ACTIVITY 4:**

**Description: Citizen Engagement and Biosurveillance of EAB**

University of Minnesota Extension will continue to engage volunteers as well as other community groups to monitor EAB with the smoky winged beetle bandit wasp and other early detection techniques. By examining the prey beetles of the smoky winged beetle bandit, *Cerceris fumipennis*, we learn which species of wood-boring beetles, including EAB, are in an area. Early detection techniques, such as looking for fresh woodpecker damage in ash trees, provide volunteers with another tool for identifying EAB infestations in their neighborhoods and communities. A Community Program Specialist will build upon the network of volunteers developed in the previous ENRTF funded project to expand statewide participation, outreach, and educational efforts.

**Summary Budget Information for Activity 4:**

<b>ENRTF Budget:</b>	<del>\$190,425</del>
	<b>\$188,050</b>
<b>Amount Spent:</b>	<b>\$188,050</b>
<b>Balance:</b>	<b>\$ 0</b>

Outcome	Completion Date
1. Train and coordinate volunteers to monitor colonies	09/30/2019
2. Educate and train volunteer groups on EAB early detection methods	06/30/2020
3. Beetles identified and data entered into a Forest Service database	06/10/2020

**Activity 4 Status as of November 30, 2017:**

The program involved **58 volunteers** in the 2017 summer field season, up from 65 in 2016. There were **460 hours** spent on *Cerceris* scouting and biosurveillance, approximately the same as 453 hours in 2016. We had 6 “super volunteers” who contributed a collective total of 222 hours!



Along with monitoring at known *Cerceris fumipennis* sites, volunteers and staff also search new ballfields and suitable habitats for additional *Cerceris fumipennis* wasp nesting sites where future biosurveillance can be conducted. **In summer of 2017, 197 new sites were searched in 84 communities:** Adams, Afton, Altura, Bayport, Becker, Bloomington, Brainerd, Brooklyn Center, Byron, Center City, Chisago City, Claremont, Clear Lake, Clearwater, Cokato, Dassel, Deerwood, Dodge Center, East Bethel, Eden Prairie, Edina, Elba, Elgin, Falcoln Heights, Fountain, Fridley, Garrison, Howard Lake, Kasson, Kellogg, Lake City, Lake Elmo, Lake St. Croix Beach, Lakeland, Lanesboro, Le Roy, Lindstrom, Little Canada, Long Prairie, Mahtomedi, Mantorville, Maple Grove, Maplewood, May Township, Mazeppa, Mendota Heights, Milville, Minneapolis, Nisswa, North Branch, North St. Paul, Oak Park Heights, Oakdale, Onamia, Oronoco, Ostrander, Owatonna, Pine Island, Plymouth, Preston, Racine, Ramsey, Red Wing, Rochester, Rockville, Roseville, Royalton, Sartell, Sauk Rapids, Shoreview, Spring Valley, St. Charles, St. Cloud, St. Louis Park, St. Mary’s Point, St. Paul, Stewartville, Stillwater, Vadnais Heights, Wabasha, Waite Park, White Bear Lake, Zimmerman, and Zumbro Falls. These new sites searched were found within 22 counties: Anoka, Benton, Chisago, Crow Wing, Dakota, Dodge, Fillmore, Goodhue, Hennepin, Meeker, Morrison, Mower, Olmsted, Ramsey, Sherburne, Stearns, Steele, Todd, Wabasha, Washington, Winona, and Wright.

From all this searching, a total of **30 new *Cerceris* nesting sites were found** (29 last year). Currently there are a total of 86 known *Cerceris fumipennis* nesting sites around Minnesota.

Biosurveillance was conducted at 32 biosurveillance sites in 23 different cities: Afton, Bloomington, Brooklyn Center, Eden Prairie, Frontenac, Garrison, Lake St. Croix Beach, Lakeland, Marine on St. Croix, Minnetonka, Nisswa, Oakdale, Red Wing, Rochester, Rockville, Scandia, Shoreview, St. Paul, Taylors Falls, Waite Park, Wayzata, West St. Paul, White Bear Lake, Wyoming. These sites were found within 9 counties: Chisago, Crow Wing, Dakota, Goodhue, Hennepin, Olmsted, Ramsey, Stearns and Washington.

A total of **288 buprestid beetles were captured in the summer of 2017** (up from 183 in 2016). These will be identified.

EAB was captured from the smoky winged beetle bandit wasps at 3 sites by volunteers this field season:

- Two EAB was recovered at Zumbro South field in Rochester: one on 7/13/17 and one on 7/19/17

- One EAB was recovered at Turtle Lake Elementary School in Shoreview on 7/14/17
- Four EAB were recovered from Galtier Elementary School in St. Paul on 7/27/17 and 7/31/17

Two of the largest known *Cerceris fumipennis* nesting sites are found along the St. Croix River corridor (Marine on St. Croix and Taylors Falls). With EAB spreading north up the Mississippi River from Houston and Winona counties, these sites near the St. Croix River will be strategic sites to monitor in the future. The large colony size at these sites also support the collection of statistically significant numbers of buprestid beetles as well as volunteer satisfaction.

Three of the summer field trainings took place out of the metro area in areas of high EAB risk (St. Cloud area and Brainerd Lakes area). Having volunteers monitor these greater Minnesota sites for the presence of EAB creates a cadre of master volunteers who can act as EAB educators and natural resource advocates in their communities. As they share stories about their biosurveillance volunteer work with their neighbors and friends they help carry the message of EAB prevention, signs and symptoms, and treatment to their sphere of influence.

**Activity 4 Status as of May 31, 2018:**

The winter was spent identifying many of the 288 specimens captured in the summer of 2017. A total of 39 different species were identified (including emerald ash borer). A list of the determinations by county is provided here:

**CHISAGO COUNTY**

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Agilus bilineatus</i> (Weber)	1
<i>Agilus liragus</i> (Barter & Brown)	1
<i>Agilus obsoletoguttatus</i> (Gory)	4
<i>Agilus pensus</i> (Horn)	1
<i>Agilus politus</i> (Say)	3
<i>Actenodes simi</i> (Fisher)	1
<i>Agilus</i> sp.	5
<i>Agilus nigricans</i> (Gory)	1
<i>Agilus obsoletoguttatus</i> (Gory)	2
<i>Brachys ovatus</i> (Weber)	2
<i>Buprestis consularis</i> (Gory)	2
<i>Buprestis maculativentris</i> (Say)	2
<i>Chrysobothris sexsignata</i> (Say)	1
<i>Chrysobothris shawnee</i> (Wellso & Manley)	2
<i>Chrysobothris viridiceps</i> (Melsheimer)	1
<i>Dicerca asperata</i> (Laporte & Gory)	6
<i>Dicerca caudata</i> (LeConte)	43
<i>Dicerca divaricata</i> (Say)	14
<i>Dicerca tenebrica</i> (Kirby)	7
<i>Dicerca lurida</i> (Fabricius)	8
<i>Eupristocerus cogitans</i> (Weber)	2
<i>Poecilonota cyanipes</i> (Say)	2
<b>Total</b>	<b>111</b>

**CROW WING COUNTY**

<b>Buprestid beetle species</b>	<b># of this species found</b>
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<i>Buprestis maculativentris</i> (Say)	1
<i>Buprestis striata</i> (Fabricius)	2
<i>Dicerca caudata</i> (LeConte)	1
<i>Dicerca divaricata</i> (Say)	1
<i>Dicerca tenebrosa</i> (Kirby)	3
<i>Poecilonota cyanipes</i> (Say)	1
<b>Total</b>	<b>9</b>

#### GOODHUE COUNTY

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Agrilus bilineatus</i> (Weber)	1
<i>Agrilus liragus</i> (Barter & Brown)	3
<i>Agrilus obsoletoguttatus</i> (Gory)	1
<i>Agrilus vittaticollis</i> (Randall)	1
<i>Buprestis consularis</i> (Gory)	3
<i>Chrysobothris viridiceps</i> (Melsheimer)	1
<i>Chrysobothris sexsignata</i> (Say)	2
<i>Dicerca divaricata</i> (Say)	1
<i>Dicerca tenebrica</i> (Kirby)	2
<b>Total</b>	<b>15</b>

#### HENNEPIN COUNTY

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Actenodes acornis</i> (Say)	1
<i>Agrilus bilineatus</i> (Weber)	1
<i>Agrilus carpini</i> (Knull )	1
<i>Agrilus liragus</i> (Barter & Brown )	1
<i>Agrilus quadriguttatus</i> (Gory)	1
<i>Agrilus</i> sp	3
<b>Total</b>	<b>8</b>

#### OLMSTED COUNTY

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Agrilus planipennis</i> (Fairmaire)	2
<i>Chrysobothris femorata</i> (Olivier)	1
<i>Chrysobothris viridiceps</i> (Melsheimer)	1
<i>Dicerca caudata</i> (LeConte)	2
<i>Dicerca tenebrica</i> (Kirby)	1
<i>Poecilonota ferrea</i> (Melsheimer)	1
<i>Spectralia gracilipes</i> (Melsheimer)	1
<b>Total</b>	<b>9</b>

#### RAMSEY COUNTY

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Actenodes acornis</i> (Say)	1
<i>Agrilus egeniformis</i> (Champlain & Knull)	1
<i>Agrilus lecontei</i> (Saunders)	2

<i>Agrilus pensus</i> (Horn)	5
<i>Agrilus planipennis</i> (Fairmaire)	6
<i>Agrilus politus</i> (Say)	6
<i>Agrilus quadriguttatus</i> (Gory)	1
<i>Agrilus</i> sp	2
<i>Buprestis maculativentris</i> (Say)	1
<i>Chrysobothris sexsignata</i> (Say)	1
<i>Dicerca</i> sp.	1
<i>Eupristocerus cogitans</i> (Weber)	1
<b>Total</b>	<b>28</b>

#### STEARNS COUNTY

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Agrilus liragus</i> (Barter & Brown)	1
<i>Buprestis consularis</i> (Gory)	1
<i>Buprestis maculativentris</i> (Say)	2
<i>Dicerca caudata</i> (LeConte)	1
<i>Dicerca divaricata</i> (Say)	3
<i>Dicerca tenebrosa</i> (Kirby)	1
<i>Poecilonota cyanipes</i> (Say)	2
<i>Poecilonota ferrea</i> (Melsheimer)	1
<b>Total</b>	<b>12</b>

#### WASHINGTON COUNTY

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Actenodes acornis</i> (Say)	1
<i>Agrilus anxius</i> (Gory)	1
<i>Agrilus bilineatus</i> (Weber)	7
<i>Agrilus carpini</i> (Knull)	1
<i>Agrilus cliftoni</i> (Knull)	1
<i>Agrilus liragus</i> (Barter & Brown)	12
<i>Agrilus nigricans</i> (Gory)	1
<i>Agrilus</i> sp.	6
<i>Buprestis consularis</i> (Gory)	2
<i>Buprestis striata</i> (Fabricius)	1
<i>Chrysobothris shawnee</i> (Wellso & Manley)	3
<i>Chrysobothris sexsignata</i> (Say)	5
<i>Chrysobothris viridiceps</i> (Melsheimer)	1
<i>Dicerca asperata</i> (Laporte & Gory)	4
<i>Dicerca caudata</i> (LeConte)	16
<i>Dicerca divaricata</i> (Say)	8
<i>Dicerca lurida</i> (Fabricius)	1
<i>Dicerca tenebrica</i> (Kirby)	9
<i>Dicerca tuberculata</i> (Laporte & Gory)	3
<i>Eupristocerus cogitans</i> (Weber)	2
<i>Phaenops aeneola</i> (Melsheimer)	1
<i>Poecilonota cyanipes</i> (Say)	3
<i>Poecilonota ferrea</i> (Melsheimer)	2

<i>Spectralia gracilipes</i> (Melsheimer)	3
<b>Total</b>	<b>96</b>

**Volunteer Appreciation Event**

Each spring, we show appreciation for our Wasp Watcher volunteers by inviting them to visit the Entomology department for a celebration of their accomplishments and a tour of the U of MN Insect Collection. It is a great opportunity to build camaraderie, share wasp watching stories, learn from each other and look ahead to the next wasp watching season. Our volunteer appreciation event this year was on Tuesday, March 13 and was enthusiastically received by our volunteers. Two volunteers even drove down from Brainerd for the event.

**Training**

We have 12 field trainings scheduled for the upcoming weeks from Rochester to Nisswa and are preparing for those.

**Activity 4 Status as of November 30, 2018:**



**2018 Field Season Results**

The Wasp Watchers Program continues to grow as volunteers become more invested and outreach efforts continues to connect with more communities in greater Minnesota. The Wasp Watchers Program saw significant outcome growth in doubling the number of buprestids captured by citizen scientist volunteers. There was an increase in both number of volunteers and number of volunteer hours reported. In addition, the program is drawing new volunteers in new regions of the state. As a population hub, the seven county metro area still draws significant volunteer numbers, but 29 out of the 56 biosurveillance sites were out of the seven county metro area. Wasp Watcher volunteers are monitoring sites in larger Minnesota cities such as Rochester, Mankato, St. Cloud, and Brainerd.

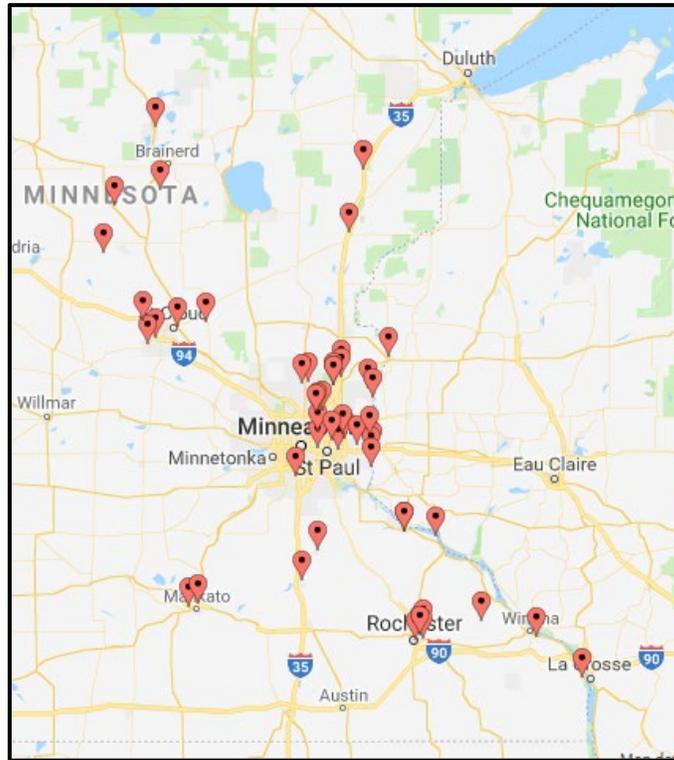
The program involved a total of **71 volunteers** in the 2018 summer field season, an increase from the 58 one year prior. They were able to contribute **585 hours of volunteer time** (up from 460 last year). Honorable mention is given to four “Super Volunteers” who contributed 221 hours of their time!

The Wasp Watchers Program collected **659 buprestid beetles** in the summer of 2018 (vs. 288 in 2017). Of these 659 beetles, **36 were emerald ash borer**. There were multiple EAB finds at wasp nesting sites (ballfields). This list indicates only the first finds at each site.

- Wakondiota Park, Frontenac on 6/28/2018
- Flicek Park, Maplewood on 7/7/2018
- La Crescent-Hokah Middle School, La Crescent on 7/9/2018
- Battle Creek Middle Schol, St. Paul on 7/10/2018
- Quarry Hill ballfield, Rochester on 7/10/2018
- Austin Park, Circle Pines on 7/11/2018
- Golden Lake Elementary School, Circle Pines on 7/11/2018
- East Park, Rochester on 7/16/2018

- Elba ballfield, Elba on 7/17/2018
- Emerald Hills Park, Rochester, 7/17/2018

Overall, **biosurveillance was conducted at 56 sites in 40 communities:** Afton, Bayport, Bloomington, Burnsville, Circle Pines, Collegeville, Columbus, Cushing, Duellm, Elba, Faribault, Frontenac, Ham Lake, Hinckley, Lake Elmo, Lake St. Croix Beach, Lakeland, La Crescent, Lino Lakes, Mankato, Maplewood, Marine on St. Croix, Nisswa, North Mankato, Northfield, Oakdale, Red Wing, Rochester, Rockville, Roseville, Scandia, Shoreview, St. Cloud, St. Mathias Township, St. Paul, Swansville, Taylors Falls, Willow River, Winona, Wyoming. These sites covered **19 counties across Minnesota:** Anoka, Benton, Blue Earth, Chisago, Crow Wing, Dakota, Goodhue, Hennepin, Houston, Morrison, Nicollet, Olmsted, Pine, Ramsey, Rice, Sherburne, Stearns, Washington, Winona.



**Map of 2018 Biosurveillance sites**



Conservation Corps members conduct biosurveillance at St. John's Prep school ballfield in Collegeville.

Along with monitoring at known *Cerceris fumipennis* sites, volunteers and staff also search new ballfields and suitable habitats for additional *Cerceris fumipennis* wasp nesting sites where future biosurveillance can be conducted. In the summer of 2018, **196 new sites searched in 88 communities:** Albany, Andover, Bellechester, Big Lake, Blaine, Bloomington, Buckman, Caledonia, Cannon Falls, Chisago City, Circle Pines, Cleveland, Cold Spring, Collegeville, Columbus, Cottage Grove, Cushing, Dakota, Duelm, Dundas, Eitzen, Faribault, Foley, Forest Lake, Fort Ripley, Golden Valley, Goodview, Ham Lake, Hastings, Hayfield, Hillman, Hinckley, Howard Lake, Inver Grove Heights, Jenkins, Kasota, Kenyon, La Crescent, Lake Elmo, Lastrup, Le Center, La Crescent, Lent Township, Lexington, Lindstrom, Lino Lakes, Little Falls, Mahtomedi, Mankato, Maplewood, Medford, Minnesota City, Montgomery, Nerstrand, Newport, North Mankato, Northfield, Oakdale, Pequot Lakes, Pickwick, Pierz, Red Wing, Rochester, Rollingstone, Royalton, Sandstone, Sartell, Spring Grove, St. Anna, St. Charles, St. Joseph, St. Louis Park, St. Mathias township, St. Paul, St. Wendell township, Stacy, Swanville, Upsala, Waite Park, Waverly, West Concord, White Bear Lake, White Bear Township, Willow River, Winona, Woodbury, Wyoming. These new sites searched were found within **23 counties:** Anoka, Benton, Blue Earth, Chisago, Crow Wing, Dakota, Dodge, Goodhue, Hennepin, Houston, Le Sueur, Morrison, Nicollet, Olmsted, Pine, Ramsey, Rice, Sherburne, Stearns, Steele, Washington, Winona, and Wright.

In total, there were **40 new *Cerceris* nesting sites found** (up from 30 last year). Currently there are a total of 121 known *Cerceris fumipennis* nesting sites around Minnesota.

**Summary: Wasp Watchers growth from 2017 to 2018**

Areas of Growth	2017	2018
Number of buprestid beetles captured	288	659
Number of sites monitored	32	56
Number of communities with biosurveillance sites	23	40
Number of volunteers	58	71
Number of volunteer hours	460	585

Areas of keen interest for next year include 1.) Sites near the St. Cloud area along the Interstate 94 corridor (Rockville, Collegeville, St. Cloud), 2.) Sites along the Interstate 35 North corridor (Hinckley & Willow River), 3.) Sites along the St. Croix River corridor (Marine on St. Croix and Taylors Falls). These transportation and river way corridors are logical places to watch for natural and human-caused EAB spread.

**Activity 4 Status as of May 31, 2019:**

As summarized in the previous update, Wasp Watcher volunteers monitored 56 wasp nesting sites in the state of Minnesota in the summer of 2018 and captured 676 buprestid beetles, more than double the number of beetles captured in 2017. EAB were found at 10 monitored sites. Due to the great increase in beetles collected, we are still identifying the specimens.

### **Volunteer Appreciation Event**

The Wasp Watchers Program hosted a Volunteer Appreciation event on Tuesday, March 19<sup>th</sup> to recognize the time and energy our citizen scientist volunteers have committed to the program. Volunteers were invited to visit the Entomology department for a celebration of their accomplishments and a tour of the University of Minnesota Insect Collection. It was an opportunity to share the data collected and results of our field season, exchange wasp watching stories, and plan ahead for the next wasp watching season.

### **Upcoming Summer Trainings:**

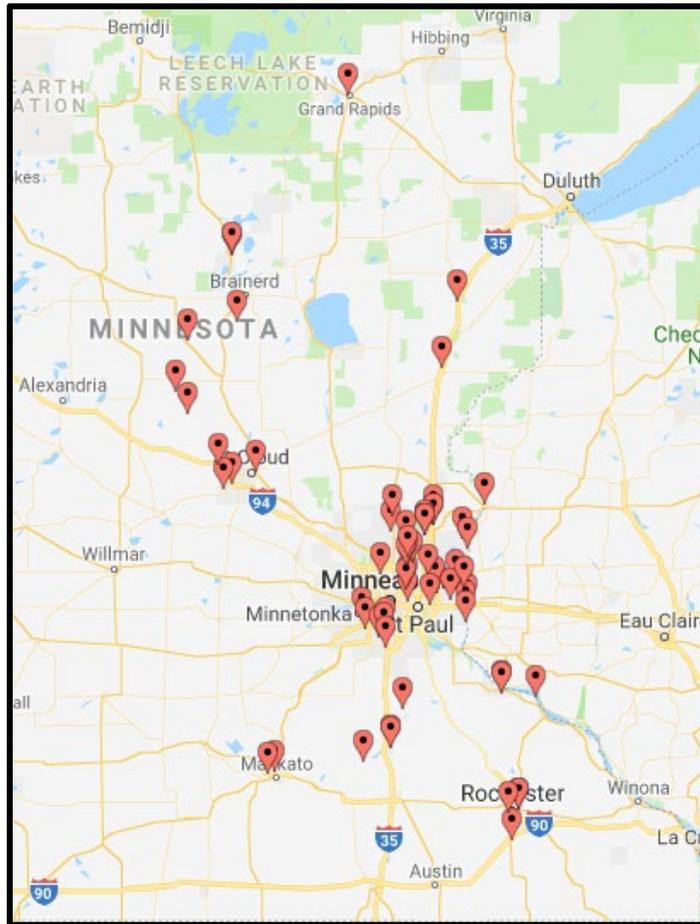
During this reporting period the Wasp Watchers program staff has scheduled and prepared for 18 Wasp Watchers field trainings in July of 2019. These trainings are open to the public and are listed on the [Wasp Watchers website](#) under News and Events. Pre-registration is requested.

- Saturday, July 6 at Forest Heights Park, North Mankato at 1:00-2:30pm
- Sunday, July 7: Pine Island 5-12 School, Pine Island, 11:00am-12:30pm
- Sunday, July 7: Herb Vik Athletic Field, Mazeppa, 1:00-2:30pm
- Monday, July 8 at Wakondiotia Park, Frontenac at 11:00am-12:30pm
- Monday, July 8 at Twin Bluff Middle School, Red Wing at 1:00-2:30pm
- Tuesday, July 9 at Monroe School, North Mankato at 1:00-2:30pm
- Wednesday, July 10 at Tolzmann Park, Wyoming at 1:00-2:30pm
- Thursday, July 11 at Rice Lake Elementary, Lino Lakes at 1:00-2:30pm
- Friday, July 12 at City Park, Upsala at 11:00am-12:15pm
- Friday, July 12 at Swanville Elementary School, Swanville at 12:30pm-1:45pm
- Friday, July 12 at Cushing Community Park, Cushing at 2:15pm-3:30pm
- Saturday, July 13 at Marine Elementary, Marine on St. Croix at 1:00-2:30pm
- Sunday, July 14 at Minnesota State Academy for the Deaf, Faribault at 1:00pm
- Monday, July 15 at Taylors Falls Elementary School, Taylors Falls at 1:00-2:30pm
- Tuesday, July 16 at Willow River ballfields at 1:00-2:30pm
- Friday, July 19 at John Clark Elementary School, Rockville at 1:00-2:30pm
- Sunday, July 21 at Nisswa Elementary School at 1:00-2:30pm
- Monday, July 22 at St. Mathias park, St. Mathias at 1:00-2:30pm

### **Activity 4 Status as of November 30, 2019:**

#### **Biosurveillance Sites:**

- There were 65 sites where biosurveillance for emerald ash borer was conducted. These biosurveillance sites were found in 45 different communities: Afton, Bayport, Blaine, Bloomington, Brooklyn Park, Burnsville, Cedar, Circle Pines, Collegeville, Columbus, Cushing, Eden Prairie, Faribault, Frontenac, Grand Rapids, Ham Lake, Hinckley, Lake Elmo, Lake St. Croix Beach, Lakeland, Lino Lakes, Marine on St. Croix, Maplewood, Minnetonka, Morristown, Nisswa, North Mankato, Northfield, Oakdale, Red Wing, Rochester, Rockville, Roseville, Scandia, Shoreview, St. Cloud, St. Mathias Township, St. Paul, Stewartville, Stillwater, Taylors Falls, Upsala, White Bear Lake, Willow River, Wyoming
- These sites were found within 16 counties: Anoka, Chisago, Crow Wing, Dakota, Goodhue, Hennepin, Itasca, Morrison, Nicollet, Olmsted, Pine, Ramsey, Rice, Sherburne, Stearns, Washington



*Map of 2019 Biosurveillance sites*

**Volunteers**

There were 72 volunteers engaged in 762 hours of wasp watching activities during 9 weeks this summer (from June 28-August 23). This is an increase from 585 volunteer hours in 2018.



**Collections**

The Wasp Watchers Program collected 1063 buprestid beetles (metallic, wood boring beetles) at 65 biosurveillance sites. This is an increase from 676 beetles collected at 56 sites in 2018.

**EAB found in 2019 with biosurveillance:**

- EAB was captured from the smoky winged beetle bandit wasps at 6 sites this field season.
- These sites were: **Anoka County:** Golden Lake Elementary School (Circle Pines), Rice Lake Elementary School (Lino Lakes); **Olmsted County:** Bamber Valley Elementary School (Rochester), Mayo High School (Rochester), Meadow Park (Stewartville) **Ramsey County:** Galtier Elementary School (St. Paul)

**Searching for new sites to monitor**

Along with monitoring at known *Cerceris fumipennis* sites, volunteers and staff also search new ballfields and suitable habitats for additional *Cerceris fumipennis* wasp nesting sites where future biosurveillance can be conducted.

- New sites searched for the presence of *Cerceris fumipennis*: **145 sites searched, in 80 communities:** Afton, Albert Lea, Albertville, Alden, Altura, Avon, Bejou, Bemidji, Blaine, Blooming Prairie, Breezy Point, Burnsville, Callaway, Cass Lake, Cedar, Center City, Chatfield, Cokato, Conger, Dassel, Dayton, Denmark, Eagan, Eagle Lake, Elbow Lake, Ellendale, Ely, Elysian, Emmons, Erskine, Farmington, Finlayson, Flensburg, Foley, Foreston, Fountain, Grand Rapids, Ham Lake, Hayward, Hinckley, Inver Grove Heights, Keewatin, Lake Crystal, Lakeville, Lanesboro, Lewiston, Lino Lakes, Little Falls, Madison Lake, Mankato, Maple Grove, Midway, Morristown, New Hope, New London, Newfolden, Newport, Nowthen, Ortonville, Otsego, Pine City, Plymouth, Racine, Rice, Ridgeway, Rochester, Rogers, Rutledge, Spring Valley, St. Charles, St. Michael, Sunbury, Tower, Upsala, Utica, Verndale, Wanamingo, Winona, Woodbury, Zumbrota.
- These new searches took place in **36 counties:** Anoka, Becker, Beltrami, Benton, Big Stone, Blue Earth, Cass, Chisago, Crow Wing, Dakota, Dodge, Fillmore, Freeborn, Goodhue, Grant, Hennepin, Itasca, Kandiyohi, Le Sueur, Mahnommen, Marshall, Meeker, Mille Lacs, Morrison, Mower, Olmsted, Pine, Polk, Rice, St. Louis, Stearns, Steele, Wadena, Washington, Winona, Wright
- Currently there are a total of 144 known *Cerceris fumipennis* nesting sites around Minnesota

**Additional highlights**

- Most northern *Cerceris* nesting site in recent years was found in **Grand Rapids** (Itasca County) in July at latitude 47.225761. Previously, most northern site was Nisswa at latitude 46.519723.
- Once again in 2019, the Wasp Watchers Program continues to grow. Volunteers are becoming more and more invested. While the number of volunteers did not grow this year, the number of hours increased by 30%.
- Volunteers reported they often educate the public during biosurveillance. While they are visiting their ballfield sites, often dog-walkers or visitors to parks will inquire what the volunteers are doing with insect collecting equipment. Wasp Watcher volunteers then share their knowledge about emerald ash borer and the process of biosurveillance and engage the public in conversations about invasive species management.

***Wasp Watchers Growth***

Areas of Growth	2017	2018	2019
Number of buprestid beetles captured	288	659	1063
Number of sites monitored	32	56	65
Number of communities with biosurveillance sites	23	40	45
Number of volunteers	58	71	72
Number of volunteer hours	460	585	762

Due to the increase in collected buprestids and time needed for the identification process, the 2018 species identification was not included in the May 2019 Update. Here is the preliminary list of identified buprestid beetles from the 2018 field season:

**ANOKA COUNTY**

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Actenodes acornis</i> (Say)	1
<i>Agrilus anxius</i> (Gory)	3
<i>Agrilus arcuatus</i> (Say)	2
<i>Agrilus bilineatus</i> (Weber)	2
<i>Agrilus difficilis</i> (Gory)	1
<i>Agrilus liragus</i> (Barter & Brown)	2
<i>Agrilus planipennis</i> (Fairmaire)	1
<i>Agrilus politus</i> (Say)	1
<i>Agrilus</i> species	3
<i>Buprestis maculativentris</i> (Say)	1
<i>Dicerca caudata</i> (LeConte)	3
<i>Dicerca divaricata</i> (Say)	3
<i>Dicerca lurida</i> (Fabricius)	1
<i>Dicerca tenebrica</i> (Kirby)	4
<i>Poecilonota cyanipes</i> (Say)	1
<i>Spectralia gracilipes</i> (Melsheimer)	1
<b>Total</b>	<b>30</b>

**BENTON COUNTY**

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Dicerca tenebrica</i> (Kirby)	1
<b>Total</b>	<b>1</b>

**BLUE EARTH COUNTY**

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Actenodes acornis</i> (Say)	1
<i>Agrilus difficilis</i> (Gory)	1
<i>Agrilus quadriguttatus</i> (Gory)	1
<i>Dicerca divaricata</i> (Say)	1
<b>Total</b>	<b>4</b>

**CHISAGO COUNTY**

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Agrilus anxius</i> (Gory)	1
<i>Agrilus arcuatus</i> (Say)	7
<i>Agrilus liragus</i> (Barter & Brown)	9
<i>Agrilus obsoletoguttatus</i> (Gory)	1
<i>Agrilus politus</i> (Say)	1
<i>Agrilus</i> species	1
<i>Buprestis consularis</i> (Gory)	3
<i>Buprestis maculativentris</i> (Say)	2
<i>Buprestis striata</i> (Fabricius)	4
<i>Chrysobothris femorata</i> (Olivier)	4

<i>Chrysobothris azurea</i> (LeConte)	1
<i>Chrysobothris cribraria</i> (Mannerheim)	1
<i>Chrysobothris sexsignata</i> (Say)	4
<i>Chrysobothris species</i>	1
<i>Dicerca asperata</i> (Laporte & Gory)	1
<i>Dicerca caudata</i> (LeConte)	4
<i>Dicerca divaricata</i> (Say)	27
<i>Dicerca lurida</i> (Fabricius)	3
<i>Dicerca tenebrica</i> (Kirby)	11
<i>Eupristocerus cogitans</i> (Weber)	3
<i>Phaenops aeneola</i> (Melsheimer)	1
<i>Poecilonota cyanipes</i> (Say)	11
<b>Total</b>	<b>101</b>

**CROW WING COUNTY**

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Agrilus arcuatus</i> (Say)	1
<i>Brachys ovatus</i> (Weber)	1
<i>Buprestis striata</i> (Fabricius)	1
<i>Chrysobothris rotundicollis</i> (Gory and Laporte)	1
<i>Dicerca caudata</i> (LeConte)	10
<i>Dicerca divaricata</i> (Say)	5
<i>Dicerca tenebrica</i> (Kirby)	11
<i>Dicerca tenebrosa</i> (Kirby)	3
<i>Poecilonota cyanipes</i> (Say)	2
<i>Poecilonota ferrea</i> (Melsheimer)	2
<b>Total</b>	<b>37</b>

**GOODHUE COUNTY**

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Actenodes acornis</i> (Say)	1
<i>Agrilus bilineatus</i> (Weber)	1
<i>Agrilus liragus</i> (Barter & Brown)	1
<i>Agrilus obsoletoguttatus</i> (Gory)	2
<i>Buprestis consularis</i> (Gory)	2
<i>Chrysobothris femorata</i> (Olivier)	1
<i>Chrysobothris sexsignata</i> (Say)	1
<i>Chrysobothris viridiceps</i> (Melsheimer)	2
<i>Dicerca caudata</i> (LeConte)	4
<i>Dicerca divaricata</i> (Say)	3
<i>Dicerca tenebrica</i> (Kirby)	3
<i>Spectralia gracilipes</i> (Melsheimer)	1
<b>Total</b>	<b>22</b>

**HENNEPIN COUNTY**

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Chrysobothris viridiceps</i> (Melsheimer)	1
<b>Total</b>	<b>1</b>

**HOUSTON COUNTY**

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Chrysobothris sexsignata</i> (Say)	1
<b>Total</b>	<b>1</b>

**MORRISON COUNTY**

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Agrilus anxius</i> (Gory)	1
<i>Agrilus obsoletoguttatus</i> (Gory)	1
<i>Agrilus</i> species	1
<i>Dicerca caudata</i> (LeConte)	8
<i>Dicerca divaricata</i> (Say)	12
<i>Dicerca lurida</i> (Fabricius)	1
<i>Dicerca tenebrica</i> (Kirby)	6
<i>Dicerca tenebrosa</i> (Kirby)	3
<i>Poecilonota cyanipes</i> (Say)	1
<i>Poecilonota ferrea</i> (Melsheimer)	7
<b>Total</b>	<b>41</b>

**NICOLLET COUNTY**

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Chrysobothris femorata</i> (Olivier)	1
<b>Total</b>	<b>1</b>

**OLMSTED COUNTY**

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Agrilus arcuatus</i> (Say)	2
<i>Agrilus bilineatus</i> (Weber)	4
<i>Agrilus difficilis</i> (Gory)	1
<i>Agrilus planipennis</i> (Fairmaire)	10
<i>Agrilus</i> species	1
<i>Chrysobothris azurea</i> (LeConte)	1
<i>Chrysobothris sexsignata</i> (Say)	1
<i>Chrysobothris viridiceps</i> (Melsheimer)	2
<i>Dicerca caudata</i> (LeConte)	1
<i>Dicerca divaricata</i> (Say)	2
<i>Spectralia gracilipes</i> (Melsheimer)	2
<b>Total</b>	<b>27</b>

**PINE COUNTY**

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Dicerca tenebrica</i> (Kirby)	3
<b>Total</b>	<b>3</b>

**RAMSEY COUNTY**

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Actenodes acornis</i> (Say)	1
<i>Agrilus anxius</i> (Gory)	1
<i>Agrilus arcuatus</i> (Say)	6
<i>Agrilus difficilis</i> (Gory)	2

<i>Agrilus granulatus</i> (Say)	1
<i>Agrilus liragus</i> (Barter & Brown)	1
<i>Agrilus planipennis</i> (Fairmaire)	23
<i>Agrilus quadriguttatus</i> (Gory)	2
<i>Buprestis consularis</i> (Gory)	1
<i>Buprestis maculativentris</i> (Say)	1
<i>Buprestis striata</i> (Fabricius)	1
<i>Chrysobothris femorata</i> (Olivier)	3
<i>Chrysobothris sexsignata</i> (Say)	1
<i>Chrysobothris viridiceps</i> (Melsheimer)	1
<i>Dicerca caudata</i> (LeConte)	1
<i>Dicerca divaricata</i> (Say)	2
<i>Dicerca tenebrica</i> (Kirby)	1
<i>Dicerca tenebrosa</i> (Kirby)	1
<i>Poecilonota cyanipes</i> (Say)	1
<b>Total</b>	<b>51</b>

#### RICE COUNTY

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Actenodes acornis</i> (Say)	1
<i>Dicerca lurida</i> (Fabricius)	1
<b>Total</b>	<b>2</b>

#### SHERBURNE COUNTY

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Agrilus arcuatus</i> (Say)	1
<i>Agrilus</i> species	2
<i>Buprestis consularis</i> (Gory)	1
<i>Dicerca tenebrica</i> (Kirby)	1
<b>Total</b>	<b>5</b>

#### STEARNS COUNTY

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Agrilus liragus</i> (Barter & Brown)	1
<i>Agrilus quadriguttatus</i> (Gory)	1
<i>Agrilus</i> species	1
<i>Buprestis consularis</i> (Gory)	5
<i>Buprestis maculativentris</i> (Say)	9
<i>Chrysobothris viridiceps</i> (Melsheimer)	1
<i>Dicerca caudata</i> (LeConte)	6
<i>Dicerca divaricata</i> (Say)	7
<i>Dicerca tenebrica</i> (Kirby)	1
<i>Dicerca tenebrosa</i> (Kirby)	18
<i>Poecilonota cyanipes</i> (Say)	1
<b>Total</b>	<b>51</b>

#### WASHINGTON COUNTY

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Actenodes simi</i> (Fisher)	1

<i>Agrilus anxius</i> (Gory)	1
<i>Agrilus arcuatus</i> (Say)	4
<i>Agrilus bilineatus</i> (Weber)	2
<i>Agrilus carpini</i> (Knull)	1
<i>Agrilus difficilis</i> (Gory)	2
<i>Agrilus liragus</i> (Barter & Brown)	4
<i>Agrilus obsoletoguttatus</i> (Gory)	2
<i>Agrilus politus</i> (Say)	1
<i>Agrilus quadriguttatus</i> (Gory)	4
<i>Agrilus</i> species	15
<i>Brachys ovatus</i> (Weber)	1
<i>Buprestis consularis</i> (Gory)	3
<i>Buprestis striata</i> (Fabricius)	10
<i>Chrysobothris femorata</i> (Olivier)	1
<i>Chrysobothris sexsignata</i> (Say)	3
<i>Chrysobothris viridiceps</i> (Melsheimer)	1
<i>Dicerca asperata</i> (Laporte & Gory)	15
<i>Dicerca caudata</i> (LeConte)	22
<i>Dicerca divaricata</i> (Say)	30
<i>Dicerca lurida</i> (Fabricius)	3
<i>Dicerca tenebrica</i> (Kirby)	17
<i>Dicerca tenebrosa</i> (Kirby)	3
<i>Phaenops aeneola</i> (Melsheimer)	1
<i>Poecilonota cyanipes</i> (Say)	7
<i>Poecilonota ferrea</i> (Melsheimer)	2
<b>Total</b>	<b>156</b>

#### WINONA COUNTY

<b>Buprestid beetle species</b>	<b># of this species found</b>
<i>Agrilus planipennis</i> (Fairmaire)	1
<i>Dicerca asperata</i> (Laporte & Gory)	2
<i>Dicerca lurida</i> (Fabricius)	4
<i>Dicerca tenebrica</i> (Kirby)	1
<i>Poecilonota ferrea</i> (Melsheimer)	1
<b>Total</b>	<b>9</b>

We gave two academic conference presentations this fall, and are preparing these results for scientific publication. The lead graduate student completed her MS degree and has now joined the Peace Corps in Senegal, West Africa where she is working with communities.



*Wasp watching with families*

**Activity 4 Status as of November 30, 2020:**

In the past year, we focused on sunseting the extremely successful Wasp Watchers program. Collected materials have been organized and collated with records and will be incorporated into the University research collection when the pandemic allows access to the University again.

We submitted two scientific publications based on the graduate student research on jewel beetle [buprestid] surveillance. Both were accepted and will appear in the coming months! The first, appearing shortly in the journal *Environmental Entomology*, details factors that influence buprestid biodiversity in Minnesota. We report 1,939 beetles collected as part of the research component of the project, consisting of 11 genera and 51 species including nine new state records. Beetles in the genus *Agilus* represented the most common genus collected, followed by *Dicera*. We found that species richness tended to decrease in sites with many emerald ash borers, which may reflect a tendency of wasps to return preferentially to high-density infestations of emerald ash borers. We also found that buprestid biodiversity tended to increase with the number of dead trees within a 200m radius of the *Cerceris* nesting sites. Comparatively little research has been done on biodiversity of insects other than pollinators in the urban environment, so our work helps understand what species richness exists in the trees and how the continued invasion of emerald ash borer might affect insect arboreal communities.

In the second publication, to appear shortly in *The Coleopterists Bulletin*, we integrated collections of jewel beetles from Wasp Watchers with specimens from the University of Minnesota Insect Research Collection to create an exhaustive checklist of 5,127 specimens documenting 107 species present in the state – including new records collected as part of Wasp Watchers. This list includes notes on host plants, collection method, and collection date range with associated maps. This work is important to give us a baseline of jewel-beetles present now and provides a reference point in case another invasive wood-borer like emerald ash borer arrives to the state.

We will include copies of both publications in the final report when they appear in print (est. December 2020 and March 2021).

**Activity 4 Status as of May 31, 2021: N/A**

**Final Report Summary:** Both publications referenced above have been published and are attached to this report. We are also very pleased to share a FREE non-academic publication on *The Jewel Beetles of Minnesota* that details not only the complete checklist from the scientific publication but also maps showing numbers of beetles collected and latest year collected (going back to 1880 using museum specimens). This work can be found on this permalink: <https://hdl.handle.net/11299/218928>

We have already been making good use of the guide as new collections are compared to the checklist to see if new wood-boring species are introduced to our state. Please feel free to download, share, and use the guide!

## **V. DISSEMINATION:**

**Description:** We will communicate about biocontrol of EAB and our citizen science effort of biosurveillance with the public, land managers and researchers. Webpages will be used for communication

<http://www.mda.state.mn.us/plants/pestmanagement/eab/eabbiocontrol.aspx> of activities and outcomes and will be updated bi-annually. Communication with the public will be via news media (television, print and radio) and social media with Facebook and Twitter. Updates will be communicated with land managers at the multi-agency and open to the public EAB Forum meetings (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 the 2018 Upper Midwest Invasive Species Conference and other meetings (LCCMR funding will not be used for meetings).

### **Status as of November 30, 2017:**

#### **EAB biocontrol presentations**

- Osthus, J. et al. Implementation of Biological Control of Emerald Ash Borer in Minnesota. Presented to attendees of the workshop on the Future of Ash Forests on 7/26/17. Over 170 people attended the workshop held in Duluth.
- Osthus, J. et al. Implementation of Biological Control of Emerald Ash Borer in Minnesota. Angie Ambourn presented to attendees of the Metropolitan Mosquito Control District annual training for employees on 7/26/17. Covered in the presentation was the basics of biocontrol, implementation, how mosquito control efforts might overlap in areas where MDA is doing biocontrol and in what manner to coordinate those efforts.
- EAB biocontrol was included as a topic on the Minnesota Invasive Species Advisory Council tour held in Duluth on 9/12/17. Jonathan Osthus gave an informal presentation to tour participants at Hartley Park, the first biocontrol release site initiated in Duluth.
- Jenifer Burington gave presentations on the biology and management of emerald ash borer including biocontrol to the city of Woodbury on 9/20/17 and Martin County on 11/14/17. The presentations were well attended with approximately 30 city staff at the Woodbury presentation and over 40 attendees at the Martin County presentation.



*Figure. Workshop for Wasp Watcher volunteers at Robert's Bird Sanctuary.*

### **Media**

- Duluth News Tribune, Fox21 and WDIO ABC EYEWITNESS NEWS interviewed Jonathan Osthus on 7/27/17 for a media event highlighting EAB biocontrol work being done at Hartley Park in Duluth.

### **Wasp Watchers outreach presentations**

- Eleven biosurveillance trainings were held in July and August. Forty-nine participants came from a variety of backgrounds: master gardeners, master naturalists, families with youth, and city and county natural resource professionals.
- August 22, 2017: Workshop for Wasp Watcher volunteers on EAB Biocontrol (co-hosted by MDA and U of MN Extension). Attendees were dedicated Wasp Watcher volunteers seeking more information on strategies used in managing EAB. These volunteers become community educators and advocates.

### **Other**

- The bi-monthly EAB Forum was held on 9/7/17 at the MDA in which status updates on survey, regulation, biocontrol, outreach and research were given to cooperators around the state.

### **Status as of May 31, 2018:**

#### **EAB biocontrol presentations**

- Mallet, C. et al. EAB biocontrol basics presented to public works staff at city of Lino Lakes on 12/14/2017.
- Mallet, C. et al. EAB biocontrol basics presented to public works staff at city of Lakeville on 12/15/2017.
- Mallet, C. et al. EAB biocontrol basics presented to public works staff at city of Eden Prairie on 12/19/2017.
- Mallet, C. et al. EAB biocontrol basics presented to natural resource managers at EAB regional meeting near St. Cloud on 1/30/2018 and in Mankato on 2/8/2018.

#### **EAB Field Workshops**

- EAB Field workshops were hosted in Lakeville 3/19/18 – 3/23/18 and Duluth 4/3/18 – 4/5/18. EAB early detection, management (including biocontrol), and reporting were discussed during hour long sessions with 2 to 3 held each day.

#### **Wasp Watchers outreach presentations**

- Wasp Watchers staff presented at 7 meetings or conferences including EAB regional meetings, a citizen science webinar, county Master Gardener and Master Naturalist volunteer groups, Central Minnesota Audubon chapter, St. Croix River Association Speaker series, and Gathering Partners for Natural Resources

conference. There were 135 participants at these events and the webinar was recorded and posted online for future access (28 views to date).

### **Biosurveillance Research presentations**

- The graduate student amended on Activity 4, Marie Hallinen, was able to present some of her work on diversity of woodboring beetles found in Minnesota at the national scientific meeting of the Entomological Society of America in December of 2017. Her research presentation was entitled, “What can biosurveillance about emerald ash borer tell us? Robbing the smokey winged beetle bandit wasp in Minnesota.” Marie won a President’s Prize (first place) in the Invasive Species division, highlighting the quality of this work and LCCMR’s investment in biological control and biosurveillance.

### **Other**

- The EAB forums hosted by MDA were held on 12/7/17 and 4/12/18. Status updates on survey, regulation, biocontrol, outreach and research were given to stakeholders around the state.
- The Wasp Watchers Program created and distributed the 2017 Field Report which is shared with volunteers and supporters of the Wasp Watchers program.

### **Status as of November 30, 2018:**

#### **EAB biocontrol presentations**

- Chris Mallet presented “EAB biological control and parasitoid recovery in Minnesota” at the Upper Midwest Invasive Species Conference on 10/16/18.
- Jonathan Osthus presented “EAB biocontrol basic overview” to public works staff in Golden Valley, MN on 11/20/18.

#### **Wasp Watchers outreach presentations**

- Classroom presentation for 20 Master Naturalist Volunteers in June 2018.
- 11 Field trainings this summer with 56 participants in Rochester, Frontenac, Wyoming, Shoreview, Rockville, Taylors Falls, Marine on St. Croix, St. Paul, Maplewood and Nisswa. The participants came from a variety of backgrounds: Master Gardeners, Master Naturalists, families with youth, and city or county natural resource professionals.
- Wasp Watcher presentation at the Citizen Science Symposium hosted by U of MN Extension and Science Museum with 82 participants on 11/28/18.

### **Biosurveillance Research presentations**

- The graduate student on Activity 4, Marie Hallinen, presented her work at two conferences:
  - Upper Midwest Invasive Species conference, October 15-18, Rochester MN
  - Entomological Society of America conference, November 11-15, Vancouver, BC
  - Both presentations were well received as this is the first systematic approach to augment citizen science with museum records to create a checklist of woodboring beetles in the state. Personnel from federal agencies in both the United States and Canada were very interested in this surveillance tool, how it located early infestations of emerald ash borer, and any new insect threats that might be identified.

### **Status as of May 31, 2019:**

#### **EAB biocontrol presentations**

- Mallet, C. et al. Status of EAB biocontrol in Minnesota update given at MN DNR Forestry 2019 Forest Health Workshop, Walker, MN on 2/5/2019.

- Mallet, C. et al. EAB biocontrol basics presentation given at EAB regional meetings held in Detroit Lakes and St. Paul, MN on 2/27/2019 and 3/5/2019.

#### **EAB field workshops**

- Osthus, J. et al. EAB biocontrol basics presentations given at field workshops held in Clearwater, Duluth and Minneapolis. (3/25/19 - 3/27/19 Minneapolis), (12/20/18 & 3/28/19 - 3/29/19 Clearwater) and (4/2/19 - 4/4/19 Duluth)

#### **Other**

- Updates were made to the EAB biocontrol webpages that included consolidation of parasitoid wasp pages, updated release numbers and creation of new page with a summary of EAB Biocontrol Phase 3.

#### **Wasp Watcher Outreach**

- Wasp Watchers staff presented at four meetings or conferences including a MDA EAB webinar, county Master Gardener and Master Naturalist volunteer groups, and the Natural Resources Symposium hosted by the Natural Resource Association of Graduation Students at the University of Minnesota. There was a total of 355 participants at these events.
- The Wasp Watchers Program created and distributed the 2018 Field Report which is shared with volunteers and supporters of the Wasp Watchers program. Copies available upon request!

#### **Status as of November 30, 2019:**

##### **EAB biocontrol presentations**

- Osthus, J. et al. EAB and EAB biocontrol basics presentation given to City of New Ulm staff on 11/19/19.
- Osthus, J. et al. EAB and EAB biocontrol basics presentation given to Stearns County Master Gardeners on 10/7/19 to about 50 people.
- Burington, J. et al. EAB and EAB biocontrol basics presentation given at Nobles, Steele and Brown Counties Emergency Quarantine public meetings on 9/4/19, 10/1/19 and 10/8/19.

##### **Citizen science presentations:**

- We conducted 15 field trainings this summer with 58 participants in Laporte, North Mankato, Frontenac, Wyoming, Lino Lakes, Upsala, Swanville, Cushing, Marine on St. Croix, Faribault, Willow River, Rockville, Nisswa, and St. Mathias.
- The participants came from a variety of backgrounds: Master Gardeners, Master Naturalists, families with youth, and city or county natural resource professionals.
- Wasp Watchers Poster and Exhibit at the Citizen Science Symposium, CitSciMN, on November 22, 2019. 71 participants

##### **Conference presentation:**

North Central Forest Pest Workshop Sept 24-27, 2019, The Morton Arboretum in Lisle, IL. Kees, A.M., Hallinen, M.J., Schultz, J., and B.H. Aukema. A preliminary checklist of Minnesota jewel beetles captured by foraging smokey winged beetle bandit wasps.

Entomological Society of America Nov 17-20, 2019, St. Louis, MO. Kees, A.M., Hallinen, M.J., Schultz, J., and B.H. Aukema. Prey diversity of foraging *Cerceris fumipennis* and factors influencing buprestid diversity and species distributions in Minnesota

##### **Press Coverage:**

[Biosurveillance: Citizen Science uses wasps to track destructive beetles](#)

## Other

- Chris Mallet was interviewed by the local community newspaper Sun Thisweek on 6/29/19 about EAB biocontrol work in the city of Eagan. The city of Eagan also posted video to their city website highlighting the work being done. Article - [https://www.hometownsource.com/sun\\_thisweek/community/eagan/wasps-released-to-curb-emerald-ash-borer-in-eagan/article\\_7c796e98-99c9-11e9-90a1-bfe86e451e58.html](https://www.hometownsource.com/sun_thisweek/community/eagan/wasps-released-to-curb-emerald-ash-borer-in-eagan/article_7c796e98-99c9-11e9-90a1-bfe86e451e58.html)  
Video - <https://www.cityofeagan.com/eab-control>
- Jonathan Osthus gave an interview on radio station WJON 95.3 FM in St. Cloud, MN on 11/25/19. Emerald ash borer field workshops and biological control program were discussed.

## Status as of November 30, 2020:

### EAB Biocontrol Presentations:

- Osthus, J. et al. EAB and EAB biocontrol presentation given during EAB Forest Management Webinar with DNR and U of M Extension on April 7<sup>th</sup>, 2020.
- Osthus, J. et al. EAB biocontrol presentation given during EAB Forest Management Webinar with U of M Extension on September 15<sup>th</sup>, 2020.
- Mallet, C. et al. EAB Biocontrol presentation given during Upper Midwest Invasive Species Conference held virtually on November 6<sup>th</sup>, 2020.

### EAB Field Workshops:

- Osthus, J. EAB biocontrol basics presentations given at field workshops held in Rockville (12/2/19 – 12/3/19), Lino Lakes (3/10/20 - 3/11/20) and Medford (3/2/20 - 3/3/20).
- Mallet, C. EAB biocontrol basics presentations given at Rochester Arborist Workshop on 2/20/2020.

## Status as of May 31, 2021: N/A

## Project Results Use and Dissemination

Throughout the duration of the project, results were disseminated through a variety of venues. A wide and diverse audience was reached through interviews with local press, informational webinars, outdoor training sessions held throughout the state, and at academic and natural resource professional conferences and meetings. Parasitoid release and recovery results from activity 1 and 2 can be viewed through an interactive online map at <https://www.mda.state.mn.us/plants/pestmanagement/eab/eabbiocontrol>. Through the work on activity 3 of this project, models have been created and published forecasting the expected overwintering mortality of the introduced larval parasitoid *Spathius galinae*. This information is of vital importance to the successful implementation of EAB biological control throughout North America (Wittman, Aukema, Duan, and Venette (2021) Forecasting overwintering mortality of *Spathius galinae* in North America. *Biological Control*. 160: 104694). Activity 4 of this project produced tremendously valuable baseline data on the buprestids found in Minnesota. Two journal articles were published detailing a checklist of buprestids found in Minnesota (Hallinen, Steffens, Schultz, Aukema (2021) The Buprestidae (Coleoptera) of Minnesota, with a discussion of the emerald ash borer, *Agrilus planipennis* Fairmaire. *The Coleopterists Bulletin* 75: 173-190) as well as a study on their habitat features (Hallinen, Wittman, Aukema (2020) Factors associated with diversity and distribution of buprestid prey captured by foraging *Cerceris fumipennis* (Hymenoptera: Crabronidae) (*Environmental Entomology* 49: 1363-13763). A free and accessible guide was created from these publications called The Buprestidae of Minnesota and can be downloaded from the permalink <https://hdl.handle.net/11299/218928>.

## Final Report Summary:

Dissemination activities occurred through a variety of venues throughout the project leading to a wide and diverse audience being reached. Local news interviews, presentations and workshops were given. These occurred at professional conferences, local public meetings, citizen science training sessions and through widely

available webinars. Most presentations and workshops were directed at city, county, and private natural resource managers around the state to help better inform management strategies for dealing with EAB.

MDA additional dissemination since November 2020:

EAB Biocontrol Presentations:

- Osthus, J. et al. EAB and EAB biocontrol presentation recorded for the Mdewakanton Sioux Tribe earth week webinar series April 12<sup>th</sup>, 2021.

EAB Field Workshops:

- Osthus, J. EAB biocontrol basics presentations given at field workshops held in Rockville (3/4/21 – 3/5/21), Faribault (3/2/21 – 3/3/21), Lino Lakes (3/9/20 - 3/10/21), Worthington (3/17/21 - 3/18/21).

U of M additional dissemination since November 2020:

- Wittman, J.T., Duan, J., Venette, R.C., and B.H. Aukema. Cold tolerance and overwintering mortality of *Spathius galinae* in Minnesota. 2020 Upper Midwest Invasive Species Conference Nov 2-6, 2020, Virtual.
- Mwangola, D.M., Burrington, J., Ambourn, A., Abrahamson, M.D., and B.H. Aukema. The continued search for associational protection against emerald ash borer. 2020 Upper Midwest Invasive Species Conference Nov 2-6, 2020, Virtual.
- Mwangola, D.M., Burrington, J.A., Ambourn, A.K., Abrahamson, M.D., and B.H. Aukema. The search for associational protection in insecticide-treated urban ash in Minnesota (invited in Urban Forestry session organized by K.D. Chase). Entomological Society of America Nov 16-19, 2020 Virtual.
- Wittman, J.T., Aukema, B.H., Duan, J.J., and R. C. Venette. Forecasting overwintering mortality of *Spathius galinae* in North America. North American Forest Insect Work Conference May 26-28, 2021, virtual.
- Mwangola, D.M., and B.H. Aukema. The search for associational protection in urban forests treating for emerald ash borer. North American Forest Insect Work Conference May 26-28, 2021, virtual.

Publications:

- Wittman, Aukema, Duan, and Venette (2021) Forecasting overwintering mortality of *Spathius galinae* in North America. *Biological Control*. 160: 104694
- Hallinen, Steffens, Schultz, Aukema (2021) The Buprestidae (Coleoptera) of Minnesota, with a discussion of the emerald ash borer, *Agrilus planipennis* Fairmaire. *The Coleopterists Bulletin* 75: 173-190
- Hallinen, Wittman, Aukema (2020) Factors associated with diversity and distribution of buprestid prey captured by foraging *Cerceris fumipennis* (Hymenoptera: Crabronidae). *Environmental Entomology* 49: 1363-13763
- The Buprestidae of Minnesota available from <https://hdl.handle.net/11299/218928>.

**VI. PROJECT BUDGET SUMMARY:**

**A. Preliminary ENRTF Budget Overview:**

**\*This section represents an overview of the preliminary budget at the start of the project. It will be reconciled with actual expenditures at the time of the final report.**

Budget Category	\$ Amount	Overview Explanation
Personnel:	Amendment approved 2/13/20: \$267,090	Amendment approved 2/13/20: Take \$4,700 from RS1 salary and use for Travel and Supplies. <b>MDA</b> One 3 yr FTE Research Scientist 1 salary \$44,500/yr & 22.6% fringe for Activities 1 & 2

		<p><b>MDA</b> Two PTE-FTE Plant Industry Inspector wages \$18.95/hr &amp; 28.97% fringe for Activities 1 &amp; 2</p> <p><b>MDA</b> One PTE-FTE Plant Health Specialist 1 wages \$20.37/hr &amp; 13.15% fringe for Activities 1 &amp; 2</p>
Equipment/Tools/Supplies:	Amendment approved 2/13/20: \$5,700	Amendment approved 2/13/20: Add \$700 to supply budget. <b>MDA</b> supplies include pan traps, propylene glycol, gloves, insect vials, sieves, etc. for Activities 1 & 2
Travel Expenses in MN:	Amendment approved 2/13/20: \$24,500	Amendment approved 2/13/20: Add \$4,000 to travel budget. <b>MDA</b> mileage for Activities 1 & 2 at 54 cents/mile <b>MDA</b> meals and lodging for Activities 1 & 2 (approx. 20 days of travel/yr for a Student worker and EAB Biocontrol Coordinator and 10 days of travel/yr for 3 yrs for the PI)
Other:	\$150	<b>MDA</b> shipping bioagent coolers and specimens for official identification for Activity 1
<b>Contract with U of M</b>	<b>\$433,560</b>	
Personnel:	Amendment approved 2/13/20: \$409,300	<p><b>U of M</b> One FTE Technician, 1 yr, salary \$46,000 inclusive of 27.4% benefits for Activity 2</p> <p><b>U of M</b> One graduate student, 2 yr. MS position, \$56,000 inclusive of stipend, tuition and 17.6% fringe for Activity 2</p> <p><b>U of M</b> One graduate student, 2 yr 4 mo. MS position, \$100,000 inclusive of stipend, tuition and 17.6% fringe for Activity 3</p> <p><b>NEW LINE (shifting part grad student from Activity 2 to 4): U of M:</b> Graduate Student: \$44,000 (82.4% salary (stipend &amp; tuition), 17.6% fringe); 100% FTE for 1 year for Act. 4</p> <p>Amendment approved 6/11/19: Revise graduate students on Activity 2,3,4 from \$56K, \$100K, \$44K (sum \$200K) to \$22K, \$60K, 36K (sum \$118K). Salary savings of \$92K shift to technician split between Activities 3,4. <i>No overall change in personnel budget or scope of work.</i> Amendment approved 2/13/20: Add \$20,500 projected cost savings to end of project from supplies/print/ship/travel to technician Act. 3/4 given large numbers of specimens due to program success. Again, no overall change in objectives or scope of work.</p> <p><b>U of M</b> One partial faculty summer salary support, \$18,000 inclusive of 33.6% benefits for each Activities 2 &amp; 3</p> <p><b>U of M</b> One undergraduate student approx. 16 weeks per yr for 3 yrs, wages \$12.50 x 40 hrs x 16 wks with no charge for benefits as undergrads for Activities 2 &amp; 3</p>

		<b>U of M</b> One 3 yr PTE-FTE Community Program Specialist wages \$20/hr & 7.65% fringe, 40 wks @ 20hrs/wk & 12 wks @ 40hrs/wk for Activity 4
U of M Professional/Technical/Service Contracts:	\$ 6,500	<b>U of M</b> One 3 yr PTE Insect Taxonomist stipend \$6,500 (100% stipend, 0% fringe) for Activity 4
Equipment/Tools/Supplies:	Amendment approved 2/13/20: \$4,175	<b>U of M</b> supplies include nets, personal protective equipment, vials, insect collection kits, curating supplies & rearing supplies for Activities 2, 3 & 4
Printing:	Amendment approved 6/11/19: \$8,360 Amendment approved 2/13/20: \$3,200	<b>U of M</b> printing manuals, id guides, recruitment flyers and promotions products for Activity 4
Travel Expenses in MN:	Amendment approved 6/11/19: \$18,000 Amendment approved 2/13/20: \$9,910	<b>U of M</b> mileage for Activities 2, 3 & 4 at 54 cents/mile <b>U of M</b> meals and lodging for Activities 2, 3 & 4 (approx. 11 days of travel/yr for Community Program Specialist and Grad students)
Other:	\$1,000 Amendment approved 2/13/20: \$475	<b>U of M</b> shipping beetles from volunteers and to taxonomist for Activity 4
<b>TOTAL ENRTF BUDGET: \$729,000</b>		

**Explanation of Use of Classified Staff:** In order to retain Chris Mallet as the current Research Scientist 1 for the project we had to move him from temporary unclassified status to permanent classified status. We are using two permanent intermittent staff for Activities 1 and 2 in the Plant Industry Inspector 1 classification who would otherwise not be working.

**Explanation of Capital Expenditures Greater Than \$5,000:** N/A

**Total Number of Full-time Equivalent (FTE) Directly Funded with this ENRTF Appropriation:**

One 3 yr full-time Research Scientist 1 = 2080\*3 = 6,240 hrs  
Two 3 yr part-time Plant Industry Inspector 1 = 500\*3 = 1,500 hrs  
One 2 yr part-time Plant Health Specialist 1 = 500\*2 = 1,000 hrs  
One 1 yr Technician = 2080\*1 = 2,080 hrs  
Two 3 yr full-time graduate students = 2080\*2\*3 = 12,480 hrs  
Two 0.5 mo. faculty (summer) = 80\*2\*3 = 480 hrs  
One 3 yr part-time undergrad student = 40\*16\*3 = 1,920 hrs  
One 3 yr part-time Community Program Specialist = 1280\*3 = 3,840 hrs  
One 3 yr part-time Insect Taxonomist = 80\*3 = 240 hrs  
Total hours = 28,780  
Total FTEs = 29,780/2080 = 14.32

**Total Number of Full-time Equivalent (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:** N/A

**B. Other Funds:** N/A

Source of Funds	\$ Amount Proposed	\$ Amount Spent	Use of Other Funds
<b>Non-state</b>			
	\$N/A	\$N/A	
<b>State (in-kind)</b>			
MDA Oversight of project, 5% FTE MDA Scientist	\$15,000	\$0	
<b>TOTAL OTHER FUNDS:</b>	<b>\$15,000</b>	<b>\$0</b>	

**VII. PROJECT STRATEGY:**

**A. Project Partners:**

**Partners receiving ENRTF funding**

- Dr. Brian Aukema, Associate Professor with U of M, Activity 2 – Assessing biological control establishment and impact and Activity 4 - Citizen Engagement and Biosurveillance of EAB; with biosurveillance capture identifications in conjunction with Jeffrey Hahn, Entomologist with U of M Extension. Dr. Robert Venette, Research Biologist and Adjunct Associate Professor, USDA Forest Service and U of M, Activity 3 – Assess new bioagent cold hardiness of *Spathius galinae*. U of M contract total = \$433,560. Jonathan Osthus, Research Scientist, Minnesota Department of Agriculture, Activities 1 & 2– Expand biological control implementation, assessing biological control establishment and impact. MDA total = \$295,440

**Partners NOT receiving ENRTF funding**

- For EAB biosurveillance, we will draw on volunteers from Forest Pest First Detectors, Minnesota Master Naturalist and 4H programs. For all activities, we will collaborate with USDA APHIS and Forest Service EAB biocontrol researchers, DNR, MNDOT, other federal and state agencies, counties, municipalities and private landowners.

**B. Project Impact and Long-term Strategy:**

Minnesota EAB biological control is entering the third phase of implementation with establishment of biological control agents documented in the southeast and Twin Cities. The project will guide implementation of this third phase to determine impacts and develop a road map of a successful long-term EAB biocontrol program. As predicted since the start of this project, EAB has increased in density and distribution in the state and will continue to do so. Early detection efforts remain critical to implementing EAB management in a timely manner to ensure best possible outcomes. We plan to use biosurveillance and citizen engagement to help monitor for new EAB infestations and inform potential new biocontrol release locations. We will continue to release biological control agents on the leading edges of EAB populations in order to establish parasitoids that will move and spread with EAB. Assessing the impact of EAB biological control agents on EAB populations at two sites post release will provide in-depth analysis of the dynamics at work in two distinct locations. This work will lead to a better understanding of which methods of recovery provide the best data and most efficient use of resources. Cold hardiness testing of the newly approved, *Spathius galinae* will inform best timing strategies for release as well as generate climate analysis maps. This will lead to improved understanding of where in the state, if any, is too cold for *S. galinae* to establish.

Although it may take decades to determine the efficacy of EAB biological control nationwide, it is vitally important to implement best available management tools now to help reduce and potentially limit the devastating impacts of EAB in the future as other tools also improve. By developing a cohesive biological control implementation strategy we leave Minnesota in the best possible situation to manage our states extensive ash resource.

**C. Funding History:**

Funding Source and Use of Funds	Funding Timeframe	\$ Amount
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LCCMR Emerald Ash Borer Biocontrol Research and Implementation project	July 1, 2011 - June 30, 2014	\$500,000
LCCMR Improving Emerald Ash Borer Detection Efficacy for Control	July 1, 2013 – June 30, 2016	\$600,000
LCCMR Biosurveillance and Biocontrol of EAB – Phase 2 project	July 1, 2014 – June 30, 2017	\$447,000

**VIII. REPORTING REQUIREMENTS:**

- The project is for 4 years, will begin on 07/01/17, and end on 06/30/21.
- Periodic project status update reports will be submitted November 30th and May 31st of each year.
- A final report and associated products will be submitted between June 30 and August 15, 2021.

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

**X. FEE TITLE ACQUISITION/CONSERVATION EASEMENT/RESTORATION REQUIREMENTS:** N/A

# EAB Biocontrol Phase 3: Assessment & Citizen Engagement

**Cold Tolerance**

**Citizen Engagement**

**\*New this year!**

*Spathius galinae*





## Implementation

Year	2010	2011	2012	2013	2014	2015	All Years (30 Sites)
# Releases	3,326	30,717	45,321	51,176	46,496	182,512	359,548!



## IMPACT?



Adult parasitoid wasp recovery



Monitoring for parasitized EAB eggs & larvae



**Environment and Natural Resources Trust Fund  
M.L. 2017 Final Project Budget**

**Project Title:** Emerald Ash Borer Biocontrol – Phase III

**Legal Citation:** M.L. 2017, Chp. 96, Sec. 2, Subd. 06b

**Project Manager:** Jonathan Osthus

**Organization:** Minnesota Department of Agriculture

**M.L. 2017 ENRTF Appropriation:** \$ 729,000

**Project Length and Completion Date:** 4 years, June 30, 2021

**Date of Report:** August 11, 2021



ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Amended Activity 1 Budget 2/13/20	Amount Spent	Revised Activity 1 Balance	Amended Activity 2 Budget 8/31/21	Amount Spent	Revised Activity 2 Balance	Amended Activity 3 Budget 8/31/21	Amount Spent	Activity 3 Balance	Amended Activity 4 Budget 8/31/21	Activity 4 Spent	Revised Activity 4 Balance	TOTAL BUDGET	TOTAL BALANCE
<b>BUDGET ITEM</b>														
<b>Personnel (Wages and Benefits)</b>	\$174,200	\$174,200	\$0	\$90,890	\$90,890	\$0							\$265,090	\$0
<b>Amended 2/13/20 MDA:</b> Research Scientist 1: \$168,880 ( 77.4% salary, 22.6% fringe); 100% FTE for 3 years for Act. 1 & 2														
<b>MDA (11/20/2017):</b> Plant Industry Inspector 1: \$72,210 ( 71.03% salary, 28.97% fringe); 24% FTE for 3 years for Act. 1 & 2														
<b>NEW LINE MDA (05/16/2018):</b> Plant Health Specialist 1: \$24,000 (86.85% salary, 13.15% fringe); 33% FTE for 2 years for Act. 1 & 2														
<b>Equipment/Tools/Supplies</b>	\$1,700	\$1,700	\$0	\$4,000	\$4,000	\$0							\$5,700	\$0
<b>Amended 2/13/20 MDA:</b> supplies include pan traps (\$750), propylene glycol (\$1,250), cut resistant gloves (\$100), insect vials (\$300), petri dishes (\$200), sieves (\$150), etc. \$5,700 ( \$1,700 Act. 1 and \$4,000 Act. 2)														
<b>Travel expenses in Minnesota</b>	\$20,000	\$20,000	\$0	\$4,500	\$4,500	\$0							\$24,500	\$0
<b>Amended 2/13/20 MDA:</b> Travel to and between data gathering and biocontrol release sites in SE, Metro and Northern MN. Mileage: \$16,000; Lodging: \$5,000; Meals: \$3,500 (Act. 1 & 2)														
<b>Other</b>				\$150	\$150	\$0							\$150	\$0
<b>MDA:</b> Shipping bioagent coolers and specimens for official identification \$150														
<b>Contract with U of M total is \$433,560</b>														
<b>U of M Personnel (Wages and Benefits)</b>				\$101,800	\$101,800	\$0	\$139,963	\$139,963	\$0	\$171,180	\$171,180	\$0	\$412,944	\$0
<b>U of M:</b> Technician: \$46,000 (72.6% salary, 27.4% fringe); 100% FTE for 1 year for Act. 2														
<b>U of M:</b> Graduate Student: \$56,000(82.4% salary (stipend & tuition), 17.6% fringe); 100% FTE for 2 years for Act. 2														
<b>U of M:</b> Graduate Student: \$100,000 (82.4% salary (stipend & tuition), 17.6% fringe); 100% FTE for 3 years for Act. 3														
<b>NEW LINE (shifting part grad student from Activity 2 to 4): U of M (11/27/2017):</b> Graduate Student: \$44,000 (82.4% salary (stipend & tuition), 17.6% fringe); 100% FTE for 1 year for Act. 4														
Amendment approved 6/11/19: shift grad student allocations Activities 2 (\$56K), 3,(\$100K), 4 (\$44K) to Act. 2 (\$22K), 3 (\$60K), 4 (\$36K). Salary savings of \$82K is moved to technician help Activities 3, 4 (\$41K each). No change to overall personnel budget or scope of work.														

<b>Amendment request 2/13/20:</b> allocate projected \$20,500 savings from Activities 2,3,4 supplies, travel, shipping, printing to technician split between Activities 3 & 4 (cold toelrance work, finishing curation of buprestid checklist)														
<b>U of M:</b> Partial Faculty summer salary: \$18,000 (67.4% salary, 33.6% fringe); 4% FTE for 3 years for Act. 2														
<b>U of M:</b> Partial Faculty summer salary: \$18,000 (67.4% salary, 33.6% fringe); 4% FTE for 3 years for Act. 3														
<b>U of M:</b> undergraduate student: \$24,000 (100% salary, 0% fringe); 30.8% FTE for 3 years for Act. 2 & 3														
<b>U of M:</b> Community Program Specialist: \$82,800 (92.35% salary, 7.65% fringe); 61.5% FTE for 3 years for Act. 4														
<b>U of M Subcontract</b>										\$6,459	\$6,459	\$0	\$6,459	\$0
Insect Taxonomist (Buprestidae expert Wayne Steffens): \$6,500 (100% stipend, 0% fringe); 4% FTE for 3 years for Act. 4														
<b>Equipment/Tools/Supplies</b>				\$327	\$327	\$0	\$234	\$234	\$0	\$2,687	\$2,687	\$0	\$3,248	\$0
<b>Amended 11/27/19: U of M:</b> supplies include \$350 Act.2 (vials, safety & PPE, etc.), \$125 Act. 3 (vials, rearing supplies, etc.) and \$3700 Act. 4 (nets, currating supplies, etc.)														
<b>Printing</b>										\$1,364	\$1,364	\$0	\$1,364	\$0
<b>Amended 11/27/19: U of M:</b> manuals (\$50), recruitment flyers (\$50) and promotions products (\$1,100) Ammdment approved 6/11/19: Buprestid list (\$2,000)														
<b>Travel expenses in Minnesota</b>				\$1,770	\$1,770	\$0	\$1,415	\$1,415	\$0	\$6,035	\$6,035	\$0	\$9,220	\$0
<b>Amended 2/13/20: U of M:</b> Travel to and between data gathering, biosurveillance and biocontrol release sites in SE, Metro and Northern MN. Lodging: \$560; Meals: \$350; Amendment approved 6/11/19: mileage Request 11/27/19 reduction to \$9000														
<b>Other</b>										\$325	\$325	\$0	\$325	\$0
<b>Amended 2/13/20: U of M:</b> Shipping beetles collected by volunteers(statewide) and to taxonomist (Duluth). \$475														
<b>COLUMN TOTAL</b>				\$195,900	\$195,900	\$0	\$203,437	\$203,437	\$0	\$141,612	\$141,612	\$0	\$188,050	\$188,050
													\$0	\$729,000
														\$0