Rosemount Parks Invasive Species Management and Education Plan

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On behalf of

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This publication may be available in alternate formats upon request.

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Introduction

The Resilient Communities Project (RCP) is a program operated by the University of Minnesota, designed to address issues of sustainability within a community. Each year the RCP selects a city within the Twin Cities Metropolitan area; Rosemount Minnesota was selected as the 2014-2015 Resilient Communities Partner (Center for Urban and Regional Affairs, 2015)

The goal of the RCP is to allow university students an opportunity to investigate a problem within the chosen community and develop a plan for lasting sustainability and community resilience. This gives university students an authentic experience creating an action plan to address real-life issues impacting a community (Center for Urban and Regional Affairs, 2015). This investigation was prepared by students enrolled in the University of Minnesota Duluth EnEd 5325 Sustainability Issues Investigation course to investigate sustainable practices for education regarding invasive species management within Rosemount parks. Our investigation furthers recommendations for invasive species management included in the Long Term Management Plan prepared by University of Minnesota Duluth students in the fall 2014 EnED 4315 Operations and Management course.

Sustainability can be defined as the act of fusing people and their environments. It addresses how people maintain, uphold and defend their community. Sustainability is composed of three parts: environmental, economic, and social. Finding a solution that balances all three of these aspects is critical to the success of any sustainable project. This project is presented in the sustainability context, the environmental, economic, and social factors are all taken into consideration.

City of Rosemount and Investigation areas

The city of Rosemount Minnesota is located 15 miles south of the downtown areas of Minneapolis and St. Paul and falls within Dakota County (Figure 1). Rosemount was founded by Irish and Scottish immigrant farmers, and agriculture remains a major industry for the community (City of Rosemount, 2015). Rosemount's current population is 23,000 people; this population figure is expected to double by the year 2030. A census of the community shows that one third of the population is between the ages of 25 and 44 and one fourth of the population is school-aged children (City of Rosemount, 2009). Many Rosemount residents take advantage of the close location of their home to the major work centers of the Twin Cities resulting in an average income for residents at a comfortable $69,000. Although the city is close to an urban business center, the town has been able to maintain the historic landmarks and traditions of a small town as well and keep a sense of place for community residents (City of Rosemount, 2009).

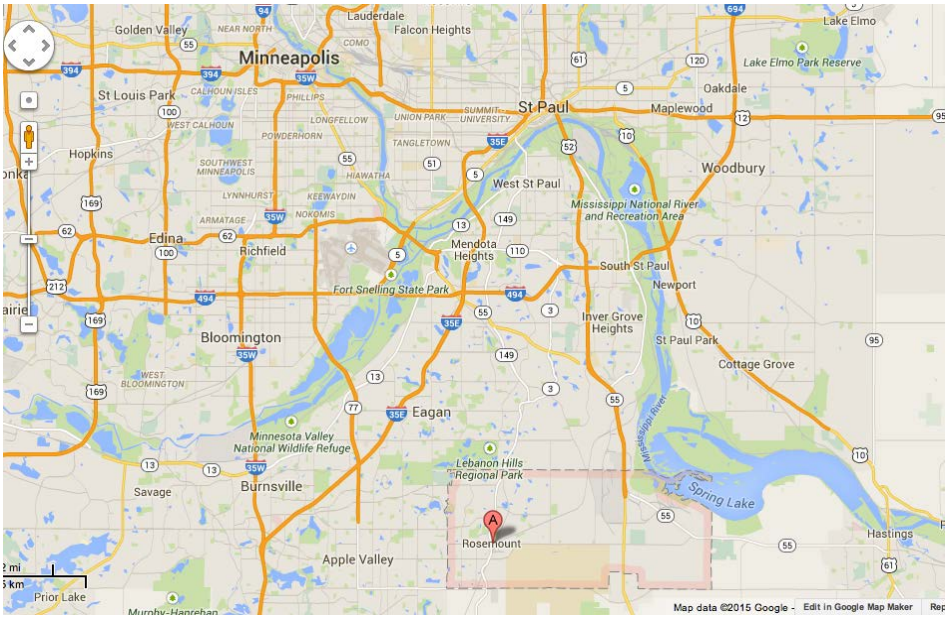

Figure 1: City of Rosemount. Image from Google Maps

Rosemount occupies an area of 36 square miles; 302 acres of land have been reserved as parkland (City of Rosemount, 2015). This investigation will address current issues facing two of the Rosemount parks: Carroll's Woods and Schwarz Pond (Figure 2). Carroll's Woods and Schwarz Pond are adjacent to one another and bordered by Rosemount High School, Rosemount Community Center, and private residences.

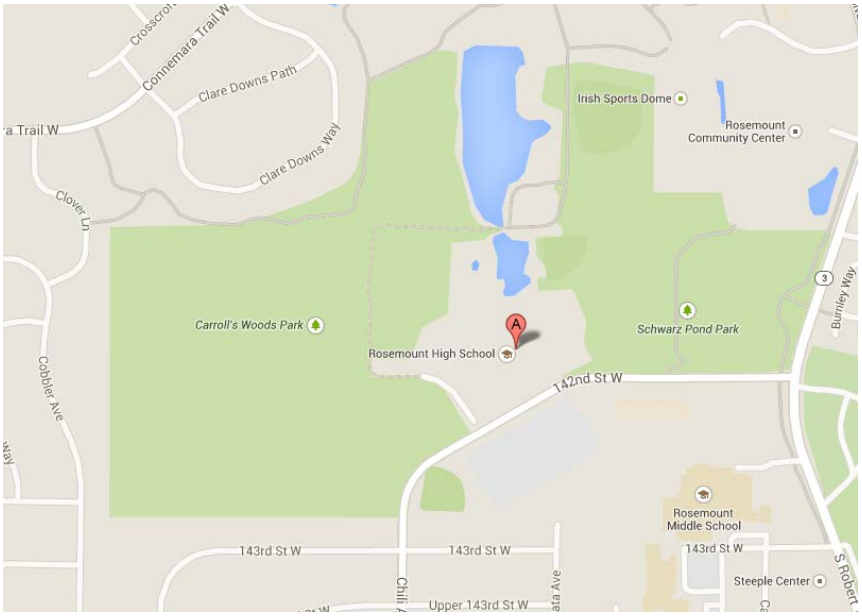

Figure 2: Location of Carroll's Woods and Schwarz Pond Park in Rosemount, MN. Image from Google Maps.

Carroll's Woods

Carroll's Woods is a forested 45-acre park in Rosemount, MN and can be accessed though Cobbler Ave, Clover Lane, and Schwarz Pond Park (City of Rosemount, 2015). It has a system of nature trails where native vegetation species can be viewed and enjoyed. The park is open for year-round use. The land for Carroll's Woods was donated to the city and was designed to be a preserve of native hardwood tree species such as red oak *(Quercus rubra)*, elm *(Ulmus americana),* and ash *(Fraxinus nigra)* as well as home to other vegetation like elderberry *(Sambucus canadensis)*, dogwood *(Cornus racemosa),* and highbush cranberry *(Viburnum trilobum)*.

Schwarz Pond Park

Schwarz Pond Park covers 63 acres adjacent to Carroll's Woods and the parks are connected by shared nature walking trails. The park features include a nature area, skate park, paved walking trails, playground equipment and fishing opportunities. The ecosystem around Schwarz Pond has been restored to an open prairie setting providing a home for native prairie grasses like prairie cordgrass *(Spartina pectinata)* as well as providing a home for Minnesota wildflowers. This restored prairie is actively managed for exotic species like spotted knapweed *(Centaurea stoebe)* and thistle *(Cirsium arvense)*. In addition, this prairie is actively being managed, controlling the growth of Siberian elm *(Ulmus pumila)*, silver maple *(Acer saccharinum),* and boxelder *(Acer negundo)* trees to keep the area as an open prairie.

Issue

We were given the task to provide recommendations for management of two invasive species within these parks. An invasive species is a species that has been brought to an area outside of its native home and causes harm to the environment, economy, or human health. Some high priority invasive species in Minnesota are the emerald ash borer, common buckthorn, zebra mussels, and Eurasian water milfoil (Minnesota Department of Natural Resources, 2015). The term invasive species should not be confused with exotic species. An exotic species is an organism that is outside of its native home (Virginia Invasive Species Council, 2005) but is less obtrusive in their reproductive behaviors and does not have the same negative impacts to the environment, economy or human health.

Ecologically, invasive species have a detrimental effect on the biodiversity of a habitat. Species diversity in a park is a valuable resource for reasons of aesthetic beauty, but more importantly it contributes towards productive soil, clean water & air, recreation, and provides

opportunities for education. Replacement costs for lost diversity are extremely high and replacement is sometimes impossible in any case; for this reason, prevention of invasive species establishment is preferable (Virginia Invasive Species Council, 2005)

This investigation of invasive species at Schwarz Pond Park and Carroll's Woods will:

- Give recommendations for the development of an invasive species and invasive pest management plan for the City of Rosemount, MN at Schwarz Pond Park and Carroll's Woods.
- Create a sustainability education plan that will inform the public on:
    - Invasive species and their management
    - How residents can be involved in the management plan
    - What residents can do to mitigate the spread of invasive species into the parks

Invasive Species at Carroll's Woods and Schwarz Pond Park

Common Buckthorn

Common buckthorn (*Ramnus cathartica)* was brought to North America from Europe for use as an ornamental hedge. In the 1930s, the sale of buckthorn was prohibited but not before it escaped developed areas and established in forests and other open areas. Since buckthorn is an introduced species, there are no natural controls to curb its spread in the environment (Minnesota Department of Natural Resources, 2015).

Common buckthorn is a bushy plant that can grow up to 25 feet high. It gains its leaves early in the spring and is able to retain them through November. It has glossy, egg-shaped leaves that come to a point. In August, buckthorn produces a black ¼ inch fruit. These features are shown below in Figure 3.

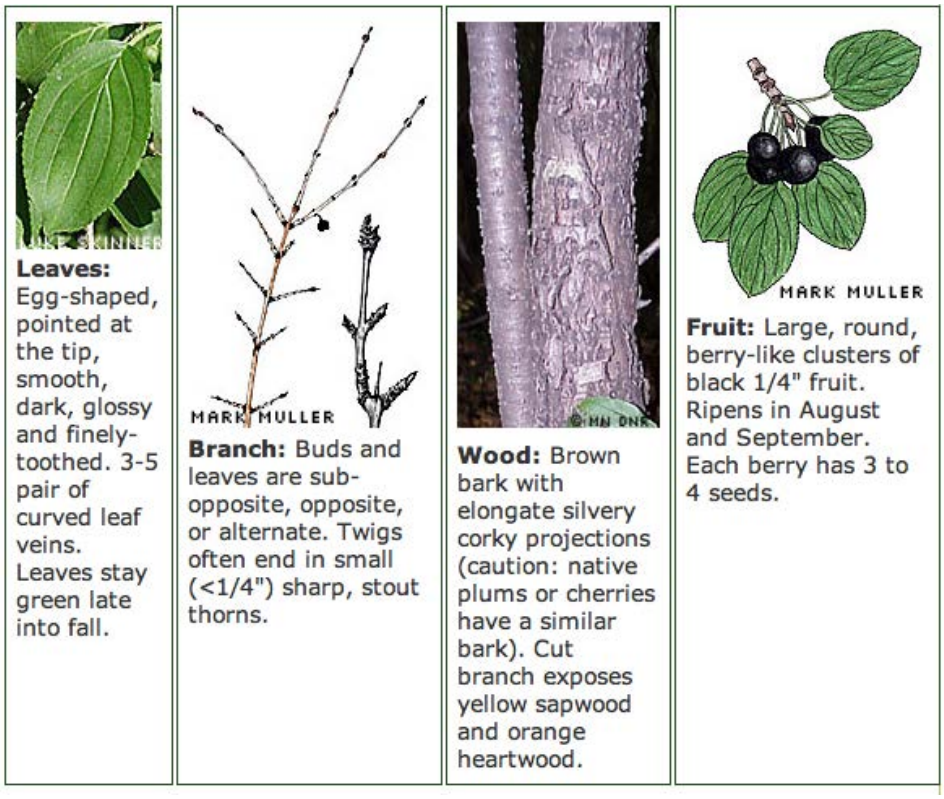

Figure 3: Identifying features of common buckthorn *(Ramnus cathartica).* Image from Minnesota Department of Natural Resources

Buckthorn causes many problems including outcompeting and replacing native plants. When buckthorn outcompetes native plants, it contributes to soil erosion by decreasing ground cover. It then forms a dense layer of vegetation, which degrades wildlife habitat by not allowing easy access for animals to move below the understory. This layer of vegetation also inhibits sunlight absorption for native plants.

Buckthorn is a problem in Minnesota because it does not have any natural predators, to curb its colonization into new areas, which results in an uncontrollable spread. Buckthorn seeds are easily dispersed by birds, increasing the spread into new areas (Minnesota Department of Natural Resources, 2013). Buckthorn acts as a host for pests that pose a problem for the agriculture industry of Rosemount. One pest of note is the crown rust fungus, a wind-spread fungus that is the most damaging pest of oats in the US (US Department of Agriculture, 2008).

Buckthorn is also a common host to the soybean aphid, an invasive species that feeds on soy plants (Grettenberger & Tooker, 2011).

Emerald Ash Borer

The emerald ash borer (EAB) (*Agrilus planipennis*) is an invasive beetle species, originally from northeastern China and transported to the US on wood shipping crates. Adults are easily identifiable by their bright metallic emerald green carapace (Figure 4). The first record of EAB in North America was in 2002; they were found on dead ash trees in Michigan and Ontario, Canada (Haak et. al, 2002). Since the initial introduction, millions of ash trees have been killed across North America (Herms & McCullough, 2014).

Figure 4: Adult emerald ash borer. Image from Minnesota Department of Natural Resources

Adult EAB beetles lay their eggs inside cracks of the ash bark in June to late July; the eggs hatch within two weeks (Herms and McCullough, 2014). EAB larvae feast on the cambial tissue of the tree trunk though the fall, creating S-shaped trails as they feed (Figure 5). As mature adults leave the ash trees a characteristic D-shaped exit hole is left behind, shown in Figure 5. Larvae that do not pupate in the fall will overwinter in the cambial tissue and resume feeding in spring.

Ash trees are killed within 2-3 years of EAB infection. All species of North American ash are at risk of EAB infection (Herms and McCullough, 2014).

Figure 5: S-shaped trails in bark caused by ash borer larvae. Image from Minnesota Department of Natural Resources

Figure 6: Infested ash tree with 1/8 inch D-shaped exit hole. Image from Minnesota Department of Natural Resources.

Adult ash borer are not strong fliers, but they are able to travel up to one-half mile a year. The most common vector for the spread of ash borer is though the transport of firewood. To stop this spread, many states and municipalities have enacted regional quarantine zones, banning the transport of firewood and other ash materials into and out of the quarantined areas (US Department of Agriculture, 2013).

The first case of EAB infestation in Dakota County was confirmed in December 2014 at Lebanon Hills Regional Park in Eagan, Minnesota (Minnesota Departent of Agriculture, 2014). This park is approximately five miles north of Schwarz Pond Park and Carroll's Woods Park. Dakota County is now under a metro quarantine zone stopping the transport of ash materials outside of the quarantine zone (Minnesota Departent of Agriculture, 2014, City of Rosemount, 2015).

Rosemount has been conducting some management for ash borer within the city. As of January 2015, approximately 150 ash trees have been removed from city parks and 130 ash trees have been removed from boulevards (City of Rosemount, 2015).

Research Methods

The investigation team set out to answer the following question: what are the most cost-effective and sustainable best-management practices for the invasive species affecting Schwarz Pond Park and Carroll's Woods? To answer this question, we conducted an interview with Rosemount park staff, reviewed literature on current management for the invasive species under review and performed a cost-benefit analysis to guide our recommendations.

Interviews with City of Rosemount staff

The investigation team conducted interviews with City of Rosemount staff to determine what invasive management practices are currently in place. Below are the questions that were asked as part of this interview:

Questions for City of Rosemount staff

- What kind of invasive species management practices are currently in place?
- How prevalent is buckthorn in the parks?
- What is the potential impact if emerald ash borer (EAB) gets into the park?
- What would you like the community of Rosemount to know about these invasive species?
- In addition to buckthorn and EAB, what other invasive species are of concern in the parks?
- How can the public be useful in combating the spread of these species if they can be made sufficiently knowledgeable?
- Is there a way we could reach the public to give interviews through you?
- What, if any, involvement do the local schools have with the parks?

Based on the received responses, there is little community involvement for management of these invasive species within the parks at the present time. The city is monitoring the parks for an ash borer infestation, but currently there is not a management plan in place for emerald ash borer. The city estimates that ash trees account for 10 percent of the over story at Carroll's Woods.

Carroll's Woods has a severe buckthorn infestation consisting of both young and mature plants. Community organizations have conducted buckthorn pulls in the past with no follow-up. The city has not managed for the buckthorn infestation.

Rosemount would like to have a management plan in place for infestations of both species that will include outreach and involvement with the community.

Literature Review

Buckthorn

Iannone et. al. performed a three year field study that looked at the effectiveness of amending the land in limiting the reinvasion of buckthorn by comparing the effects of mulching or tilling. The study found that tilling helped to delay reinvasion of buckthorn by killing undetected small buckthorn plants that were missed in the initial removal. Soil tilling may also disturb soils or harm native seed banks and plants that persisted during the invasion. Buckthorn returned throughout the experiment, but it returned later in plots that were both mulched and tilled than in plots that were only tilled. Additionally, buckthorn yearlings grew best in mulch-only plots, suggesting that managers should avoid surface application of mulch (Iannone et. al., 2013).

Reinvasion via stump resprouting can be greatly reduced by applying herbicide to recently cut stumps. Reinvasion from remnant seed, however, can be more challenging to control (Iannone et. al., 2013). Managers are encouraged to remove exotic shrubs in the winter to limit disturbances to the soil, native plants, and native animals. One downside to winter removal is that winter snow could hide smaller buckthorn plants allowing them to trigger reinvasion (Iannone et. al., 2013).

The Minnesota Department of Natural Resources (DNR) has provided recommendations for the removal of buckthorn. The DNR recommends that if buckthorn is less than ⅜ inch diameter, it can be removed by hand. If it is larger than ⅜ inch, it should be removed with a hand-pulling tool. When pulling, it is important to minimize soil disturbance and replant the

cleared area with native species to reduce buckthorn re-infestation. The DNR recommends spraying foliage with herbicides (i.e. Roundup™ spray) if pulling of individual plants is impractical (Minnesota Department of Natural Resources, 2013).

For plants larger than two inches in diameter, it is best to cut the stems at the surface and treat with an herbicide to prevent re-sprouting. Application of a dyed herbicide will make it clear which stumps have already been treated. The best time to cut and treat stumps is in late summer and throughout the fall. Herbicide is recommended over burning as you can utilize it as a management tool at any time of year. See Appendix A for the DNRs list of recommended herbicides and proper dilutions (Minnesota Department of Natural Resources).

Emerald Ash Borer

Discussion for the treatment of EAB from literature is divided into three main methods for control: insecticides, biological controls, and ash tree removal.

Insecticides

Several insecticide products are available for control of EAB. The most common methods for treatment are direct injection into the trunk and drenching, a process where the insecticide is applied to the soil near the trunk. The insecticide then spreads through the tree killing the EAB larvae that live within the cambium tissue (Squibb & Herbert, 2006).

Soil injection techniques require specialized equipment and must be carried out by professionals. A hole is drilled into the base of the tree and penetrates to the cambial layer or sapwood, the layer of tissue under the bark where the transport vessels of the tree lie. The insecticide is then introduced into the hole using a specialized needle. Depending on the technique, the needle may be highly pressured to help with injection. After two to four weeks,

the chemical has moved through the transport system of the tree, killing the EAB larvae that live within the cambial tissue (Squibb & Herbert, 2006)

Not all ash trees are worth treating with insecticides. Due to the expense of treatment, the literature recommends assessing individual trees or groups of trees based on location and health before deciding whether to use insecticides, especially given that treatment must be administered over the course of several years. Treatments are suggested only for ash trees located within 15 miles of a confirmed EAB site or for trees located within a quarantined area. Insecticide treatments are not necessary for ash trees located outside of these areas. Even within the 15-mile radius, not all trees should be treated. Trees with greater than 50% canopy thinning should be removed and destroyed in accordance with established guidelines. Insecticide treatments are most effective in trees with less than 50% canopy thinning, as chemicals cannot travel within trees that already have severely weakened transport systems (Williamson and Liesch, 2014). It is important to recognize that insecticides are effective when applied to trees that are still relatively healthy, as insecticides cannot repair EAB damage (Squibb & Herbert, 2006).

A comparison of various chemicals available to homeowners and professionals is available Appendix A. Soil drench, soil injection and trunk injection techniques are considered. All insecticide treatments, including injection, must be done annually (North Central IPM Centre, 2014).

Biological Control

Some authorities have come to believe that eradication of EAB is not feasible for most landowners and that biological control is the only realistic option. Biological control is defined as the reduction of pest populations by natural enemies (Hoffman & Frodsham, 1993). For EAB, this method involves introducing an exotic parasite to the infected area that reduces the EAB

population. Most of the potential control species that have been mooted are parasitoid wasp species, either native to the US or to the EAB's native regions of Asia. These wasps generally reproduce by inserting their eggs into or onto the eggs or larvae of the EAB, killing the young beetles (Bauer et. al., 2008). Biological control of EAB is a relatively recent field and most of the information available is instructional, with little data available about the long-term success of biological control schemes.

At least three species of parasitoid wasps, native to China, have been approved by the US Department of Agriculture's Animal & Plant Health Inspection Service (APHIS). The species are *Spathius agrili*, *Tetrastichus planipennisi*, and *Oobius agrili* (Minnesota Department of Agriculture, 2011). These insects are bred specifically for biological control of EAB at the USDA APHIS Biological Control Production Facility in Brighton, MI. Permits to acquire and release these species can be obtained from APHIS. Information about the parasitic wasps and how to obtain permits can be found in Appendix B. It is believed that these species will not negatively influence native species or environments once released.

Because of the lack of information regarding the success and impacts of this technique, the Minnesota Department of Agriculture suggests that biological control be used as only one part of an integrated management policy. The department advises the use of biological control alongside quarantines, regulation of movement of firewood, strategic tree removal, and outreach and education (Minnesota Department of Agriculture, 2011).

Removal of Trees

Ash trees can be removed prior to infection by EAB. This can be done as a precautionary measure to prevent the further spread of EAB when EAB has been reported close to a site. Removal must be carried out by an insured, licensed arborist or tree specialist (Hoover, 2009).

Wood from these trees can still be used for lumber, firewood, and landscaping materials as long as it does not leave the quarantined area.

Cost-benefit Analysis

A Cost-benefit Analysis (CBA) ranks potential solutions in order to determine the best strategy to solve an issue. We performed a CBA on different management strategies for both common buckthorn and EAB.

Cost Benefit Analysis – Buckthorn

Table 1: Common Buckthorn Management Strategies Cost-benefit Analysis

Criteria	Status Quo	Pulling	Herbicide
Cost (Short Term)	$0.00 (5)	$14,500 (4)	$4.2 million (1)
Cost (Long Term)	Loss of native species (1)	$100,000 (2)	$0.00 (5)
Time to completion	0 months (5)	Years (1)	Months (4)
Effectiveness of removal (Palumbo Landscaping)	No (0)	Yes (5)	Yes (5)
Effect on other plants	Loss of biodiversity (1)	Native populations can re-establish (5)	May initially kill other plants in area (3)
Community involvement and Education	Poor (0)	Good community involvement (5)	Some education (2)
TOTAL	**12**	**22**	**20**

Table 1 compares strategies for buckthorn management: pulling, herbicide, and status quo (no action). We evaluated these strategies using the following metrics: short term cost, long term cost, time to completion, effectiveness of removal, effect on other plants, and community involvement and education. We used a scale of 0-5 to evaluate the management strategies using each criteria with 5 being optimum and 0 being not at all.

All costs are rough estimates. The short-term cost of pulling was estimated to be the cost of purchasing thirty $150 Uprooter landscaping tools along with an estimated $10,000 worth of salary for the person in charge of the project. It was assumed that the person in charge of coordinating and marketing the buckthorn pulls would have other responsibilities; the city of Rosemount may fill in more accurate salary figures. The long term cost of buckthorn pulling would be the cost of providing this salary for at least 10 years because buckthorn seeds remain viable within the soil for 5-7 years and pulling needs to be done during this entire time to be effective.

The short term cost of buckthorn chemical treatment and removal (herbicide) was based entirely on estimates obtained from Palumbo Landscaping, a private Minnesota based landscaping company. According to their website, "for larger projects consisting of several acres of land, a general rule of thumb is $900 per thousand square feet of infested forest" **(Palumbo Landscaping)**. This company would supply all of the equipment, chemicals, and manpower for buckthorn removal. The total cost was calculated assuming that the entire 108 acres of Carroll's Woods and Schwarz Pond Park was infected with buckthorn. No costs were estimated for the status quo as it is difficult to quantify the value of ecosystem services provided by native populations but harmful factors such as higher soil erosion, loss of animal habitat, and the carrying of harmful pests for agriculture was assumed to lead to high costs.

Due to our heavy use of estimates and assumptions the difference between one or two points on the CBA is very minimal. While it is clear that the status quo is least desirable, the results are very close between pulling and herbicide. Pulling is a less expensive strategy which provides many opportunities for community involvement and education. It also is less harmful to the immediately surrounding vegetation; however, it is only a viable strategy if there is long-term support in administration, as pulling needs to be consistent over many years to fully eliminate buckthorn. Herbicide carries a much greater short-term cost but is much quicker. The use of herbicides allows for minimal community involvement and education.

Cost Benefit Analysis – Emerald Ash Borer

Table 2: EAB management strategies cost-benefit analysis

Criteria	Status Quo	Insecticides	Biological Control	Removal of Trees
Cost (Short Term)	$0.00 (5)	$0.00 (5)	$10,000 (4)	$13,000 (4)
Cost (Long Term)	Expensive (1)	$40,000 (3)	Unknown (2)	None (5)
Time to completion	0 months (5)	Years (1)	Unknown (2)	Months (4)
Effectiveness of removal	No (0)	Mostly (4)	Unknown (2)	Yes (5)
Health of ash trees	Poor (1)	Good (4)	Unknown (2)	Removed (0)
Community involvement and Education	Poor (0)	Can be some education (2)	Can be community involvement with monitoring (4)	Can be some education (2)
TOTAL	**12**	**19**	**16**	**20**

We performed a similar CBA on EAB management strategies. The criteria evaluated were: short term cost, long term cost, time to completion, effectiveness of removal, health of ash trees, and community involvement and education. This analysis is above in Table 2,

management costs were based on Purdue University "Emerald Ash Borer Cost Calculator," an interactive cost calculator available for use at http://extension.entm.purdue.edu/treecomputer/index.php?page=comparator/master_s.php -

We estimated the number and size of ash trees in the parks; the city of Rosemount could get more accurate values if they surveyed their parks and used the calculator with more accurate numbers. Insecticide costs are all long-term because the insecticides could not be applied until the EAB was actually detected in the park. Removal costs were assumed to be short term but they could be short term or long term depending on whether the park planned to wait for an invasion before removing the trees.

Biological control was more difficult to estimate because long term studies have not been done, so long term costs and effectiveness could not be estimated. Parasitoids may be provided by government agencies in return for long term monitoring data so the only short-term cost assumed was personnel to be in charge of the project. A partial salary estimate of $10,000/year was used in this CBA as in the buckthorn CBA. The long-term cost of the status quo was assumed to be expensive although it is difficult to quantify.

We found that insecticides and tree removal had similar ratings according to our system. Insecticides are a good proven management method but are much more expensive and a larger time commitment than ash tree removal. Removal of ash trees is an effective way to clear an area of EAB but it has its own set of downfalls such as loss of aesthetic beauty in the park and habitat for wildlife.

Final Recommendations

Common buckthorn management

As explored in the CBA above, our recommendations for management of common buckthorn are either pulling or chemical treatment. Buckthorn pulling requires a long-term champion in the park's administration. If the project is not kept up rigorously for at least 10 years it will not be effective. Buckthorn pulling creates ample opportunities for community involvement and education. Chemical treatment is a more immediate solution but it is much more expensive than buckthorn pulling and may damage the surrounding vegetation when applied.

EAB management

Our recommendations for EAB management are insecticides or ash tree removal. Insecticides are more expensive than ash tree removal although they both need to be administered by experts. Ash tree removal is a more immediate solution but the ecosystem services provided by the ash trees such as aesthetic value and wildlife habitat are lost.

Public Education

As part of an integrated management policy, we recommend the use of a public education plan alongside the invasive species management plans. Treatment of buckthorn and EAB requires years of follow-up activities to prevent them from returning. The chances of achieving this are made more favorable by having an informed and concerned public. Below are community outreach and education plans.

Community Buckthorn Pull

Schwarz Pond Park has covered pavilions that can be a base of operations for a large community event, hosted by the city park, to utilize the park's spaces and resources to provide a day of activities and information about invasive species. Buckthorn would be the natural focus for such an event, as it is more obvious and easily detectable than EAB, and can be removed manually by laypersons. Incorporate social elements such as food, music, and games as well as information (via pamphlets & sessions led by park staff or specially-designated education staff) and demonstrations on identification and physical removal of buckthorn. The focus of the event would be to make the public aware of the necessity of being involved with follow-up operations in the future. Appendix C contains suggestions and sample advertisements for an organized community event, sample plans to organize the event, and suggestions for additional community follow-up.

Neighbors Meeting/School & Teacher Involvement

Much of the area adjacent to the parks is residential. It is essential to educate the residents in the area about ash borer and buckthorn invasions of the area and how they can protect their homes from the invasion as well as stop the spread of invasive species into the parks. Efforts should be made to forge links with nearby residents and the schools that are adjacent to the parks. Care should be taken to involve neighbors, teachers and students in invasive species themed events whenever possible to foster feelings of involvement. Meetings with teachers or residents in the aftermath of events could remind all involved that invasive species management is a long-term process that requires community cooperation.

The parks neighbor Rosemount High School and Rosemount Middle schools. Student volunteers can be organized together to coordinate a buckthorn pull in exchange for service hours.

Interpretative Signs & Informational Pamphlets

Permanent interpretation signs could be placed at areas that are either clearly infested by invasive species or areas that have had management for invasive species. These signs could be simple, providing information for the community about the invasive species, why it is problematic, and how to recognize it. There are multiple entrances to the parks and located at each entrance is a park map. The recommended interpretative signs can be placed adjacent to these trail maps.

Figure 7: Park trail marker at an entrance to Carroll's Woods. Photo by Rebecca Bryan.

If appropriate, the signs could suggest what the public should do if they spot the invasive species elsewhere. One option could be as simple as contacting a relevant authority. Pamphlets containing more in-depth information should be provided by the city and accessible at multiple points with the parks for interested individuals. Examples of these signs and pamphlets can be found in Appendix C. The Minnesota DNR has additional educational handouts available to the public and can be requested though any Minnesota DNR office.

Tree Labels

Tagging trees or plants that have either been affected by or treated for invasive species could be a quick, inexpensive and highly visual way of getting the magnitude of the problem across to the public. Each tree could be ringed with a sash that explains very simply what the relevant species is or what type of management has been carried out. Another alternative would be to have a relevant website URL and a QR code that can be scanned by a smartphone on each sash that would send interested parties to relevant websites to get more information about the invasive species and how to help manage the spread of the invasive.

Summary

The city has worked diligently to restore parts of the parks to a more natural and ecologically balanced system. Continuation of this work will require addressing the issue of invasive species. Management of invasive species in Carroll's Woods and Schwarz Pond Park will be an ongoing issue for the community of Rosemount. Creation of an action plan that can be sustainable for the city to implement and maintain will require cooperation from city officials and Rosemount community members. It will be difficult and costly for complete eradication of the invasive species but through a community effort positive change can be enacted. Engaging community members in the protection of their public spaces though outreach and education, can make the city of Rosemount a healthier and more sustainable place.

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Appendices
Appendix A: Invasive Species Chemical Treatment Options
Appendix B: Biological Control for Emerald Ash Borer
Appendix C: Community Outreach and Educational Materials

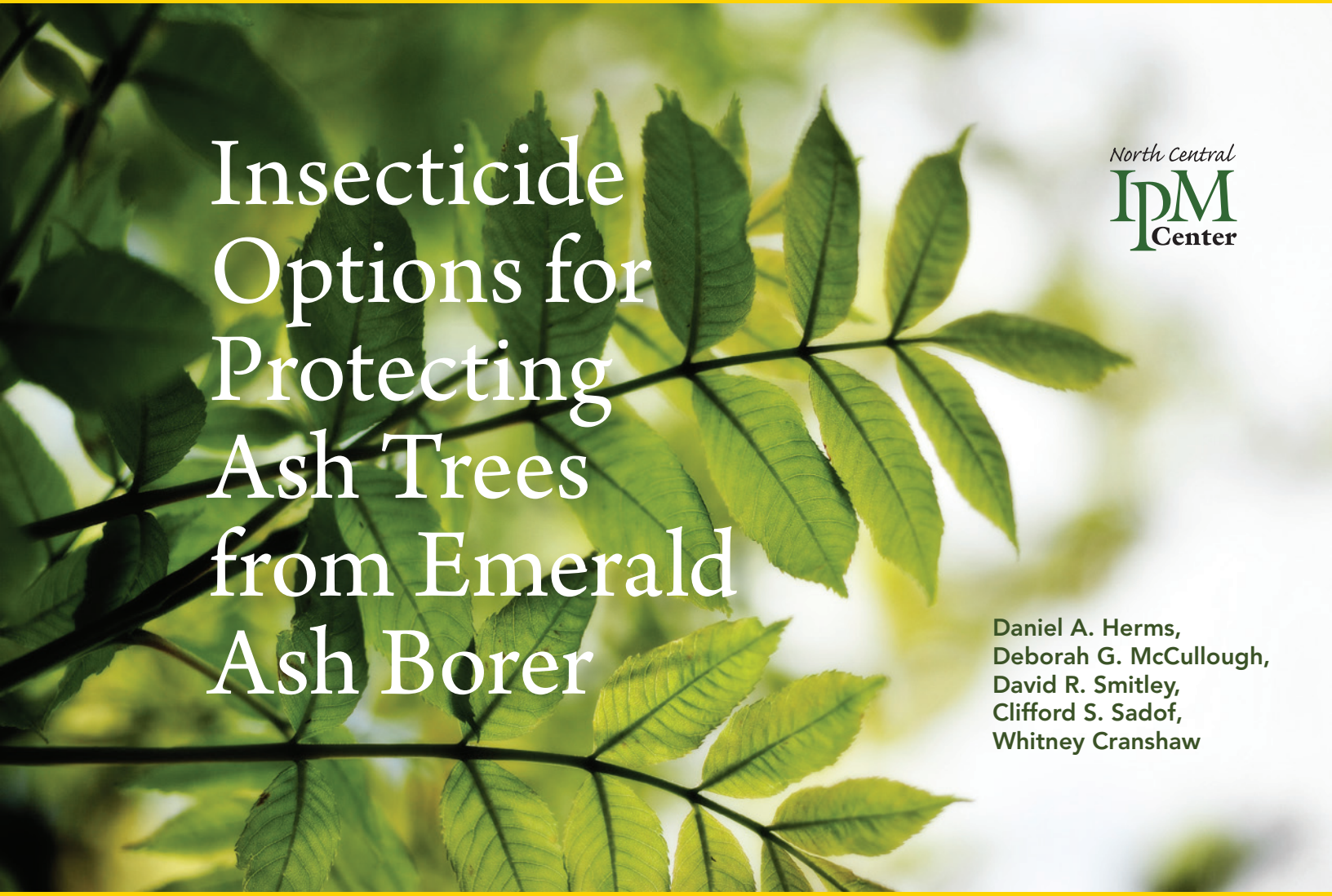
Appendix A: Invasive Species Chemical Treatment Options

Minnesota Department of Natural Resources list of herbicides for controlling buckthorn

Herbicides to Control Buckthorn

Trade Name	Chemical Name	Concentration	Use
Ortho Brush-B-Gon	Triclopyr amine	Ready to use - do not dilute	Cut stump
Ferti-Lome Brush Killer and Stump Killer	Triclopyr amine	Ready to use - do not dilute	Cut stump
Garlon 3A	Triclopyr amine	Mix one part Garlon 3A with 3 parts water (this achieves a 25% solution)	Cut stump
Garlon 4	Triclopyr ester	Mix one part Garlon 4 with 3 parts bark oil/diluent (this achieves a 25% solution)	Cut stump or basal bark
Pathfinder II	Triclopyr ester	Ready to use - do not dilute	Cut stump or basal bark
Roundup, Rodeo, Accord, Etc.	Glyphosate	▪ Cut stump: Look for at least 25% active ingredient glyphosate for cut-stump treatments. If using Roundup Concentrate you can mix 1 part water with 1 part herbicide to achieve a 50% solution. ▪ Foliar spray: Lower concentrations (2% active ingredient) work for foliar spray of seedlings. If using Roundup Concentrate you can mix a 1:50 to 1:20 herbicide:water ratio.	Cut stump or foliar spray

SECOND EDITION



Insecticide Options for Protecting Ash Trees from Emerald Ash Borer

North Central IPM Center

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Clifford S. Sadof,
Whitney Cranshaw

The Ohio State University
College of Food, Agricultural, and Environmental Sciences

Michigan State University

Purdue Extension | Local Faces Countless Connections

Colorado State University Extension

SECOND EDITION

Insecticide Options for Protecting Ash Trees from Emerald Ash Borer

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Table 1. Insecticide options for professionals and homeowners for controlling EAB that have been tested in multiple university trials. Some products may not be labeled for use in all states. Inclusion of a product in this table does not imply that it is endorsed by the authors or has been consistently effective for EAB control. Additional imidacloprid products may be available in your area. See text for details regarding effectiveness.

Insecticide Formulation	Active Ingredient	Application Method	Recommended Timing
Products Intended for Sale to Professional Applicators			
Merit® (75WP, 75WSP, 2F)	Imidacloprid	Soil injection or drench	Early to mid-spring or mid-fall
Safari ™ (20 SG)	Dinotefuran	Soil injection or drench	Mid- to late spring
Transect ™ (70WSP)	Dinotefuran	Soil injection or drench	Mid- to late spring
Xytect™ (2F, 75WSP)	Imidacloprid	Soil injection or drench	Early to mid-spring or mid-fall
Zylam® Liquid Systemic Insecticide	Dinotefuran	Soil injection or drench	Mid- to late spring
Azasol™	Azadirachtin	Trunk injection	Mid- to late spring after trees have leafed out
Imicide®	Imidacloprid	Trunk injection	Mid- to late spring after trees have leafed out
TREE-äge™	Emamectin benzoate	Trunk injection	Mid- to late spring after trees have leafed out
TreeAzin®	Azadirachtin	Trunk injection	Mid- to late spring after trees have leafed out
Safari™ (20 SG)	Dinotefuran	Systemic bark spray	Mid- to late spring after trees have leafed out
Transect (70 WSP)	Dinotefuran	Systemic bark spray	Mid- to late spring after trees have leafed out
Zylam® Liquid Systemic Insecticide	Dinotefuran	Systemic bark spray	Mid- to late spring after trees have leafed out
Astro®	Permethrin	Preventive trunk, branch, and foliage cover sprays	Two applications at 4-week intervals; first spray should occur at 450-550 degree days (50°F, Jan.1); coincides with black locust blooming
Onyx™	Bifenthrin		
Tempo®	Cyfluthrin		
Sevin® SL	Carbaryl		
Products Intended for Sale to Homeowners			
Bayer Advanced™ Tree & Shrub Insect Control	Imidacloprid	Soil drench	Early to mid-spring
Optrol ™	Imidacloprid	Soil drench	Early to mid-spring
Ortho Tree and Shrub Insect Control Ready to Use Granules®	Dinotefuran	Granules	Mid- to late spring

Appendix B: Biological Control for Emerald Ash Borer

United States Department of Agriculture

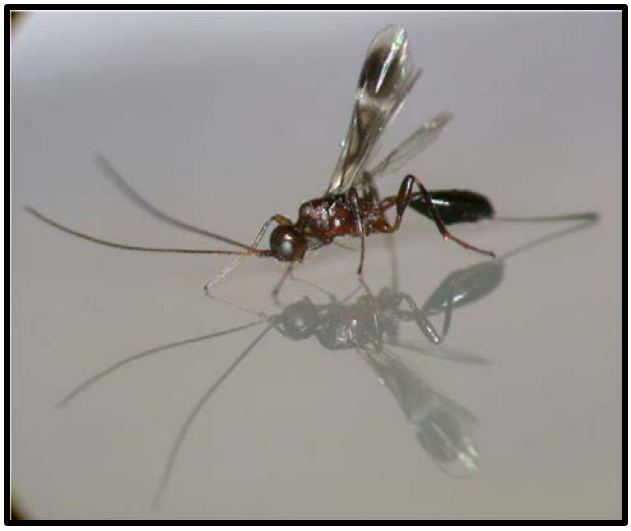
Animal and Plant Health Inspection Service

Agricultural Research Service

US Forest Service

Cooperating State Departments of Agriculture

Emerald Ash Borer Biological Control Release and Recovery Guidelines



Emerald Ash Borer, *Agrilus planipennis* (Fairmaire), Biological Control Release and Recovery Guidelines – May 2013

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Cover photographs by: Top left: David Cappaert, Contractor, Michigan State University (*T. planipennisi*)
Middle right: Tracy Ayer, Technician, USDA APHIS PPQ CPHST (*S. agrili*)
Bottom left: Deborah Miller, Entomologist, USDA FS NRS (*O. agrili*)

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CONTENTS

APPENDICES

INTRODUCTION

BRIEF HISTORY OF EAB IN NORTH AMERICA

Emerald ash borer (EAB), a beetle from Asia that feeds on ash trees, was discovered as the cause of extensive ash mortality in southeast Michigan and adjacent areas of Canada in 2002. It is thought that this destructive pest was introduced in the early 1990's in infested solid wood packing material originating in Asia.

Shortly after EAB was discovered in North America, federal and state regulatory agencies placed infested counties under quarantine and eradication activities were initiated. Due to the magnitude of the EAB infestation in North America, the potential for natural and artificial dispersal of EAB, limited EAB detection and control methods, and high costs, program objectives shifted away from eradication to containment and management of the pest. By June 2013, EAB infestations were known in twenty states (Connecticut, Illinois, Indiana, Iowa, Kansas, , Kentucky, Maryland, Massachusetts, Michigan, Minnesota, Missouri, New Hampshire, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, Wisconsin and West Virginia) and two Canadian provinces (Ontario and Quebec). At present, the most promising long-term approach for reducing EAB populations and conserving ash in forested areas of North America is biological control.

LIFE-CYCLE OF EAB

EAB takes one or two years to complete its life-cycle depending on temperatures (latitude and altitude), local population density, and tree health. Below is a description of the one-year EAB life-cycle:

Adults

EAB adults begin to emerge from the trunks of ash trees after the accumulation of 400-500 growing degree days base 50°F (GDD). Peak adult activity occurs at ~1000 GDD. After emergence, adults fly into the ash canopy where they feed on leaves throughout their lives. EAB adults start mating one week after emergence, and females begin laying eggs 2-3 weeks later. In the field, EAB adults are readily observed mating and egg-laying on the trunks of ash trees on warm, sunny afternoons. The adults of both sexes are strong fliers.

Eggs

A female EAB may lay >200 eggs in her lifetime, depositing them individually or in groups on the bark along the trunk and portions of the major branches. Eggs are laid in areas where the bark is rough, and between bark layers or in bark crevices. Eggs are approximately 1.0 mm long x 0.6 mm wide and creamy white when laid; fertile eggs gradually turn amber after a few days (Appendix A). The eggs hatch after about two weeks.

Larvae

Newly hatched larvae bore through the bark to the phloem and outer layer of new sapwood where they feed until the weather gets too cold in the fall. There are four stages of larval development (instars) (Appendix A). As they feed, the larvae create long serpentine galleries filled with frass, which enlarge in width as they grow (Appendix A). Larvae are creamy white, and dorso-ventrally flattened (Appendix A). When fully mature, fourth-instar larvae are 26 to 32 mm long. Their head is mostly retracted into the prothorax with only the dark brown mouthparts visible. The prothorax is enlarged, with the mesothorax and

metathorax slightly narrower. Larvae have 10 bell-shaped abdominal segments and a pair of small brown structures called urogomphi, which are characteristic of all larvae in the genus *Agrilus* (Appendix A).

Overwintering larvae, prepupae, pupae, and adults

In the fall, mature fourth-instar EAB larvae excavate pupal chambers in the sapwood or outer bark where they fold into overwintering "J-shaped larvae" (Appendix A). In the spring, the J-shaped larvae shorten into prepupae then shed their cuticle to become naked pupae. Pupae are initially creamy white, but the eyes turn red and the body begins to darken as they develop (Appendix A). To emerge from ash trees, adults chew D-shaped exit holes (Appendix A) through the bark and are capable of immediate flight upon emergence. EAB larvae that are immature as cold weather arrives in the fall will simply overwinter in their larval gallery. Mature larvae complete development (i.e. become an adult beetle) the following spring, whereas younger larvae may require another summer of feeding to complete development.

DAMAGE AND SIGNS OF INFESTATION

EAB larvae damage ash trees by feeding on the phloem. In a new infestation, when just a few EAB larvae infest a tree, the tree responds by forming scar tissue or "callous" around EAB galleries, and the tree may show few outward signs of infestation. On some trees or branches, however, the callous may cause the bark to split, exposing the EAB gallery beneath (Appendix A). As EAB larval density increases, the movement of nutrients through the phloem is disrupted and evidence of tree stress increases such as yellow foliage on dying branches, dead branches, small leaves, thinning crowns, and epicormic shoots (Appendix A).

Woodpeckers feed on EAB larvae living under the bark of trees. We have found woodpecker feeding is one of the best indicators of early EAB infestation with the most obvious symptoms including bark scaling (removal of bark flakes) and feeding holes through the bark (Appendix A). Although difficult to detect, especially high in the canopy, the D-shaped exit holes chewed by emerging adults are diagnostic indicators of EAB infestation (Appendix A).

ECONOMIC CONSEQUENCES OF EAB INFESTATIONS

The cost of managing EAB is already high. On average, federal and state resource managers spend $29.5 million per year to manage EAB populations. The compensatory value of the 8 billion ash trees in U.S. timberland potentially infested with EAB is $282 billion. States in the eastern U.S. produce nearly 114 million board feet of ash saw timber annually, with a value of $25.1 billion. White, black, and green ash make up >7 percent of the hardwood stand mix and 5.5 percent of the total stand mix (including conifers) in the northeastern United States and eastern Canada. The wood is used for a variety of applications including tool handles, baseball bats, furniture, cabinetry, basketry, solid wood packing materials, pulp, and paper. The continued spread of EAB threatens our ash resources and will permanently alter ecosystems in the eastern states. The 16 native species of ash, some with limited distributions in North America, are now threatened by EAB.

In addition to its value to the timber industry and the forest ecosystem, ash is one of the most popular landscape trees because of its tolerance of a range of environmental conditions and resistance to other pests. Ash was the most commonly planted tree species used to replace elm trees decimated throughout North America by Dutch elm disease and for new residential

and commercial developments. The estimated cost of treating, removing, and replacing 37.9 million ash trees in urban and residential settings in 25 states is $25 billion. Nationwide, the nursery industry produced an estimated 2 million ash trees each year. With median approximate values ranging from $50 to $70 per tree, the annual ash nursery stock was worth between $100 and $140 million.

HOST RANGE OF EAB

In eastern North America, EAB attacks ash species in the genus *Fraxinus*, including but not limited to green ash (*F. pennsylvanica*), white ash (*F. americana*), black ash (*F. nigra*), pumpkin ash, (*F. profunda*), and blue ash (*F. quadrangulata*). In China, native ash species, including *F. chinensis* and *F. mandshurica*, are less susceptible to EAB than North American species commonly planted in China such as velvet ash (*F. velutina*) and green ash.

BIOLOGICAL CONTROL OF EMERALD ASH BORER

Biological control (or biocontrol) is the practice of importing and releasing natural enemies from a pest's native range to control populations in the area of introduction. Biocontrol has been used for over 100 years in the U.S. and has successfully controlled invasive plant and insect pests such as gypsy moth, winter moth, ash whitefly, eucalyptus longhorned borer, purple loosestrife, and Klamath weed. Because EAB is from northeast Asia, U.S. and Chinese scientists have been searching for EAB and its natural enemies in that region since 2003. In Asia, EAB population densities are relatively low due to the combined effects of EAB-resistance in Asian ash species, scarcity and patchiness of forests, and the EAB natural enemy complex. Exploration for EAB natural enemies in China by USDA and Chinese researchers yielded several hymenopteran parasitoids. Three of these parasitoids have been approved for release as biological control agents of EAB in the U.S.

NATIVE NATURAL ENEMIES

In southeast Michigan, <1% EAB larval parasitism was found by researchers surveying for potential natural enemies of EAB in 2003 and 2004. Parasitoid species reared from ~3,000 EAB larvae included several native hymenopteran species: *Phasgonophora sulcata* (Chalcididae), *Spathius floridanus* (Braconidae), *Atanycolus* spp. (Braconidae), and one exotic parasitoid *Balcha indica* (Hymenoptera: Eupelmidae). No native egg parasitoids have been reared from EAB eggs. More recently, *Atanycolus* spp. were found parasitizing up to ~70% EAB larvae locally in Michigan, but overall populations of EAB are not controlled by native natural enemies. The development of a biological control program for EAB management using non-native parasitoids continues to progress because parasitism of EAB

in the U.S. is low compared to that reported for our native *Agrilus* spp. and for EAB in China.

BIOLOGY OF EAB PARASITOIDS

Oobius agrili parasitizes up to 60% of EAB eggs laid during the summer in some areas of China. Tiny female *Oobius* accomplish this by searching the bark of ash trees for EAB eggs, which are laid in bark crevices and between layers of bark. When *Oobius* finds an EAB egg, it injects its own egg inside (Appendix B) where it will hatch, grow, and kill the host egg. An *Oobius* adult will emerge and repeat the cycle for at least two generations during the EAB egg-laying season. Each *Oobius* adult parasitizes an average of ~80 EAB eggs during its lifetime. *Oobius* spend the winter as larvae inside EAB eggs and emerge as adults the following spring.

Spathius agrili parasitizes up to 90% of EAB larvae in ash trees in some parts of China. Female *Spathius* parasitize EAB larvae by drilling through the bark (Appendix B) and laying an average of 8 eggs on the outside of its host. The hatching parasitoid larvae (Appendix B) feed and develop on the EAB larva, causing its death. The cycle is repeated 1-2 times each summer and fall depending on climate. *Spathius* overwinter as larvae or pupae in the host gallery. Mature larvae spin silken cocoons in which they pupate and emerge as adults during the summer.

Tetrastichus planipennisi is another larval parasitoid of EAB from China, where it attacks and parasitizes up to 50% of EAB larvae in some areas. The life cycle of *Tetrastichus* is similar to that of *Spathius,* however, the female parasitoid lays eggs inside EAB larvae where the parasitoid larvae grow, eventually killing their host. *Tetrastichus* completes several

generations each year, and one EAB larva can produce >130 *Tetrastichus* adults. They survive the winter as larvae inside their host or host gallery under the bark of ash trees (Appendix B).

REARING EAB PARASITOIDS

The USDA APHIS PPQ Biological Control Production Facility in Brighton, MI was designed to produce EAB parasitoids for field release. These small parasitic wasps must be reared in EAB eggs or larvae, which are produced or harvested from bolts of ash trees felled in nearby woodlots. Although the parasitoids are reared and stockpiled throughout the year for release during the field season, the rearing methods are time and labor intensive. At the present time, production of EAB eggs and larvae limits the number of parasitoids that can be produced. Thus, demand for biological control agents may exceed production for the foreseeable future.

The EAB egg parasitoid, *Oobius*, is reared in eggs laid by EAB adults. Initially, the adult beetles are reared from infested ash trees, which were harvested and refrigerated the previous winter or early spring. After emergence from ash logs, EAB adults are fed greenhouse-grown or field-collected ash leaves throughout their lives. In the field, EAB females oviposit on the bark of ash trees, but in the laboratory, they will deposit their eggs on paper. EAB eggs attached to paper are then exposed to *Oobius* females, which parasitize the eggs. *Oobius* will be shipped in plastic cups as adults or as pupae in EAB eggs on paper.

The two species of EAB larval parasitoid, *Spathius* and *Tetrastichus*, are reared in small-diameter ash bolts in which EAB larvae are grown or inserted under the bark. These infested ash bolts are exposed to either *Spathius* or *Tetrastichus* adults, which detect and parasitize

EAB larvae feeding under the bark. Most of the EAB larvae used to produce larval parasitoids are now produced in the laboratory by applying EAB eggs to live ash logs in which the EAB larvae grow until mature. Parasitoids are then placed with these logs, and parasitism will occur readily.

In the past, adult parasitoids were shipped and released; however, we will begin shipping ash bolts containing *Spathius* or *Tetrastichus* pupae in 2013. This will change how parasitoids are released into the field: ash bolts containing parasitoid pupae will be taken to the field sites and attached to release trees where the parasitoids will emerge naturally under field conditions. Following the evaluation in 2013/2014, shipment of ash bolts containing parasitoid pupae will potentially become the standard method of delivery.

PROJECT STATUS

In January 2009, a Biological Control Production Facility became operational in Brighton, MI. As of February 2013, this facility has reared and released over 720,000 EAB parasitoids in fourteen states. These releases will continue while scientists continue to study the establishment, dispersal, and impact these natural enemies have on suppressing EAB populations and the recovery of ash trees. Scientists will also continue to explore the U.S. and Asia for additional EAB natural enemies for possible use in the EAB biological control program. Most recently, a new species of *Spathius* was discovered attacking EAB larvae in Korea and Russia, where the climate is different than in Tianjin, China, where *S. agrili* was collected. Host specificity testing is complete for *Spathius galinae*, and an application for a release permit has been submitted.

FIELD RELEASE

This section provides guidance for obtaining permits, selecting parasitoid-release sites, collecting data on site characteristics, and releasing the parasitoids. For the EAB Biocontrol Program to monitor and evaluate the establishment of EAB parasitoids and the impact of EAB biocontrol, researchers and state cooperators receiving parasitoids from USDA APHIS Biological Control Production Facility must agree to submit their data to a centrally managed, online, searchable database (www.mapbiocontrol.org). The database will store data on where, when, how, under what conditions, and how many parasitoids were released and established. Personnel can use a hand-held computer (such as a Getac or Ashtech) with a built-in GPS unit to collect data in the field, or data can be entered online. The data in the GPS device should be synchronized with a central database for storage and analysis after every data collection occurrence.

OUTLINE OF PROCEDURES FOR EAB BIOCONTROL RELEASES

- **Obtain APHIS release permit.** Permits need to specify receipt of the three species of parasitoids, **EAB** eggs and juvenile stages, and **ash host material.**

- **Select a release site** in an area with good access, high density of ash trees of various sizes, and low to moderate EAB density.

- **Obtain Local Land-Use Permits**

- **Enter Data** about the site location into mapBioControl (www.mapbiocontrol.org). Take site coordinates in the center of the plot where the releases will occur. When you login, you will be asked to agree to enter release and recovery data into mapbiocontrol and agree to sample the release sites to determine which species of parasitoids have established.

- **Collect General Site Details and Physical Characteristics** using a handheld GPS unit (we recommend the Getac or Ashtec brands) or enter the information into the mapBioControl web site (www.mapbiocontrol.org).

- **Synchronize your GPS unit.** The units should be synchronized every time data are collected to prevent the loss of data.

- **Request Parasitoids for Release** once your site has been approved.

- **Collect Data on Release Trees** (size, EAB density, tree health) using a handheld GPS unit or enter data online.

- **Release Parasitoids:** Release at least the minimum recommended number of parasitoids in the spring, mid-summer, and late summer in Year 1 and Year 2. Enter Release data using the handheld GPS device or online at mapbiocontrol.org.

- **Assess Parasitoid Establishment:** Determine if the three parasitoids are established at each site **at least one year following the final release (**Year 3). This can be done during the winter or early spring (for bark sampling or log debarking) or summer (for yellow pan traps or sentinel logs). Several methods are available for parasitoid recovery, with the choice of method depending on the specific circumstances of each release site.

OBTAINING PERMITS

An APHIS PPQ permit is required to release the three EAB parasitoids, *Oobius agrili*, *Spathius agrili*, and *Tetrastichus planipennisi*, in each state. To apply for the permit, complete PPQ Form 526 "Application for Permit to Move Live Plant Pests, Noxious Weeds, or Soil" online at the APHIS ePermit system: http://www.aphis.usda.gov/permits/learn_epermits.shtml; however, you must first receive a USDA eAuthentication account: http://www.aphis.usda.gov/permits/eauth_epermits.shtml. The ePermit system allows you to submit and track permit applications, receive permits, and apply for renewals and amendments online. The permitting process may take four to six months to complete. Parasitoids may either be shipped as adults or as immatures inside EAB eggs or small ash logs. The ash logs will mostly contain parasitized EAB, but a few EAB could escape parasitism and emerge as adults. Therefore, your permit application should

include the host plant (ash), juvenile stages of EAB (eggs, larvae, and pupae), and each parasitoid species.

RELEASE SITE SELECTION

Although improved rearing methods and increased staff have allowed for the production and release of greater parasitoid numbers than in the past, each parasitoid is still rather costly to produce. Therefore, parasitoids should be released at sites where they have the highest probability of establishment. The information below will help researchers and the Rearing Facility Manager determine which sites are most appropriate for release.

General Site Characteristics

Locate parasitoid-release sites in naturally forested areas, woodlots, or wooded wetlands and riparian zones. To allow for parasitoid establishment and dispersal, do not select release sites that may be harvested or developed in the next 5 years. State, county, city, and township parks, recreation areas, and game areas are less likely to be disturbed than private lands. Avoid sites with excessive human activity, as well as sites along roads, trails, or railroad tracks, and in picnic areas, golf courses, and open park lands. Ash trees in such public areas may be treated with insecticide or removed.

Minimum Acreage

Wooded areas at least 40 acres in size are preferred as parasitoid-release sites. Smaller release sites (<40 acres) will require higher ash densities and ash corridors connecting the release sites to other wooded areas. Examples of ash corridors are rivers, ditches, highways,

and fence rows. Use of these criteria will facilitate parasitoid reproduction, establishment, and dispersal to nearby areas.

Relative Density of Ash

At least 25% of the trees over 4 cm DBH should be ash, with a higher percentage of ash even better. The percentage of ash can be estimated as <25%, 26-50%, 51-75%, or 76-100%.

Ash Tree Size Class

Ideally, parasitoid-release sites should contain a variety of ash size classes ranging from seedlings to mature trees. Older and highly stressed ash trees in a stand are generally attacked first by EAB and tend to die off more quickly. Although these trees are unlikely to benefit from EAB biological control, they will provide a high density of EAB eggs and larvae, increasing the probability of parasitoid reproduction at the site. Smaller trees, saplings, and seedlings provide potential for regeneration of ash trees, and will support EAB and their natural enemies following the loss of larger ash trees in the stand. *Tetrastichus*, which has a short ovipositor, appears most likely to establish in areas with some smaller, thin-barked ash trees, where EAB larvae are more accessible.

Density of EAB

Low to moderate EAB-population densities are recommended for potential parasitoid-release sites. Stands with many dead and dying trees are not appropriate as release sites because ash and EAB may decline before the parasitoids become well established. The most accurate method of estimating EAB density requires felling and peeling the bark from ash trees to count EAB present under the bark and along the trunk. This direct estimate of EAB density,

however, is difficult, labor intensive, destructive, and counter-productive in areas where EAB density is low. Therefore, we recommend using an indirect EAB-density estimate based on the signs and symptoms of EAB infestation in ash trees.

During the winter, before spring leaf flush, the symptoms of EAB attack on declining ash trunks include woodpecker feeding and bark scaling, bark splits, EAB-emergence holes, epicormic shoots and stump sprouts. Symptoms of dead ash trees include bark that is falling off trees, leaving exposed galleries and D-shaped exit holes (Appendix A).

After leaf flush, the condition of ash trees can be visually ranked according to the five crown-condition classes illustrating typical EAB-induced decline; crown condition 1 is a healthy canopy, 2, 3, and 4 show increasing decline and 5 is dead (Appendix C). Overall, ash trees at a potential release site should be fairly healthy, with an average crown condition of 1 to 2 (healthy or mostly healthy) and only a few trees in condition classes of 4 to 5 (dying or dead). The presence of EAB must be confirmed at each potential release site. This is done by selecting ash trees with signs of stress from a possible EAB infestation. On these potentially infested trees, remove sections of bark using a chisel or draw knife to confirm the presence of EAB galleries or EAB life stages (Appendix A). When the density of EAB is low to moderate, most EAB will be higher on the trunks, thus confirmation may require felling and debarking ash trees in the stand.

Access and local use permits

Select release sites at locations that are relatively easy to access because personnel will need to visit the site periodically for parasitoid release and recovery activities. Obtain permission from land owners for use of the site to both release parasitoids and fell some ash trees over a

period of three to four years. Keep in mind that it may take months to obtain permission or land-use permits from land owners or park managers.

PRE-RELEASE SITE ASSESSMENT

Prior to requesting parasitoids for release, we recommend collecting some preliminary data on site characteristics that will help the Biocontrol Rearing Facility Staff assess whether your site is appropriate for parasitoid release. We recommend collecting the data while in the field using handheld GPS units (such as Getacs or Ashtechs), which will capture the longitude and latitude data and have drop down menus for other necessary data. General Site Details and Physical Details data can also be entered online at www.mapbiocontrol.org. Be sure that when data are collected using a GPS device that you are at the location where parasitoids will be released. Do not collect GPS coordinates next to the road. Ideally the parasitoids should be released in the center of the forest, or at least 100 m from the road or other non-forested areas. Once the data are collected and the GPS unit is synchronized, the Rearing Facility Manager can review the site and determine if the site is appropriate for release. The information provided, including location, size (number of acres or hectares), percentage ash, and EAB density will assist the Rearing Facility Manager and state cooperators in prioritizing and selecting the best site(s) for parasitoid release.

To enter data about a new **Release Site** into mapbiocontrol, click on "Release" in the green banner. Click the "New" button in the upper gray table, and then enter the following data:

- Status: Select "Proposed" because the site has not yet been approved.
- State
- Date

- Site Name
- Site Location (Enter general information such as county, town, park name, address, etc.)
- Latitude (dd.dddddd)
- Longitude (dd.dddddd)
- Plot (whether it is a release or control plot)
- Type (program or research)

To continue entering data about your new site, click on the site in the upper table to highlight it (it will turn yellow). Then click on one of the tabs below. When you click on the General Details Tab or the Physical Details Tab you will need to highlight the line of blanks in the lower table (it will turn yellow) before you can click on the "Edit" button to enter the data. To see more information about each entry item hover the mouse over the category. Enter site characteristics data as follows:

General Details

- Size of wooded area in acres (you can use the measurement tools with Google Earth or ArcGIS Explorer)
- % ash (estimate)
- Dominant Tree Species
- 2nd most Dominant Tree Species (if applicable)
- 3rd most Dominant Tree Species (if applicable)
- EAB Density (Low, Medium, High)

Physical Details

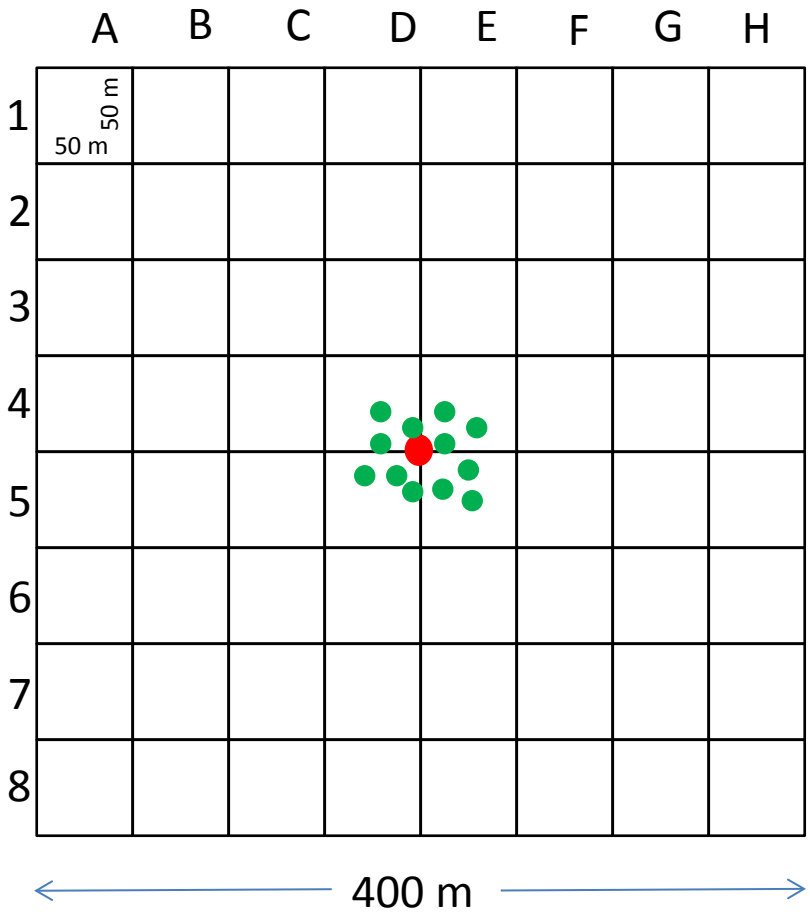
- Topographic Position (Upper Slope, Mid Slope, Lower Slope, Level)
- Flooding (Dry all year, Seasonally Wet, Wet all Year)
- Degree of Isolation (Surrounded by non-woodland or connected to other woodlots)

PRE-RELEASE SITE PREPARATION

Location of release trees

After a site is chosen for parasitoid release, select a group of EAB-infested ash trees located near the center of your site (Fig. 1). This will be the parasitoid-release epicenter. Positive signs of EAB include woodpecker scaling and feeding, bark splits, epicormic shoots, poor crown condition, and/or EAB- emergence holes. Select one tree (it does not have to be an ash) as the release epicenter (Fig. 1, red dot in center of plot).

Figure 1



Mark the epicenter tree with flagging or tree paint and take the GPS coordinates.

Plot design and tree selection

Generally, each plot will be 4 ha (200 m x 200m) divided into sixty-four 50 m x 50 m cells surrounding the epicenter point (Fig. 1). In most plots, sampling will occur in the 16 central grid cells, however, given that not all field sites will be square (along rivers, for instance they will be long and thin) the sampling grid contains 64 cells, 16 of which will be used for sampling. You will not have to lay the grids out in the woods. Once the GPS points have been taken for the release trees, the grid cells will be laid over the points and you will be able to see where you are in relation to the grid cells when you use the GPS device.

Select three ash trees >4 cm DBH in each of the four central cells that are closest to the epicenter point; these will be the 12 parasitoid-release trees (Fig. 1, green dots in central four grid cells). Tag each tree by nailing a durable, pre-numbered, aluminum tree tag with an aluminum nail to the tree above 1 m and in consistent manner to assist those attempting to find those trees when returning to the site (NOTE: Nails will have to be removed from the tree after the project is completed if the trees are not felled and sampled). Let the nail head protrude from the tree to allow for tree growth. Also, flag all trees with brightly colored flagging so they are easier to find, and record the location of each tree using high resolution GPS.

COLLECTION OF DATA FROM RELEASE TREES

Collect data for each of the 12 release trees using a handheld GPS unit or enter the data on the mapBioControl web site. Collect the following information:

Date. Month, day, year when data were collected.

GPS coordinates. The GPS units in the Getac or Ashtech devices are accurate to within approximately 1-3 m. Stand as close as possible to the release tree to record the latitude and longitude in decimal degree format.

DBH. Record the diameter of each tree (in centimeters) at breast height (1.37 m above the forest floor).

Crown Class. The health of ash trees is estimated by recording the crown class on a scale of 1-5 (Appendix C). A crown class of 1 indicates a full healthy crown, while a dead tree receives a rating of 5.

Epicormic shoots. Epicormic shoots are sprouts that emerge from dormant buds along the trunk or branch of a tree (Appendix A). They are produced by the tree as a means of compensating for the loss of leaf surface, in this case due to damage from the EAB. Epicormic shoots tend to be green rather than brown in color and emerge directly from the trunk rather than following the normal branching pattern of the tree. Count or estimate the number of epicormic shoots on the upper and lower half of the main trunk of each tree.

Number of EAB exit holes. Count the number of EAB exit holes (Appendix A) you can detect on the trunk up to approximately 1.5 m.

Number of bark splits. Ash bark often will split when there is an EAB gallery beneath the bark (Appendix A). Record the number of bark splits visible on the lower 1.5 m of trunk.

Woodpecker feeding damage. Woodpeckers feed on EAB larvae located under the bark and leave a characteristic hole in the bark. In addition, foraging woodpeckers often remove

flakes of bark, leaving light colored patches on the trunk (Appendix A). Record whether woodpecker feeding damage is evident in the upper and lower half of the tree.

PARASITOID RELEASE

WHICH SPECIES TO RELEASE

Prior to 2012, the EAB Biocontrol Program provided the three EAB biocontrol agents to each state for release upon request. Releases of *Tetrastichus* and *Oobius* will continue in all states. *Spathius agrili*, however, may not be surviving adequately in northern regions. Therefore, the EAB Biological Control Program will now provide *S. agrili* for programmatic releases in areas below the 40th parallel north. If any portion of a county falls on or below the 40th parallel north, that county is eligible for *S. agrili* releases. Release and evaluation efforts in more southern areas, particularly in Kentucky, Missouri, Tennessee, Virginia and West Virginia have been more recent and performance of *S. agrili* is not yet known. Monitoring for *S. agrili* establishment will continue at sites where *S. agrili* was released in the past and at new sites south of the 40th parallel.

TIMING OF RELEASE

Spring Tetrastichus and Spathius releases: In more northerly states or locations early in the EAB-infestation cycle when EAB densities are low, EAB may take two years to develop to the adult stage. Eggs laid late in the year also may fail to develop to the J-larval stage. Under these circumstances, the third- and fourth-instar larvae needed for parasitism by *S. agrili* and *T. planipennisi* are present during spring, summer, and fall. After 300 growing

degree days (GDD base 50ºF) have accumulated in your area, we will contact you about shipping the larval parasitoids, *Tetrastichus* and *Spathius*, for a spring release.

Summer Oobius releases: *Oobius agrili* lays its eggs inside EAB eggs, therefore, releases should be initiated 2-3 weeks after EAB adults begin to emerge (EAB adults take several weeks to mature before mating and laying eggs). We will contact you about receiving shipments of *Oobius* when ~800 GDD have accumulated. In northern areas or areas with late emergence of EAB adults, *Oobius* releases may continue through August. Two helpful handouts on the timing of EAB emergence are online at:

http://www.ipm.msu.edu/landreport/2004/EAB_tracking.pdf

http://www.emeraldashborer.info/files/handoutforpdf.pdf.

Late summer/Fall release of Tetrastichus and Spathius: Both larval parasitoids attack mature (late 3rd and 4th instar) EAB larvae. In southern areas and late in the EAB-infestation cycle when population densities are high, EAB populations are more synchronized and mature larvae are more abundant from mid-summer to fall. Begin late summer/fall releases when 1800 GDD have accumulated. Because of diapause considerations, we find that *Spathius agrili* should not be released after the end of August, however *Tetrastichus* can overwinter in any stage and releases can continue as long as field conditions are favorable for adult oviposition and the EAB larvae haven't entered the overwintering chambers.

NUMBER AND FREQUENCY OF RELEASES

The minimum numbers of parasitoids recommended for release are listed below by species. The actual numbers shipped, however, will vary depending on total availability during any given week and the number of release sites requiring insects. Whenever more parasitoids are

available they will be shipped and should be released because the probability of establishment is increased when more parasitoids are released. Each release will consist of a specified number of female parasitoids previously exposed to male parasitoids for mating and an unspecified number of males. Because weather patterns in any given year can impact the synchrony between availability of the appropriate stages of EAB and release timing, releases should be made during two years.

Spring Tetrastichus and Spathius release: You will be shipped a minimum of 200 *Tetrastichus* and 200 *Spathius* females (where appropriate) every other week for 5 weeks beginning when 300 GDD have accumulated, for a minimum of 600 females released for each species. When more than 200 parasitoids are available for shipment, you will receive more for release.

Oobius release: Release a minimum of 100 *Oobius* per week for four to six weeks for a total of a minimum of 400 to 600 released.

Late summer Tetrastichus and Spathius release: Release a minimum of 200 females of each species every other week for 5 weeks beginning when 1800 GDD have accumulated. A minimum of 600 females will be released for each species.

REQUESTING PARASITOIDS

Email all parasitoid requests to Stephanie Likens (Stephanie.Likens@aphis.usda.gov) and copy Jonathan Lelito (Jonathan.Lelito@aphis.usda.gov). The Request Tab on mapbiocontrol.org is currently under development and should not be used at this time.

RECEIPT OF PARASITOIDS

Parasitoids are shipped by overnight delivery in a cooler, and should arrive by 10:30 AM at most locations. Adult *Spathius and Tetrastichus* will be shipped either as developing pupae inside ash bolts or as adults in 16-oz plastic cups with screening on the lid. Ash bolts will contain a hanging device for easy mounting on release trees. Honey will be smeared on the screening as a source of food for the adult parasitoids in cups. Adult *Oobius* will be shipped in plastic cups. Honey will be streaked on the side of the cup. *Oobius* may also be provided as pupae inside EAB eggs on paper inside plastic cups that can be mounted on release trees.

The parasitoids should be released the same day they are received. If you are unable to release parasitoids on the scheduled day because of personnel shortages or adverse weather conditions are predicted, contact the Biological Control Release Coordinator at least a day in advance to arrange for a different shipping date. After arrival, transport the parasitoids in the cooler to the release site and release on the designated trees.

CARE OF ADULT PARASITOIDS IF RELEASE IS DELAYED

If there is an unforeseen delay caused by late delivery or unexpected weather conditions, the parasitoids will require your care to survive in their shipment cups beyond the day of arrival. To care for the parasitoids, unseal and open the cooler, remove and open the bags. Inside each bag will be a number of labeled cups or vials containing small groups of live parasitoids. To maintain sufficient ambient moisture for the parasitoids, we recommend placing the rearing cups in a clear plastic storage tub with moistened paper toweling. Before placing the cups in the plastic tub, check each cup for the presence of honey. Honey provides the parasitoids with food and some moisture during shipping. The *Oobius* should

not require additional honey and easily escape or are injured when the cup is opened. If no honey is visible on the screening on the lids of the cups with *Spathius* or *Tetrastichus*, put two or three drops of honey on the screening and gently smear it.

TRANSPORTING PARASITOIDS TO FIELD SITES

Carry the cups or infested logs inside the cooler when transporting parasitoids to the field for release. For delayed releases they do not need to be re-bagged for local transport. Care should be taken to keep the cooler out of direct sunlight or other potentially hot (e.g., a sealed vehicle) environments. The trunk of a vehicle will suffice, but an air conditioned interior is even better, provided the vehicle will not be allowed to sit unattended in the sun for any period. ***Keep the cooler in the shade at all times*** because parasitoids are extremely sensitive to overheating. Keep the cooler closed except to remove the cups or logs with parasitoids for release. Carry the cooler carefully and avoid sudden movements. Parasitoids are extremely small and susceptible to drowning in droplets of water or honey if the cup is inadvertently shocked or dropped.

RELEASE OF PARASITOIDS

Adult Parasitoids. If possible, release the parasitoids in the morning or evening so they can move about in the environment before the onset of high afternoon temperatures. Parasitoids should be released onto the 12 pre-designated tagged release trees. Carefully remove the lid and place the cup or vial next to the trunk of the tree. If *Oobius* are resting in the crack between the cup and the lid, open the lid on the side nearest them to avoid crushing them. On warm sunny days, most of the parasitoids will crawl up to the lip of the cup or vial onto the tree trunk or simply fly away. On cooler days, most of the parasitoids will remain in the

cups. To dislodge these parasitoids, hold the cup upside down at a slight angle against the tree trunk and gently tap the cup it against the tree, causing the parasitoids to jump or fly onto the tree trunk. Move the cups from tree to tree to ensure the number of each species is somewhat evenly distributed across the release trees.

Parasitoid Pupae in Logs. The small ash logs containing parasitoid pupae will come with a pre-drilled hole, through which you can insert a long nail (4-5") to nail into the tree trunk or hang from a branch using a zip-tie or sturdy twine. You will need some large nails with wide heads and a hammer to hang the logs or zip-ties to secure the logs to the branches of smaller trees. Other options for hanging the small logs include tapping a nail into the top of the bolt and hanging the bolt from a short piece of twine, wrapped around a horizontal branch of the tree – this is particularly effective on large trees where trunk diameter interferes with the hanging of the log on the side of the trunk. The logs should remain in the field for at least 3-4 weeks to assure that all the parasitoids have emerged as adults. Remove the nails from the trees when you recover the logs because nails will harm sawmill equipment if the trees are harvested.

Every time you release parasitoids, enter the following information into your GPS device or mapbiocontrol:

- Release Date
- Release time
- Weather Conditions (Sunny, Partly Cloudy, Foggy, Light Rain, Moderate Rain, Heavy Rain, Thunderstorms)
- Wind Speed (Light, Moderate, Strong)

- Temperature (Degrees Fahrenheit)
- Number Female *Oobius* Released
- Number Female *Spathius* Released
- Number Female *Tetrastichus* Released
- Number Females of other species released
- Notes

EVALUATING PARASITOID ESTABLISHMENT

Several methods have been developed that can successfully recover the three exotic parasitoids of EAB. Unfortunately none of the methods is consistently more effective than the others, and there are circumstances where parasitoids are recovered using one method but not others. The method we recommend cooperators use as a first choice is felling trees and either debarking them or putting the logs in emergence tubes. Using these methods we are certain that recovered parasitoids attacked EAB (tree debarking) or at least attacked an insect (probably EAB) in an ash log (logs in emergence tubes). If samples are taken during the winter, these methods can recover all three parasitoid species. However, there will be situations where cutting trees is impractical or not allowed, and we present alternative methods including yellow pan traps, egg- or larval-sentinel logs, and searching for EAB eggs. All sampling to recover parasitoids should begin at least one year after the final release at a given site. By waiting at least one year, parasitoid populations will have time to build up in and around the release site, increasing the probability of detecting the parasitoids using current methods. Below we describe the three parasitoid species and how their life cycle affects recovery sampling:

Tetrastichus planipennisi is a gregarious endoparasitoid (internal parasitoid) of EAB larvae, and 20 to >100 *Tetrastichus* larvae develop inside their host. *Tetrastichus* may have three to four generations per year. An EAB larva parasitized by *Tetrastichus* may 1) look healthy; 2) appear lumpy like a "braided rope"; 3) be replaced by a mass of small grub-like larvae (white), pupae (color ranges white to bluish-black) and/or adults (dark metallic blue); or, 4) be consumed, leaving only the head and tail of the EAB larva and small black spots in the gallery (the spots are waste excreted by each *Tetrastichus* adult after pupation is complete) (Appendix B). The parasitoids spend the winter in the EAB gallery and may be recovered by debarking ash trees. The insects will also emerge from logs brought into a warm environment and can be captured by placing the logs in cardboard tubes fitted with collection jars. *Tetrastichus* will attack larvae in sentinel logs, and adults have been recovered in yellow pan traps in the late summer.

Spathius agrili is a gregarious ectoparasitoid (external parasitoid) of EAB larvae, and all life stages live on the outside of the host. *Spathius* eggs and small larvae are difficult to see with the naked eye, but by late fall, most will be large larvae (Appendix B) or will have spun silken cocoons and will be fairly easy to see in the EAB galleries (Appendix B). *Spathius* requires a period of chill to break diapause, thus cutting trees for debarking or rearing in cardboard tubes should not take place before January. Like *Tetrastichus*, this larval parasitoid can sometimes be recovered in sentinel logs and yellow pan traps.

Oobius agrili spends the winter in diapause inside EAB eggs, which are difficult, but not impossible, to find sheltered between layers of bark and in bark crevices. EAB eggs are light brown or gold, whereas *Oobius*-parasitized eggs are often dark brown or black in color (Appendix B). One can collect EAB eggs directly from the bark of ash trees, placing the

eggs in a warm environment until adult parasitoids emerge. Alternatively, pieces of bark containing parasitized eggs can be collected and placed in cardboard emergence tubes in a warm environment for parasitoid emergence. Small ash logs on which EAB females have deposited eggs in the laboratory can be brought to the field as egg sentinel logs to recover *Oobius*, but they take some time and expertise to construct. To date, *Oobius* have not been recovered in yellow pan traps.

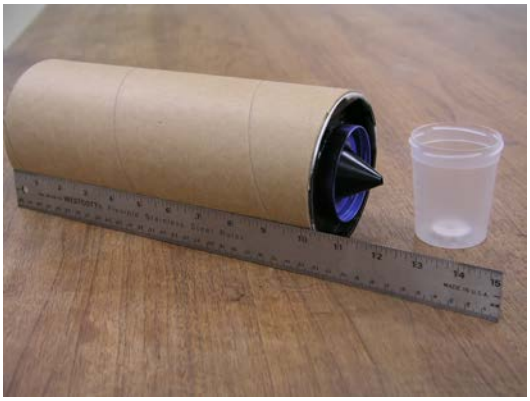
NOTE: If you would like examples of parasitoid adults, larvae, pupae or cocoons to help with field identification, please contact the Rearing Facility Manager for specimens. If you have questions about where to purchase supplies and/or questions about how to consturct sentinel logs, yellow pan traps, or emergence tubes, please call one of the authors.

TREE FELLING AND DEBARKING OR EMERGING IN CARDBOARD TUBES

Cutting trees to determine parasitoid establishment should be done from January through April (after the insects have received enough cold to break diapause), at least one year after the final release at a given site. Select four trees near the release epicenter that are alive (based on bark peeling and confirmation of live phloem), show signs of damage due to EAB, and are not too large to cut down safely. Select and fell living EAB-infested trees that are less than 10-inches DBH. Record the tree number, GPS coordinate, date the tree was felled and the DBH of each tree. If you have a handheld GPS unit, you can enter these data in the field before felling the tree.

OPTION 1: DEBARKING

Before debarking the logs to recover larval parasitoids, search for parasitized EAB eggs on the bark or put samples of the bark in rearing tubes to collect emerging *Oobius* adults.



Placing Bark in Rearing Tubes to Recover Oobius. For each 1 m length of tree, carefully remove 40 cm^2 of bark (approximately 10 X 40 cm or 20 X 20 cm depending on the size of the log). Place the pieces of bark in a paper bag (plastic will cause the bark to mold) for storage or directly in emergence tubes and hold in well-lit area at room temperature. Paper bags containing bark samples can be refrigerated (4°C) in a large plastic bag for up to three months.

***What will I need to make rearing tubes to rear Oobius from Bark Samples*?**

1. a well-lit room, heated at 70 to 80°F, with shelving to hold the rearing tubes
2. 4-inch diameter cardboard tubes for different diameter logs; number of rearing tubes depends on the amount of space and shelving
3. *Oobius*-rearing tubes are cut down to 10-inches in length
4. recessed end-caps that fit inside the end of each tube
5. plastic-adhering black spray paint
6. small plastic funnels
7. large refrigerator or cold-room at 34°C
8. urine specimen cups

9. hole cutter slightly smaller than the diameter of the specimen cup lid
10. hole cutter smaller than the diameter of widest part of funnel
11. hot glue gun and glue sticks
12. fine forceps
13. 1 mL screw-top plastic vials with o-rings
14. Magnifying glasses or dissecting microscope

The following is a brief description of how to make and start using rearing tubes for emergence of *Oobius*: Purchase 4-inch diameter cardboard mailing tubes with caps for both ends. Cut the tubes down to 10-inch lengths.

Spray paint the cardboard-tube caps and funnels black with plastic-adhering spray paint. At the base of each funnel, cut off the stem. Modify the cap at the front of the tube (toward light) by cutting a hole (use a hole-cutter), slightly smaller than the diameter of a specimen-cup lid, in the center of the cap. Modify lids of specimen cups by cutting a hole (use a hole-cutter) large enough to allow the funnel be seated flush with the top of the lid. Hot-glue the funnel into the hole in the lid with the funnel facing inward. Hot-glue the lid to the specimen cup into the hole in the cardboard-tube cap with the threaded side facing out. Screw the collection jar onto its lid. *Oobius* will be attracted to the small hole of light in the specimen cup, which should be checked every two days for emerged parasitoids; remove and cap the emergence cup and freeze it. After a day or two and the parasitoids are dead, place parasitoids into 1.5 mL microcentrifuge tubes using fine-forceps using a dissecting microscope (due to small size of *Oobius*). Using a fine-tipped pen such as a Sharpie®, label each sample with the state, site, date, and tree number on each small tube. Keep adults

stored in the freezer until the samples are sent to the APHIS Biocontrol Rearing Facility for identification. Enter the date and number of specimens shipped into MapBioControl.

To further evaluate these bark samples for egg parasitism by *Oobius,* the dried bark can be sifted through plastic window screening. The EAB eggs are then readily sorted from the sifted debris in a white porcelin baking dish under a dissecting microscope or magnifying glasses. For a detailed analyses of parasitism among egg samples, place the eggs in a small petri dish or vial and send to Leah Bauer, USDA Forest Service, Northern Research Station, 1407 S. Harrison Rd., East Lansing, MI 48823.

***Peeling Logs to Recover Larval Parasitoids*:**

Both species of larval parasitoid can be found in EAB galleries under the bark. Logs are easiest to peel if debarked soon after felling, but if you need to store the ash logs in a cold chamber, seal the ends (for example Anchorseal®) to reduce moisture loss. If the bark is thick, scrape the outer bark off with a draw knife and carefully remove the phloem with a chisel. Phloem will easily separate from the outer sapwood when the ash logs are fairly fresh. Inspect all EAB galleries for signs of parasitized larvae (see Appendix B for photos of parasitized EAB). Carefully remove the EAB larva along with the parasitoid larvae or cocoons and place them in a small Petri Dish with a tight fitting lid (Fisher Scientific 50 X 9mm dishes – catalog number 08-757-105 is a good choice). Using a fine-tipped Sharpie, label each Petri Dish with the state, site, tree number, and date. Mail the specimens within one week to the Rearing Facility Manager for identification. For each tree, record the number of live EAB larvae, solitary larvae or

cocoons (probably *Atanycolus* – just count, do not ship), gregarious larvae (ship these for identification) and gregarious cocoons (ship these for identification). Enter these data into MapBioControl.

***Emerging Parasitoids from Logs in Rearing Tubes*:** Instead of debarking, the logs can be placed in large cardboard tubes known as "rearing tubes", which are held on shelves in a well-lit room at ~70 to 80°F for at least three months. *Oobius agrili, T. planipennisi*, *S. agrili*, and most other insects in and on the logs will emerge within one month. However, some *S. agrili* take more than three months to break diapause. Store the logs in a cold room or refrigerator (~34°F) prior to placement in the rearing tubes; ash logs can be stored for about six months. The number of rearing tubes needed depends on many factors including size of the room, the number and size of the tubes and logs, and length of time the logs are held in the tubes. Generally, the logs are held for about six weeks with one large or several smaller logs fit inside a single tube. Rearing parasitoids from logs takes up considerable space and attention to detail, it may be more practical than debarking the logs and rearing out the parasitoids.

What will I need to make rearing tubes for parasitoid emergence?

1. a well-lit room, heated at 70 to 80°F, with shelving to hold the rearing tubes

2. 8-,10-, and 12-inch diameter cardboard tubes for different diameter logs; number of rearing tubes depends on the amount of space and shelving
3. rearing tubes are typically cut down to 28- to 30-inches in length
4. recessed end-caps that fit inside the end of each tube
5. plastic-adhering black spray paint
6. small plastic funnels
7. large refrigerator or cold-room at 34°C
8. urine specimen cups
9. hole cutter slightly smaller than the diameter of the specimen cup lid
10. hot glue gun and glue sticks
11. Forceps
12. 1 mL screw-top plastic vials with o-rings
13. Magnifying glasses or dissecting microscope

The following is a brief description of how to make and start using rearing tubes for parasitoid emergence: cardboard tubes are sold in various diameters and lengths. Cut them down to a convenient length based on the size of the room, considering the weight of fresh ash logs, etc. Spray paint the end-caps black and snap one into the back of the tube. Modify the front end-cap by cutting a hole with a hole-cutter slightly less than the diameter of the lid of the urine specimen cups. Modify the lids of each specimen cup by cutting a hole (use a hole-cutter) large enough to allow the funnel be seated flush with the top of the lid. Modify the funnel by using a single-edged razor blade to notch

the funnel stem 1/2" from the tip and then to slit the end of the stem lengthwise down to the notch removing one side to create an EAB “launch pad”.

Hot-glue the funnel into the hole in the lid with the funnel facing inward. With the threads facing out, hot-glue the lid of the cup onto the cap of the tube. The cup can then be screwed onto the outside of the cap, and the cap can be snapped into the end of the rearing tube after the log is inserted. Seal the ends of each log before placing them in the tubes using either a paintable sealant or dipped into melted paraffin. After log(s) are inside the tubes, place narrow shims under and between logs; this provides space for the parasitoids to emerge. Every day or two, collect the emerged insects by unscrewing the cup, screwing on another lid quickly to avoid loss, and replacing the cup on the tube with an empty one. Freeze the insects and carefully transfer the insects to the small vials and label each vial with the state, site, date, and tree number. Keep the vials frozen until shipped overnight to the Rearing Facility Manager for identification. Enter the recovery data into MapBioControl.

YELLOW PAN TRAPS

Many adult bee and wasp species are attracted to the color yellow. In Michigan field sites where the three introduced emerald ash borer (EAB) parasitoids are established, we found yellow pan traps (YPTs) were effective at trapping the two larval parasitoids *Tetrastichus planipennisi* and *Spathius agrili*. YPTs did capture the EAB egg parasitoid *Oobius agrili* at some sites in MI, but further testing is required before we know if this is an efficient method for recovering *Oobius*. Other known EAB larval parasitoids (e.g. *Atanycolus, Spathius, Phasgonophora sulcata, Balcha indica*) were also trapped, along with many other species of bees, wasps, flies, hemipterans and beetles. YPTs are simple and inexpensive to make.

What will I need to make one YPT?

1. two 12-oz yellow plastic bowls (color: yellow sunshine; manufacturer: Festive Occasion, East Providence, RI 01916)
2. one 6-inch right-angled shelf-bracket
3. three 1.25-inch long wood screws
4. weather-proof marking pen (e.g. Sharpie) and grease pencil (needed if bowls are wet)
5. three 6-inch zip-ties
6. 20% solution of clear (not pink or green) propylene glycol (non-toxic antifreeze) diluted with water. You can type "food grade propylene glycol" into a search engine to find a supplier.
7. rechargeable portable electric screw-driver with bit and extra battery pack
8. unscented dish detergent

What will I need to collect the insect sample from the YPT?

1. One paint filter per pan trap per sample occasion
2. One Ziploc bag per pan trap per sample occasion
3. Permanent markers
4. Pencil and paper

How are the YPTs mounted? Using the electric screw-driver, attach a shelf-bracket to the trunk of a living ash tree infested with EAB. Attach the bracket ~5 feet above the ground with the three wood screws.

What about those two yellow bowls? One yellow bowl is used as a "holding-bowl." It is attached to the shelf-bracket with zip-ties threaded through the three shelf-bracket holes (on the horizontal surface). The zip ties should be threaded through pairs of holes punched into the holding bowl with a paper punch (0.5 to 1.0 cm below the lip) and then through the hole in the shelf bracket. There are two holes in the shelf bracket next to the tree and one hole at the tip. Do not pull zip-ties too tightly to avoid distorting the holding-bowl. To provide drainage in the holding-bowl, cut a hole (~1-inch-square) in the bottom with a utility knife.

The second yellow bowl or "trapping-bowl" will hold the liquid that traps insects. It rests inside the holding-bowl. To prevent overflow from the trapping-bowl after rainfall, punch at least 6 drainage holes just below the lip. Hot-glue a strip of fine-mesh screening (e.g. organdy) over the drainage holes to prevent loss of specimens during overflow. After the bracket and holding-bowl are mounted on the tree, set the trapping-bowl in the holding-bowl. Fill the trapping-bowl ~¾-full with the 20% propylene glycol solution (make sure that the propylene glycol is clear, not pink). Add one drop of unscented dish detergent to break the surface tension of the solution. This will allow inquisitive insects to become entrapped in the liquid. You will need to empty the trapping-bowl after three to seven days to avoid possible loss of the sample due to weather, vandals, wildlife, decay, etc. We find that it is most convenient to collect samples once per week; adding fresh propylene glycol after collecting the first sample and continuing weekly samples.

How many YPTs should I deploy and where? Deploy a total of 15 YPTs with one YPT per ash tree at your EAB biocontrol release site. If possible, select an ash tree at least 4-inch DBH showing some symptoms of EAB infestation (e.g. wood-pecker feeding, epicormic shoots) with crown class 2, 3, or 4. Do not put the traps on dead ash trees.

Locate the traps in the four 50-m x 50-m grid-cells surrounding the parasitoid-release epicenter. Assuming you can find the appropriate trees, place three pan traps in each of the central four cells (Fig. 1). If the site is long and thin rather than square, then you may have to select four cells in a row rather than in a square. And if most of the trees in the center are dead, you may need to move outside the central four cells to find sufficient live trees onto which to hang the traps.

Label each YPT holding-bowl with a unique ID number using a weather-proof pen (e.g. Sharpie) or grease pencil if bowl is wet. On a data sheet, record your state, YPT-ID number, date, initial of person collecting. Record the GPS coordinates – this will help you find the YPT later to recover the sample and it will let researchers know where the parasitoids were recovered.

When should the YPTs be deployed? Deploy YPTs at EAB biocontrol release sites the year following the final parasitoid releases. The adult parasitoids fly throughout the spring, summer, and early fall. However, populations build throughout the summer. We have recovered *Oobius* in YPT's at a few sites, and if you want to trap for *Oobius*, deploy YPT's in July. For larval parasitoids, the last three weeks of August and the first week of September are the best times for sampling.

How long do I leave YPTs in the field? The YPTs can be left on the trees for three to seven days. Samples left too long in the field will decay or dry up. Seven days is ideal because the longer the traps remain in the field, the more likely they will trap one of the target parasitoids. If you anticipate a heavy downpour, however, you might want to consider collecting the samples early.

How is the insect sample collected from the YPT? After locating the YPT in the field, pour the contents of the trap (insects plus liquid) through a paint filter. The propylene glycol is not toxic and can be poured on the ground. Fold the paint filter and place each one separately into a labeled Ziploc bag or whirl pak. Use a permanent marker for the label (include state, site, YPT-ID number, and date). Store samples in the refrigerator and ship within one week. If shipment is delayed, store the samples in the freezer.

What do I do with these samples? Send the samples by overnight shipping to Juli Gould, 1398 West Truck Road, Buzzards Bay, MA 02542. Enter recovery data into MapBiocontrol.

SENTINEL LOGS

Sentinel Logs are small ash logs containing EAB eggs or larvae that are placed in the field to attract female parasitoids. They are especially useful when EAB density is low and finding naturally occurring EAB eggs or larvae is difficult or time consuming.

Egg Sentinel Logs: Egg-sentinel logs (ESLs) are small ash logs on which EAB adults have laid eggs in the laboratory. Plan to deploy ESLs on or near the original *Oobius*-release trees for about 10 days (max. 14 days) between 1800 and 2500 GDD50 (growing degree days with a base of 50) (early to mid–August in central Lower Michigan). ESLs with an average of ~100 eggs/log can be produced by exposing freshly cut ash logs (6- to 7-cm diameter × 25-cm long) for two to three days to 20 gravid EAB females (mated females average 33-days-old; range 23 to 52 days) and 10 males in 3.8-L ventilated plastic jars with fresh ash leaves with petiole sealed in a water-filled vial. To reduce EAB morality, change the leaves and the jars daily, and remove and replace dead EABs with live ones of similar age and sex. To prepare the log for exposure to EAB, dip each end in paraffin or other log sealant, and wrap it loosely with a spiral of curling ribbon (attach each end with a thumb tack). The ribbon encourages EABs to oviposit on the log. After two to three days, remove the ribbon, count and circle the eggs with a fine-tip marker, and place the ribbon back over the eggs (use thumb tacks to support the ribbon over spiral of eggs). The ribbon reduces egg predation in the field. Ants are the most common predator of EAB eggs in urban and suburban areas and are not readily deterred by the ribbon. To limit ant predation on the ESLs, therefore, select ash trees for placement of ESLs in wooded areas as far away from pavement (e.g. sidewalks, roads, buildings, parking lots, etc.) as possible. To deploy an ESL, attach an eyelet screw to one end of the log and attach it to the tree with a nail; place another nail underneath the log and bend it up into the bottom of the log to help stabilize it. Be sure to remove the nails when you retrieve the logs from the field. After retrieving the logs from

the field, remove the EAB eggs (on a small bark flake using utility knife). Place the eggs from each ESL in 100-mm ventilated Petri dishes, tape dish closed, label with the state, site, and ESL number, and ship immediately to the Rearing Facility Manager to assess parasitism of the EAB eggs.

Larval Sentinel Logs. Larval-sentinel logs (LSLs) can be made by cutting small ash logs (~5 cm dia × 18 cm long), inserting five 3rd- or 4th-instar EAB larvae in chambers cut under bark flaps, securing the bark flaps with rubber bands, sealing the ends of the logs with Parafilm or AnchorSeal, and hanging them on ash trees. Large screw eyes should be inserted into one end of each log, and logs

should be hung on release trees at your release site. Retreive the logs after they have been in the field for 1-2 weeks. Carefully split the logs and remove each larvae, place in a 100-mm Petri dish, tape close, label, and send the larvae to the Biocontrol Rearing Facility.

COLLECTION OF EAB EGGS

Evidence of *Oobius agrili* parasitism can be found by collecting EAB eggs. Although this can be at any time during the year due to persistence of EAB eggs on ash bark,

Oobius populations tend to be highest during the fall (through November). EAB eggs are laid in bark crevices or under bark flaps, so use a utility or pocket knife to gently lift off layers of the bark to find eggs. A headband magnifier, such as an Optivisor®, or magnifying reading glasses can help the collector see the small eggs. Gently remove the egg on a thin layer of bark with the point of the knife; place the eggs from each sample in 100-cm diameter ventilated Petri dish, tape the dish closed. Label each vial with the state, site, date, and tree number. Send the samples as soon as possible to the Rearing Facility Manager for insect emergence and identification, and enter collection data (Appendix H) into Mapbiocontrol. If the samples must be held for more than two weeks, they should be stored in the refrigerator.

ENTER RECOVERY DATA

It is critical that the EAB Biological Control Program have data on where EAB parasitoids are establishing. Once you have completed surveys to detect established parasitoids, enter the data into www.mapbiocontrol.org. Data on samples that were collected but no parasitoids were recovered are also critical. When you enter the mapbiocontrol.org web site, click on RECOVERY in the green banner at the top. Click the New button to enter new data. You will be asked to enter the following data:

- **Trap ID:** This is the unique trap ID that you have given each yellow pan trap, sentinel log, or cut tree. This data is critical because the scientists who identify collected parasitoids need to match the identified insects to the sites and locations where the parasitoids were recovered.
- **Latitude** (dd.ddddd)
- **Longitude** (dd.dddd)

- **Site ID** Once you type in the Latitude and Longitude of your sample, the database will select some nearby sites from which to choose. Select the appropriate site. If you happened to find parasitoids not connected with any particular release or control site, simply select NO Site.
- **State**
- **Date Sample Collected**
- **Sample Method** (Yellow Pan Trap, Tree Debarking, Logs in Tubes, Bark in Tubes, Sentinel Eggs, Sentinel Larvae, Egg Collection, Other)
- **Number of Samples**
- **Possible EAB Parasitoids Recovered?** Yes or No

If you did recover some possible EAB parasitoids, record the date they were shipped for identification and the person they were shipped to. The data on the number of released parasitoids recovered will be entered into the database by the identifier.

Forest Type

On mapbiocontrol.org in the Release section, there is a tab for Forest Type. Collecting Forest Type data is not required, but if you have time and resources it will greatly assist researchers in determining which types of forest compositions are more likely to promote establishment of EAB parasitoids.

Ash Health Assessment

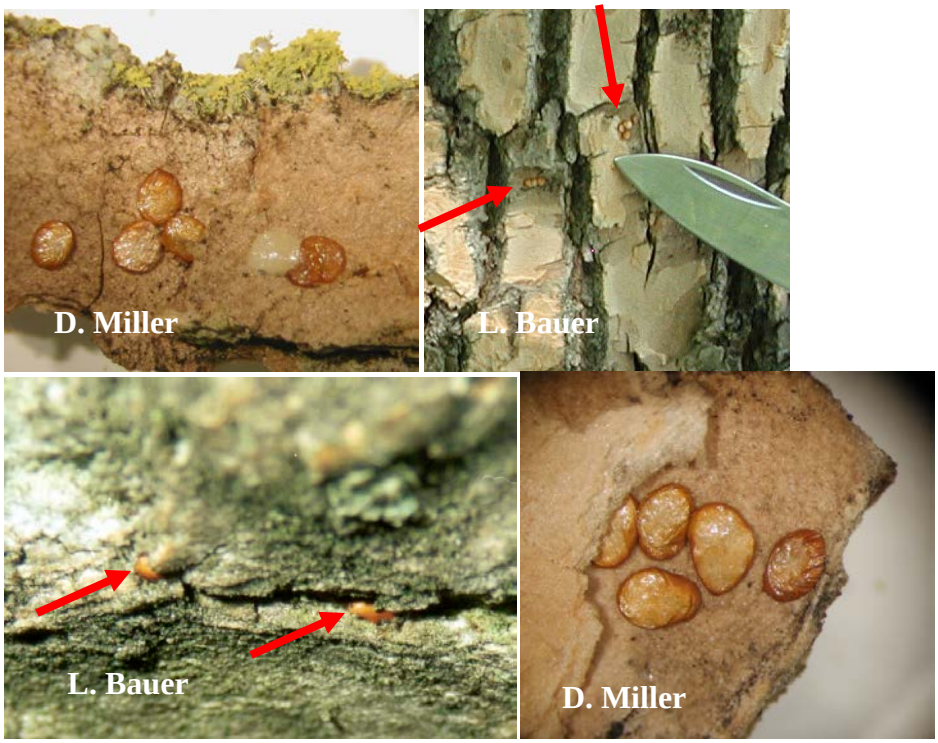
On mapbiocontrol.org in the Release section, there is a tab for Ash Health Assessment. Collecting Ash Health Assessment data is not required, but if you have time and resources it

will greatly assist researchers in determining the trajectory of ash mortality and how it correlates with the establishment of EAB parasitoids.

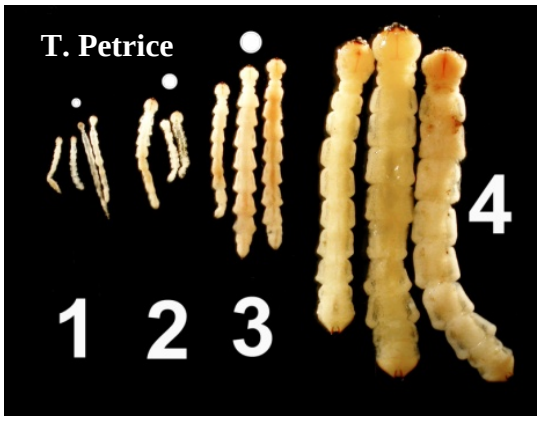
Mention of companies or commercial products does not imply recommendation or endorsement by the U.S. Department of Agriculture over others not mentioned. USDA neither guarantees nor warrants the standard of any product mentioned. Product names are mentioned solely to report factually on available data and to provide specific information.

EAB Life-Stages

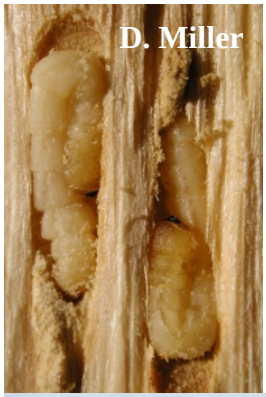
EAB eggs (newly laid egg is white, clutches of eggs that were under bark flakes, single eggs in bark crevices)

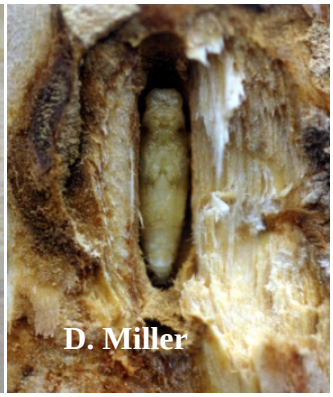


EAB larvae (1-4 indicates the four instars)

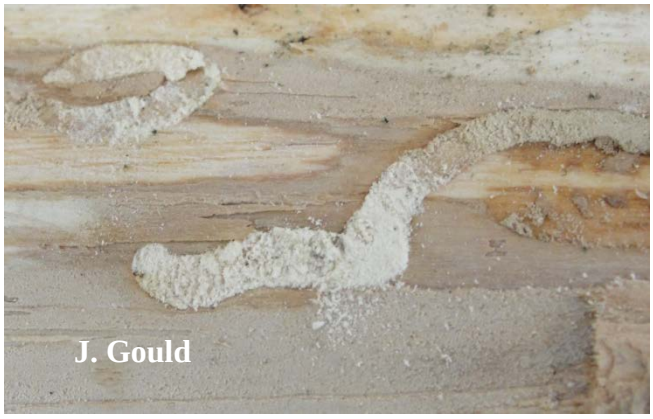


EAB J-shaped larvae, pre-pupa, pupae





External signs of EAB overwintering chamber under the bark. The photo on the left shows the EAB gallery filled with light colored frass and the photo on the right shows the exits to three overwintering chambers, each with 2 holes filled with frass.



EAB Adult

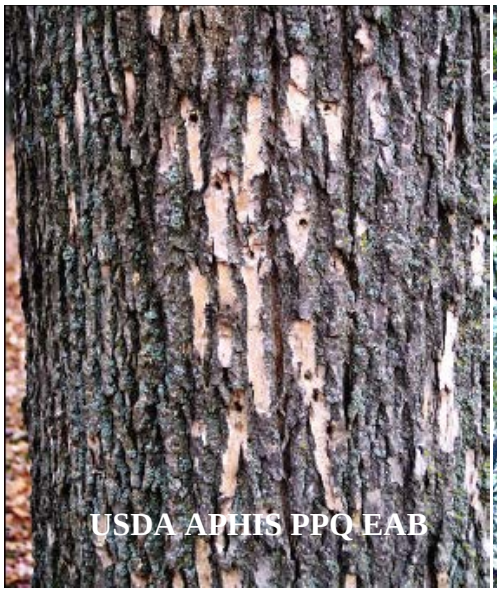
Signs of EAB infestation

Thinning Ash Crowns

Epicormic Shoots in Winter and Summer

Bark Split with Larval Galleries Beneath the Bark (note callusing around old gallery)

Damage from Woodpecker Feeding



D-shaped exit holes

Larval Galleries

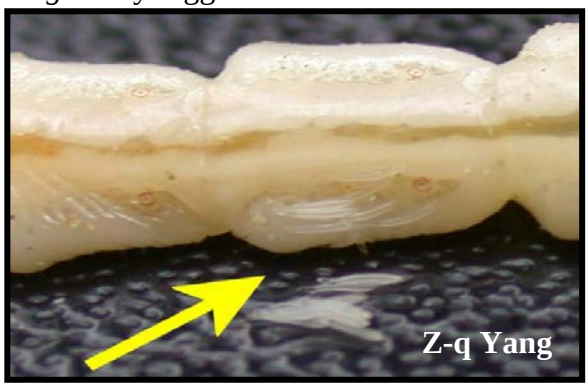
Additional photos and specific morphological and physiological information can be found in the EAB Program Manual at:

http://www.aphis.usda.gov/import_export/plants/manuals/domestic/downloads/emerald_ash_borer_manual.pdf

Life stages of EAB Parasitoids

Spathius agrili

S. agrili lays eggs on the surface of EAB larvae.



Larvae of *S. agrili* feed externally on an EAB larva.

Silken cocoons of *S. agrili* in the host gallery contain mature larvae or pupae.

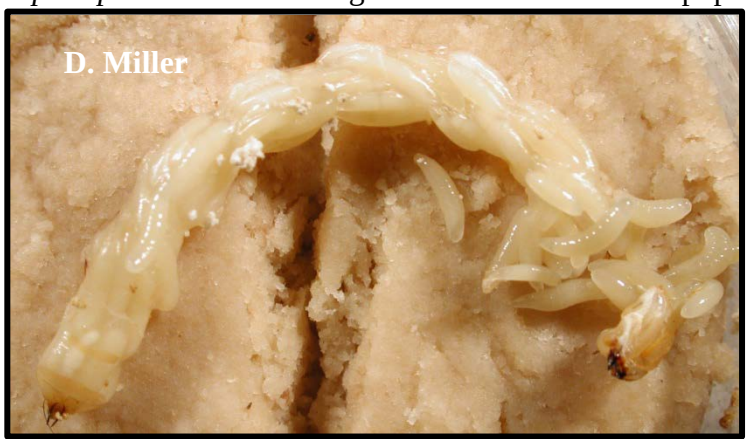
Female *S. agrili* lay eggs through ash bark onto an EAB larva.

Tetrastichus planipennisi

Immature T. planipennisi larvae inside EAB

Mature *T. planipennisi* larvae inside an EAB larva

T. planipennisi larvae emerge from host remains and pupate in the gallery.



T. planipennisi larvae develop asynchronously, and larvae and pupae are often found together inside one EAB gallery.

T. planipennisi female lays eggs in an EAB larva through ash tree bark.

Oobius agrili

EAB eggs often turn dark brown when parasitized by *O. agrili;* unparasitized, healthy eggs remain amber in color (center egg).

Adult *O. agrili* chew a circular hole through the EAB egg shell and emerge.

O. agrili female parasitize EAB eggs laid on ash bark.


D. Miller

Appendix C – Crown Condition of Ash Trees

Crown-class condition for ash trees infested with EAB (Smith, A. 2006. Effects of community structure on forest susceptibility and response to the emerald ash borer invasion of the Huron River watershed in southeast Michigan. M.S. Thesis, The Ohio State University)

After full leaf flush, rank the canopy or crown conditions of ash trees from 1 to 5. Crown-class 1is a healthy tree with no obvious signs of decline, 2, 3, and 4 show successive canopy thinning, and 5 is a dead tree.

1

2

3

4

5

Appendix D – Helpful Links

mapBioControl (to enter release and recovery data)

www.mapbiocontrol.org

e-authentication application

http://www.aphis.usda.gov/permits/eauth_epermits.shtml

e-permits

http://www.aphis.usda.gov/permits/learn_epermits.shtml

Growing Degree Days

http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/cdus/degree_days/grodgree.txt

http://uspest.org/US/

For MI: http://www.enviroweather.msu.edu/homeMap.php

Timing of EAB Emergence

http://www.ipm.msu.edu/landreport/2004/EAB_tracking.pdf

http://www.emeraldashborer.info/files/handoutforpdf.pdf

General EAB Information

EAB Program Manual

http://www.aphis.usda.gov/import_export/plants/manuals/domestic/downloads/emerald_ash_borer_manual.pdf

APHIS Emerald Ash Borer Home Page

http://www.aphis.usda.gov/plant_health/plant_pest_info/emerald_ash_b/index.shtml

Emerald Ash Borer Info

http://www.emeraldashborer.info/

Forest Service EAB Information

http://na.fs.fed.us/fhp/eab/

http://nrs.fs.fed.us/disturbance/invasive_species/eab/control_management/biological_control/

Appendix C: Community Outreach and Educational Materials

Invasive Species Alert: Common Buckthorn

What Is It?

Buckthorn is originally an ornamental shrub from Europe. It is now considered an invasive threat to Minnesota habitats.

Why Are We Concerned?

Buckthorn outcompetes native plants, degrades wildlife habitat, promotes loss of soil, is easily spread and also serves as habitat for disease-causing fungi.

Orange layer under bark

Berries

How Do You Identify It?

Some signs of Common Buckthorn are:

- Deciduous shrubs to medium-sized trees (up to 25ft tall)
- Smooth, glossy, finely-toothed egg-shaped leaves
- Thorn-like spines growing from end of twigs
- Black, berry-like clusters that ripen in August.
- Orange layer under outer bark

How Can You Help?

- Inform neighbours and park authorities of buckthorn spotted in the area
- Pull buckthorn using hand or mechanical removal
- Apply herbicides to cut stumps to prevent resprouting
- Participate in local buckthorn pulls

For more information please contact park officials

Buckthorn branch

Invasive Species Alert: Emerald Ash Borer

What Is It?

Emerald Ash Borer (EAB) is a beetle native to Asia that:

- Has become a destructive invasive species across North America
- Was first found in the the US in Michigan in 2002
- Infects and kills all North American ash tree species

Emerald Ash Borer Adult

Why Are We Concerned?

EAB larvae feeds below the bark of an ash tree cutting off transport vessels. They first colonize the top of the tree, eventually moving down through it which causes a gradual decline in the trees's health that is often irreversible.

"S"-Shaped tunnels created by larvae

How do you identify it?

EAB is difficult to spot until a tree has been heavily infected for quite some time. Even then, it may require expert attention to diagnose correctly. Some signs of infections that can spotted on ash trees are:

- Trees have thin, dying canopies
- "D"-shaped ⅛" holes left in bark by exiting adults
- Characteristic winding "S"-shaped tunnels under the bark

How can we stop the spread of EAB?

- Don't move campfire wood from place to place in known EAB infected areas
- Report sightings of the above characteristics to relevant authorities

Emerald Ash Borer

What Is It?

The emerald ash borer (EAB) (*Agrilus planipennis*) is an invasive beetle originally from Asia. Adult beetles are easily identifiable by their bright metallic emerald green. The first record of EAB in North America was in 2002 in Michigan.

Why Are We Concerned?

Since the initial introduction of emerald ash borer, millions of ash trees have been killed across the continent. The larvae kill the trees by building galleries within the transport vessels that move water and nutrients around the tree. This disruption ultimately kills the tree.

The first case of EAB infestation in Dakota County was confirmed in December 2014 at Lebanon Hills Regional Park in Eagan, Minnesota. This park is approximately five miles north of Schwarz Pond Park and Carroll's Woods Park. The county is now under a metro quarantine zone stopping the transport of ash materials outside of the zone. Unless action is taken emerald ash borer is expected to reach the Rosemount parks no later than 2025.

How Do I Know If I Should Act?

Diagnosis of EAB infestation can be difficult even for experts as symptoms often do not appear until the tree has been infected for some time

Treatment may be necessary if your trees are within 15 miles of a recorded EAB infection. While trees with over 50% crown loss may be unable to be saved, action can be taken to save other trees in the area.

Use resources such as the Minnesota Department of Agriculture EAB status map (see More Information) to check where EAB has been reported near and decide if it is necessary to treat your ash trees.

What Are My Options?

According to the most recent research and field trials by universities and government scientists, the most effective option is currently insecticide injection. The insecticide needs to be injected into the transport system of the tree in order to kill off the EAB larvae that live within this system. There are several types of chemical currently available. Another option is to try to remove trees proactively before the beetle arrives.

More Information

Rosemount Park System-
http://www.ci.rosemount.mn.us
MN Department of Agriculture-
http://gis.mda.state.mn.us/eab/

Rosemount Parks

Common Buckthorn and Emerald Ash Borer

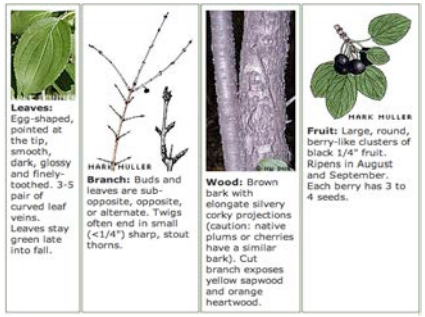
Help save our parks from invasive species!

Rosemount Park System

Common Buckthorn

What Is It?

An invasive shrub brought over from Europe as an ornamental plant to be used for hedging. It quickly spread past the confines of human settlement into forests, wetlands and prairies across Minnesota.



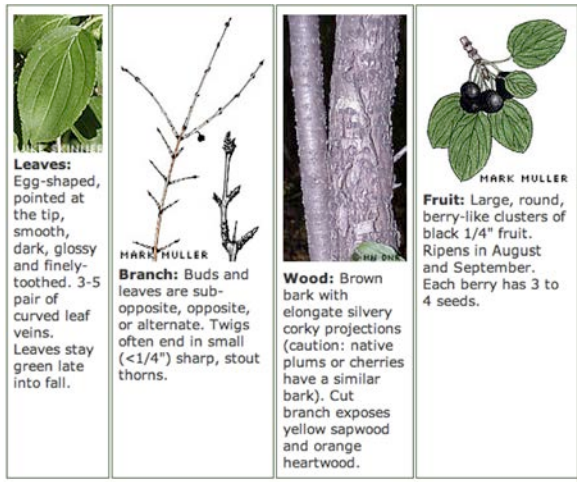
Why Are We Concerned?

Buckthorn is an invasive species that out-competes native plants, degrades wildlife habitat, promotes loss of soil, is easily spread and also serves as habitat for disease-causing fungi such as crown rust fungus.

How it is spread?

Common buckthorn spreads easily due to small mammals and birds eating the buckthorn berries. Each berry contains 3-4 seeds and has a laxative property. Buckthorn seeds will stay in the ground for up to 5 years making it very hard to control.

How Do You Identify It?



Removal techniques

The best way to remove common buckthorn depends on the size of the plant. If the plant is <2 inches in diameter should be removed by pulling by hand. If the buckthorn has a diameter of >2 inches it should be cut and herbicide should be applied to the stump to prevent re-sprouting. Tilling the soil after removal has been shown to help prevent re-invasion.

ROSEMOUNT
MINNESOTA

How Can You Help?

There are many ways you can help stop the spread of buckthorn in your neighborhood. Some ways include:

- Informing neighbors and park authorities of buckthorn spotted in the area
- Pull buckthorn using hand or mechanical removal
- Apply herbicides to cut stumps to prevent re-sprouting
- Participate in local buckthorn pulls
- Learn more information by contacting park officials

Learn more

Minnesota DNR-
http://www.dnr.state.mn.us/invasives/

USDA NISIC
http://www.invasivespeciesinfo.gov/plants/buckthorn.shtml

WHAT: COMMUNITY PICNIC & BUCKTHORN PULL
WHEN: JULY 17 AT 11AM
WHERE: PICNIC AREA AT SCHWARZ POND

FEEL FREE TO BRING A DISH!

SCHWARZ POND AND CARROLL'S WOODS ARE HOSTING A COMMUNITY & FAMILY PICNIC EVENT. COME TO EAT GOOD FOOD, TAKE PART IN ACTIVITIES & LEARN ABOUT HOW YOU CAN HELP PROTECT THE PARKS FROM BUCKTHORN & OTHER PROBLEM SPECIES!

Buckthorn removal at Carroll's Woods Park
Rosemount, MN

I. Invasive Species Community Event - Buckthorn Pull

II. The goal of this activity is to engage the community in removal of buckthorn from Carroll's Woods and Schwarz Pond in Rosemount, MN

III. Community Objectives
1. Educate the community of Rosemount, Minnesota about the infestation of buckthorn at Carroll's Woods and Schwarz Pond Park
2. Engage the community in removal efforts of common buckthorn at Carroll's Woods and Schwarz Pond

IV. This activity is for community members in Rosemount, MN

V. Duration
3-6 hours

VI. Location
1. Community members assemble at picnic/playground at Schwartz Pond Park. Direction from city staff and tools distributed in this location.
2. Buckthorn removal to be done along paths in Carroll's Woods

VII. Content and Methods

Common buckthorn is an invasive species, first used as decorative vegetation for hedge material, however, it has since become a problem. Buckthorn is able to outcompete native species for resources in the soil as well as sunlight. In spring, buckthorn is one of the first plants to gain leaves, restricting access to sunlight for plants that come later. This leads to a decrease in native species as well as increase soil erosion. Buckthorn has no biological controls, the most effective method of control of buckthorn is though manual removal or chemical treatment. The most common way that buckthorn is spread to a new area is though the distribution of buckthorn seeds.

Many public spaces have organized an event where members of the community come together to remove common buckthorn from an area. These events are designed to educate the public about invasive species and ways they can prevent the spread of the invasive at home and within the community. A buckthorn pull event can be done as part of a larger community picnic to foster positive attitudes about removal efforts.

Before the scheduled buckthorn pull:
Park and city staff need to identify the areas within the parks that they would like the removal efforts to be concentrated. Buckthorn is difficult to remove when the surrounding soil is dry. If there has not been a rain within five days of the pull date, the park staff should pre-moisten the soil to aid in removal efforts in area to be cleared.

Schwarz Pond and Carroll's woods are surrounded by residential houses as well as two schools, the park staff need to contact local utility companies to come check area for underground utilities such as gas, water or electric prior to scheduling the buckthorn pull event.

Day of pull:

After the participants gather, have a member of the park staff give direction to the participants on how to identify buckthorn and the best method for removal of buckthorn (park staff are encouraged to show participants pictures of buckthorn attached to this plan or have examples of buckthorn that have been previously removed).

Minnesota Department of Natural Resources Recommendations for removal of buckthorn:

Buckthorn plants that are up to 0.5" in diameter:

- Buckthorn this size can be pulled by hand, ensure that the root system comes with the plant when pulling

Buckthorn plants with a diameter of 0.5" to 1.0":

- Use hand tools like a garden trowel to aid in removing the root system instead of pulling directly on the buckthorn stem.

Buckthorn plants with a diameter between 1.0" to 1.5" in diameter:

- Using a spade, pierce soil 8" from the base of buckthorn plant and pull back with the spade, breaking the roots of the plant. Continue this process around the base of the buckthorn plant until a circle around the base of the plant is complete. The plant as well as the root mass can be lifted. Gently breakaway loose soil and tramp down hole to reduce any soil erosion.

Buckthorn with a diameter of 2" or greater:

- One option for larger buckthorn specimens is to use the Uprooter tool. This tool is available for purchase online. To use the Uprooter, clamp the jaws of the tool to the base of the tree, right at the soil line. Use the handle as a lever and push the handle down to the ground until the plant gives way or a snap (breaking of the buckthorn's taproot below the soil) is heard. See attached directions for further instruction on how to use the Uprooter tool.
- Buckthorn that is to large to be pulled by hand can be cut with a chainsaw. The remaining stump can be treated with an herbicide such as Roundup.

Disposal of buckthorn after pull:

Reserve some buckthorn stems that have a diameter between 1.5" and 2" for use in a follow-up activity. The remainder of the pulled buckthorn can be disposed of accordingly:

Branches

- Small branches can be broken up in field and left behind for ground cover and erosion prevention.
- Fed into be a wood chipper and resulting chips reused as mulch

Large segments of cut buckthorn can be used as firewood

VIII. Management and Safety

1. Prior to scheduled buckthorn pull date, contact local utility companies (gas, water, sewer, electric, data) to search for buried lines.
2. Safety Equipment
    - Protective eyewear
    - work gloves
    - hearing protection for power tools

- First aid kit
- Insect repellent
- Covered pavilion for sun protection
- Limit use of chainsaws, weed whacker, or other power tools to park staff.

3. In the event of a severe thunderstorm or tornado alerts, the event should be cancelled and rescheduled to a different day.
4. Provide cold water and beverages for community volunteers to prevent any heat-related injuries.
5. When advertising event to community, state that volunteers need to be wearing closed-toe shoes and long pants to protect from brush debris.

IX. Equipment

1. handouts with buckthorn in various growth stages
2. hand saws
3. Uprooter weed wrench removal tool
4. spades
5. chainsaw
6. axes
7. chemical Herbicide (Roundup) and herbicide applicator

X. Foul Weather Alternative

1. If a severe thunderstorm or tornado is forecasted, the event should be cancelled and rescheduled to a different day.

XI. Assessment

1. No formal assessment for activity

XII. Follow-up

1. City parks department to hold event where pulled buckthorn is re-purposed into walking sticks
2. Event where areas cleared of buckthorn are re-planted with native plant species
3. Buckthorn community event to be held annually in park during the summer.

XII. References

http://www.theuprooter.com/buckthorn-removal.html

Buckthorn: A threat to our native woodland ecosystem, Janet VanSloun Larson, March 2009

Minnesota Department of Natural Resources; Buckthorn: What you shoud know, what you should do

http://www.backpacker.com/gear/trekking-poles/make-your-own-walking-stick/

Buckthorn: A threat to our native woodland ecosystem, Janet VanSloun Larson, March 2009

Minnesota Department of Natural Resources; Buckthorn: What you shoud know, what you should do

UPROOTER MADE IN THE USA

Tool Operation & Guarantee

Please read these safety tips, operation instructions, & guarantee prior to operating the Uprooter. Suggestions for troubleshooting and handling varied conditions and situations can be found under Tips & Tool Care on the Uprooter website (TheUprooter.com)

Safety Rules

REMEMBER TO:

1. **Look and Know What's Behind You**—View the area behind you and make sure there are no sharp objects or dangerous changes in terrain. Prepare for the fall in the case a root breaks or an uneven jaw placement slips off.
2. **Watch Your Fingers**—Keep your fingers out of the jaws as well as any moving or mechanical parts to avoid crushing and pinching fingers.
3. **Be Courteous of Others**—Watch for others nearby when using or carrying the Uprooter. It's best to carry the tool with the base behind you and the long lever arm in front.
4. **Always Use:**
   Eye Protection
   Gloves

Basic Operation

Placing the Jaws

Open the jaws until you feel them lock open. Place the jaws around the stem and disengage the lock by putting your foot on the top of the lifting arm behind the jaw and pulling back on the grip handle. You may continue to stabilize the tool with your foot while clamping the jaws to ensure a solid fit.

Uprooting the Plant

Once the jaws are clamped on, pull down firmly on the lever arm. If the plant seems to be uprooting easily, just keep pulling. If it feels more difficult, pull and release repeatedly as though pumping on the lever arm. You may hear a "pop" sound underground indicating the tap root has snapped. Other tools may be used to loosen the surface soil if needed.

Uprooter Guarantee

The Uprooter is 100% guaranteed for function, materials, and workmanship. If your Uprooter is not effective for your job, you can return it in new condition and we will exchange it or refund the purchase price. If you want to return your Uprooter due to a manufacturing defect, we will pay the return shipping for the part in question (base or lever arm), repair or replace it, and return it to you for free. Otherwise, shipping charges for return transactions are the responsibility of the customer. If the tool is used improperly, it can lead to the bending and permanent damage of parts. Our guarantee excludes damage incurred while utilizing the tool under the below circumstances:

Single-Person Operation Only—Uprooter is designed to operate under the force of one person. Using a team to pull on the lever can bend and permanently damage the lever arm.

No Cheating—The use of a cheater pipe can lead to a bent handle.

Keep Fulcrum Flat on the Ground—Fulcrum not flat when pulling can result in a bent fulcrum.

Do Not Pull Sideways—Uprooter is designed pull straight back and should be pulled only at this angle.

Leaves: Egg-shaped, pointed at the tip, smooth, dark, glossy and finely-toothed. 3-5 pair of curved leaf veins. Leaves stay green late into fall.

Branch: Buds and leaves are sub-opposite, opposite, or alternate. Twigs often end in small (<1/4") sharp, stout thorns.

Wood: Brown bark with elongate silvery corky projections (caution: native plums or cherries have a similar bark). Cut branch exposes yellow sapwood and orange heartwood.

Fruit: Large, round, berry-like clusters of black 1/4" fruit. Ripens in August and September. Each berry has 3 to 4 seeds.

Above is a guide from the Minnesota Department of Natural Resources on how to idendity common buckthorn.

Carroll's Woods Park
Rosemount, MN

I. Buckthorn Walking sticks

II. This activity is designed to transform a stalk of buckthorn that was pulled in an earlier buckthorn removal event by the community

III. Activity objectives
- Continue education of community residents of the buckthorn invasion at Carroll's Woods and Schwarz Pond park
- Create a walking stick for the participants from buckthorn that had been pulled from parks

IV. This activity is for community members in Rosemount, MN

V. Duration
3 hours

VI. Location
1. Schwarz Park Pavilion

VII. Content and Methods

Common buckthorn is an invasive species, first used as decorative vegetation for hedge material, however, it has since become a problem. Buckthorn is able to outcompete native species for resources in the soil as well as sunlight. This leads to a decrease in native species as well as soil erosion. Buckthorn has no biological controls, the most effective method of control of buckthorn is though manual removal. Buckthorn that has been pulled as part of a previous community pull can be re-purposed into a walking stick that can be used by people as they enjoy the trails at Carroll's Woods Park. This activity is designed to be done by any member of the city park staff and for community residents of any age.

Although buckthorn is an invasive species, its wood has an aesthetic quality. People have re-purposed buckthorn into objects such as wooden carvings or garden features. This activity is an opportunity to continue the education of Rosemount community residents regarding invasive species in the park as well as engage the community in furthering actions to remove invasive species.

After participants assemble, give an overview regarding buckthorn as an invasive species in Rosemount and the removal efforts by the city. Because this activity involves the use of knives, educate participants where safety equipment can be found. Distribute provided protective eyewear to participants.

To begin, have participants select a buckthorn stick that was obtained from previous removal efforts and distribute the carving knives. Note, children need to be supervised when handling and using the carving knives. The chosen stick should come up to the participants armpit, cut down any over-sized sticks to fit participants.

The first step in making the walking stick is to remove any branches from the buckthorn with the knife. Next, remove the outer bark layer. The bark can be removed completely, or in a pattern for aesthetics. After the bark has been removed, smooth the surface of the wood with

sandpaper, starting with coarse grit and ending with a finer grit.

The final step to create a walking stick is to create a handgrip. Have the walking stick creator stand and grasp the walking stick as if they are hiking, their elbow should be at a comfortable 90^{O} angle. Just about ½ inch above the handgrip, make a mark where a ¼ hole will be drilled. Drill a hole completely though the stick and thread the pre-cut cord though the hole. Additional items like beads or bells can be added to the strap. Tie off the cord to the desired strap length. Moisten a cloth with paint thinner and run down the length of the sanded stick, this will remove any residual sawdust from sanding. Add a coating of mineral oil if desired and go hiking in Carroll's Woods with a new buckthorn walking stick!

At home, participants can further treat their walking stick for lasting protection. To accomplish this, the stick needs to dry for two weeks. At the end of the drying process, a desired wood stain followed by an application of urethane will enhance the natural character of the wood and give lasting protection.

VIII. Management and Safety

1. Safety Equipment
    - Protective eyewear
    - First aid kit
    - Covered pavilion for sun protection
2. In the event of a severe thunderstorm or tornado alerts, the event should be cancelled and rescheduled to a different day.

IX. Equipment

1. Buckthorn branches with a diameter of 1" to 1.5" that have been cut to a length of 3-4 feet
2. sharp carving knifes
3. protective eyewear
4. Handsaw
5. Power drill with ¼" drill bit
6. Sandpaper: coarse and fine grits
7. Material for a hand strap (for example, leather cord or nylon paracord) pre-cut to 2 foot lengths.
8. Mineral oil

X. Foul Weather Alternative

1. This activity is designed to be conducted in the covered pavilion at Schwarz Pond Park and therefore can be conducted outside, even if there is light precipitation. If a severe thunderstorm or tornado is forecasted, the event should be cancelled and rescheduled to a different day.

XI. Assessment

1. No formal assessment for activity

XII. Follow-up

1. Additional activity done in parks re-planting native species
2. Buckthorn community event to be held annually in park during the summer.
3. At home, participants can add wood stains or a urethane sealant to their walking stick

XII. References

Native Species replanting
Carroll's Woods Park
Rosemount, MN

I. Native Species replanting

II. This activity continues the educational outreach for buckthorn abatement in Carroll's Woods in Rosemount by re-planting the areas with native species after areas of the park have had buckthorn pulled or treated.

III. Activity objectives
- Continue education of buckthorn invasion of Carroll's Woods
- Re-establish native plant species in areas once impacted by buckthorn

IV. This activity is for community members in Rosemount, MN

V. Duration
3-6 hours

VI. Location
1. Schwarz Park Pavilion - initial gathering point for instruction and materials
2. Replanting done at cleared locations of Carroll's Woods

VII. Content and Methods

Common buckthorn is an invasive species, first used as decorative vegetation for hedge material, however, it has since become a problem. Buckthorn is able to outcompete native species for resources in the soil as well as sunlight. This leads to a decrease in native species as well as soil erosion. Buckthorn has no biological controls, the most effective method of control of buckthorn is though manual removal. By re-establishing the native species, to an area, it will be more difficult for buckthorn to come back in an area it once occupied. In addition, re-planting of native species will restore the ecosystem.

A previous plan gave an outline on how to manage a buckthron pull. This plan is designed to be a guide on re-planting the cleared area with native plants to prevent buckthorn from re-establishing in the cleared area. Select native plants that are appropriate for the ecosystem. Carroll's Woods is a hardwood forest, it would not be ecologically correct for this are to be replanted with prairie grasses. Some common examples of plants that have been replanted after communities have done a buckthorn removal are listed below under Equipment. Choose a variety of plant species to increase the ecological diversity

VIII. Management and Safety
1. Safety Equipment
   - First aid kit
   - Insect repellent
   - Covered pavilion for sun protection
2. In the event of a severe thunderstorm or tornado alerts, the event should be cancelled and rescheduled to a different day.
3. Provide cold water and beverages for community volunteers to prevent any heat-related injuries.

4. When advertising event to community, state that volunteers need to be wearing closed-toe shoes and long pants to protect from brush debris.

IX. Equipment

1. Hand trowels
2. Spades
3. Plant mulch - preferably buckthorn wood chips from earlier community buckthorn pull
4. Native plant species (some examples, other native plant species not listed below can be planted):

    Carroll's Woods (hardwood trees and shurbs)

    - high-bush cranberry
    - nannyberry
    - chokecherry
    - grey dogwood
    - pagoda dogwood
    - American hazelnut
    - black chokeberry
    - blue beech, ironwood
    - downy serviceberry
    - common ninebark

X. Foul Weather Alternative

1. If a severe thunderstorm or tornado is in the forecast, the event should be cancelled and rescheduled to a different day.

XI. Assessment

1. No formal assessment for activity

XII. Follow-up

1. Establish an annual community buckthorn pull in the parks
2. Replant cleared area with native species on an annual basis.

XII. References

Buckthorn: A threat to our native woodland ecosystem, Janet VanSloun Larson, March 2009

Minnesota Department of Natural Resources; Buckthorn: What you shoud know, what you should do