Control Options for Emerald Ash Borer in Colorado

Colorado State University Extension

Introduction – Some Common Questions Related to the Control of Emerald Ash Borer

www.eabcolorado.com

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Some Common Questions Related to the Control of Emerald Ash Borer (EAB)

Adult of the emerald ash borer. Photograph courtesy of Howard Russell/Michigan State University and BugWood.org.

Why should I try to control emerald ash borer? Emerald ash borer (EAB), *Agrilus planipennis*, is an extremely destructive insect of ash trees (*Fraxinus* species), including the kinds of ash (green ash, white ash) that are widely planted in Colorado. It is far more damaging to trees than any other insect that previously has been found in the state and, as populations of the insect increase in the infested areas, it very likely ultimately will kill any unprotected ash trees.

Emerald ash borer is a species native to parts of eastern Asia that was accidentally introduced into North America, probably sometime in the 1990s. It is not a very damaging insect in its native land, where the ash species that grow there have evolved resistance to it and natural controls limit its injury.

Ash trees showing advanced thinning due to effects of emerald ash borer feeding injuries. This photograph was taken in Michigan in 2002, the first year emerald ash borer was detected in North America. Photograph courtesy of David Cappaert/Michigan State University and BugWood.org.

Unfortunately the species of ash that are native to North America have very little resistance to this new pest and emerald ash borer is devastating to the kinds of ash trees grown in the state. In the Midwest and eastern areas of North America where this insect has been present for several years, EAB has already killed many millions of ash trees. It is expected that emerald ash borer will ultimately kill almost every unprotected ash tree presently growing in North America.

I have treated my ash trees in the past for borers. Wasn't this for the emerald ash borer?

Lilac/ash borer larvae and associated damaged under the bark of ash. This insect has long been present in Colorado and has often been known as the 'ash borer'. It is far less damaging to ash trees than is the emerald ash borer. Photograph by David Leatherman/Colorado State Forest Service, retired.

There are several insects that are native to North America, long present in Colorado, and that tunnel into trunks and limbs of ash. Most commonly encountered is the **lilac/ash borer** (*Podosesia syringae*) a type of wood boring caterpillar that usually tunnels into the lower trunk of the tree. Various **ash bark beetles** (*Hylesinus* species) are fairly common in branches, particularly those that are damaged or overshaded. Some other insects that may be found occasionally tunneling limbs of ash include the **flatheaded appletree borer** (*Chrysobothris femorata*) and **redheaded ash borer** (*Neoclytus acuminatus*).

These are all insects that are normal residents of ash trees. Most cause very little damage and may only be found in trees or limbs that are suffering from serious stress or injury. Of these native, wood boring insects of ash, the lilac/ash borer is potentially the most injurious. However, the damage potential of the emerald ash borer far exceeds any of these other insects.

Larva of the emerald ash borer. Photograph courtesy of David Cappaert/Michigan State University and BugWood.org.

How fast does emerald ash borer kill ash trees?

Emerald ash borer damages trees by tunneling areas under the bark, producing girdling wounds that interfere with movement of water and nutrients. The damage is progressive, with more effects of infestation becoming visible as increasing numbers of insects develop within and damage the plant.

Extensive larval tunneling in an ash tree killed by emerald ash borer. Photograph courtesy of Eric Day/VPI & SU and BugWood.org.

When emerald ash borer first arrives and becomes established in a neighborhood it is usually present in low numbers and is very difficult to detect. However, they survive and reproduce well so that populations build steadily and within a few years it may be possible to observe some external evidence of infestation. A thinning of the leaf canopy is the most consistent symptom associated with EAB injury.

Often, about the time symptoms first become noticeable the populations of EAB explode in numbers and damage accelerates greatly. During this period of peak outbreak even trees that previously appeared healthy may die within just a couple of years.

Where is emerald ash borer found in North America?

'EAB tree #1', the first tree in Colorado where emerald ash borer was detected, in Boulder, in September 2013. Photograph by Whitney Cranshaw/Colorado State University.

Emerald ash borer was originally detected in southern Michigan in 2002. It has since spread rapidly and, by the end of 2013, has been detected in 22 states and two provinces. Colorado is the most recent state where this insect has been detected, being found in Boulder in September 2013. It is also the first state in the western US where EAB has been detected.

At present (winter 2014) Boulder is the only place within Colorado where EAB has been detected. However, the insect will spread in the upcoming years and it is reasonable to expect that essentially all of northeastern Colorado will be infested within a decade.

An ash tree across the street from 'EAB tree #1'. This tree has been infested for several years and is showing EAB-related canopy thinning. Photograph by Whitney Cranshaw/Colorado State

Also, with greater attention being given to this insect following the Boulder detection, it is now much more likely that any other infestations in the state, if any, may be identified. Any needed updates on the distribution of emerald ash borer in Colorado will be made available through several outlets, including the Colorado Department of Agriculture site at www.eabcolorado.com

How does emerald ash borer spread? The adult beetle can fly and that is how it spreads naturally. Normally they will fly only short distances, staying in the near vicinity of the tree from which they developed.However, some will fly longer distances and, with the aid of favorable winds, it is possible that a few may fly several miles if the right conditions come together. This natural spread will cause the present outbreak of EAB to expand beyond Boulder in the next few years to progressively encompass the areas of the state within the South Platte Drainage. This includes the greater Denver Metro area, Fort Collins, Greeley and all the communities further downriver.

Adult of the emerald ash borer with wings spread showing the purple abdomen. Photograph courtesy of David Cappaert/Michigan State University and BugWood.org.

However, emerald ash borer can also be spread if it is carried by humans. Transport of firewood or other ash materials harboring live emerald ash borers is the way that this insect is carried over long distances. This is undoubtedly the means by which it carried across the eastern plains and was introduced into Boulder, an event which seems to have occurred at least four years prior to its detection.

Geographic barriers present in Colorado, notably mountains and large expanses of ash-free forest, can be expected to prevent natural spread of EAB to much of Colorado outside the South Platte drainage. As a result these areas of the state (outside the South Platte drainage) remain no more-nor less-at risk of emerald ash borer infestation than they were before the Boulder detection. However, the entire state will always be at risk of the insect being introduced on infested firewood or other material containing live EAB that originated from some area where this insect is present. National quarantines of infested counties (including Boulder County in Colorado) are in place to try and prevent this type of human-assisted spread of EAB.

Can plants recover from injury by emerald ash borer? Trees can recover from EAB injury–to a point. If one attempts to control EAB with insecticides it is most likely to be effective if the ash tree is still relatively healthy. If trees have already sustained EAB injuries that have caused the leaf canopy to thin 30-50%, it is probably too late to save the tree.

This is because most of the 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. When EAB larvae feed, their galleries injure the phloem and xylem that make up the plant's circulatory system. This interferes 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 extensive. When damage has progressed too far, insecticides can no longer move within the tree in a manner to provide effective EAB control.

An ash tree that is showing epicormic branching on the trunk. Epicormic branching occurs when normal movement of nutrients and water is disrupted, such as occurs with the wounding produced by emerald ash borer. Photograph courtesy of Edward Czerwinski/Ontario Ministry of Natural Resources and BugWood.org.

Often 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. When effective controls are applied, in many cases, the tree canopy will 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.

Are there treatments to control emerald ash borer? There are several treatments that have been identified that can be used to manage emerald ash borer. All involve the use of insecticides which have to be applied on an annual or biannual basis to maintain control. These treatments are the subject of this publication and are discussed below.

What are the effects of these insecticides on other insects, birds, mammals, etc.? The best summary of the subject presently available is the sheet *Frequently Asked Questions Regarding Potential Side Effects of Systemic Insecticides Used To Control Emerald Ash Borer* (www.emeraldashborer.info/files/Potential_Side_Effects_of_EAB_Insecticides_FAQ.pdf) This was prepared by University Extension and research scientists from the Midwest and it attempts to answer the most commonly asked questions on this subject based on the information that is known.

Are there biological controls useful for control of emerald ash borer? In the areas of Asia where emerald ash borer is native there are several important natural controls at work. Most important are defenses produced by the trees, which protect them from attacks of invading organisms common to the region, such as emerald ash borer. In addition, there are numerous natural enemies, notably various species of parasitic wasps. Together, the inherent resistance of Asian species of ash combined with the natural enemies very effectively limit emerald ash borer so that it rarely causes serious damage.

Host plant resistance is largely absent from the native North American species of ash that we grow, and always will be, greatly undermining the potential of natural controls. However, there is work being done by federal agencies to identify parasites of the emerald ash borer present in

Asia. Some of these have been found suitable for introduction and release into North America. Already a few of these introduced natural enemies have been released in EAB outbreak areas of the Midwest and in some cases they seem to have proved capable of establishing and reproducing.

This work with natural enemies is ongoing. It is hoped that natural enemies may be useful in helping to suppress EAB populations in the post-outbreak phase. If effective, these may then allow some reduction in the need for treatments in the future and, possibly, allow some of the remaining native ash to survive without treatment. Only preliminary information is presently available but, in a few years, we can expect there to be a much better understanding of how much potential they may have in suppressing emerald ash borer in North America.

At some point in the future it may be decided that some of the more promising natural enemies may be suitable for introduction into Colorado. This is a decision that will be done by state and federal agencies, who will consider not only the possible benefits of such introductions but also possible risks.

Should I try to control emerald ash borer? The decision on what to do about managing this insect will have to be done individually by every owner for every ash tree in an area where this insect becomes established. This calculation will have to consider all the costs of treatment and balance these against the costs associated with not attempting to control EAB injury. Often the most critical factor in these decisions will be how much the tree is valued.

Unfortunately there will be costs associated with this insect regardless of what choice is made. Trees that are infested with emerald ash borer that are untreated or ineffectively treated will die prematurely, requiring their removal and, often, the purchase of replacement trees.

Some models exist to attempt to determine the economic value of trees, such as the National Tree Benefit Calculator: www.treebenefits.com/calculator/ These can come up with figures on values related to benefits the trees provide in terms of air quality, shade, property value, etc. What they cannot capture is personal value of the tree to the owner.

When should I begin to treat for emerald ash borer? There can be some benefit to the health of the tree if treatments are applied to trees that are already infested or can be expected to be infested with emerald ash borer during the present growing season. However, since EAB is extremely difficult to detect in trees in early stages of infestation this decision will often have to be an educated guess, based on the information available on where the insect is known to be present within Colorado.

As of January 2014 EAB had only been found within a relatively confined area of the City of Boulder and overall EAB populations still appear to be low at these areas. Trees within the area of known EAB infestation, and up to a 5 mile radius of this infestation, may benefit from EAB treatment beginning in 2014. However, over time emerald ash borer will expand its distribution and an increasingly larger area will be determined to be infested with EAB. **As new infestations are detected, information on the distribution of the insect in Colorado will be updated. One source summarizing the distribution of this insect in the state that is useful**

to reference is the web site maintained by the Colorado Department of Agriculture: www.eabcolorado.com.

Since most EAB treatments provide control for one year or, at most, two years following application there is no benefit in treating a tree prior to when EAB is present.

When can I discontinue treatments for emerald ash borer? Once established at a location emerald ash borer can be expected to survive in the area as long as any ash trees remain. Therefore some management of emerald ash borer will be required for as long as one wishes to maintain the tree.

Controls will have to be particularly intensive during the period when the insect populations increase to high levels and many ash trees in the neighborhood decline rapidly and die. After this wave of ash tree mortality is past, and populations of remaining trees consist largely of those that were effectively treated, numbers of emerald ash borers can be expected to decline dramatically. In this post-outbreak period it may be possible to reduce treatment intensity, although some management will always be required. Several years from now, when the first areas of Colorado affected by EAB go into the post-outbreak phase, there should be considerably more information available as to how to manage this phase of the emerald ash borer infestation.

Generalized Life History of the Emerald Ash Borer

Emerald ash borer in Colorado has a life cycle that normally takes one year to complete. During winter the life stage present is a full grown larva (a type of flatheaded borer) that lives within a chamber cut into the outer sapwood of the wood.

Full grown larvae of emerald ash borer in the typical curled position they take during winter and prior to pupation. Photograph courtesy of Houping Liu/Michigan State University and BugWood.org.

Pupa of the emerald ash borer. Photograph courtesy of David Cappaert/Michigan State University and BugWood.org.

In spring it will transform to the pupal stage, during which it transitions to the ultimate adult form.

The adult, a type of metallic wood borer, emerges from the tree by cutting through the bark, producing a D-shaped exit hole. Adults of the emerald ash borer likely will normally begin to emerge in early–to-mid May, with peak emergence in June. However, there is some range in the time of beetle emergence, which may extend into midsummer.

(left) Emerald ash borer adults in process of emerging from trunk. Photograph courtesy of Debbie Miller/USDA Forest Service and BugWood.org.

(right) Mating pair of emerald ash borers. Photograph courtesy of David Cappaert/Michigan State University and BugWood.org.

They then move to the crown of the tree where they feed on ash leaves, making small cuts along the edges of the leaves. After about a week of feeding, the now mature adults will begin to mate and a few days after mating females will begin to lay eggs. Eggs are laid on the surface of the bark, usually deposited singly into cracks and crevices. Females typically live for about a month and during this time will lay several dozen eggs.

Emerald ash borer eggs. Eggs are laid on bark and originally are white, darkening within a couple of days. Photograph courtesy of Debbie Miller/USDA Forest Service and BugWood.org.

Eggs hatch in about a week and the tiny, newly hatched larvae burrow through the bark. They enter and begin to feed on the tissues under the bark, the phloem, cambium and outer sapwood where they spend all of their larval life. During the course of feeding the larvae produce meandering galleries that progressively widen as the larvae grow. Ultimately the gallery produced by a single larva may range over an area ranging from 4 to 20” (10-50 cm) in length. Larvae feed until cooler fall temperatures arrive, when they prepare for overwintering by tunneling a bit deeper into the sapwood to produce the overwintering chamber.

Emerald ash borer larvae. The larvae are minute after egg hatch but grow steadily through the summer. Photograph courtesy of David Cappaert/Michigan State University and BugWood.org.

Larval tunnels produced by emerald ash borer. Such wounds interfere with the movement of water, nutrients – and systemic insecticides. Photograph by Art

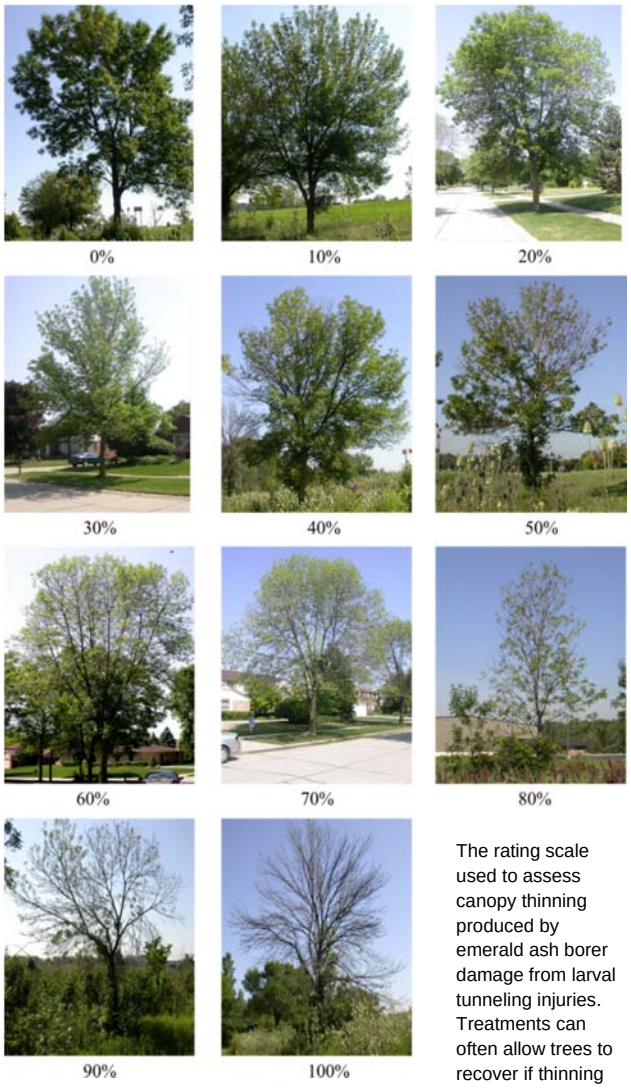
Nature of the Damage Produced by Emerald Ash Borer

Damage by the emerald ash borer is produced by the developing larvae, a type of flatheaded borer. They feed under the bark, chewing through the tissues of the phloem and outer sapwood of the tree, producing meandering tunnels that widen as the larvae grow.

These injuries interrupt the flow of water and nutrients through the tree. Continued infestation and damage cause progressive negative effects on the overall health of

the tree. As effects of injuries from EAB accumulate, external symptoms begin to appear, notably a thinning of the leaf canopy. Left untreated, infestations of EAB will progress to ultimately kill the tree.

Trees have some ability to repair injuries produced by EAB larval tunneling, forming callous tissues that overgrow damaged areas. The ability of trees to recover is related to tree health, with vigorously growing trees best able to produce some recovery. Trees in poor health from stress such as poor siting, drought and previous injuries may have very little ability to tolerate and repair EAB damage. However, during peak periods of outbreaks, when large numbers of EAB are present laying eggs on trees, even the most vigorously growing ash trees will be quickly overwhelmed by EAB attacks and will decline rapidly.



The rating scale used to assess canopy thinning produced by emerald ash borer damage from larval tunneling injuries. Treatments can often allow trees to recover if thinning has not exceeded 30-50%. This series of photographs was provided courtesy of David Smitley/Michigan State University.

The timely use of effective treatments for control of EAB can prevent much of the injury. And, to a point, treatments can stabilize the effects of past EAB injury. Where previous EAB injuries have not been too extensive and effective treatments are used, trees may recover. As a guideline, ash trees that are showing less than between 30-50% crown thinning as a result of EAB injuries may recover if effective treatments are employed; trees showing greater evidence of injury likely cannot be salvaged by any treatments.

Many factors will affect the speed that EAB will damage a tree. Initial tree health is one factor but most important is the size of the local EAB population. When EAB originally colonizes a neighborhood they are present in low numbers and trees may sustain little damage during this initial period of establishment. However, EAB populations build rapidly and often within 5 years of the initial infestation in a neighborhood very large numbers of EAB may be present. During this period, when EAB outbreaks peak, large number of eggs are laid and large amounts of injury may be done in a very short time. Trees may be so extensively damaged that they may die within a year or two during the outbreak phase.

The emerald ash borer is now a permanent resident in parts of northeastern Colorado, and, in areas where it is present, some control will have to be maintained for the life of any ash tree that the owner wishes to keep. However, after the peak outbreak passes and most ash trees have

been killed, EAB populations will drop dramatically. It is thought that at this time, after the peak outbreak, it may be possible to reduce treatment intensity and still maintain adequate control of new injuries.

Target EAB Stages for Control and Control Options

Controls used for EAB generally target two of the life stages. Adults can be killed as they feed on ash leaves on trees treated with insecticides effective against EAB. These treatments are best timed to be present in trees during the peak period of adult activity, which likely will occur sometime between mid-May and late June.

Emerald ash borer adult and associated chewing injury. Adults feed on leaves before they lay eggs and systemic insecticides can kill them during this period. Photograph courtesy of Debbie Miller/USDA Forest Service and BugWood.org.

Early stage larvae that tunnel under the bark can be killed with insecticides that move systemically in the tree to the tissues where they are feeding (phloem, outer sapwood). These treatments are optimally timed to be present when young larvae are present and before there has been extensive injury; prior injuries that disrupt movement of water and nutrients will similarly disrupt distribution of systemic insecticides. The peak period when early stage larvae are present will likely occur sometime between late May and early July.

Emerald ash borer egg just prior to hatch. After hatch the larva will begin to tunnel into the tree, ultimately settling below the bark where it spends most of its life. Photograph courtesy of Houping Liu/Michigan State University and BugWood.org.

In general there are four control approaches considered for use in management of emerald ash borer:

1. ***Soil applications of systemic insecticides.*** Two insecticides can be applied to the root system of ash trees and will subsequently be taken up by the roots–imidacloprid and dinotefuran.
2. ***Non-invasive systemic trunk sprays.*** The insecticide dinotefuran can be applied as a coarse spray onto the trunk of ash trees and will be absorbed through the bark.
3. ***Trunk injections with systemic insecticides***. Some insecticides can be injected into the lower trunk of trees and then will move systemically in the tree. These include emamectin benzoate, azadirachtin, and imidacloprid.
4. ***Persistent surface-applied contact insecticides.*** A standard method of controlling many borers and bark beetles is to apply a persistent insecticide onto the trunk and branches to kill adults as they lay eggs and to kill newly hatched larvae before they enter the plant. Various pyrethroid insecticides are usually used for this purpose (e.g., bifenthrin, cyfluthrin, permethrin).

Table 1. A Summary of Control Options Used for Emerald Ash Borer Control

Method of Application	Active Ingredient	Trade Names	Optimum Timing*	Notes
Soil drench, soil injection	imidacloprid	Merit®, Criterion®, Xytect®, Zenith®, Bandit®, several retail formulations	Around bud break	Relatively slow to move into tree so allow 4-6 weeks to reach highest levels in leaves. Soil must remain moist following application. Do not apply to any areas of soil where flowering plants that are visited by bees could pick up residues of the insecticide. Annual treatments required.
Soil drench, soil injection	dinotefuran	Safari®, Zylam®Transtect®	A few weeks after bud break, often mid-late May	Moves into plants faster than imidacloprid (2-3 weeks) so applications are later. Highly water soluble and should not be used if there is risk of leaching into water bodies or groundwater. Do not apply to any areas of soil where flowering plants that are visited by bees could pick up residues of the insecticide. Annual treatments required.
Systemic bark spray	dinotefuran	Safari®, Zylam®, Transtect®	A few weeks after bud break, often mid-late May	Moves into plants at effective levels within 2-3 weeks. Some, but not all, formulations suggest use of adjuvant. Do not allow drift onto any flowering plants that are visited by bees that could pick up residues. Annual treatments required.
Trunk injection	emamectin benzoate	TREE-Age®	Typically when adults are starting to emerge and lay eggs. However, long residual activity allows considerable latitude in application timing.	*Restricted Use Pesticide* due to acute toxicity. Biannual application. Has repeatedly demonstrated high level of control that can persist at least two years. Requires drilling holes into lower trunk.
Trunk injection	azadirachtin	TreeAzin®	Typically when adults are starting to emerge and lay eggs (May).	Natural product derived from neem tree seeds. Annual treatments likely to be required but there is some evidence of ability to control larvae in second year of application. Requires drilling holes into lower trunk.
Trunk injection	imidacloprid	Ima-Jet®, Imicide®, Pointer®, Xytect® Infusible	Typically when adults are starting to emerge and lay eggs (May).	Requires drilling holes into lower trunk (Ima-Jet, Imicide, Xytect) or injecting insecticide directly under bark (Pointer). Annual treatments required.
Residual bark, foliage spray	bifenthrin, permethrin, cyfluthrin	Onyx®, Astro®, Tempo®, many other formulations	Applied to bark when adults lay eggs and egg hatch. Applications to foliage can kill adults when they feed after emergence.	Requires whole tree sprays that cover bark to kill adults on bark and larvae as they hatch from eggs before they enter trees. Spraying foliage to kill adults can improve control. Two applications normally will be needed annually. High potential for drift. Non-systemic in plants and will not kill larvae under bark.

* The target life stages of the emerald ash borer with systemic insecticides (soil injections, soil drenches, systemic bark sprays with dinotefuran, trunk injections) are adults that feed on leaves after emergence and young larvae under the bark. The target life stages of the residual bark surface sprays with pyrethroid insecticides (bifenthrin, permethrin, cyfluthrin) are primarily adults when they are on bark and the larvae as they hatch from eggs before they enter trees. Application to the foliage can kill adults feeding on foliage before eggs are laid.

Soil Applications of Systemic Insecticides

Two insecticides that can move systemically in plants can be applied to the soil and will subsequently move in the plant to help manage emerald ash borer. Imidacloprid is most widely available, including formulations available through retail outlets. Dinotefuran is marketed solely to commercial applicators. A summary of the available products for soil treatment use is in Table 1 (above).

Table 2. Systemic insecticides used for control of emerald ash borer that are applied to the soil. Percent active ingredient is in parentheses ( ). Rates of use are specified on the label directions and all insecticides must be used only in a manner that is consistent with specified label uses. Links to the labels of commercially marketed formulations are provided (links tested January 10, 2014).

Imidacloprid-containing insecticides sold for use by commercial applicators

Criterion® 2F (21.4%) www.backedbybayer.com/lawn-and-landscape-management/insecticides/merit-2-f/label_and_sizes
Criterion® 75WSP (75%) www.backedbybayer.com/lawn-and-landscape-management/insecticides/merit-75-wsp/label_and_sizes
Lesco Bandit® 2F (21.4%) www.backedbybayer.com/lawn-and-landscape-management/insecticides/merit-2-f/label_and_sizes
Lesco Bandit® 75WSP (75%) www.backedbybayer.com/lawn-and-landscape-management/insecticides/merit-75-wsp/label_and_sizes
Merit® 2F (21.4%) www.backedbybayer.com/system/product/product_label_pdf/52/Merit-2F-432-1312-1-gal-110519AV1-SRL.pdf
Merit® 75WSP (75%) www.backedbybayer.com/lawn-and-landscape-management/insecticides/merit-75-wsp/label_and_sizes
Merit® 75WP (75%) www.backedbybayer.com/system/product/product_label_pdf/32/Merit-75-WP.pdf
Prokoz Zenith® 2F (21.4%) www.backedbybayer.com/lawn-and-landscape-management/insecticides/merit-2-f/label_and_sizes
Prokoz Zenith® 75WSP (75%) www.backedbybayer.com/lawn-and-landscape-management/insecticides/merit-75-wsp/label_and_sizes
Xytect® 2F (21.4%) www.treecarescience.com/pdf/Insecticides/Xytect-2F_Specimen_Label.pdf
Xytect® 75WSP (75%) www.treecarescience.com/pdf/Insecticides/Xytect-75-WSP_Specimen_Label.pdf

Imidacloprid-containing insecticides sold through retail outlets

Bayer® Advanced 12 Month Tree & Shrub Insect Control Concentrate (2.94%)
www.bayeradvanced.com/tree-shrub-care/products/12-month-tree-shrub-insect-control-landscape-formula/sizes
Bayer® Advanced 12 Month Tree & Shrub Protect & Feed (1.47%)
www.bayeradvanced.com/tree-shrub-care/products/12-month-tree-shrub-protect-feed/sizes
Bayer® Advanced 12 Month Tree & Shrub Protect & Feed Concentrate II (0.74% + 0.37% chlothianidin)
Bonide® Annual Tree and Shrub Control (with Systemaxx) (1.47%) www.bonide.com/lbonide/backlabels/l609.pdf
Ferti-lome® Tree and Shrub Systemic Insect Drench (1.47%)
www.fertilome.com/ProductFiles/10206%20Tree%20Shrub%20Systemic%20Insect%20Drench%20Approved%2003-26-12.pdf
Ortho Bug B gon Year-Long Tree & Shrub Insect Control (1.47%) www.scotts.com/smg/goprod/ortho-bug-b-gon-year-long-tree-and-shrub-insect-control/prod10700018/ (Note: This link is not the label, which is apparently unavailable on-line)

Dinotefuran-containing insecticides sold for use by commercial applicators

Safari® 20SG (20%) www.valent.com/Data/Labels/2012-SAF-0001%20Safai%2020%20SG%20-%20form%201510-D.pdf
Zylam® Liquid (10%) www.gordonsprofessional.com/pdfs/ZylamLiquid-SL.pdf
Transtect® 75WSP (75%) www.treecarescience.com/pdf/Insecticides/Transtect_Specimen_Label.pdf

Rates of use vary depending on the size of the tree. The diameter of the tree at breast height (DBH) is normally used as the measure of tree size and all formulations marketed for commercial application have label uses directions for amount to apply that is based on DBH. (DBH measurements are generally measured at 4.5 feet above the ground.) Most commercial formulations of imidacloprid (2F, 75WSP formulations) allow higher rates of use on larger trees (greater than 15 inches diameter). These higher rates are usually required to get consistent EAB control on large trees, which have a proportionately greater canopy and trunk volume than do small diameter trees.

Formulations of imidacloprid sold through retail outlets specify application rates that vary by *tree circumference* (about 3X tree diameter).

Both can be applied either as a soil drench or injected into the soil using special equipment for this latter type of application. With soil drench applications the amount of insecticide needed for the tree is premeasured and mixed with several gallons of water. It is then poured onto the soil at the base of the tree, within 2-3 feet of the trunk. If present, mulches and weed fabric barriers must be removed from the site where the insecticide is applied. Soil drench treatments cannot be applied to areas of soil where flowering plants are present that are visited by bees. If flowering plants are present at the base of the tree where treatments are applied (e.g., dandelion weeds, flowers planted at the base of the tree) alternative controls must be used.

Alternately these insecticides can be injected into the soil. This involves the use of specialized equipment that allows the injection of small amounts of diluted insecticide in

Altering Rates of Imidacloprid by Tree Size

Imidacloprid is the most widely accessible of the insecticides used for emerald ash borer and is primarily applied as a soil drench or injection early in the season around the time of bud break. It is then picked up by the roots of the tree and moves systemically to the leaves (where adults feed) and the phloem/sapwood area under the bark (where larvae feed).

All soil-applied imidacloprid products indicate that the amount of insecticide to be used varies by the size of the tree. This is normally determined by the trunk **d**iameter at **b**reast **h**eight (DBH). Retail formulations of imidacloprid sold through nurseries and hardware stores indicated rates of use based on trunk circumference.

Furthermore, all commercial formulations (2F, 75WSP) indicate a range of rates. For example, the 2F formulations normally allow uses of 0.1-0.2 fl. oz. of the product for each inch of trunk diameter. In this example the higher rate (0.2 fl. oz.) corresponds to what is often referred to in research trials as the "1X rate", which is equivalent to 1.4 grams of imidacloprid active ingredient per inch diameter.

Lower rates (1/2X-1X) are usually adequate for smaller ash trees, particularly when there are not large populations of EAB present. However, in larger trees, which have proportionately much greater volume, higher rates usually are needed to provide control of emerald ash borer. These higher rates—the "2X rate"—are allowed in trees exceeding 15 inches diameter and are recommended for control.

The amounts of various imidacloprid formulations that would provide a 1/2X, 1X, or 2X rate are summarized as follows:

1X Rate of Imidacloprid for Soil Application to Control Emerald Ash Borer

For the 75% Water Soluble Packet (75WSP) formulations: 1.6 oz (1 packet) for trees of 24 inches of cumulative trunk diameter (DBH)

For the Flowable (2F) formulations: 0.2 fl oz per inch of tree diameter (DBH)

For the Merit 75WP formulation: 1.4 teaspoons/inch trunk diameter (DBH)

2X Rate (Allowed only on trees exceeding 15 inches diameter)

For the 75% Water Soluble Packet (75WSP) formulations: 1.6 oz (1 packet) for trees of 12 inches of cumulative trunk diameter (DBH)

For the Flowable (2F) formulations: 0.4 fl oz per inch of tree diameter (DBH)

½X Rate (Generally used on smaller trees and when local infestations are low)

For the 75% Water Soluble Packet (75WSP) formulations: 1.6 oz (1 packet) for trees of 48 inches of cumulative trunk diameter (DBH)

For the Flowable (2F) formulations: 0.1 fl oz per inch of tree diameter (DBH)

For the Merit 75WP formulation: 0.7 teaspoons/inch trunk diameter (DBH)

For the 1.47% formulations sold at retail outlets: 1 fl. oz/inch of tree circumference*

Note: Rates of most formulations used for control of emerald ash borer as soil treatments are based on trunk diameter (DBH – diameter breast height) at 4.5 feet. * However, retail formulations (typically 1.47% active ingredient) have use directions based on *trunk circumference*.

multiple spots within the drip line of the tree. The use of soil injections avoids the presence of surface residues of the insecticide and allows the insecticide to bypass surface barriers (e.g., mulch, fabric barriers, thick layers of turfgrass thatch) that may prevent the insecticide from sufficiently reaching the root system of the tree.

An application of a systemic insecticide being applied as a soil drench to the base of a tree. Photograph courtesy of University of California Statewide IPM Program.

The optimum timing of treatment depends on the product being used. Imidacloprid is relatively less water soluble and mobile in plants than is dinotefuran, but persists considerably longer. It is often best applied around the time of bud break or within a couple weeks after bud break–levels of insecticide needed to control EAB can be expected to be present in ash foliage about 3-6 weeks after application. Dinotefuran will be absorbed and mobilized in the plant much quicker, typically being present in foliage at sufficient levels for EAB control within 2-3 weeks after application. Soil applications of dinotefuran are therefore best applied a few weeks later than imidacloprid, typically in mid-May through early June. (Note: Trees will not begin to absorb and translocate any insecticides until leaves are present and water is moving through the plant for transpiration.)

Regardless of method of application, following treatment *the area where the insecticide was applied must be irrigated sufficiently to remain moist enough so that roots of the trees can absorb the insecticide*; soil applied insecticides will not be adequately taken up by plants from dry soil. The treated site should remain moist for at least two weeks following application. Excessive irrigation that saturates soils for long periods and/or allows run-off should be avoided as it will decrease uptake, and may cause insecticide to leach into groundwater or run-off the site. (Dinotefuran, being much more water soluble, carries far greater risks of run-off and leaching into groundwater than does imidacloprid.)

There is a restriction on the amount of imidacloprid that can be used on an area basis. Total use per year is limited to 0.4 lbs of imidacloprid (active ingredient)/acre.


A systemic insecticide (dinotefuran) being applied as a non-invasive trunk spray. Photograph courtesy of Utah State University IPM Program.

Non-invasive Systemic Trunk Sprays

The systemic insecticide dinotefuran (Safari®, Zylam®, Transtect®) can be applied as a coarse spray onto the trunk. It is a highly water soluble insecticide and is quite mobile in plants, which allows it to be absorbed through the bark where it can then be moved through the tree to provide control. Under favorable

conditions it can be expected within 2-3 weeks after application to move into leaves in sufficient concentration to kill emerald ash borer adults feeding on leaves. It also will distribute to areas under the bark where larval stages of the emerald ash borer feed.

Rates of use are based on tree size (DBH) and a range of rates are listed on labels. Although not specified on labels, the higher rates are likely more appropriate on the larger diameter trees with thicker bark, whereas lower rates can be effectively used on smaller trees with thinner bark.

The use of a surfactant is included in the label directions of some formulations (e.g., Zylam) but not others. Surfactants may be useful in improving coverage and allowing the applied insecticide to move into the bark fissures where it is more readily absorbed by the tree.

Optimum timing of the dinotefuran trunk sprays for EAB control would be in the period beginning a couple weeks after bud break. Although it is readily absorbed by the tree, dinotefuran is less persistent than are the other systemic insecticide used for EAB control, and treatments made too early in the season may diminish in concentration during periods when emerald ash borer is active later in the season.

There is a restriction on the amount of dinotefuran that can be used on an area basis. Total use per year is limited to 0.54 lbs of dinotefuran (active ingredient)/acre.

Limits on the Maximum Use of Imidacloprid and Dinotefuran for Emerald Ash Borer Control

The use of injected systemic insecticides to trees always involves relatively high amounts of insecticide be applied/plant. Furthermore, most of the insecticides used in this manner–whether soil applied, trunk banded or trunk injected–do specify maximum amounts of the active ingredient that can be used on an area (acre) basis.

To date this has rarely, if ever, been a problem in Colorado since the maximum amounts of use have not been met by the suite of insect problems for which these insecticides have been applied in the past. However, with the establishment of emerald ash borer, and the treatments that will be used for its management, there will very likely be conflicts in this area. These will involve two of the systemic insecticides that are used for control, imidacloprid (Merit, Zenith, Xytect, etc.) and dinotefuran (Safari, Zylam, Transtect).

Imidacloprid. This is likely to be the most commonly used insecticide for emerald ash borer due to cost, effectiveness, and ease of use. It will be applied primarily as a soil drench/soil injection treatment; trunk injections may be a minor use. Application rates will typically be at the "1X" rate of 1.4 grams ai/inch of trunk diameter. On larger trees above 15 inches diameter the 2X rate is recommended. Homeowner/retail products of imidacloprid appear to allow a rate of use of about 1/2X.

The maximum rate of imidacloprid allowed per acre per year is 0.4 lbs, from all uses in a year. If imidacloprid is applied at the 1X rate the maximum amount of imidacloprid allowed per year is the amount that would be used to treat ash trees of a cumulative diameter (DBH) of 126 inches. At the 2X rate, required for larger trees, the maximum amount is met at when trees of a cumulative diameter of 63 inches are treated (e.g., 2 or 3 trees).

Dinotefuran. Dinotefuran will likely be used primarily as a trunk band spray, applied as a drenching spray to the lower trunk for uptake through the bark. It is also labeled for use as a soil injection but its higher cost (relative to imidacloprid) – and high potential for leaching– will likely mean it is little used in this manner.

The maximum amount of dinotefuran that can be used is 0.54 lbs/acre/year. (This is equivalent to 2.7 lbs of the formulated Safari 20SG product or 79 fl oz of Zylam Liquid). A range of rates are labelled for trunk spray applications of dinotefuran products that would allow trees of cumulative diameter between 64-120 inches be treated with this product per acre in a single growing season.

Trunk Injections with Systemic Insecticides

Systemic insecticides can be applied to trees by injecting them into the trunk. Two insecticides used for control of emerald ash borer–TREE-Age® (emamectin benzoate) and TreeAzin®

(azadirachtin) can only be used for EAB control when injected. Imidacloprid, most commonly used as a soil treatment for EAB control, can also be trunk injected (IMA-jet, Imicide, Pointer®, Zytect Infusible).

A systemic insecticide being injected into the soil near the base of a tree. Photograph courtesy of Utah State University IPM Program.

Trunk injected insecticides are most often applied by drilling holes into the base of the tree, typically at intervals of about 6 inches. The insecticides flow into the trees either from a series of individual capsules or a reservoir of insecticide used to treat the entire tree. Most applications are designed to allow the insecticide to flow fairly passively into the tree with minimal pressurization, although one system (Arbor-jet) uses a system of sustained pressurization. The Wedgle® system, involving Pointer®, injects small amounts directly under the bark without drilling.

Injecting trees correctly requires considerable skill so that the insecticide may flow readily into the tree and to avoid excessive tree wounding. Trunk injections should only be done by licensed professional arborists with experience in the practice of injecting trees.Use of TREE-age® is further restricted being registered as a *Restricted Use Product*, which can only be used by a certified pesticide applicator or person under immediate supervision of a certified applicator.

Trunk injections require holes be drilled into the base of the tree. The insecticide is then injected into these openings. Photograph courtesy of Bob Hammon/Tri-River Extension, Colorado.

The tree wounding required by trunk injections is of some concern. Evidence from the Midwest indicates that trunk injection wounds usually close over rapidly as callous tissues overgrow the wounded area. The ability to close over wounds will be related to the overall health of the tree, with more vigorous trees most capable of producing rapid wound closure. Slow growing trees with little stored energy reserves, such as ash trees grown on sites where drought and heat stress are common, can be expected to have poorer capacity to close over trunk injection wounds.

Trunk injection using the Arbor-jet system. For emerald ash borer control this is usually used to apply the insecticide TREE-Age® (emamectin benzoate). Photograph courtesy of David Cappaert/Michigan State University and BugWood.org.

Trunk injected insecticides often can move rapidly into and through plants. Thus they are often best applied at some point after EAB adults have begun to emerge, are feeding on leaves, and are beginning to lay eggs. However, since all the insecticides used

as trunk injections can persist for months and can kill young larvae as well as adults, optimal treatment timing may occur over a several week period.

Another consideration of when to apply trunk injected insecticides is whether conditions exist for rapid uptake of the treatments during application and their subsequent movement through the plant. This occurs most rapidly when plants are actively transpiring (moving water through the plant and evaporating it through leaves and stems.) Conditions that favor transpiration include soil that is sufficiently moist, soil temperatures are above 45°F, and ambient air temperatures are between 40° to 90°F. Uptake of the insecticide and movement within the tree will be slow if soils are too dry (or persistently saturated), temperatures are too cold or too hot, and significant transpiration does not occur in the dormant season when leaves are not present.

The length of time these trunk injected insecticides can provide control varies by product. Imidacloprid trunk injections can provide control for a single season, as do the more commonly used soil applications of this product. At the other extreme, TREE-age® (emamectin benzoate) has been shown to consistently provide a very high level of EAB control for two years following application. TreeAzin® (azadirachtin), a product more recently marketed and used in the U.S., seems to provide intermediate persistence, showing some ability to control EAB larvae the year following application.

Trunk injection using the EcoJet system, which applies the emerald ash borer treatment TreeAzin® (azadirachtin). Photograph courtesy of Paul Bolan/BioForest Technologies, Inc.

Persistent Surface-Applied Contact Insecticides

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. Protective cover sprays are designed to prevent EAB from entering the tree and, unlike the control options with systemic activity, will have no effect on larvae feeding under the bark.

Trunk injection using the Mauget system. For emerald ash borer control this is usually used to apply the insecticide Imicide (imidacloprid). Photograph courtesy of David Cappaert/Michigan State University and BugWood.org.

Cover sprays should be timed to occur when most adult beetles are feeding and beginning to lay eggs. Adult activity can be difficult to monitor because there are no effective pheromone traps for EAB. However, first emergence of EAB adults generally occurs between 450-550 degree days (starting date of January 1, base temperature of 50˚F), which in the Midwest

corresponds well with full bloom of black locust (*Robinia pseudoacacia*). Generally two applications have to be applied during late spring/early summer to maintain adequate coverage throughout the period when emerald ash borer is present on trees, laying eggs and eggs are hatching.

It must 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 and the use of whole tree spraying increases many of these risks to non-target organisms, in comparison with other EAB control options.

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www.emeraldashborer.info/files/multistate_eab_insecticide_fact_sheet.pdf

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