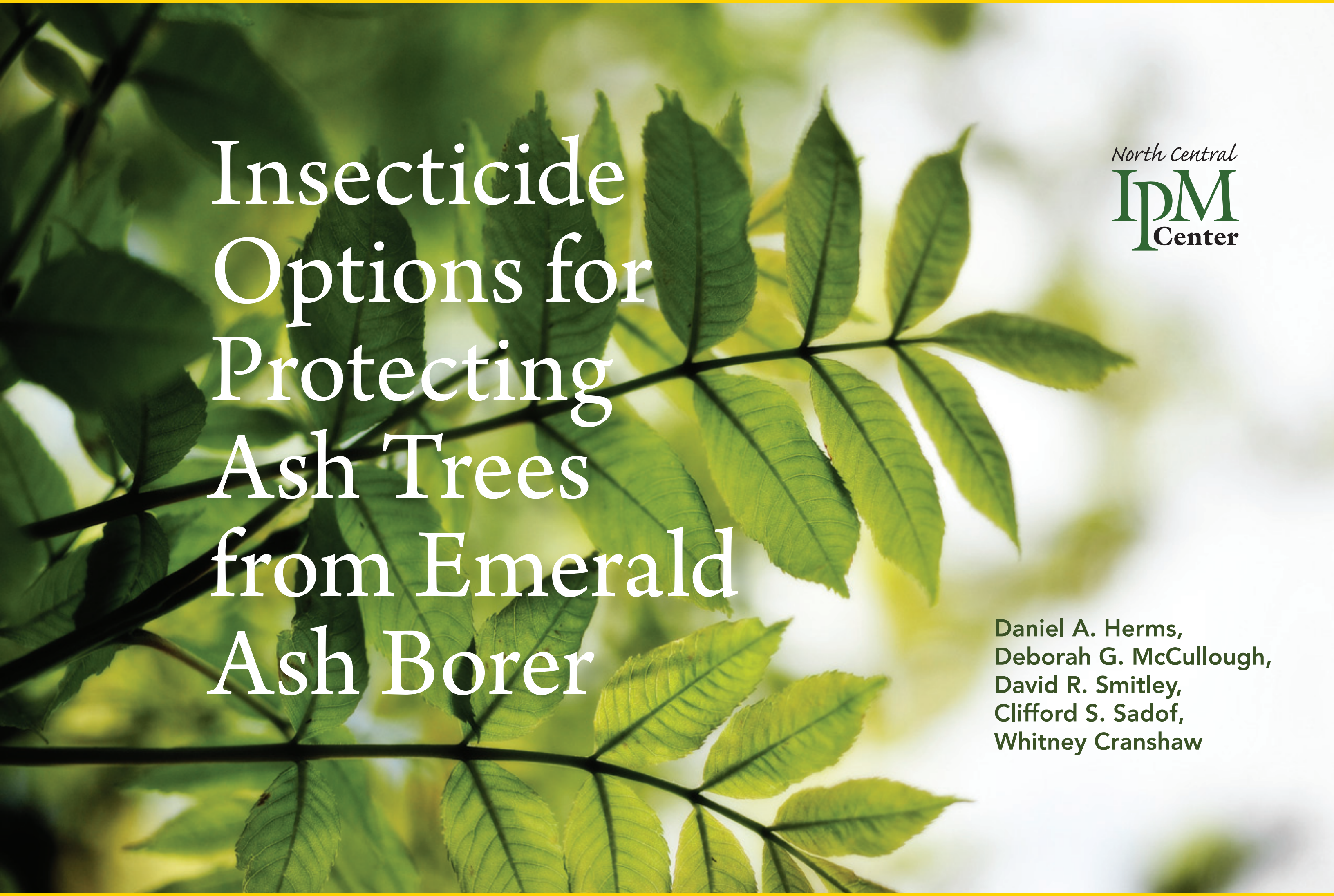
SECOND EDITION



Insecticide Options for Protecting Ash Trees from Emerald Ash Borer

North Central IPM Center

Daniel A. Herms,
Deborah G. McCullough,
David R. Smitley,
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

Daniel A. Herms[1], Deborah G. McCullough[2], David R. Smitley[3], Clifford S. Sadof[4], Whitney Cranshaw[5]

[1]Professor, Department of Entomology, The Ohio State University, Ohio Agricultural Research and Development Center, Wooster, OH 44691

[2]Professor, Department of Entomology and Department of Forestry, Michigan State University, East Lansing, MI 48824

[3]Professor, Department of Entomology, Michigan State University, East Lansing, MI 48824

[4]Professor, Department of Entomology, Purdue University, West Lafayette, IN 47907

[5]Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Ft. Collins, CO 80523

Insecticide Options for Protecting Ash Trees from Emerald Ash Borer (Second Edition) is funded in part by the USDA-NIFA North Central Integrated Pest Management Center (Funding Award: 2011-51120-31160).

Contents

Insecticide Options for Protecting Ash Trees from Emerald Ash Borer

Emerald ash borer (*Agrilus planipennis* Fairmaire), an invasive insect native to Asia, has killed untold millions of ash trees (*Fraxinus* species) in urban, rural and forested settings. This beetle was first identified in 2002 in southeast Michigan and Windsor, Ontario. As of April 2014, emerald ash borer (EAB) infestations were known to be present in 22 states as well as two Canadian provinces. Surveys continue and additional infestations will be found as EAB continues to invade North America. Ash trees are common in urban landscapes and residential areas across much of the continental US. Many homeowners, tree care professionals, and municipalities would like to protect valuable ash trees from EAB.

Since 2002, our ability to control EAB and effectively protect ash in the landscape has progressed substantially. Scientists have learned much about this insect and how it interacts with its host trees. New insecticide products and application methods have been developed and tested. Results of field trials have shown that even large ash trees can be effectively and consistently protected over multiple years, even in areas with high densities of EAB. Recent economic analyses have concluded that treating landscape ash trees with effective systemic insecticides is much less costly than removing trees.

Our understanding of how EAB can be managed successfully with insecticides has advanced since this bulletin was initially published in 2009. This version has been revised to address frequently asked questions and reflect the current state of understanding of insecticide options for controlling EAB and their effectiveness. It is important to note that research is an ongoing process. Scientists from universities, government agencies and companies will continue to make discoveries and advance EAB management and ash conservation.

Answers to Frequently Asked Questions

What options do I have for treating my ash trees?

Several insecticide options are available to effectively treat landscape ash trees threatened by EAB. Products listed in Table 1 have been evaluated by university and government scientists in field trials. Keep in mind, however, that controlling insects that feed under the bark with insecticides has always been challenging. This is especially true with EAB because most of our native North American ash trees have little natural resistance to this pest. Effective control of EAB requires some care when selecting an insecticide product and application method to ensure the product is applied at the proper rate and time.

I know my tree is already infested with EAB. Will insecticides still be effective?

It is best to begin using insecticides while ash trees are still relatively healthy. By the time most people notice canopy thinning or dieback, EAB has already caused considerably injury to the vascular system of the tree. An effective insecticide may stop additional damage, but it cannot reverse damage that has already occurred and it takes time for trees to recover. Most insecticides used for EAB control act systemically - the insecticide must be transported within the tree. In other words, a tree must be healthy enough to carry a systemic insecticide up the trunk and into the branches and canopy. Trees are damaged by EAB larvae feeding in galleries under the bark. These galleries injure the phloem and xylem tissue that plants use to transport nutrients and water. A few galleries have only a small effect on most trees. As the EAB population grows and more larvae feed on a tree, however, the galleries interfere with the ability of the tree to transport nutrients and water, as well as insecticides. As a tree becomes more and more infested, the injury becomes more severe. Canopies become thin because fewer leaves can be supported by the tree. Large branches or even the trunk can be girdled and killed by the larval galleries.

Multi-year studies have shown that if more than 50% of the canopy has been killed by EAB or if the canopy appears to be thin and carrying less than half as much foliage as it should, it is probably too late to save the tree. The ability of trees to recover from low to moderate EAB injury can vary, depending on the extent of the damage and which control options are used. Studies have also shown that if the canopy of a tree is already declining when insecticide treatments are initiated, the condition of the tree may continue to deteriorate during the first year of treatment. If treatment is effective, the tree canopy will usually begin to improve in the second year of treatment. This lag in the reversal of canopy decline probably reflects the time needed for the tree to repair its vascular system after the EAB infestation has been reduced.

My ash tree looks fine but EAB has been detected in the vicinity of my property. Should I start treating my tree?

Detecting new EAB infestations and identifying ash trees that have only a few larvae is very difficult. Ash trees with low densities of EAB larvae often have few or even no external symptoms of infestation. In addition, scientists have learned that most female EAB lay their eggs on nearby trees, i.e. within 100 yards of the tree from which they emerged. A few female beetles, however, appear to disperse much further, anywhere from 0.5 miles to 2-3 miles. Therefore, if your property is within 10-15 miles of a known EAB infestation, your ash trees are probably at risk. If your ash trees are more than 10-15 miles beyond an infestation, it is probably too early to begin insecticide treatments. Treatment programs that begin too early waste money and result in unnecessary use of insecticide. Conversely, treatment programs that begin too late will not be as effective.

Remember, however, that new EAB infestations have been discovered every year since 2002 and existing EAB populations will build and spread over time. Quarantine maps found on the www.emeraldashborer.info website can help you stay up-to-date regarding locations of known infestations. You can use the links in this website to access specific information for individual states. When an EAB infestation is detected in a state or county for the first time, it will be added to these quarantine maps.

Note, however, that once EAB has been found in a county, surveys by regulatory officials end. Similarly, once an entire state is declared to be infested, regulatory surveys may cease. Therefore, quarantine maps may or may not adequately reflect the current distribution of EAB in such areas. Personnel from city, county or state agencies sometimes continue to survey or monitor local EAB infestations. City foresters, county extension offices or state departments of agriculture may have information on local EAB distribution. There is no substitute for local knowledge and tree care professionals should actively monitor changes in the condition of local ash trees.

When is the best time to treat my trees?

As with any pest management effort, optimal timing is required to achieve best control. Two life stages of EAB are targeted by treatments: adult beetles and young larvae. Therefore, systemic insecticide applications should be made in time to allow for uptake and distribution of the insecticide within the tree to ensure adult beetles and very young larvae encounter the toxin. Non-systemic cover sprays, which are less commonly used, should be applied to foliage to target adult beetles, as well as the trunk and branches to help control newly hatched larvae. Thorough coverage is critical for achieving successful control.

Adult EAB feed on ash foliage throughout their life span and females must feed on leaves for at least 14 days before they begin laying eggs. This provides a window of opportunity to control the adults before any new eggs or larvae are produced. The onset of adult beetle emergence begins from early May (southern Ohio) to early June (central Michigan) and peaks two to three weeks later. Beetle emergence may begin sooner at locales farther south or later in more northern areas. Regardless of location, emergence of adult EAB consistently begins at 450-550 growing degree days, based on a threshold of 50 °F and a starting date of January 1. Beetles are most abundant at about 1,000 growing degree days. Cumulative growing degree days are tracked and posted on websites of many land grant universities as well as the NOAA website. First emergence

Ash trees on a street in Toledo in 2006 and 2009 before and after being impacted by EAB.

of EAB also closely coincides with the period when black locust trees bloom. This phenological indicator is a reliable predictor of EAB emergence across a wide region, ranging from southern Michigan to Kentucky and Maryland.

Peak egg hatch and larval establishment occur between early June and mid-August, depending on location and weather. As a general rule, young larvae are more susceptible to insecticides than are older larvae. Moreover, controlling young larvae prevents damage to the tree caused by older larvae that feed in larger galleries and thus injure more area on the tree. The efficacy of insecticide treatments will likely decline if they are applied later in the growing season when larger, more mature larvae are present. Consistent with this, MSU scientists found that imidacloprid trunk injections made in mid-May were 70% more effective against EAB than those made in mid-July.

For imidacloprid soil treatments, which require four to six weeks for uptake and distribution of the insecticide within the tree, applications should be made in mid-March to late April, depending on your region. Treatments should be applied on the earlier side of these schedules in more southerly locations and later side in more northerly regions. Soil applications of dinotefuran can be applied 2-3 weeks later than imidacloprid because it is more soluble and is taken up and transported through the tree more rapidly. Basal trunk sprays of dinotefuran move into trees even faster and can be made between late May and mid-June. Optimal timing for trunk injected products is just after trees have leafed out, typically from mid-May through early or mid-June. When treating larger trees, treat on the earlier side of the recommended timing, because large trees may require more time for uptake and transportation of the insecticide than small trees. Imidacloprid soil applications can also be made in fall, from mid-October to mid-November. However, this timing is less efficient and studies have shown that higher rates must be applied in the fall than in spring to achieve similar levels of control.

Sometimes, a tree is not known to be infested until in late June or early July. Although late treatments are not optimal, there may still be some benefit to treating the tree if the treatment can be made promptly. Consider using a treatment approach that maximizes rate of uptake and within-tree distribution. Uptake of dinotefuran is faster than imidacloprid because it is more soluble. Basal trunk sprays with dinotefuran will be taken up faster than soil applications (see discussion below). Trunk injections will be taken up faster than soil applications, assuming the injections can be made under favorable conditions (e.g. adequate soil moisture, moderate humidity and air temperature). Even in a best case scenario, it will still likely take one to two weeks for the systemic insecticide to move throughout the tree.

How can I convince my community that action must be taken before it is too late to save the ash trees?

The first step is to educate your community about the threat posed by EAB and the value of the ash trees in the community. Members of some communities have acquired permission to mark ash trees with visual tags. This allows residents to clearly see the extent of the resource at risk. Other suggestions for organizing communities can be found in the "Neighbors Against Bad Bugs" website. You will want to cooperate with your city forester who may already have an inventory of street trees. An inventory will help identify where the ash trees are located, the size and species of the ash trees, and the proportion of the public forest at risk. Some cities use sophisticated inventory systems that even calculate the value of the services provided by the ash trees. In Milwaukee, WI, for example, the capacity of ash trees to filter storm water saves the city more than enough money to justify the cost of treating the trees. Other cities use similar programs to create visible tree tags that tally the dollar value of the services provided by each tree. The National Tree Benefits Calculator website provides information on calculating the value of trees for professional arborists and urban foresters. You may also wish to estimate or compare costs of different management responses to the EAB invasion over time. The EAB Cost Calculator website at Purdue University, for example, allows users to enter their own tree inventory, compare local costs of treatment options or tree removal, and print reports. Links to these websites are available at www.emeraldashborer.info or by using the website name in a google search.

I realize that I will have to protect my ash trees from EAB for several years. Is it worth it?

The economics of treating ash trees with insecticides for EAB protection are complicated and depend on several factors. Tree size, health, location and value should be considered, along with the cost of the insecticide and expense of application, the likelihood of success, and potential costs of removing the trees. Scientists, however, have compared costs of removing urban ash trees versus treating the same trees with emamectin benzoate, which provides two years of EAB control. Results consistently show treatment costs are much lower than removal costs. As treatment options continue to evolve, costs of treatment will likely change. It will be important to stay up to date on these options and management recommendations.

Benefits of treating trees can be more difficult to quantify than costs. Healthy landscape trees typically increase property values, provide shade and cooling, and contribute to the quality of life in a neighborhood. Landscape trees, especially mature trees, capture storm water, reducing potential pollution of streams and rivers. The economic benefits provided by trees increase with the size of the tree, as does the cost of removal. Hence, it may be particularly economical to treat larger trees. Many people are sentimental about their trees. These intangible qualities are important and should be part of any decision to invest in an EAB management program.

It is also worth noting that the size of EAB populations in a specific area will change over time. Populations initially build very slowly, but later increase rapidly as more trees become infested. As EAB populations reach peak densities, a high proportion of the untreated ash trees in a given area will decline and die, usually over a 3-5 year period. Once untreated ash trees in the area succumb, however, the local EAB population will decrease substantially. Ongoing studies in southeast Michigan and northwest Ohio, for example, indicate EAB populations still persist but at much lower densities simply because few mature ash trees remain in this area. Young ash saplings in forests or woodlots will likely be colonized by EAB eventually, so landscape ash may continue to face some risk of EAB infestation. It seems likely, however, that surviving ash trees can be managed with less frequent treatments once the EAB invasion has passed. Studies on the dynamics of EAB populations and whether the intensity of insecticide treatments can decrease after the local EAB population has collapsed are underway in Michigan and Ohio.

My customers want to know about the environmental effects of systemic insecticides used to protect ash trees from EAB.

People often have questions about whether systemic insecticide products used to protect ash trees will harm the environment or other organisms such as woodpeckers. A bulletin entitled "Frequently Asked Questions Regarding Potential Side Effects of Systemic Insecticides Used to Control Emerald Ash Borer" is available on the www.emeraldashborer.info website. The 4 page bulletin can be viewed on the website or downloaded and printed for distribution.

Insecticide Options for Controlling EAB

Insecticides that can effectively control EAB fall into four categories: (1) systemic insecticides that are applied as soil injections or drenches; (2) systemic insecticides applied as trunk injections; (3) systemic insecticides applied as lower trunk sprays; and (4) 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 are marketed for use by homeowners while others are intended for use only by professional applicators. The "active ingredient" refers to the compound in the product that is actually toxic to the insect.

Formulations included in Table 1 have been evaluated in multiple field trials conducted by the authors and other university and governments researchers. Inclusion of a product in Table 1 does not imply that it is endorsed by the authors or has been consistently effective for EAB control. Please see the following sections for specific information about results from these trials.

Strategies for the most effective use of these insecticide products are described below. It is important to note that pesticide labels and registrations change constantly and vary from state to state. It is the legal responsibility of the pesticide applicator to read, understand and follow all current label directions for the specific pesticide product being used.

Using Insecticides to Control EAB

Soil-Applied Systemic Insecticides

Imidacloprid and dinotefuran are systemic insecticides that can be applied as soil drenches or soil injections. Both are sold under numerous brand names for use by professional applicators and homeowners. Those that have been tested by the authors are listed in Table 1; other similar products are also available. Soil applications can applied as a drench by mixing the product with water, then pouring the solution directly on the soil around the base of the trunk, or injected a few inches below ground at multiple locations near the base of the tree. The insecticide is taken up by the roots of the tree and then moves (translocates) throughout the tree.

Products designed for homeowners have some restrictions that do not apply to professional formulations. Homeowner products can be applied as a soil drench or as granules that are watered into the soil, but not as a soil injection. Homeowners are also restricted to making only one application per year.

Professionals can apply these products as a soil injection as well as a soil drench. Soil injections require specialized equipment, but offer the advantage of placing the insecticide below mulch or turf and directly into the root zone of the tree. This also can help to prevent runoff on slopes. Injections should be made just deep enough to place the insecticide beneath the soil surface (2-4 inches). Soil injections should be made within 18 inches of the trunk. Studies have shown uptake is higher and the treatment more effective when the product is applied at the base of the trunk where the density of fine roots is highest. As you move away from the tree, large radial roots diverge like spokes on a wheel and fine root density decreases. Soil drenches offer the advantage of requiring no special equipment for application other than a bucket or watering can. However, imidacloprid can bind to surface layers of organic matter, such as mulch or leaf litter, which can reduce uptake by the tree. Before applying soil drenches, it is important to remove, rake or pull away any mulch or dead leaves so the insecticide solution is poured directly on the mineral soil.

Rates of soil applied insecticides needed to provide effective control may vary depending on the size of the tree and the intensity of pest pressure at the site. Higher rates of some imidacloprid products available to professionals and homeowners can be applied to large trees with trunk diameters greater than 15 inches. Lower rates are effective on smaller trees and when EAB populations and pest pressure are relatively low. When treating larger trees with imidacloprid or dinotefuran soil treatments, particularly when EAB density is high, studies have shown that applying the highest labeled rate is most effective. Only some imidacloprid products can be applied at the higher rate and only if trees are greater than 15 inches in diameter, so please review the label closely when selecting a product.

Treatment programs must also comply with the limits specified on the label regarding the maximum amount of insecticide that can be applied per acre during a given year.

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
Xylam® Liquid Systemic Insecticide	Dinotefuran	Soil injection or drench	Mid- to late spring
Xytect™ (2F, 75WSP)	Imidacloprid	Soil injection or drench	Early to mid-spring or mid-fall
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

EAB adults must feed on foliage before they become reproductively mature.

This restricts the number of trees that can be treated in an area.

Soil applications should be made when the soil is moist but not saturated. Insecticide uptake will also be limited when soil is excessively dry. You may need to irrigate the soil surrounding the base of the tree before and possibly after the insecticide application if soils are dry. However, water-logged soil can result in poor uptake if the insecticide becomes excessively diluted and can also result in puddles of insecticide that could wash away, potentially entering surface water or storm sewers. To further protect surface and ground water, soil applications should not be made to excessively sandy soils with low levels of organic matter that are prone to leaching, especially where the water table is shallow, or where there is risk of contaminating gutters, lakes, ponds, or other bodies of water.

No soil applications should be made where there are roots of flowering plants that are visited by bees and other pollinators. This situation is most likely to occur where flowering plants are established around the base of an ash tree. In these situations the flowering plants should either be destroyed or insecticide should be applied via trunk injection to ensure the toxins will not be taken up by the flowering plants.

Trunk-Injected Systemic Insecticides

Several systemic insecticide products can be injected directly into the trunk of the tree including formulations of azadirachtin, emamectin benzoate, and imidacloprid (see Table 1). An advantage of trunk injections is that they can be used on sites where soil treatments may not be practical, effective or appropriate, including trees growing on excessively wet, sandy, compacted or restricted soil environments. Trunk injections generally involve drilling through the bark and into the outer sapwood at the base of the tree. Drilling wounds could cause long-term damage, especially if treatments are applied annually. Recent studies of emamectin benzoate (TREE-age™) injected with Arborjet equipment and imidacloprid (Imicide®) injected with Mauget capsules in May, however, showed ash trees rapidly recovered and began producing new wood over the wounds in late summer. Application methods that rely on high pressure injections of insecticide through needles inserted into small holes may damage the tree if the pressure causes the bark to bulge and separate from the cambium. This is most likely to occur in spring and can cause larger wounds that result from death of the vascular tissue at the point of separation.

Products applied as trunk injections are typically absorbed and transported within the tree more quickly than soil applications. Allow at least two and preferably three to four weeks for most trunk-injected products to move through the tree. Optimal timing of trunk injections occurs after trees have leafed out in spring but before EAB eggs have hatched, or generally between mid-May and mid-June. Uptake of trunk-injected insecticides will be most efficient when trees are actively transpiring. Best results are usually obtained by injecting trees in the morning when soil is moist but not saturated. Uptake will be slowed by hot afternoon temperatures and dry soil conditions. Irrigating trees during droughty conditions will help with insecticide uptake and translocation within the tree.

Noninvasive, Systemic Basal Trunk Sprays

Dinotefuran is labeled for application as a noninvasive, systemic trunk spray for EAB control. It belongs to the same chemical class as imidacloprid (neonicotinoids) but is much more water soluble and moves more readily through plants. The formulated insecticide is sprayed on the lower five to six feet of the trunk using a common garden sprayer and low pressure. Research has shown that the insecticide penetrates the bark and is transported systemically throughout the tree.

The basal trunk spray offers the advantage of being quick and easy to apply and requires no special equipment other than a garden sprayer. This application technique does not wound the tree, and when applied correctly, the insecticide does not enter the soil. Sprayers must be calibrated to ensure the appropriate amount of the formulated product is applied to each tree.

Dinotefuran can be mixed with surfactants that may facilitate its movement into the tree, particularly on large trees with thick bark. However, in field trials, adding a surfactant did not consistently increase the amount of insecticide recovered from the leaves of treated trees or improve the effectiveness of the application.

Protective Cover Sprays

Insecticides can be sprayed on the trunk, branches and (depending on the label) foliage to kill adult EAB beetles as they feed on ash leaves, and newly hatched larvae as they chew through the bark. Thorough coverage is essential for best results. Products that have been evaluated as cover sprays for control of EAB include some specific formulations of permethrin, bifenthrin, cyfluthrin and carbaryl (see Table 1).

Protective cover sprays are designed to control EAB adults and perhaps very young larvae that have just hatched from eggs. Sprays will have no effect on larvae feeding under the bark. Cover sprays should be timed to occur when most adult beetles have emerged and are feeding on ash leaves. For best results, consider two applications, one at 500 DD_{50} (as black locust approaches full bloom) and a second spray four weeks later.

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 (MSU) and The Ohio State University (OSU). The following sections summarize key results of these trials.

Healthy ash trees that have been protected with imidacloprid soil drenches in 2009 growing next to untreated ash trees injured by EAB. The same street in 2011 following six consecutive years of treatments during a peak EAB outbreak. Untreated trees declined and were removed.

Keep in mind that maintaining good growing conditions and avoiding major stresses will improve your chances of successfully protecting your trees. Be sure to water trees during extended dry periods.

Soil-Applied Systemic Insecticides

Efficacy of soil-applied systemic insecticides for controlling EAB has been inconsistent. In some OSU and MSU trials, EAB control was excellent, while others yielded poor results.

EAB larvae damage the vascular system of the tree as they feed, which interferes with movement of systemic insecticides in the tree.

Application protocols and conditions of the trials have varied considerably, making it difficult to reach firm conclusions about sources of variation in efficacy. This inconsistency may reflect the fact that application rates for soil-applied systemic insecticides are based on amount of product per inch of trunk diameter or circumference. As the trunk diameter of a tree increases, the amount of vascular tissue, leaf area and biomass that must be protected by the insecticide increases exponentially. Consequently, for a particular application rate, the amount of insecticide applied as a function of tree size is proportionally decreased as trunk diameter increases. Hence, application rates based on diameter at breast height (DBH) may effectively protect relatively small trees but can be too low to effectively protect large trees. Some systemic insecticide products address this issue by increasing the application rate for large trees.

Some imidacloprid formulations can be applied to trees with a trunk diameter greater than 15 inches at a rate that is twice as high (2X rate) as the rate used for smaller trees (1X rate). In an OSU study in Toledo, Ohio underway since 2006, imidacloprid soil drenches have effectively protected ash trees ranging from 15-22 inches in diameter when applied at the 1X rate in spring, or at the 2X rate when applied in spring or fall. These treatments were effective even during years of peak pest pressure when all of the untreated trees died. Trees treated in fall with the 1X rate, however, declined and were removed. In another OSU multi-year trial with trees up to 22 inches DBH, dintotefuran soil applications, as well as basal trunk sprays (see below) were effective when applied at the highest labeled rate. However, lower rates were less effective. We are not aware of any studies that evaluated soil applied insecticides with trees larger than 22 inches DBH.

Insecticide placement may also affect efficacy. Recent studies have shown that soil drenches and injections made at the base of the trunk result in more effective uptake than applications made on grid or circular patterns under the canopy away from the trunk.

Trunk-Injected Systemic Insecticides

Emamectin benzoate • In several intensive studies conducted by MSU and OSU researchers, a single injection of emamectin benzoate (TREE-äge™) in mid-May or early June provided excellent control of EAB for at least two years, even when EAB densities were high. For example, in a highly-replicated study conducted on trees ranging in size from 5 to 21-inch DBH at three sites in Michigan, untreated trees had an average of 68 to 132 EAB larvae per m^2 of bark surface, which represents high pest pressure. In contrast, trees treated with low rates of emamectin benzoate (0.1-0.2 g ai / inch DBH) had, on average, only 0.2 larvae per m^2, a reduction of >99 percent. When additional trees were felled and debarked two years after the emamectin benzoate injection, there were still virtually no larvae in the treated trees, while adjacent, untreated trees at the same sites had hundreds of larvae.

In two Ohio studies with street trees ranging in size from 15- to 25-inch DBH, a single application of emamectin benzoate provided excellent control for two years, even at the lowest rate. There was no sign of canopy decline in treated trees and very few emergence holes, while the canopies of adjacent, untreated trees exhibited severe decline and extremely high numbers of emergence holes. In another trial, large trees, ranging from 32 to 47 inches DBH, were treated in alternate years with emamectin benzoate at medium-low or medium-high rates. Canopies of all treated trees remained healthy four years later (after two treatments) despite high pest pressure and numerous declining (untreated) trees in the immediate vicinity.

Additional studies have been conducted since then in other sites and all have produced similar results. Injections of emamectin benzoate, even at the lowest rate on the label (0.1 ga ai/DBH inch), provide nearly complete EAB control for two years. Depending on application rate and pest pressure, treatment with emamectin benzoate may even protect trees for three years. Moreover, in side-by-side comparisons, emamectin benzoate was more effective than other systemic neonicotinoid products.

Azadirachtin • Results from a two-year study in Michigan replicated at three sites showed azadirachtin products affect EAB differently than other insecticide products. For example, adult EAB beetles fed for six days on leaves from trees treated with a high rate of azadirachtin (TreeAzin®), then fed on leaves from untreated trees for the remainder of their life span. In contrast to trees treated with either emamectin benzoate (trunk injection) or dinotefuran (basal trunk spray), leaves from the azadirachtin trees were not acutely toxic to adult beetles. However, azadirachtin reduced the ability of mature female beetles to produce viable eggs that successfully hatched. Young females, conversely, appeared to recover and were able to reproduce normally.

When the trees in this study were felled and debarked after two years of exposure to EAB, it was apparent that numerous EAB larvae had begun feeding on trees treated with TreeAzin but died while still young and small. Very few live larvae were present on the trees treated in both years with TreeAzin. When trees were treated only the first year but not the second year, density of live larvae was 75-80% lower than on untreated control trees. Results from this study suggest that in most years, TreeAzin will effectively protect ash trees for two years, but when EAB densities are high, annual applications may be prudent.

Imidacloprid • Trunk injections with imidacloprid products have provided varying degrees of EAB control in trials conducted at different sites in Ohio and Michigan. In an MSU study, larval density in trees treated with Imicide® injections were reduced by 60 percent to 96 percent, compared to untreated controls. There was no apparent relationship between efficacy and trunk diameter or infestation pressure. In another MSU trial, imidacloprid trunk injections made in late May were more effective than those made in mid-July, and IMA-jet® injections provided higher levels of control than did Imicide®, perhaps because the IMA-jet® label calls for a greater amount of active ingredient to be applied on large trees. In an OSU study in Toledo, IMA-jet® provided excellent control of EAB on 15- to 25-inch trees under high pest pressure when trees were injected annually. However, trees that were injected every other year were not consistently protected.

Healthy ash trees protected with emamectin benzoate trunk injections behind an untreated, declining tree.

In a discouraging study conducted in Michigan, ash trees continued to decline from one year to the next despite being injected in both years with either Bidrin (Inject-A-Cide B®) or imidacloprid. The imidacloprid treatments consisted of two consecutive years of Imicide® (10% imidacloprid) applied using Mauget® micro-injection capsules, or an experimental 12% formulation of imidacloprid in the first year followed by Pointer™ (5% imidacloprid) in the second year with both applied using the Wedgle™ Direct-Inject™ System. All three treatment regimens suppressed EAB infestation levels in both years, with Imicide® generally providing best control under high pest pressure in both small (six-inch DBH) and larger (16-inch DBH) caliper trees. However, larval density increased in treated and untreated trees from one year to the next. Furthermore, canopy dieback increased by at least 67 percent in all treated trees (although this was substantially less than the amount of dieback observed in untreated trees). Even consecutive years of these treatments only slowed ash decline under severe pest pressure.

In a head-to-head comparison of products conducted by OSU researchers, emamectin benzoate trunk injections (0.4 g a.i. / inch DBH applied during the first year in May) and imidacloprid soil drenches (applied in both years in May at the highest labeled rates) provided effective control of EAB. In contrast, trees treated with Pointer™ (5% imidacloprid applied in both years in May at the highest labeled rate) and the untreated trees declined substantially over the two year study period. In another MSU study, ACECAP® trunk implants (active ingredient is acephate) did not adequately protect trees > 15-inch DBH under high pest pressure.

Noninvasive Systemic Basal Trunk Sprays

Studies to date indicate that the effectiveness of dinotefuran basal trunk sprays are similar to soil applications of dinotefuran or imidacloprid. MSU and OSU studies have evaluated residues in leaves from trees treated with the basal trunk spray. Results show that the dinotefuran effectively moved into the trees and was translocated to the canopy at rates similar to those of other trunk-injected insecticides, and faster than other soil-applied neonicotinoid products.

As with imidacloprid treatments, control of EAB with dinotefuran has been variable in research trials. In an MSU study conducted in 2007 and 2008, annual dinotefuran trunk sprays reduced EAB larval density by approximately 30 to 60 percent compared to the heavily infested untreated trees. As with dinotefuran and imidacloprid soil applications, the basal trunk treatment was effective for only one year and would have to be applied annually.

In a five-year OSU study with trees up to 22 inches DBH, dinotefuran basal bark sprays provided effective protection when applied at the highest labeled rate (average of less than 5% canopy decline compared with nearly 80% average canopy decline for untreated trees). A lower rate was not as effective (almost 20% average canopy decline).

Protective Cover Sprays

MSU studies have shown that applications of Onyx™, Tempo® and Sevin® SL provided good control of EAB, especially when the insecticides were applied in late May and again in early July. Acephate sprays were less effective. BotaniGard® (*Beauvaria bassiana*) was also ineffective under high pest pressure. Astro® (permethrin) was not evaluated against EAB in these tests, but has been effective for controlling other species of wood borers and bark beetles.

In another MSU study, spraying Tempo® just on the foliage and upper branches or spraying the entire tree were more effective than simply spraying just the trunk and large branches. This suggests that some cover sprays may be especially effective for controlling EAB adults as they feed on leaves in the canopy. A single, well-timed spray was also found to provide good control of EAB, although two sprays may provide extra assurance given the long period of adult EAB activity.

It should be noted that spraying large trees is likely to result in a considerable amount of insecticide drift, even when conditions are ideal. Drift and potential effects of insecticides on non-target organisms should be considered when selecting options for EAB control.

Key Points and Summary Recommendation

- Insecticides can effectively and consistently protect even very large ash trees from EAB, even under intense pest pressure.
- Drought stress inhibits uptake and transport of systemic insecticides. Supplemental irrigation will be needed during dry periods.
- Unnecessary insecticide applications waste money. However, EAB infestations are very difficult to detect when populations are low. Once EAB has been detected within 10-15 miles, your trees may be at risk. Be aware of the status of EAB in your location. Current maps of counties and states where EAB has been found are available at www.emeraldashborer.info. Remember, however, that once a county is quarantined, regulatory surveys end and maps for that county are no longer updated. In some areas, local information on EAB infestations may be available from city, county or state officials.
- Trees exhibiting more than 50 percent canopy decline (thinning or dieback) are unlikely to recover even if treated with a highly effective systemic insecticide. Trees that are already infested and showing signs of canopy decline when treatments are initiated may continue to decline the first year after treatment, and then begin to improve the second year, as the trees recover. Effectiveness of products varies and depending on the product applied and the pest pressure, trees with lower levels of canopy decline may not recover despite treatment.
- Emamectin benzoate consistently provides at least two years of EAB control with a single application, even in large and very large trees under intense pest pressure. It also provided a higher level of control than other products in side-by-side studies.
- Trunk injections of azadirachtin affect EAB differently than other systemic insecticides. Results from a recent study indicate azadirachtin should provide effective protection for one to two years, depending on EAB pressure.
- Basal trunk sprays with dinotefuran applied annually effectively protected ash trees up to 22 inches DBH in several studies. It is important to calibrate sprayers to ensure the proper rate of the formulated product is applied.
- Imidacloprid and dinotefuran soil applications provided effective EAB control of trees up to 22 inches DBH (larger trees were not tested) when applied annually at the highest labeled rate, even under intense pest pressure. Soil drenches and injections are most effective when the product is applied at the base of the trunk. Generally, imidacloprid soil applications are more effective when applied in the spring than in the fall. Soil injections should be no more than 2-4 inches deep, to avoid placing the insecticide beneath feeder roots of the tree. To facilitate uptake, systemic trunk and soil insecticides should be applied when the soil is moist but not saturated or excessively dry.
- When treating trees greater than 15 inches DBH with imidacloprid soil applications, select a product that allows a higher rate (2X rate) to be used. Not all imidacloprid products can be applied at that rate, so check the label carefully. Users must comply with all restrictions on the frequency of applications and the amount of insecticide that can be applied per acre in a given year.

The Cooperative Emerald Ash Borer Program

For more information and to download
additional copies of this bulletin:

www.emeraldashborer.info/

The Ohio State University EAB Outreach Team

www.ashalert.osu.edu

Purdue Extension

www.eabindiana.info

Colorado State

www.ext.colostate.edu/pubs/insect/emeraldashborer

June 2014

Bibliographic Citation: Herms DA, McCullough DG, Smitley DR, Clifford CS, Cranshaw W. 2014. Insecticide options for protecting ash trees from emerald ash borer. North Central IPM Center Bulletin. 2nd Edition. 16 pp.