Emerald Ash Borer Management Plan

Columbia, Missouri

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Acknowledgement

Columbia's vision to promote and preserve the urban forest and improve the management of public trees was a fundamental inspiration for this project. This vision will ensure canopy continuity, which will reduce stormwater runoff and improve air quality, public health, and aesthetic values.

Notice of Disclaimer Inventory data collected during the 2013 and 2014 inventory are a product provided by Davey Resource Group, a division of The Davey Tree Expert Company. Inventory data are based on visual recording at the time of inspection. Visual records do not include individual testing or analysis and do not include aerial or subterranean inspection. Data collected prior to the 2013 street tree inventory and used in this plan were not conducted by Davey Resource Group. Records may not remain accurate after inspection due to variable deterioration of inventoried material. All ash trees with recorded attributes of *Unknown* or *Unassigned* were categorized as removals with a size class of 7–12 inches DBH. Davey Resource Group is not responsible for differences and inaccuracies in data collected prior to the 2013 inventory. Davey Resource Group provides no warranty with respect to the fitness of the urban forest for any use or purpose whatsoever. Clients may choose to accept or disregard Davey Resource Group's recommendations or to seek additional advice. Important: know and understand that visual inspection is confined to the designated subject tree(s) and that the inspections for this project are performed in the interest of facts of the tree(s) without prejudice to or for any other service or any interested party.

Definitions

DBH—diameter at breast height; represents the diameter in inches of a trunk cross-section measured at 4-1/2 feet above ground level; a basis for estimating or identifying tree volume, value, management needs and costs, utilization options, etc.

EAB—the emerald ash borer insect; as an adult it measures approximately 1/2 inch in length by 1/8 inch wide, is metallic green in color, and is somewhat bullet-shaped. The larvae can reach a length of a little more than 1 inch, are white to cream colored, and have a 10-segmented abdomen with a pair of brown, pincher-like appendages on the last segment.

EAB Management Plan—a document delineating local EAB management activities and processes, includes scope and purpose; authority; responsibility; policies and procedures; actions/tasks; available resources; forms and contracts; technical references and support information (such as surveying and reporting protocols); and similar content.

infestation—refers to an area where the ash trees have been positively identified as having a sustained population of EAB.

Executive Summary

Emerald ash borer (EAB, *Agrilus planipennis*) is an exotic beetle that was discovered in southeastern Michigan near Detroit in summer 2002. The adult beetle causes minimal damage to trees, but the larvae feed on the inner bark, which disrupts the tree's ability to move water and nutrients. It is believed that EAB arrived in the United States on solid wood-packing material carried in cargo ships or airplanes originating in its native Asia. Since its discovery in Michigan, EAB has been confirmed in Colorado, Connecticut, Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Minnesota, Missouri, New Hampshire, New York, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia, and Wisconsin. EAB has killed tens of millions of *Fraxinus* spp. (ash) trees in these states.

While no EAB infestation of ash trees in Columbia, Missouri, has been reported or confirmed as of March 2014, with EAB confirmed within the State of Missouri, all ash trees within Columbia are at risk of infestation and death if proactive treatment does not occur.

Trees are key components of the urban environment and contribute greatly to the quality of life in Columbia. They allow residents to interact with nature and provide for relaxation and recreation in ways that enhance a sense of community. In many communities, trees are viewed as great assets, and providing adequate maintenance for public trees within a budget is a common concern, especially for populations affected by EAB.

The best approach to maintaining a community forest is to have an organized, proactive management program including a tree inventory, tree management plan, and inventory management software. With these tools, the City of Columbia can develop a tree management program that allows staff to prioritize, schedule, and budget effectively. In February 2014, Davey Resource Group conducted an ash tree inventory of the remaining un-inventoried areas of Columbia. This resultant *Emerald Ash Borer Management Plan* provides an analysis of ash trees inventoried in Columbia, Missouri, through a series of inventories and provides short- and long-term management strategies that will help manage the impact of EAB throughout Columbia's street tree program.

The major findings of the 2014 ash tree inventory analysis include the following:

- Davey Resource Group inventoried 394 additional ash trees in Columbia, Missouri.
- 76% (298 trees) were *Fraxinus pennsylvanica* (green ash) and 24% (96 trees) were *F. americana* (white ash).
- The majority of the ash population was in Fair condition (54%).

Based on inventory results and pest management principles, these management activities are recommended:

- Know the pest and its life cycle; this is important for a positive diagnosis and proper management and strategy implementation.
- Understand the economic threshold level. The economic threshold is the level at which the costs involved in managing a pest infestation exceed the value that a tree or plant is providing. In an urban situation, the economic value of a tree can be tied to the benefits it provides. These benefits include, but are not limited to, aesthetic, environmental, and cultural benefits. This concept, on a general level, amounts to determining whether or not a tree is worth the costs of mitigation against a pest problem compared to its value to the community.

- The current management recommendations include removing all ash recommended for removal during the inventory assessment, removing all ash with diameters less than 3 inches DBH, removing all ash in Poor condition, treating the remaining desirable trees in the population, and replacing removed trees.
- Regular, proactive monitoring is perhaps the most important part of a pest management program. Monitoring pest activity can be done through visual inspection. Perform annual tree inspections performed by an International Society of Arboriculture Certified Arborist.
- Establish an ash tree nuisance ordinance for private property, maintained by the City Arborist to ensure public safety and proactive management of the pest.
- Keep an up-to-date inventory by recording all population changes and work performed in TreeKeeper®. It is necessary to properly identify trees and accurately assess their existing condition to successfully manage a pest outbreak.

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Purpose

The potential impact of EAB in Columbia, Missouri, necessitates an effective plan to prevent the consequences of this insect. This *Emerald Ash Borer Management Plan* provides information that will allow the City of Columbia to preemptively respond to EAB and manage the community forest. This information will allow City staff to make informed decisions about the identification, management, and control of EAB. By implementing the recommendations in this management plan, the District will distribute the costs associated with large-scale tree mortality over a manageable period and will reduce the negative social and economic impacts that such an extensive loss will have on the quality of life within the community.

Emerald Ash Borer

EAB is an exotic Asian insect pest that was found in Ohio in 2003; northern Indiana in 2004; northern Illinois and Maryland in 2006; western Pennsylvania and West Virginia in 2007; Wisconsin, Missouri, and Virginia in 2008; Minnesota, New York, and Kentucky in 2009; Iowa and Tennessee in 2010; Connecticut, Kansas, and Massachusetts in 2012; and New Hampshire, North Carolina, Georgia, and Colorado in 2013. This invasive borer has killed millions of trees in urban and forested areas, from young trees to established, maturing, and mature specimens. All North American ash appears to be susceptible, including *Fraxinus nigra* (black ash), *F. quadrangulata* (blue ash), white ash, and green ash.

Identification

The adult beetle is elongate, metallic green, and between 3⁄8- and 5⁄8-inch long (Figure 1). Adults emerge from late May until early August feeding on a small amount of foliage (this causes jagged leaf edges). Females lay eggs deep into bark crevices on lower main branches. After the eggs hatch, the larvae tunnel through the bark and feed on the phloem and outer sapwood for several months. The mature larvae are cream colored and are between 1- and 1-1⁄4-inch long. Fully grown larvae overwinter under the bark or sometimes in pupal cells made of outer sapwood. There is one generation per year, but some larvae can remain in the tree for two years.

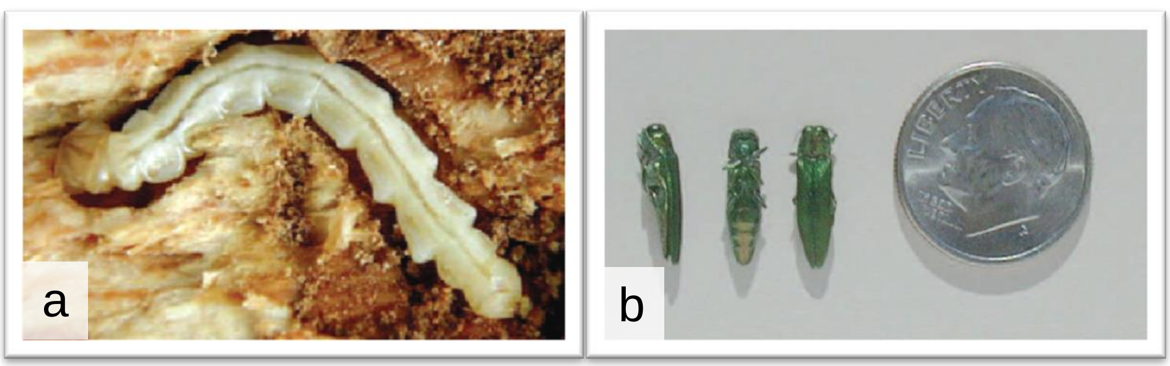

Figure 1. Larvae (*a*) and adult (*b*) forms of emerald ash borer (*Agrilus planipennis*).

Photograph courtesy of Michigan State University.

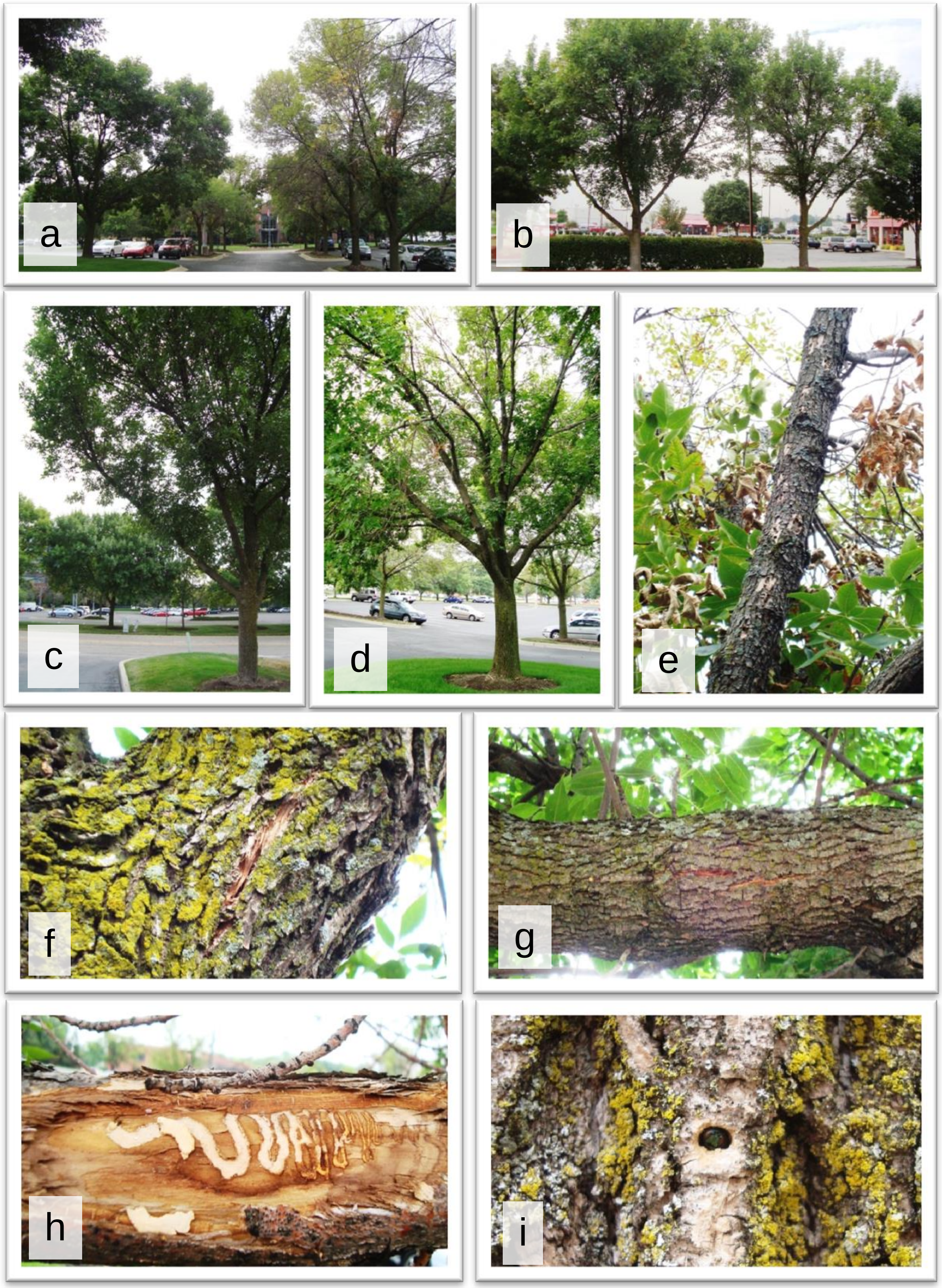

*Figure 2. Symptoms of emerald ash borer (*Agrilus planipennis*) include less dense canopy from: dieback (*a*); sprouting within the tree canopy (*b, c, *and* d*); increased woodpecker activity (*e*); splitting of bark along branches (*f *and* g*); serpentine galleries in the actively-growing layer under bark (*h*); and D-shaped borer exit holes (*i*).*

Photographs were taken August 2011 at an infested location on the north side of Indianapolis, Indiana.

Initial symptoms include yellowing and/or thinning of the foliage and longitudinal bark splitting (Figure 2). The entire canopy may die back, or symptoms may be restricted to certain branches. Declining trees may sprout epicormic shoots at the tree base or on branches. Removal of bark reveals tissue callusing and frass-filled serpentine tunneling. The S-shaped larval feeding tunnels are about 1⁄4 inch in diameter. Tunneling may occur from the upper branches to the trunk and root flare. Adults exit from the trunk and branches in a characteristic D-shaped exit hole that is about 1⁄8 inch in diameter. The intense tunneling disrupts water and nutrient flow causing trees to lose between 30% and 50% of their canopies during the first year of infestation. Trees often die within 2 to 5 years following infestation. See Appendix A for more information about EAB and ash tree identification.

Ash Tree Inventory

A tree inventory collects information about trees and stores that information in a database. It is crucial to know each tree's location and condition to effectively manage the urban forest. In February 2014, Davey Resource Group inventoried the ash tree population within the street rights-of-way of 414 miles of Columbia's public maintained streets.

The 394 ash trees inventoried in 2014 were combined with the existing inventory data provided by the City of Columbia for a total of 4,305 inventoried trees. These trees do not represent a complete inventory of all the public streets in Columbia, Missouri. Of the 4,305 street trees inventoried, 678 (16%) were ash trees. Of these, 10% (428 trees) were white ash; 6% (248 trees) were green ash; and less than 1% (2 trees) were blue ash. Most ash inventoried were between 7 and 18 inches DBH and were rated in Fair (54%) or Poor (11%) condition. Table 1 illustrates Columbia's current inventoried ash tree population organized by diameter class and condition.

Table 1. Columbia's Inventoried Ash Population

		Diameter Class (inches)										
		Unknown	Young		Established	Maturing		Mature			Total	Percent
			1–3	4–6	7–12	13–18	19–24	25–30	31–36	37–42		
Condition	Good	1	3	9	26	5	1	0	0	0	45	7
	Fair	7	65	57	121	90	17	9	1	0	367	54
	Poor	2	6	15	17	18	12	5	1	1	77	11
	Critical	1	0	0	1	0	1	0	0	0	3	<1
	Dead	0	1	2	3	1	0	0	0	0	7	1
	Unassigned	29	117	6	23	4	0	0	0	0	179	26
	Total	40	192	89	191	118	31	14	2	1	678	100
	Percent	6	41		28	22		2			-	100

During the inventory, a risk assessment was performed for each tree. Tables 2 summarizes this information on the ash tree population. Davey Resource Group arborists assessed the possibility of replacing each ash tree. Currently 671 ash trees would be suitable for a replacement species; 7 trees were listed as being in a poor location and are not suitable for replanting.

Table 2. Risk Rating by Primary Maintenance Recommendation

	Risk Rating								
Primary Maintenance	N/A	3	4	5	6	7	8	Total	Percent
Removal	10	2	2	2	10	11	3	40	6
Recommended Tree Pruning	42	0	13	117	136	41	2	351	52
Young Tree Train	0	26	94	33	7	1	0	161	24
Unassigned	126	0	0	0	0	0	0	126	18
Total	178	28	109	152	153	53	5	678	-
Percent	26	4	16	22	23	8	<1	-	100

Management Recommendations

Columbia has a wonderful living, growing resource within its urban forest that needs to be managed efficiently and effectively. Recommendations, maintenance schedules, and budget requirements are outlined in this EAB Management Plan to assist the City of Columbia in achieving both short- and long-term management goals. Implementing the proposed program will provide the City with maximum economic, aesthetic, and environmental benefits from its community forest.

EAB Management Options

There are several EAB management strategies: Do Nothing, Remove and Replace All Ash, Treat All Ash, or a Combination of the removal and replacement and treatment strategies. This section will allow the City to explore different EAB strategies and develop an economical EAB strategy that will benefit Columbia and increase public safety. The following are current strategies for managing EAB and the costs associated with these strategies.

EAB Strategy 1: Do Nothing

This means letting EAB run its course and having no strategy for dealing with EAB. This strategy includes not removing and not treating any ash trees. This strategy is economical in the beginning of an infestation because it costs the City no money, but it would become a severe public safety issue as the first year of infestation. This reactive-style management strategy is not recommended due to increased possibilities of legal costs related to safety and the prolonged uncontrollable costs related to higher risk removals.

EAB Strategy 2: Remove and Replace All Ash

This strategy includes preemptively removing all 678 ash trees without regard to EAB infestation status and replacing the ash with other tree species. Due to the level of EAB presence in Missouri, all removals and replanting would need to be completed within a 5-year plan. This strategy does maintain public safety, but upfront costs will be great. Additionally, removing mature ash trees that are in Good and Fair condition would take away all of the environmental, economic, and social benefits that these trees provide to the park and surrounding community. It will be very important to replace all ash trees once they have been removed. In some cases, new planting locations will need to be identified because 7 existing ash tree locations are not recommended for replanting.

The total approximate costs for this strategy were calculated using average removal costs by diameter class and average planting, mulching, and watering costs reported by reputable tree care companies across North America. Data for 40 trees provided by the City did not include *diameter* class information; for purposes of cost estimations these sites were included in the 7–12 inch diameter size class. Table 3 shows an estimated total cost of $328,550; $138,710 would be the approximate cost to remove all ash trees; and $189,840 would be the approximate cost to purchase, install, mulch, and water new trees. See Appendix B for a suggested species planting list.

Table 3. Cost to Remove and Replace All Ash

Management Strategy	Management Action	# of Trees	Cost
Remove and Replace All Ash	Remove All	678	$138,710
	Replace All	678	$189,840
	Total	1,356	$328,550

EAB Strategy 3: Treat All Ash

This strategy would remove and replace 176 ash trees recommended for removal or with unassigned attributes in the inventory data, as well as treat the 502 remaining ash. Treating all ash trees could reduce the annual mortality rate, stabilize removals, and would be less expensive than removing and replacing all ash trees. Treating all ash trees along the City streets would also enable these trees to keep supplying the City of Columbia and the residents with the environmental, economic, and social benefits that they provide. On the other hand, treating all ash trees is not an ideal practice because some of these ash trees are less desirable and will still need to be removed.

The total approximate costs for this strategy were calculated in the same manner as in Strategy 2 with the addition of calculating treatment costs per inch DBH using the TREE-äge® insecticide. Treatment costs are averages extracted from bids received by communities in the eastern United States. Table 4 shows the estimated cost of this strategy at $121,045. Removing the recommended 176 ash trees would cost approximately $21,365, replacing those removed trees with another tree species would cost approximately $49,280, and treating the 502 remaining trees would cost approximately $50,400 biannually. Treatments would need to occur every other year following the initial treatment to minimize future infestations. Appendix C contains information regarding treatment options.

Table 4. Cost to Treat All Ash

Management Strategy	Management Action	# of Trees	Cost
Treat All Ash Trees	Inventory Recommended Removals	176	$21,365
	Replace Removals	176	$49,280
	Ash Trees Treatment (TREE-äge®)	502	$50,400
	Total	854	$121,045

EAB Strategy 4: Combination of Removals and Treatment

This management option is intended to give the City of Columbia a more economical management strategy for managing EAB while saving mature ash trees, controlling annual removals, reducing upfront cost, minimizing overall cost, and increasing public safety. Table 5 presents an EAB management matrix intended to organize trees under consideration for removal followed by replacement and trees under consideration for treatment. Table 5 excludes 199 trees recommended for removal or that has a designation of *Unassigned* for condition, diameter size, and recommended maintenance needs. Those trees should be removed due to existing conditions and elevated risk.

Table 5. EAB Matrix Table

		Diameter Class (inches)								
		1–3	4–6	7–12	13–18	19–24	25–30	31–36	37–42	Total
Condition Class	Good	3	9	26	5	1				44
	Fair	65	57	121	90	17	9	1		360
	Poor	6	15	17	18	12	5	1	1	75
	Total	74	81	164	113	30	14	2	1	479

Based on these numbers, Davey Resource Group makes the following recommendations:

143 Trees to Be Removed

- Trees in the Poor condition class are recommended for removal because they are more susceptible to EAB infestation and if not removed could pose a public safety issue in the future. A total of 75 Poor condition trees are recommended for removal and replacement.
- The remaining 68 trees are 3 inches and less DBH and are recommended for removal and replacement. It is in the best interest of the City to remove these trees and replace them with a more diversified mix of trees. The label for TREE-äge® recommends treating trees greater than 3 inches DBH. It is more reasonable to remove these trees and replace them with 1- to 2-inch DBH trees. Often, in-house staff can perform this work.

268 Low–Moderate Priority Candidate Trees for Chemical Treatment

- The intent here is to defer the removal of the Fair condition class trees that were between 4 and 18 inches DBH. These 268 trees are considered Low–Moderate Priority for chemical treatment. Treating these trees now could stabilize annual budgets and removal costs in following years. Eventually, the City of Columbia may want or need to reduce the number of treatment to lessen maintenance costs. If reducing treatments is financially necessary, Davey Resource Group suggests cutting back with this group of trees. As treatments stop, those trees may become infested with EAB and will have to be removed in a timely manner. Treating these trees now to defer costs will be economically beneficial and can reduce the chance of a public safety issue in the near future. Replace any removed trees.

68 High Priority Candidate Trees for Chemical Treatment

- The intent here is to keep trees in Good condition and the larger Fair condition trees around for as long as possible. Treating these 68 ash trees will allow for the prolonged enjoyment of the environmental, economic, and social benefits these ash trees provide.

Operationalizing Strategy 4

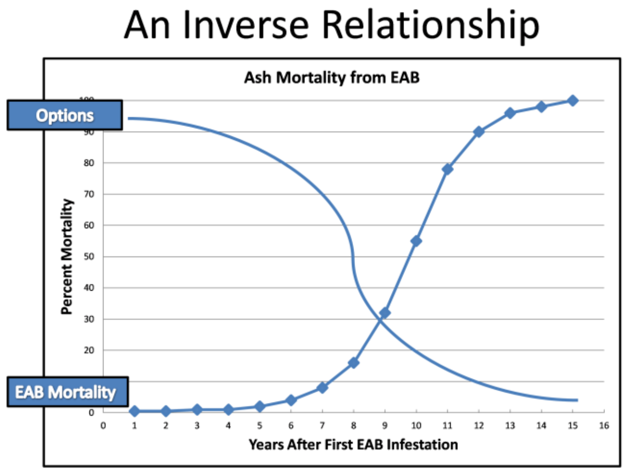

Figure 3: EAB Mortality Curve. As confirmation and spread of EAB directly impacts a city, the response options quickly decrease.

The City of Columbia is at the threshold of EAB Management. Currently there have been no confirmed infestations of EAB throughout the City; however, at the rate the beetle spreads, Columbia could be placed at Year 1 of the graph found in Figure 3. This position provides the City with the opportunity to be proactive in the management of the EAB threat. As seen in the graph, if the City of Columbia decides to wait for EAB to directly impact the City's ash tree population, treatment options quickly decrease resulting in a high-risk, high-cost, reactive management approach.

To properly prepare for the impact of EAB, Davey Resource Group recommends implementing Strategy 4.

This strategy has been used successfully in other community EAB management programs. The strategy for this management option includes annually removing and treating ash trees with the goal of preserving at least 68 ash trees for as long as possible to maximize the benefits already provided by the large exiting trees.

Remove all ash in Poor, Critical, and Dead condition along with all ash designated as *Unassigned* and trees less than 3 inches DBH. Treat all Fair conditioned ash trees within the 4–18 inches diameter class in order to stagger removals. During the plan, 610 ash trees will be removed and replaced.

In Year One of implementation, The City of Columbia should remove 114 of the 342 ash trees recommended for removal and treat the 336 remaining ash trees recommended for treatment. Prioritize removals based on the risk assigned during the inventory. Once all risk ratings between 7 and 10 are complete, Columbia should focus on removing the larger DBH trees that remain.

In Year Two, Columbia should remove an additional 114 ash trees marked for removal and replace as many trees as budget allows. Davey Resource Group recommends replacing at least half of the trees scheduled for removal, including inventory assessed removals and Poor condition trees. This would be 171 replants of 342 scheduled removals.

In Year Three, the remaining 114 trees recommended for removal should be removed. The majority of these trees will be trees rated in Poor condition and those trees inventoried at 1–3 inches in diameter. Another round of ash treatments should be completed. Candidate treatment trees should be inspected prior to treatment. Trees beginning to show signs and symptoms of EAB and/or have greater than 50% canopy dieback or trees with bark flaking off should be removed, not treated. Those removed should be replanted.

Year Four focuses on replanting the remaining 171 ash trees removed in Years One through Three.

In Year Five and in following years, continue biannual treatments. Remove and replace all dangerous and undesirable ash trees.

Table 6. Budget Summary for Strategy 4

	Year One (2014)	Year Two (2015)	Year Three (2016)	Year Four (2017)	Year Five (2018)	Five-Year Cost
Removals	$24,525	$24,540	$4,050			$53,115
Treatments	$40,220		$40,220		$40,220	$120,660
Replacements		$47,880		$47,880	$2,800	$98,560
Cost	$64,745	$72,420	$44,270	$47,880	$43,020	$272,335

Table 6 provides cost estimates for five years; however, treatments for desirable trees will need to continue. Preserving the ash trees will provide the city with growing environmental, economic, and social benefits for years to come. We suggest that the City of Columbia eventually remove 90% (610 trees) of its ash population and continually treat the remaining 10% (68 trees). Columbia will spend approximately $272,335 in managing its ash tree population over the next five years. All removal and planting costs are based on quotes from a large number of reputable North American tree care companies, and treatment costs are averages extracted from bids received by communities in the eastern United States. Appendix D contains a more detailed budget and timeline for each year of Strategy 4.

The City of Columbia should avoid putting all of its forestry resources into EAB management and mitigation. When Dutch elm disease was at its peak in the Midwest, the only tree work occurring in community forestry programs was the removal of infected elm trees; all other trees were not being maintained. Now, current forestry programs are dealing with many 30- to 40-year-old trees that have very poor structure because they were not maintained as young trees when Dutch elm disease was at its peak. To avoid this problem, the City should concurrently conduct routine tree inspections and implement a routine pruning cycle for the entire population while managing the EAB infestation.

Inspections

The City of Columbia has recognized that tree maintenance costs are reduced over time when trees are properly maintained. The City should maintain its current street tree inventory and pursue a complete park/public tree inventory. Much work will occur during the next five years in the street trees alone. It will be vital to the integrity of the inventory and the urban forest of Columbia for budgeting and planning purposes that the inventory database information be complete and kept up-to-date. Conduct annual inspections and update the inventory database as trees are removed, maintained, or planted. The appropriate time for EAB inspections is from June to August when all potential signs and symptoms of EAB are present and accentuated. At a minimum for each tree inspected, collect the DBH, condition rating, risk rating, and primary maintenance need.

Davey Resource Group recommends that Columbia keep the inventory up-to-date by committing to regular, routine data entry and a complete inventory of all public maintained trees. Keep all inspections, work histories, call histories, pictures, tree assessment forms, and any other pertinent data for each tree record in one management software such as TreeKeeper®. This will help to minimize the City's exposure for potential litigation and will help the City Arborist properly maintain and care for the City's urban forest.

Reforestation

As the ash tree population is being reduced within Columbia's urban forest, the City will need to come up with a plan to replant where ash trees have been removed. Prompt reforestation is vital for the City and its residents because of the numerous benefits that the 678 ash trees provide the community. Some of the benefits that these ash trees provide include, but are not limited to, removing pollutants from the air, helping moderate temperatures, reducing stormwater runoff, and providing social and psychological benefits.

If the City is to replace all ash trees, it will cost approximately $328,550. This would be a huge financial burden, but it will be important that these trees be replaced. The cost of replacing ash trees with non-host species should be spread out over multiple years by establishing a goal to replant a certain amount of trees each year. If the City were to plant 199 trees in Years One and Three, then Columbia could replace all ash trees scheduled for removal in Strategy 4. Organizing volunteer groups to participate in planting trees could help decrease the cost for planting trees. Columbia should explore grants for reforestation funding assistance.

It is important to consider diversification when replacing ash trees. Without diversification, a community is much more vulnerable to catastrophic losses that impact budgets and the urban forest. Davey Resource Group recommends that no one species represents more than 10% and that no one genus comprises more than 20% of the total grouping of trees purchased for planting. Over time, following this rule of thumb will level the overall species frequencies among the City's urban forest.

Parks

Columbia currently has 74 Parks and Recreation Facilities that should also be considered for managing EAB on a citywide level. To properly maintain the City's urban forest the park trees need to be inventoried and inspected; doing this will both aid in the overall care and maintenance of the City properties as well as identify additional ash trees that need to be managed for EAB. In addition to street trees, park trees in manicured areas present a higher liability if not properly monitored and maintained. Parks throughout Missouri tend to have areas heavily populated with ash trees. In these areas with heavy ash density, an infestation of EAB will move quickly demanding higher resources to maintain the many High Risk trees left behind.

Wooded Areas

Wooded areas should also be considered when managing EAB. Trees in wooded areas throughout the City were not located or inventoried by Davey Resource Group. All wooded areas should be visually inspected to determine the amount of ash trees present. Wooded areas with heavy ash tree populations will require more resources and could become a higher level of concern dependent on use of the area. Once a wooded area is infested with EAB, the beetle will move quickly and the City will be left with many High Risk trees.

The City should consider evaluating the current stocking level or number of ash trees in their maintained and unmaintained public spaces and develop a plan for reducing their numbers. This could include tree removals or a decision to do nothing, removing only when trees become infested and health deteriorates.

Public Education and Outreach

It is crucial for Columbia residents to be well informed about EAB. Their cooperation will be vital in helping detect EAB and replanting trees removed throughout the City. If the public is well informed, they are more likely to accept what is happening without panicking. The following are examples of how the City of Columbia could go about informing the public:

- News releases
- Community newsletter articles
- Post information about EAB and the EAB program on the City website
- Host interviews on the City Broadcast Television Station

Handling Ash Debris

In order to minimize the spread of EAB through infested material, it is vital the City of Columbia transport and process ash debris appropriately. Although EAB adults can fly, much of its rapid spread has been attributed to the movement of infested wood by human activity.

Stakeholders

It will be important for the City of Columbia to explore the option of working with different stakeholders. Working with stakeholders can benefit the City in many ways that include public education, reforestation, detection, treatments, and removals. It might be beneficial for the City to create a task force team to assist in these efforts. This task force team could be a combination of professionals who support the forestry program. Some potential stakeholders could include the following organizations:

- **Tree care businesses** could help with detecting EAB, providing treatment options, and performing removals.
- **Neighborhood organizations** could help raise money to replant trees and organize groups to plant these trees.
- **Tree/Park Board** can endorse supporting Columbia in dealing with EAB, help allocate funds to deal with EAB, and recognize EAB as a public nuisance.
- **Missouri Department of Conservation (MDC)** could help provide resources and information to the public, help the City of Columbia inquire about grants with removing and replacing ash trees, and help support the City in dealing with EAB.
- **Local nurseries** may support the program by supplying a certain amount of trees at a discounted price and provide more of a diversity of tree species.

Wood Utilization

Wood utilization has become popular because of the number of trees that have been impacted by EAB. Outside of baseball bats, ash lumber has not traditionally been used as a mainstream product. Ash is a fine lumber that has many qualities. Ash lumber can be used for a number of products ranging from park benches, shelving, furniture or flooring, picture frames, or lumber for a local school shop class.


Photographs 1 and 2. Lumber and park benches are examples of how ash wood is being utilized in communities that have been infested with EAB.

Evaluating Effectiveness

In order to measure the effectiveness of a pest management program, a method for evaluation should be followed. Specific accomplishments can be measured in comparison to the program‘s goals and recommendations. The evaluation should encompass the City’s experience, successes, and failures of the past year in order to refocus efforts and resources for the future. These include:

- Count the number of ash trees remaining in the population.
- Inspect the condition of the ash population.
- Count the number of ash trees removed.
- Count the number of ash trees treated.
- Compare the actual number of plantings to the actual number of removals.
- Compare the City’s annual forestry expenses to the budget projected in this management plan.
- Modify the planned work or increase budget requests to accomplish urban forestry goals and objectives.

EAB Updates and Information

Davey Resource Group, a division of The Davey Tree Expert Company

Joshua Behounek, Consulting Urban Forester
573-673-7530
www.davey.com

National Invasive Species Information

http://www.invasivespeciesinfo.gov/animals/eab.shtml

Missouri Department of Conservation

http://mdc.mo.gov/

U.S. Forest Service

http://www.nrs.fs.fed.us/disturbance/invasive_species/eab/

Collaborative Teams

http://www.emeraldashborer.info/index.cfm

Conclusion

To cost-effectively manage the ash population within the City of Columbia, Missouri, the City must strive to maintain a healthy tree canopy through annual tree inspections, proactive removals, treatments, and replanting of removed trees. Columbia’s urban forest is in an overall Good condition. To maintain the health and benefits of this citywide asset, Columbia will need to continue to be proactive with the management of the tree population. Parks were not inventoried and are not included in this plan. To further prepare for an infestation of EAB, Columbia should focus on managing their street tree assets as well as be proactive in managing park trees and even educating the public for private tree care. Implementing an ash tree nuisance ordinance in the City’s current Tree Ordinance should be contemplated to ensure public safety throughout the City. Implementation of this management strategy is a smart, efficient approach toward maintaining a safe, beautiful, benefit-producing community forest in the City of Columbia.

Appendix A
EAB and Ash Identification

Pest Alert

United States
Department of Agriculture
Forest Service
State and Private Forestry
Northeastern Area

NA-PR-02-04
January 2004

Emerald Ash Borer

An exotic beetle from Asia was discovered in July 2002 feeding on ash (*Fraxinus* spp.) trees in southeastern Michigan. It was identified as *Agrilus planipennis* Fairmaire (Coleoptera: Buprestidae). Larvae feed in the cambium between the bark and wood, producing galleries that eventually girdle and kill branches and entire trees. Evidence suggests that *A. planipennis* has been established in Michigan for at least six to ten years. More than 3000 square miles in southeast Michigan are infested and more than 5 million ash trees are dead or dying from this pest. This exotic pest is also established in Windsor, Ontario, Canada. In 2003, newly established populations were detected in other areas of southern Michigan and several locations in Ohio. Infested ash nursery trees were also found in Maryland and Virginia.

Identification

Adult beetles are generally larger and a brighter green than the native North American species of *Agrilus* (Fig. 1). Adults are slender, elongate and 7.5 to 13.5 mm long. Males are smaller than females and have fine hairs on the ventral side of the thorax, which the females lack. Color varies but adults are usually bronze or golden green overall, with darker, metallic, emerald green wing covers. The top of the abdomen under the wings is metallic purplish red and can be seen when the wings are spread. The prothorax, the segment behind the head to which the first pair of legs is attached, is slightly wider than the head but the same width as the base of the wing covers.


Figure 1. Adult emerald ash borer.

Larvae reach a length of 26 to 32 mm, are white to cream-colored and dorso-ventrally flattened (Fig. 2). The brown head is mostly retracted into the prothorax and only the mouth-parts are visible externally. The 10-segmented abdomen has a pair of brown, pincer-like appendages on the last segment.


Figure 2. Second, third, and fourth stage larvae.

Biology

The emerald ash borer generally has a one-year life cycle in southern Michigan but could require two years to complete a generation in colder regions. In 2003, adult emergence began in early June, peaked in late June and early July, and continued into late July. Beetles usually live for about 3 weeks and are present into mid-August. Adult beetles are active during the day, particularly when conditions are warm and sunny. Most beetles remain in protected locations in bark crevices or on foliage during rain, heavy cloud cover, high winds, or temperatures above 32°C (90°F). Beetles feed on ash foliage, usually in small, irregularly-shaped patches along the margins of leaves.

Females can mate multiple times and egg laying begins a few days after the initial mating. Females can lay at least 60 to 90 eggs during their lifetime. Eggs are deposited individually in bark crevices on the trunk or branches. Eggs hatch in 7 to 10 days.

After hatching, first instar larvae chew through the bark and into the cambial region. Larvae feed on phloem and the outer sapwood for several weeks. The S-shaped feeding gallery winds back and forth, becoming progressively wider as the larva grows (Fig. 3). Galleries are packed with fine, sawdust-like frass. Individual galleries often extend over an area that is 20 to 30 cm in length, though the length of the affected area can range from 10 to 50 cm or longer.

Feeding is completed in autumn and pre-pupal larvae overwinter in shallow chambers excavated in the outer sapwood or in the bark on thick-barked trees. Pupation begins in late April or May. Newly eclosed adults often remain in the pupal chamber for 1 to 2 weeks before emerging head-first through a D-shaped exit hole that is 3–4 mm in diameter (Fig. 4).


Figure 3. Galleries excavated by larvae.

Figure 4. D-shaped exit holes where adult beetles emerged.

Figure 5. Jagged holes left by woodpeckers

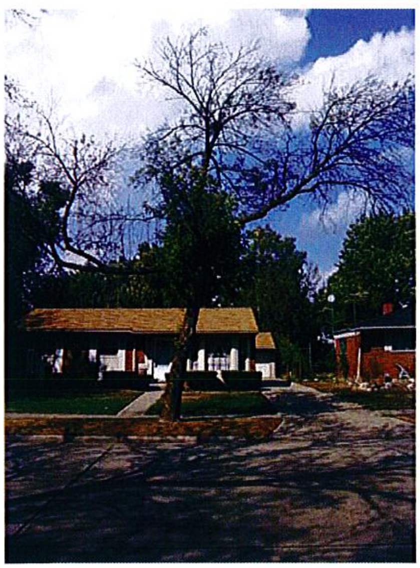

Figure 6. Much of the canopy is dead on a heavily infested ash tree.

Distribution and Hosts

The emerald ash borer is native to Asia and is known to occur in China, Korea, Japan, Mongolia, the Russian Far East and Taiwan. A Chinese report indicates high populations of the borer occur primarily in *Fraxinus chinensis* and *F. rhynchophylla* forests. Other reported hosts in Asia include *F. mandshurica* var. *japonica, Ulmus davidiana* var. *japonica, Juglans mandshurica* var. *sieboldiana* and *Pterocarya rhoifolia*. In North America, this borer has only attacked ash trees. Green ash (*F. pennsylvanica*), white ash (*F. americana*) and black ash (*F. nigra*), as well as several horticultural varieties of ash have been killed.

Symptoms

It is difficult to detect emerald ash borer in newly infested trees. Jagged holes excavated by woodpeckers feeding on pre-pupal larvae may be the first sign that a tree has become infested (Fig. 5). When a tree has been infested for at least one year, the D-shaped exit holes left by emerging adults will be present on the branches and the trunk (Fig 4). Bark may split vertically above larval feeding galleries. When the bark is removed from infested trees, the distinct, frass-filled larval tunnels that etch the outer sapwood and phloem are readily visible on the trunk and branches (Fig. 3). An elliptical area of discolored sapwood, usually a result of secondary infection by fungal pathogens, sometimes surrounds larval feeding galleries.

Serpentine tunnels excavated by feeding larvae interrupt the transport of nutrients and water within the tree during the summer. Foliage wilts and the tree canopy becomes increasingly thin and sparse as branches die. Many trees appear to lose about 30% to 50% of the canopy after 2 years of infestation and trees often die after 3-4 years of infestation (Fig. 6). Epicormic shoots may arise on the trunk of the tree, often at the margin of live and dead tissue. Dense root sprouting sometimes occurs after trees die.

Emerald ash borer has killed trees of various size and condition in Michigan. Larvae have developed in trees and branches ranging from 2.5 cm (1 inch) to 140 cm (55 inches) in diameter. Stress likely contributes to the vulnerability and rapid decline of infested ash trees. However, emerald ash borer has killed apparently vigorous trees in woodlots and urban trees under regular irrigation and fertilization regimes.

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Yu, Chengming. 1992. *Agrilus marcopoli* Obenberger. In Xiao, G., ed. Forest insects of China. 2d ed. Beijing, China: China Forestry Publishing House; 400-401. Translation by Houping Liu, USDA Forest Service.

Jendek, E. 2002. *Agrilus planipennis* fact sheet. PDF file provided by Eduardo Jendek, Institute of Zoology, Slovak Academy of Sciences, Bratislava, Slovak Republic.

Resources

Visit the following websites for information on emerald ash borer biology, identification, management, quarantines and related topics:

1. Michigan Multi-Agency Emerald Ash Borer Web Site: http://www.emeraldashborer.info
2. USDA Forest Service: http://www.na.fs.fed.us/spfo/eab/
3. Michigan Department of Agriculture: http://www.michigan.gov (keyword emerald ash borer)

Contact your State Department of Agriculture, State Forester, or County Extension Office for more information.

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Photo credits:

David L. Cappaert and Howard Russell, Michigan State University and Steven A. Katovich, USDA Forest Service.

Prepared by:

USDA Forest Service
Northeastern Area,
State & Private Forestry
Newtown Square, PA

Extension Bulletin E-2942 New, May 2005

Ash Tree Identification

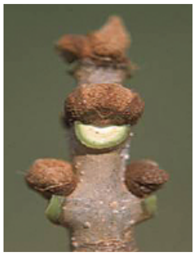
Ash species attacked by emerald ash borer include green (*Fraxinus pennsylvanica*), white (*F. americana*), black (*F. nigra*), and blue (*F. quadrangulata*), as well as horticultural cultivars of these species. Green and white ash are the most commonly found ash species in the Midwest with blue ash being rare.

While other woody plants, such as mountainash and pricklyash, have "ash" in their name, they are not true ash, or *Fraxinus* species. Only true ash are susceptible to attack by emerald ash borer.

To properly identify ash trees, use the following criteria:

Branch and Bud Arrangement

Branches and buds are directly across from each other and not staggered. When looking for opposite branching in trees, please consider that buds or limbs may die; hence not every single branch will have an opposite mate.



Diane Brown-Rytlewski

Leaves

Leaves are compound and composed of 5-11 leaflets. Leaflet margins may be smooth or toothed. The only other oppositely branched tree with compound leaves is boxelder (*Acer negundo*), which almost always has three to five leaflets. White ash (on left) and green ash (on right)

*Paul Wray, Iowa State University

Bark

On mature trees (left), the bark is tight with a distinct pattern of diamond-shaped ridges. On young trees (right), bark is relatively smooth.

*Paul Wray, Iowa State University

Seeds

When present on trees, seeds are dry, oar-shaped samaras. They usually occur in clusters and typically hang on the tree until late fall, early winter.

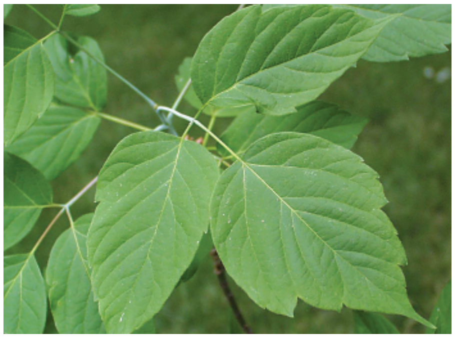
MICHIGAN STATE UNIVERSITY EXTENSION

Emerald Ash Borer

Tree Species Resembling Ash

Boxelder *(Acer negundo)*

Exhibits opposite branching and compound leaves. However, has 3 to 5 leaflets (instead of 5 to 11) and the samaras are always in pairs instead of single like the ash.



**Paul Wray, Iowa State University*

**Bill Cook, Michigan State University*

European Mountainash *(Sorbus aucuparia)*

Leaves are compound with alternate (staggered) branching. Tree bears clusters of creamy white flowers in May. Fruits are fleshy, red-orange berries.

Diane Brown-Rytlewski

**Boris Hrasovec, University of Zagreb*

Shagbark Hickory *(Carya ovata)*

Leaves are compound with 5 to 7 leaflets, but the plant has an alternate branching habit. Fruit are hard-shelled nuts in a green husk.

**Paul Wray, Iowa State University*

**Paul Wray, Iowa State University*

Elm *(Ulmus species)*

Branching is alternate and the leaves are simple with an unequal leaf base.

**Paul Wray, Iowa State University*

**Paul Wray, Iowa State University*

**Paul Wray, Iowa State University*

Black Walnut *(Juglans nigra)*

Leaves are compound with 9 to 15 leaflets, but the plant has an alternate branching habit. Fruit is a large dark brown nut inside a green husk.

**Paul Wray, Iowa State University*

Authors: Kimberly Rebek and Mary Wilson

**www.forestryimages.org*

New - 5:05 - 6,250 - KMF/LB

Extension Bulletin E-2938 Reprinted December 2005

Signs and Symptoms of the Emerald Ash Borer

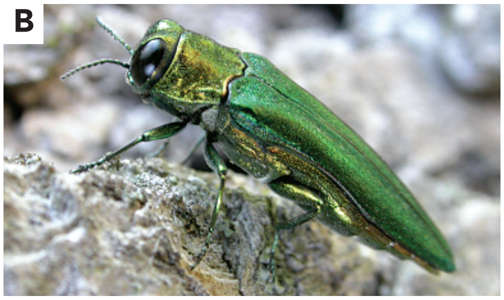
Mary Wilson, MSU Extension. Eric Rebek, Michigan State University Dept. of Entomology

Adult

A

Michigan State University

B

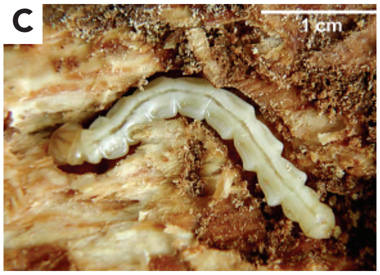


Michigan State University

- Bright, metallic green (Figs. A, B).
- 1/2 inch long, flattened back (Figs. A, B).
- Purple abdominal segments beneath wing covers.

Larva

C



D. Cappaert, MSU

- Creamy white, legless (Fig. C).
- Flattened, bell-shaped body segments (Fig. C).
- Terminal segment bears a pair of small appendages.

Canopy Dieback

D

E. Rebek, MSU

E

E. Rebek, MSU

- Begins in top one-third of canopy (Fig. D).
- Progresses until tree is bare (Fig. E).

Epicormic Shoots

F

J. Smith, USDA APHIS PPQ

G

J. Smith, USDA APHIS PPQ

- Sprouts grow from roots and trunk (Figs. F, G).
- Leaves often larger than normal.

Emerald Ash Borer

MICHIGAN STATE UNIVERSITY EXTENSION

THE OHIO STATE UNIVERSITY EXTENSION OARDC

Bark Splitting

H

J. Smith, USDA APHIS PPQ

I

A. Storer, Mich. Tech. Univ.

- Vertical fissures on bark (Fig. H) due to callous tissue formation (Fig. I).
- Galleries exposed under bark split.

Serpentine Galleries and D-shaped Exit Holes

J

D. Cappaert, MSU

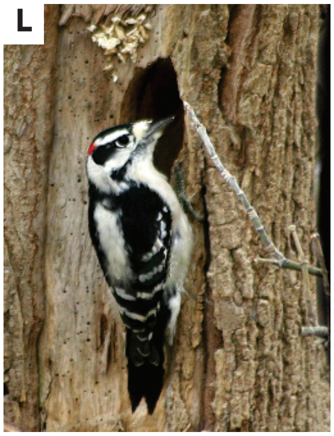
K

D. Cappaert, MSU

- Larval feeding galleries typically serpentine (Fig. J).
- Galleries weave back and forth across the woodgrain.
- Packed with frass (mix of sawdust and excrement).
- Adults form D-shaped holes upon emergence (Fig. K).

Increased Woodpecker Activity/Damage

L



D. Cappaert, MSU

M

Karen D'Angelo, MSUE

- Several woodpecker species (Fig. L) feed on EAB larvae/pupae.
- Peck outer bark while foraging (Fig. M).
- Create large holes when extracting insects (Fig. M).

Revised - 12:05 - 5M - KMF/LB

Extension Bulletin E-2939 New, February 2005

Native Borers and Emerald Ash Borer Look-alikes

Native Ash Borers


A


B

D.G. Nielsen, Ohio State University/OARDC


C

J. Solomon, USDA Forest Service www.forestryimages.com


D

D. Herms, Ohio State University/OARDC


E

D. Herms, Ohio State University/OARDC


F

D. Herms, Ohio State University/OARDC


G

D. Herms, Ohio State University/OARDC

Native ash borers are North American insects that tunnel under the bark of ash trees, sometimes causing enough damage to seriously weaken trees.

These two borers attack healthy ash trees:

Banded ash clearwing, *Podosesia aureocincta*; adult (Fig. A), larva (Fig. B).

Ash/lilac borer, *Podosesia syringae*; adult (Fig. C).

- Wasp-mimicking moths that feed on xylem of ash trees.
- Larvae are round with legs and expel frass from tree (Fig. D).
- Round exit hole (1/4 inch); pupal case exposed in exit hole upon emergence (Fig. E).

These three borers attack stressed or dying ash trees:

Redheaded ash borer, *Neoclytus acuminatus*; adult (Fig. F), larva (Fig. G).

Banded ash borer, *Neoclytus caprea*; adult (Fig. H).

- Longhorned beetles (roundheaded borers) that attack stressed ash trees, but also colonize elm, hickory, oak, linden and others.
- Larvae tunnel deep into xylem (Fig. I) and adults emerge from round-oval exit holes measuring 1/4 inch (Fig. J).


H

J. Solomon, USDA Forest Service www.forestryimages.com


I

Csoka, Hungary For Res Inst., www.forestryimages.com


J

J. Solomon, USDA Forest Service www.forestryimages.com

Emerald Ash Borer

MICHIGAN STATE UNIVERSITY EXTENSION

Native Borers (continued)

Eastern ash bark beetle, *Hylesinus aculeatus*; adult (Fig. K).

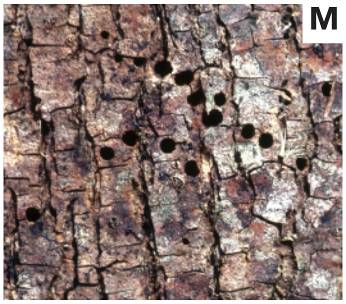
- Cylindrical bark beetle that forms galleries beneath the bark of ash trees (Fig. L).
- Infested trees peppered with tiny, round exit holes measuring approximately 1/16 inch (Fig. M).

K

J. Solomon, USDA Forest Service www.forestryimages.com

L

J. Solomon, USDA Forest Service www.forestryimages.com



M

J. Solomon, USDA Forest Service www.forestryimages.com

Emerald Ash Borer Look-alikes

The following insects are common to Michigan and could possibly be confused with emerald ash borer.

N

Michigan State University

O

University of Arkansas

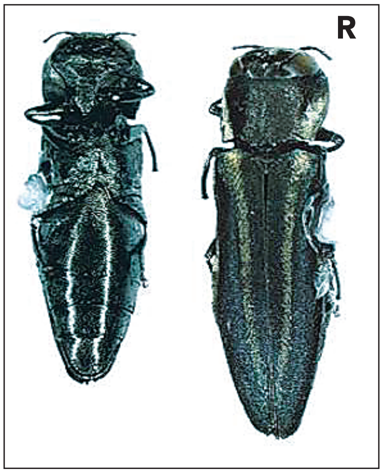
P

Michigan State University

- **Six-spotted tiger beetle**, *Cicindela sexguttata*; adult measures 1/2 inch long (Fig. N).
- **Caterpillar hunter**, *Calosoma scrutator*; adult measures 1 inch long (Fig. O).
- **Japanese beetle**, *Popillia japonica*; adult measures slightly less than 1/2 inch long (Fig. P).
- **Bronze birch borer**, *Agrilus anxius*; adult measures approximately 1/2 inch long (Fig. Q).
- **Two-lined chestnut borer**, *Agrilus bilineatus*; adult measures approximately 1/2 inch long (Fig. R).
- Several other uncommon metallic wood-boring beetles.

Q

J. Zablotny, USDA APHIS PPQ



R

J. Zablotny, USDA APHIS PPQ

New - 2:05 - 5M - KMF/LB

Appendix B
Suggested Tree Species

Proper landscaping and tree planting are critical components of the atmosphere, livability, and ecological quality of a community's urban forest. The tree species listed below have been evaluated for factors such as size, disease and pest resistance, seed or fruit set, and availability. The following list is offered to assist all relevant community personnel in selecting appropriate tree species. These trees have been selected because of their aesthetic and functional characteristics and their ability to thrive in the soil and climate (USDA Zones 5 and 6) conditions found throughout Missouri.

Deciduous Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Acer rubrum	red maple	Red Sunset®
Acer saccharum	sugar maple	'Legacy'
Acer nigrum	black maple	
*Betula alleghaniensis**	yellow birch	
*Betula lenta**	sweet birch	
Betula nigra	river birch	Heritage®
Carpinus betulus	European hornbeam	'Franz Fontaine'
*Carya illinoensis**	pecan	
*Carya lacinata**	shellbark hickory	
*Carya ovata**	shagbark hickory	
*Castanea mollissima**	Chinese chestnut	
Celtis laevigata	sugarberry	
Celtis occidentalis	common hackberry	'Prairie Pride'
Cercidiphyllum japonicum	katsuratree	'Aureum'
*Diospyros virginiana**	common persimmon	
*Fagus grandifolia**	American beech	
*Fagus sylvatica**	European beech	(Numerous exist)
Ginkgo biloba	ginkgo	(Choose male trees only)
Gleditsia triacanthos inermis	thornless honeylocust	'Shademaster'
Gymnocladus dioica	Kentucky coffeetree	Prairie Titan®
*Juglans nigra**	black walnut	
*Larix decidua**	European larch	
Liquidambar styraciflua	American sweetgum	'Rotundiloba'
*Liriodendron tulipifera**	tuliptree	'Fastigiatum'
*Magnolia acuminata**	cucumbertree magnolia	(Numerous exist)
*Magnolia macrophylla**	bigleaf magnolia	
Metasequoia glyptostroboides	dawn redwood	'Emerald Feathers'
Nyssa sylvatica	blackgum	
*Platanus occidentalis**	American sycamore	
Platanus × acerifolia	London planetree	'Yarwood'
Quercus alba	white oak	

Large Trees: Greater than 45 Feet in Height at Maturity (Continued)

Scientific Name	Common Name	Cultivar
Quercus bicolor	swamp white oak	
Quercus coccinea	scarlet oak	
Quercus lyrata	overcup oak	
Quercus macrocarpa	bur oak	
Quercus montana	chestnut oak	
Quercus muehlenbergii	chinkapin oak	
Quercus palustris	pin oak	
Quercus imbricaria	shingle oak	
Quercus phellos	willow oak	
Quercus robur	English oak	Heritage®
Quercus rubra	northern red oak	'Splendens'
Quercus shumardii	Shumard oak	
Styphnolobium japonicum	Japanese pagodatree	'Regent'
Taxodium distichum	common baldcypress	'Shawnee Brave'
Tilia americana	American linden	'Redmond'
Tilia cordata	littleleaf linden	'Greenspire'
Tilia × euchlora	Crimean linden	
Tilia tomentosa	silver linden	'Sterling'
Ulmus parvifolia	Chinese elm	Allée®
Zelkova serrata	Japanese zelkova	'Green Vase'

Medium Trees: 31 to 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Aesculus × carnea	red horsechestnut	
Alnus cordata	Italian alder	
*Asimina triloba**	pawpaw	
Cladrastis kentukea	American yellowwood	'Rosea'
Corylus colurna	Turkish filbert	
Eucommia ulmoides	hardy rubber tree	
Koelreuteria paniculata	goldenraintree	
Ostrya virginiana	American hophornbeam	
Parrotia persica	Persian parrotia	'Vanessa'
Phellodendron amurense	Amur corktree	'Macho'
Pistacia chinensis	Chinese pistache	
Prunus maackii	Amur chokecherry	'Amber Beauty'
Prunus sargentii	Sargent cherry	
*Pterocarya fraxinifolia**	Caucasian wingnut	
Quercus acutissima	sawtooth oak	
Quercus cerris	European turkey oak	
*Sassafras albidum**	sassafras	

Small Trees: 15 to 30 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Acer buergerianum	trident maple	Streetwise®
Acer campestre	hedge maple	Queen Elizabeth™
Acer cappadocicum	coliseum maple	‘Aureum’
Acer ginnala	Amur maple	Red Rhapsody™
Acer griseum	paperbark maple	
Acer oliverianum	Chinese maple	
*Acer pensylvanicum**	striped maple	
Acer triflorum	three-flower maple	
*Aesculus pavia**	red buckeye	
Amelanchier arborea	downy serviceberry	(Numerous exist)
Amelanchier laevis	Allegheny serviceberry	
*Carpinus caroliniana**	American hornbeam	
Cercis canadensis	eastern redbud	‘Forest Pansy’
Chionanthus virginicus	white fringetree	
Cornus alternifolia	pagoda dogwood	
Cornus kousa	kousa dogwood	(Numerous exist)
Cornus mas	corneliancherry dogwood	‘Spring Sun’
Corylus avellana	European filbert	‘Contorta’
*Cotinus coggygria**	common smoketree	‘Flame’
*Cotinus obovata**	American smoketree	
*Crataegus phaenopyrum**	Washington hawthorn	Princeton Sentry™
Crataegus viridis	green hawthorn	‘Winter King’
*Franklinia alatamaha**	Franklinia	
*Halesia tetraptera**	Carolina silverbell	‘Arnold Pink’
Laburnum × watereri	goldenchain tree	
Maackia amurensis	Amur maackia	
*Magnolia × soulangiana**	saucer magnolia	‘Alexandrina’
*Magnolia stellata**	star magnolia	‘Centennial’
*Magnolia tripetala**	umbrella magnolia	
*Magnolia virginiana**	sweetbay magnolia	Moonglow®
Malus spp.	flowering crabapple	(Disease resistant only)
Oxydendrum arboreum	sourwood	‘Mt. Charm’
Prunus subhirtella	Higan cherry	‘Pendula’
Prunus virginiana	common chokecherry	‘Schubert’
*Staphylea trifolia**	American bladdernut	
Stewartia ovata	mountain stewartia	
*Styrax japonicus**	Japanese snowbell	‘Emerald Pagoda’
Syringa reticulata	Japanese tree lilac	‘Ivory Silk’

Note: * denotes species that are **not** recommended for use as street trees.

Coniferous and Evergreen Trees

Large Trees: Greater than 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Abies balsamea	balsam fir	
Abies concolor	white fir	'Violacea'
Cedrus libani	cedar-of-Lebanon	
Chamaecyparis nootkatensis	Nootka falsecypress	'Pendula'
Cryptomeria japonica	Japanese cryptomeria	'Sekkan-sugi'
× *Cupressocyparis leylandii*	Leyland cypress	
Ilex opaca	American holly	
Picea omorika	Serbian spruce	
Picea orientalis	Oriental spruce	
Pinus densiflora	Japanese red pine	
Pinus strobus	eastern white pine	
Pinus sylvestris	Scotch pine	
Pinus taeda	loblolly pine	
Pinus virginiana	Virginia pine	
Psedotsuga menziesii	Douglas-fir	
Thuja plicata	western arborvitae	(Numerous exist)
Tsuga canadensis	eastern hemlock	

Medium Trees: 31 to 45 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Chamaecyparis thyoides	Atlantic whitecedar	(Numerous exist)
Juniperus virginiana	eastern redcedar	
Pinus bungeana	lacebark pine	
Pinus flexilis	limber pine	
Pinus parviflora	Japanese white pine	
Thuja occidentalis	eastern arborvitae	(Numerous exist)

Small Trees: 15 to 30 Feet in Height at Maturity

Scientific Name	Common Name	Cultivar
Ilex × attenuata	Foster's holly	
Pinus aristata	bristlecone pine	
Pinus mugo mugo	mugo pine	

This suggested species list was compiled through the use of the excellent references *Dirr's Hardy Trees and Shrubs* (Dirr 2003) and *Manual of Woody Landscape Plants (5th Edition)* (Dirr 1998). Cultivar selections are recommendations only and are based on Davey Resource Group's experience; tree availability will vary by nursery.

Appendix C
Treatment Options

Coalition for Urban Ash Tree Conservation
- Emerald Ash Borer Management Statement -

www.emeraldashborer.info/files/conserve_ash.pdf

signed 06 Jan 2011

We the undersigned strongly endorse ash tree conservation as a fundamental component of integrated programs to manage emerald ash borer (EAB) in residential and municipal landscapes. Cost-effective, environmentally sound EAB treatment protocols are now available that can preserve ash trees through peak EAB outbreaks with healthy canopy intact. Used in association with tree inventories and strategic removal / replacement of unhealthy ash, tree conservation will help retain maximum integrity and value of urban forests. This integrated approach to urban EAB management is supported by university scientists with expertise in EAB management, commercial arborists, municipal foresters, public works officials, and non-governmental organizations (NGOs).

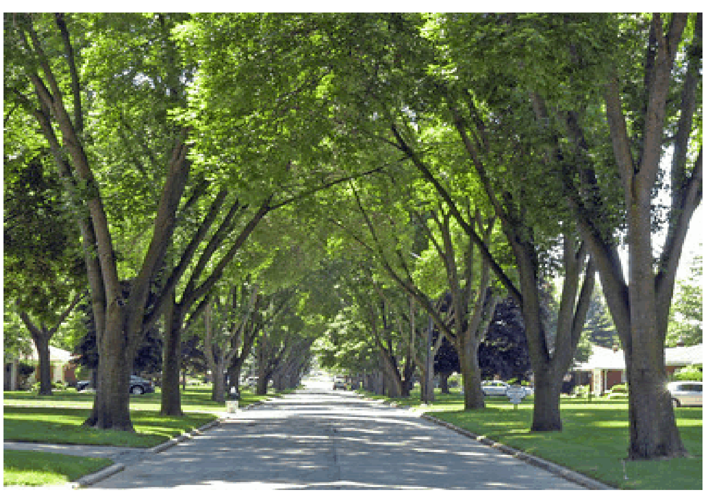
Emerald ash borer has killed millions of ash trees since its discovery in 2002 and the number of dead ash is increasing rapidly. Ash species are abundant in planted *and* natural areas of urban forests, representing 10 - 40% of the canopy cover in many communities.

Ash trees provide substantial economic and ecosystem benefits to taxpayers, ranging from increased property value, to storm water mitigation, to decreased energy demands (http://www.coloradotrees.org/benefits.htm).

Consequently, widespread ash mortality in urban forests and residential landscapes is having devastating economic and environmental impacts. Indeed, EAB is predicted to cause an unprecedented $10-20 *billion* in losses to urban forests over the next 10 years.
(http://ncrs.fs.fed.us/pubs/jrnl/2010/nrs_2010_kovacs_001.pdf)

After its initial discovery, regulatory agencies attempted to eradicate EAB through removal and destruction of all ash trees in infested areas. Unfortunately, this proved unsuccessful and was soon abandoned.

Since then, university scientists have developed and refined treatment protocols that can protect healthy ash trees from EAB and help conserve the urban forest.



Ash trees before EAB devastation -- Belvedere Dr., Toledo, OH, June 2006.

Untreated ash trees after EAB peak, Belvedere Dr., Toledo, OH, June 2009.

However, despite availability of cost-effective treatments, many municipalities, property managers, and homeowners continue to rationalize tree removal as the only viable management strategy for EAB. This is based on erroneous beliefs that tree removal slows the spread of EAB, or that treatment is not effective, economical, or environmentally sound. *Current science supports conservation via treatment as a sensible and effective tool for managing healthy ash trees in urban settings. In many cases, tree conservation is economically and environmentally superior to tree removal.*

Based on research conducted by university scientists, and careful review of the potential impacts on human health and the environment, the Environmental Protection Agency (EPA) has registered three systemic insecticides for control of EAB – dinotefuran is registered for basal trunk bark or soil application, emamectin benzoate for trunk injection only, and imidacloprid for soil application or trunk injection.

When applied *using formulations, products, and protocols documented as effective by university research,* these treatments can provide environmentally sound control of EAB, sufficient to maintain a functional and aesthetically pleasing ash canopy.

Treatment is most appropriate *after* EAB infestation has been detected within 15 miles, and is most effective when applied before trees are infested. However, treatment can also save ash trees with a low level of EAB infestation. Spring is the ideal time for treatment, but soil application in fall can be effective in some situations.

Different treatment regimens will be optimal under different situations *-- no one treatment plan or application method is best under all circumstances.*

A program of sustained treatment will be needed to conserve trees through peak EAB infestation. However, as the local EAB population declines due to death of untreated ash, it is possible that treatment frequency may be reduced. Research on this question and other aspects of EAB management is ongoing, *requiring practitioners to stay current.*

Up-to-date information about EAB insecticides, application protocols, and effectiveness can be found at:

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

In summary, urban ash conservation can be less costly than removal, especially when the significant environmental and economic benefits of established trees are considered (www.treebenefits.com, http://extension.entm.purdue.edu/treecomputer/). Furthermore, ash conservation can circumvent the substantial environmental impacts caused by wholesale deforestation of the urban landscape, as well as the documented public safety risks associated with standing dead ash trees and their removal.

-- Signed - 06 Jan 2011 --

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Standing dead ash, Belvedere Dr., Toledo, OH.

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Curbside ash removed due to EAB, Belvedere Dr.

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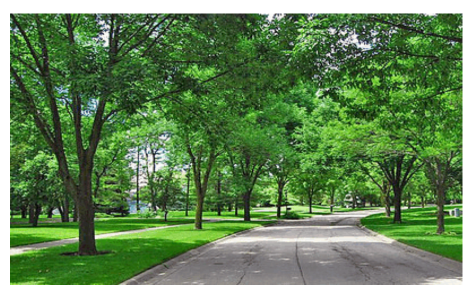

Ash trees under treatment, Lake Forest, IL, 2010.

Ohio
Emerald Ash Borer
Ash Alert Team

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

fact sheet

Insecticide Options for Protecting Ash Trees from Emerald Ash Borer and Their Effectiveness

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Ohio State University Extension personnel have received many questions from homeowners and Green Industry professionals wondering if there are insecticides capable of protecting ash trees from emerald ash borer (EAB). Research and experience have shown that insecticides can protect trees from EAB. However, success is not assured. Research suggests that best control will be obtained when treatments are initiated in the earliest stages of infestation before visible symptoms are present, or perhaps even the year before trees are infested. It is also important to realize that treatments will have to be repeated each year. In some cases, it may be more cost-effective to remove and replace the tree.

There has been much confusion surrounding the question of whether insecticides are an effective option for EAB. The answer is: "It depends on the objective." When the objective is to protect trees from being killed, insecticides have been effective. However, when the objective is to eradicate an EAB infestation to keep it from spreading, insecticides are not effective, which is why they have not been used as an eradication tool by the Cooperative EAB Program.

EAB is now firmly established in northwest Ohio and a number of isolated outlier infestations have been detected throughout the state. In response to these developments, members of the OSU Extension Nursery, Landscape, and Turf Team have developed the following recommendation regarding the use of insecticides for controlling EAB in Ohio:

> **Ash trees within Ohio Department of Agriculture's EAB quarantine, as well as those outside the quarantine but within the vicinity (i.e. 10-15 miles) of a known infestation, are considered to be at risk. Annual insecticide treatments should be considered by those in these areas who want to try to protect their ash trees.**

Trees elsewhere in Ohio are not considered to be immediately threatened, but this will change as EAB spreads and new infestations are discovered, so it is important to stay up-to-date. Locations of infestations, current quarantine maps, and other information about EAB in Ohio can be found at the following websites: www.ohioagriculture.gov/eab and www.ashalert.osu.edu.

For people who elect to treat their trees, there are several insecticide options available. It is important to keep in mind that controlling wood-boring insects with insecticides has always been a difficult proposition. This is especially true with EAB because our native North American ash trees have no natural resistance to this pest. In some university trials, insecticide treatments were effective, but in other trials the same treatments failed. Furthermore, in some studies conducted over multiple years, EAB infestations continued to increase despite ongoing treatment programs. Some arborists are combining treatments to increase the odds of success (e.g. combining a cover spray with a systemic treatment). Insecticide programs show promise, but research on chemical control of EAB is still in early stages. Scientists from universities, government agencies, and companies are conducting intensive studies to understand the circumstances under which insecticide treatments will be most effective.

Insecticide Options for Controlling EAB

Insecticides used for control of EAB fall into three categories: (1) systemic insecticides that are applied as soil injections or drenches; (2) systemic insecticides applied as trunk injections or trunk implants; and (3) protective cover sprays that are applied to the trunk, main branches, and (depending on the label) foliage. Insecticide formulations and application methods that have been evaluated for control of EAB are listed in Table 1. Some can be purchased and applied by homeowners. Others can be applied only by professional applicators. Strategies for their effective use are described below. It is important to note that pesticide labels and registrations change constantly, and can vary from state to state. It is the pesticide applicator's legal responsibility to read, understand, and follow all current label directions for the specific pesticide product being used.

Table 1. Insecticide options for professionals and homeowners for control of EAB

INSECTICIDE FORMULATION	ACTIVE INGREDIENT	APPLICATION METHOD	TIMING
Professional Use Products			
Merit® (75WP, 75WSP, 2F)	Imidacloprid	Soil injection or drench	Mid-April to mid-May
IMA-jet®	Imidacloprid	Trunk injection, Arborjet™	Mid-May to mid-June
Imicide®	Imidacloprid	Trunk injection, Mauget®	Mid-May to mid-June
Pointer™	Imidacloprid	Trunk injection, Wedgle™	Mid-May to mid-June
Inject-A-Cide B®	Bidrin®	Trunk injection, Mauget®	Mid-May to mid-June
Astro®	Permethrin	Preventive bark and foliage cover sprays	2 applications at 4 week intervals with the first when black locust is blooming (early May in southern Ohio and late May in northern Ohio)
Onyx™	Bifenthrin		
Sevin® SL	Carbaryl		
Tempo®	Cyfluthrin		
Homeowner Products			
Bayer Advanced™ Tree & Shrub Insect Control	Imidacloprid	Soil drench	Mid-April to mid-May
ACECAP® 97 Systemic Insecticide Tree Implants	Acephate	Trunk implant	Mid-May to mid-June

Using Insecticides to Control EAB

Soil-applied Systemic Insecticides

Systemic insecticides applied to the soil are taken up by the roots and translocated throughout the tree. The most widely tested systemic insecticide for control of EAB is imidacloprid, which is available for use by professional applicators and homeowners. Professional use formulations of soil-applied imidacloprid include Merit® 75WP, Merit® 75WSP, and Merit® 2F. The homeowner formulation of imidacloprid is Bayer Advanced™ Tree & Shrub Insect Control. Additional formulations of imidacloprid with different brand names are also becoming available.

All imidacloprid formulations can be applied as a drench by mixing it with water and pouring it directly on the soil at the base of the trunk. The application rates for the homeowner and professional formulations of imidacloprid are very similar (1.3 and 1.5 grams of active ingredient per inch of trunk diameter, respectively). Soil drenches offer the advantage of requiring no special equipment to apply (other than a bucket or watering can). However, surface layers of organic matter, such as mulch or leaf litter, can bind the insecticide and reduce uptake. Before applying soil drenches, it is important to remove or pull back any mulch or dead leaves so the insecticide solution is poured directly on the mineral soil.

Merit formulations can also be applied as soil injections, which require special equipment, but offer the advantage of placing the insecticide directly into the root zone. Injections should be made only deep enough (2-3 inches) to place the insecticide under the turf or mulch layer. Soil injections can be made either at the base of the trunk or on a grid pattern extending to the edge of the canopy. Recent studies have found that soil injections made immediately adjacent to the trunk (within 6-18 inches) are more effective than those made on a grid pattern under the canopy. Density of fine roots is very high at the base of the trunk and declines quickly as you move away from the tree because large radial roots diverge like spokes on a wheel prior to branching into smaller roots that ultimately terminate in feeder roots. This pattern of root distribution can be clearly observed on trees that have been recently uprooted in a storm, or when taking soil cores under the canopy, many of which will be devoid of fine roots.

Optimal timing for imidacloprid soil injections and drenches is mid-April to mid-May (treat on the early side in southern Ohio and on the later side in northern Ohio), which allows the 4-6 weeks that are necessary for uptake and distribution of the insecticide before larvae begin to establish in mid- to late June. One study with small trees indicates that imidacloprid soil drenches can also be applied successfully in the fall.

EAB larvae damage the vascular system as they feed, which interferes with translocation of systemic insecticides. Studies are underway to determine how much injury a tree can sustain before systemic insecticide treatments are rendered ineffective. It is probably unlikely to save trees showing more than 50 percent dieback, and any damage can reduce the effectiveness of systemic treatments.

Trunk-applied Systemic Insecticides

Several systemic insecticides can be injected or implanted directly into the trunk of the tree. Some formulations are applied by professionals, while others are available to homeowners. Imidacloprid is available in several professional use formulations that are injected directly into the trunk using various application systems. These include IMA-jet®, which is injected using various Arborjet™ injection systems; Mauget Imicide® micro-injection capsules; and Pointer™, which is injected using the Arborsystems Wedgle™ Direct-Inject™ injector system. Another insecticide option is Mauget Inject-A-Cide B® micro-injection capsules, which contain Bidrin® (dicrotophos). Systemic trunk implants available for purchase and application by homeowners include ACECAP® 97 Systemic Insecticide Tree Implants and Bonide® Systemic Insecticide Bullets, both of which contain acephate as the active ingredient. Both products are applied by inserting insecticide-containing capsules into holes drilled in the base of the tree trunk.

Trunk injections and implants have the advantage of being absorbed by the tree more quickly than soil applications, and can be applied where soil treatments may not be practical or effective, including trees growing on excessively wet, compacted, or restricted soil environments. However, trunk injections and implants do injure the trunk, which may cause long-term damage, especially if treatments are applied annually.

Optimal timing of trunk injections and implants is between mid-May and mid-June. Studies have shown that Inject-A-Cide B injections made as late as August can kill insects in the tree, although substantial feeding damage will have already been done. If the option exists, applications should be made earlier to prevent larval establishment.

Most efficient uptake of trunk-injected insecticides occurs when trees are actively transpiring. Best results will be obtained when injections are made on sunny days in the morning when good soil moisture conditions prevail. Uptake will be slow on cloudy days, during hot afternoons, and when the soil is dry.

Protective Cover Sprays

The objectives of protective bark cover sprays are to kill newly hatched larvae on the bark before they can enter the tree, and depending on the label, adults as they feed on foliage prior to laying eggs. Products that have been evaluated as cover sprays for control of EAB include Onyx™ (bifenthrin), Tempo® (cyfluthrin), Sevin® SL (carbaryl), Orthene® (acephate), and BotaniGard® (contains spores of the insect-infecting fungus *Beauveria bassiana*). Some of these have been much more effective than others in university trials (discussed below).

Protective cover sprays are designed to prevent infestations and must be timed precisely to be effective. Because protective residues must be present on the bark before eggs hatch to prevent infestation, they must be timed to coincide with adult emergence and oviposition, which is difficult to monitor because there are no effective pheromone traps for EAB. However, first emergence of EAB adults corresponds closely with full bloom of black locust (*Robinia psuedoacacia*), which can serve as a useful phenological indicator for accurately timing applications. Best results with cover sprays have been obtained when two applications are made, with the first as black locust reaches full bloom (early May in southern Ohio and late May in northern Ohio), and the second four weeks later.

When Should Treatments Begin?

It is difficult to determine exactly when to initiate insecticide treatments. Research suggests that best control will be obtained when treatments are initiated in the earliest stages of infestation before visible symptoms are present, or perhaps even the year before trees are infested. However, treatment programs that begin too early represent an unnecessary expense. We recommend that those who want to protect their ash trees initiate treatments if they are located within Ohio's EAB quarantine, or outside the quarantine but within the immediate vicinity (i.e. 10-15 miles) of a known infestation. Locations of infestations, current quarantine maps, and other information about EAB in Ohio can be found at the following websites: www.ohioagriculture.gov/eab and www.ashalert.osu.edu.

How Effective Are Insecticides for Control of EAB?

Extensive testing of insecticides for control of EAB has been conducted by researchers at Michigan State University and Ohio State University. Results of many of the Michigan State University trials are posted at the following website: www.emeraldashborer.info.

Soil-applied Systemic Insecticides

Efficacy of imidacloprid soil injections for controlling EAB has been inconsistent, with some trials providing excellent control, and others yielding poor results. Differences in application protocols and conditions of the trials have varied considerably, making it difficult to reach firm conclusions about sources of variation in efficacy. For example, McCullough et al. (2004) found that low-volume soil injections of Merit 75WP applied to small caliper trees (four-inch trunk diameter) using the Kioritz applicator (a hand-held device for making low-volume injections) provided very good control at one site (Airport West). However, control was poor at another site (Kensington) where the same application protocols where used to treat large caliper (13-inch DBH) trees. McCullough et al. (2004) raised the possibility that imidacloprid levels may have been too low in the larger trees to provide adequate control. Much higher pest pressure at the Kensington site also may have contributed to poor control in the large caliper trees.

In the same trials, high pressure soil injections of Merit 75WP (applied in two concentric rings, with one at the base of the tree and the other halfway to the dripline of the canopy) provided excellent control at both sites (McCullough et al. 2004). However, at a third site, soil injections applied using the same rate, timing, and application method were completely ineffective, even though tree size and infestation pressure were very similar to those at the Kensington site where control was excellent. It should be noted that recent studies have shown that Merit soil injections made at the base of the trunk resulted in more effective uptake than applications made on grid or circular patterns extending to the dripline of the canopy.

Imidacloprid soil drenches have also generated mixed results. In one trial, infestation levels in trees (with trunk diameter ranging from 7-24 inches) drenched with Merit 75WP did not differ from untreated control trees (Smitley et al. 2005a). In another study, Merit 75WP soil drenches applied to trees with trunk diameters ranging from 6-30 inches were only slightly more effective, providing 38 percent control (Smitley et al. 2005b). However, control improved after two consecutive years of treatment. In a third study with small trees, soil drenches were very effective. When applied to small caliper trees, soil drenches with Merit 75 WP and Bayer Advanced Tree & Shrub Insect Control have provided excellent control when applied in May, June, or October (Smitley et al. 2005b, 2006).

Smitley et al. (2005 a,b) concluded that a combination of tree size and degree of pest pressure provides the best explanation for variable efficacy of imidacloprid soil drenches, with soil drenches being most effective when applied to smaller trees, and least effective when applied to larger trees experiencing heavy pest pressure. Recent studies suggest that for larger trees, imidacloprid soil drenches may have to be applied two years in a row before dependable control is observed.

Trunk-applied Systemic Insecticides

Imidacloprid trunk injections also provided varying degrees of control in trials conducted at different sites (McCullough et al. 2004). Degree of control obtained with Mauget Imicide injections varied from 60 percent to 96 percent, with no apparent relationship between efficacy and trunk diameter or infestation pressure. In 2004, McCullough et al. (2005) initiated additional trials to evaluate the effects of tree size (8 vs. 20 inch DBH) and application date (May 24 vs. July 19) on efficacy of Mauget Imicide and Arborjet IMA-jet injections. Several patterns emerged from this study. First, injections made on May 24 were more effective than those made on July 19. A second finding was that the Arborjet IMA-jet injections provided higher levels of control than did the Mauget Imicide injections, perhaps because of the greater amount of active ingredient injected using the Arborjet methods. Finally, they found no clear pattern with respect to effect of tree size on efficacy of trunk injections. The two Arborjet methods provided similar levels of control on small and large caliper trees, perhaps because the IMA-jet label calls for the rate to be increased when treating larger caliper trees. Imicide injections were actually less effective on small than on large caliper trees, possibly because the intensity of pest pressure was much higher at the site with small caliper trees.

Smitley et al. (2005a) treated trees with ACECAP 97 Systemic Insecticide Tree Implants for two consecutive years, and found them to be effective the first year under relatively light pressure. However, they were not effective the second year under more intense pest pressure.

In a discouraging study, McCullough et al. (2005) found that ash trees continued to decline from one year to the next despite being treated both years with imidacloprid or bidrin trunk injections. Mauget Imicide, Wedgle Pointer, and Inject-A-Cide B trunk injections all suppressed EAB infestation levels in both years, with Imicide generally providing best control under high pest pressure in both small (six-inch DBH) and large (16-inch DBH) caliper trees. However, in all treatments, larval density increased in treated trees from the first to the second year. Furthermore, canopy dieback increased by at least 67 percent in all treated trees (although this was substantially less than the increased dieback observed in untreated trees). In another study (D. Smitley, personal communication), infestation levels were also observed to build from one year to the next, even though trees had been treated for two consecutive years with Merit soil drenches or IMA-jet trunk injections. Although untreated trees were more severely impacted, these results do suggest that even consecutive years of treatment may only slow ash decline, at least when pest pressure is severe.

Protective Cover Sprays

McCullough et al. (2004) found that one or two applications of Onyx provided good control of EAB. Sevin SL and Tempo also provided good control of EAB when two applications were applied, with the first in late May and the second in early July. Orthene was less effective. Astro® (permethrin) has not been evaluated against EAB in these Michigan tests, but has been extremely effective for controlling other species of wood-borers and bark beetles.

Smitley et al. (2005a) also tested Onyx cover sprays, and found that they gave good control the first year under relatively light pressure. However, in the second year, under heavier pest pressure, they were not effective. BotaniGard® was also ineffective under high pest pressure (D. Smitley, personal communication).

In Summary

Insecticides have shown potential for protecting trees from EAB, including soil-applied systemic insecticides, trunk-applied systemic insecticides, and protective cover sprays applied to the trunk, branches, and (depending on the label) foliage. Some formulations can be purchased and applied by homeowners. Others can be applied only by professional applicators. It is important to realize that success is not assured, and that trees will have to be treated each year. In many cases, it may be more cost-effective to remove and replace the tree. Insecticide applications have effectively protected ash trees from EAB. However, in some research trials, trees have continued to decline from EAB attack despite being treated over successive years. In other trials, treatments have failed completely. The bottom line is that research on chemical control of EAB is still in the early stages, and we still do not have enough experience to know under what circumstances insecticide treatments will be effective over the long term.

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Appendix D
EAB Maintenance Five-Year Budget

Estimated Costs for Each Activity			2014		2015		2016		2017		2018		Ten-Year Cost
Activity	Diameter	Cost/Tree	Trees	Cost	Trees	Cost	Trees	Cost	Trees	Cost	Trees	Cost	
Removal	1–3"	$25	33	$825	34	$850	99	$2,475		$0		$0	$4,150
	4–6"	$105	13	$1,365	0	$0	15	$1,575		$0		$0	$2,940
	7–12"	$220	53	$11,660	50	$11,000	0	$0		$0		$0	$22,660
	13–18"	$355	4	$1,420	18	$6,390		$0		$0		$0	$7,810
	19–24"	$525	3	$1,575	12	$6,300		$0		$0		$0	$7,875
	25–30"	$845	6	$5,070	0	$0		$0		$0		$0	$5,070
	31–36"	$1,140	1	$1,140	0	$0		$0		$0		$0	$1,140
	37–42"	$1,470	1	$1,470	0	$0		$0		$0		$0	$1,470
	43"+	$1,850		$0		$0		$0		$0		$0	$0
Activity Total(s)			**114**	**$24,525**	**114**	**$24,540**	**114**	**$4,050**	0	$0	0	$0	**$53,115**
Treatment	1–3"	$0		$0		$0		$0		$0		$0	$0
	4–6"	$0	66	$0		$0	66	$0		$0	66	$0	$0
	7–12"	$120	147	$17,640		$0	147	$17,640		$0	147	$17,640	$52,920
	13–18"	$160	95	$15,200		$0	95	$15,200		$0	95	$15,200	$45,600
	19–24"	$240	18	$4,320		$0	18	$4,320		$0	18	$4,320	$12,960
	25–30"	$300	9	$2,700		$0	9	$2,700		$0	9	$2,700	$8,100
	31–36"	$360	1	$360		$0	1	$360		$0	1	$360	$1,080
	37–42"	$420	0	$0		$0	0	$0		$0	0	$0	$0
	43"+	$500		$0		$0		$0		$0		$0	$0
Activity Total(s)			**336**	**$40,220**	0	$0	**336**	**$40,220**	0	$0	**336**	**$40,220**	**$120,660**
Tree Planting	Purchasing	$110		$0	171	$18,810		$0	171	$18,810	10	$1,100	$38,720
	Planting	$110		$0	171	$18,810		$0	171	$18,810	10	$1,100	$38,720
	Mulching	$30		$0	171	$5,130		$0	171	$5,130	10	$300	$10,560
	Watering	$30		$0	171	$5,130		$0	171	$5,130	10	$300	$10,560
Activity Total(s)			0	$0	**342**	**$47,880**	0	$0	**342**	**$47,880**	**20**	**$2,800**	**$98,560**
Activity Grand Total			**450**		**456**		**450**		**342**		**356**		
Cost Grand Total				**$64,745**		**$72,420**		**$44,270**		**$47,880**		**$43,020**	**$272,335**