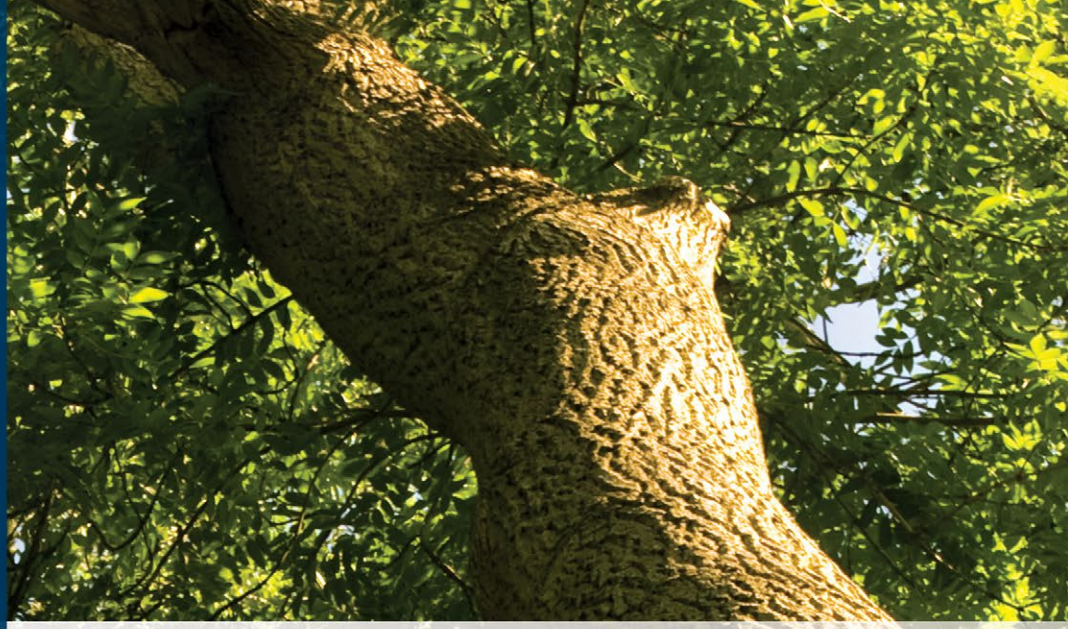
EMERALD ASH BORER

MANAGEMENT GUIDELINES

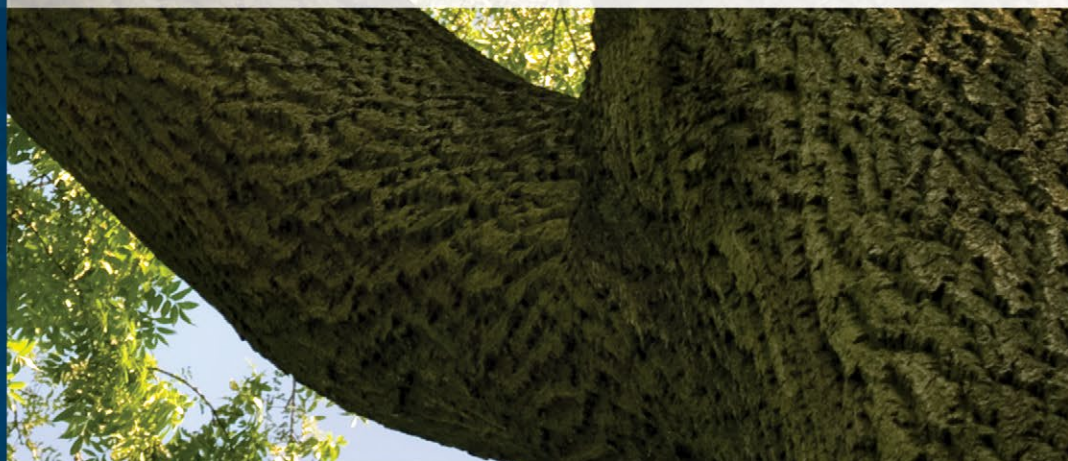


Background

Emerald ash borer (EAB), *Agrilus planipennis*, is an invasive wood-boring beetle first detected in the U.S. near Detroit, Michigan, in 2002. Since that time EAB has been responsible for killing millions of ash trees. All ash trees native to Minnesota are considered highly susceptible to EAB. Minnesota has about one billion ash trees in our forests and ash accounts for about 15 percent of trees in the average community (Natural Resources, 2010).

A single generation of EAB is completed in one to two years. Eggs are laid during the summer on trunks and branches of ash trees. Larvae hatch from the eggs and tunnel beneath the bark. Larvae make distinct “S”-shaped (serpentine) galleries and feed on the phloem of the tree. Larvae may spend the winter inside pupal chambers in the outer sapwood, bark, or in feeding galleries, and some larvae will feed for another summer before completing development. Adults emerge from ash trees through a distinct “D”-shaped exit hole during May through September. Upon emergence, adults will feed on ash leaves in the canopy before mating and laying eggs.

Trees are killed by continual insect larval feeding, and tree mortality accelerates as EAB populations increase in density. Although the beetle is capable of spreading to nearby areas through flight, the primary means of long distance EAB spread to new areas is through transport of firewood or other woody material from ash trees.



DEPARTMENT OF AGRICULTURE

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How to Confirm and Report EAB

To confirm that a tree is infested with EAB there must be at least one of these symptoms.

An "S"-shaped gallery visible underneath the bark of the suspect ash tree. There are many native insects that will make galleries under the bark of ash but none will be "S"-shaped.

EAB larva
Length up to ~1 inch

A larva pulled out from a suspect ash tree and identified as EAB. Emerald ash borer larvae look much like our other native flatheaded borers but they have a characteristic urogomphi, which look like small spine-like projection at the tail end of the insect.

EAB Adult
Length ~1/2 inch

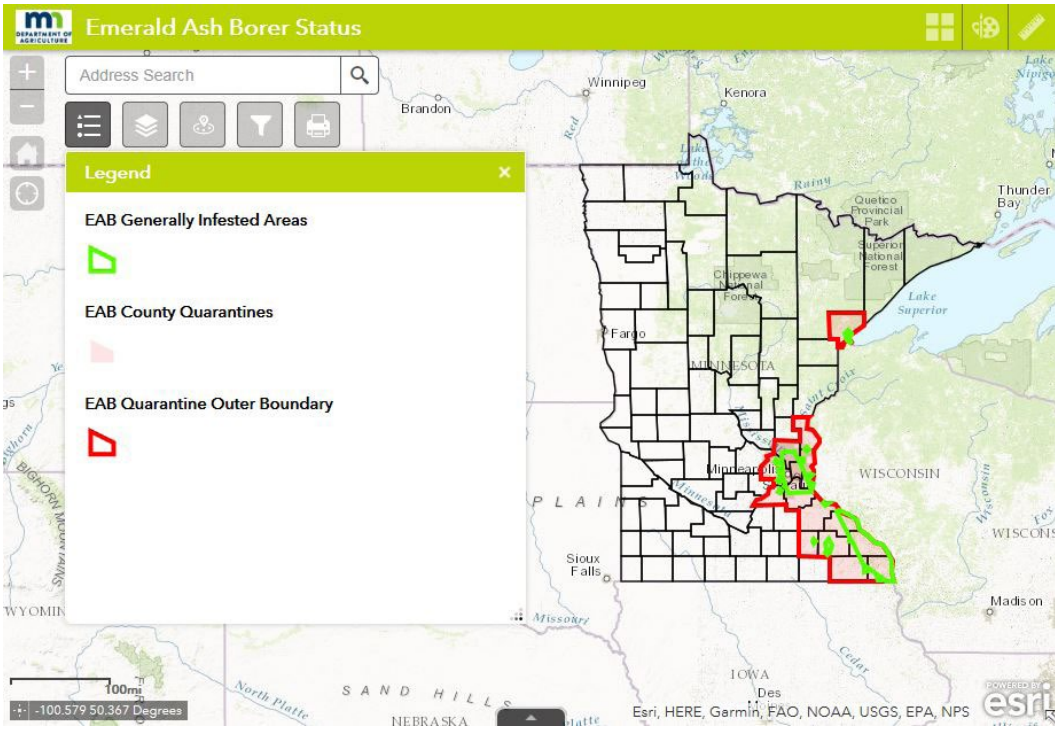
An adult EAB identified by the Minnesota Department of Agriculture (MDA) (see how to report EAB). This will be a very rare occurrence. Adult insects are not commonly seen except in areas of high insect pressure.

A "D"- shaped exit hole; however, if you think you have this, you should peel back the bark of the tree and make sure you can find the "S"-shaped gallery. "D"- shaped exit holes are easily misidentified. Only peel back bark when and if the tree is on your property or you have the permission to do so.

If EAB is suspected in a new area (town or city) of an already quarantined county, gallery photos and/ or samples of larvae, adult insects and/or photos may be submitted to the MDA for identification. This allows us to keep our online map updated and allows the public access to this information.

EAB does not need to be reported to or identified by the MDA in areas that are considered generally infested (these are areas where EAB is already known to occur). These generally infested areas are outlined in green on our online map.

Visit the MDA EAB webpage to **view a map of EAB finds in Minnesota.**



There are two main ways to report EAB to the MDA: Arrest the Pest and the Great Lakes Early Detection Network Application (GLEDN App) which is free for iOS and android smart phones and tablets.

GLEDN App: The GLEDN App is the easiest way to report EAB and other invasive species. It is designed so that all the necessary information can be taken from the field and sent to a verifier; the MDA in the case of EAB. The app allows you to take a GPS point of the location and take a picture of the insect or insect damage to send to the MDA. Your contact information is also sent so the MDA can follow up or make a confirmation quickly.

The GLEDN App also allows you to see locations of past reports of EAB while in the field. This is a helpful tool to track EAB infestations reported within your community, as well as monitor management activities such as chemical treatments and removals.

Photographing EAB

Pictures should focus on definitive symptoms of EAB. A picture of a standing ash tree will not give enough detail to identify EAB. Try to get a picture of an EAB insect gallery, EAB larva, adult beetle, or woodpecker damage (if taking pictures of woodpecker damage, try to get clear close-up pictures if possible)

**Reminder – If you think the symptoms of the tree you are reporting were caused by EAB and definitive symptoms are not present please make sure to look at other ash trees in the immediate area.*

If a clear, focused photo of symptoms is not possible, then detailed notes on the location and type of damage are very important.

Arrest the Pest: Go to **www.mda.state.mn.us/arrestthepest** for instructions. You can email at **Arrest.the.pest@state.mn.us** or call and leave a detailed message at 888-545-6684 and a specialist will get back to you. You can also submit a sample. Request a prepaid envelope from the MDA to mail in submissions. Information to submit to Arrest the Pest:

- **Pictures of suspect trees:** Pictures should be as detailed as possible and show individual symptoms rather than the whole tree. If possible, take pictures of individual woodpecks or a gallery.
- **Location of suspect trees:** Address or GPS coordinates. Either is acceptable. Also include details of location within property; including any landmarks or other features to help easily identify suspect pest location.
- **Contact information of reporter** so that the MDA can contact you if we need further clarification.

Planning for EAB

Preparing for EAB before it has been identified in your community or in close proximity is a key component of EAB management and maintaining overall tree canopy. If communities are prepared, the inevitable impact from EAB may be spread over many years as opposed to a relatively short amount of time.

Inventory

Having a tree inventory is essential to general planning and estimating the costs associated with EAB. At minimum an inventory should include species, location information, size class and condition of the tree. If a complete tree inventory is not available you should at least have an inventory of ash trees. With this information predictions can be made about how the community will be impacted by the loss of all ash trees. It is also important, if possible, to make note of the ash population on private property and in natural areas.

Detection

Early detection of EAB will allow for more management options rather than just widespread tree removal and also results in more time to manage the trees and spread the cost over a longer period of time.

Costs to consider

Removal – EAB will eventually kill most ash trees and these trees will have to be removed. Removal costs will vary depending on the size of the tree. Delaying removal of infested trees will increase costs as dead ash trees become brittle and hazardous.

Disposal of material and utilization – Ash material will have to be taken to a disposal site. State quarantines prohibit the removal of ash material out of quarantined areas without a compliance agreement. Residents should be made aware of the restrictions of wood transportation and encouraged to dispose of wood near its origin.

Insecticide treatments – Treatments for EAB can be both therapeutic and preventative. Costs will vary depending on the size of the tree. There are many benefits to having large ash trees in the environments and preserving the forest canopy. Homeowners may also be interested in treating public boulevard trees. Managers should develop a method to track treated trees within the community. Treatments can also be used to delay the cost of removal.

Reforestation – Decline in ash tree populations will require planting new trees to restore the lost canopy. It would be best to use this as an opportunity to further diversify the urban forest and plant in a purposeful and strategic manner.

For more information regarding estimating future costs or EAB, Purdue University has developed a cost calculator. It can be found at: **http://int.entm.purdue.edu/ext/treecomputer/**

Private trees

Trees on private property will have to be a part of the overall EAB management. Private trees that are not treated will eventually succumb to EAB and will need to be removed if and when they become hazardous. Some communities already have a diseased tree ordinance in place for managing Dutch elm disease and oak wilt that can be amended for EAB management. It will be up to managers to decide if there are enough resources to take action when private trees are identified as infested.

Training/Outreach/Education

Having citizens and forestry staff who are informed about EAB and its symptoms will assist in identifying EAB populations within your community. Supplying education and outreach to residents will allow homeowners to start thinking about what to do with their own ash trees when EAB arrives and be aware of the management options available. Some residents may want to begin insecticide treatments or remove and replace trees in advance of EAB which can benefit the overall tree canopy.

Detection Methods

In order to effectively manage EAB, you will need to know where it is. Opportunities for management decrease over time as trees begin to die. It is beneficial to be proactive and detect EAB in the early stages of infestation. There are multiple methods to do this and each method requires different labor inputs and yields different information. The method chosen will depend on specific management goals.

VISUAL SURVEY

When trees are lightly infested with emerald ash borer, it's unlikely there will be any visible signs of infestation on the exterior of the tree. In contrast, trees that are heavily infested with emerald ash borer are likely to display many signs of infestation including canopy thinning, damage caused by woodpecker foraging, and loose, splitting bark.

Impacts to the canopy of a tree from EAB will not be apparent until the density of larvae within the tree is relatively high with many tunnels in the stem of the tree. At this point, it may be too late to save the tree with insecticide treatments. However, other visual symptoms such as woodpecker foraging and loose, splitting bark can often be found well before EAB levels are high enough to impact the canopy.

EAB infestations tend to begin in branches, and as more larvae infest branches they are more likely to be discovered as a food source by foraging woodpeckers. This provides an opportunity to spot the damage left when EAB levels in a tree are still relatively light and generally limited to branches and upper stems. Likewise, loose bark splits may also form during this time, providing another sign that a tree may be infested with EAB.

While neither of these symptoms is diagnostic for EAB, there are characteristics particular to each that may increase suspicion that the damage is related to EAB.

The MDA has a "How To" video on visual survey techniques available at: **https://youtu.be/Bq9mZKy-3Ao**

What to look for when conducting a visual survey:

**While these symptoms are present year round, it is best to conduct visual surveys in the late winter or early spring when leaves are absent from the trees. Woodpecker activity also increases in the early spring so there is likely to be more visual signs at this time of year.*

Woodpecker damage – When woodpeckers forage on ash trees they generally knock some of the outer bark off of the area they are pecking, thereby exposing the lighter colored inner bark. These areas of lighter bark are noticeable from the ground and indicate areas where closer inspection is needed. However, it is good to note that black and white ash trees tend to display less contrast for the lighter colored inner bark compared to green ash trees due to the differing bark texture. This can lead to woodpecker damage being less noticeable at earlier stages in black and white ash trees.

When woodpeckers forage on EAB, they peck a dime to quarter-sized hole through the bark and to the surface of the sapwood. If these holes are not present, it is unlikely that woodpeckers are foraging on EAB or other insects beneath the bark of the tree. Sometimes trees have areas of outer bark that appear to have been knocked away by woodpeckers but there are no holes through the bark. There are a number of possible reasons why this could happen including woodpeckers exploring trees for insects, squirrel activity, smooth bark pathogen, weather, or other unknown causes. The important point for EAB monitoring is that woodpecker foraging on EAB should leave behind light colored holes that go through the bark and to the surface of the wood.

Once it has been determined that woodpecker foraging with holes created through the bark is present, the only certain way to identify whether it is EAB is to view the tunneling left by the insect. This can be done by finding an area where enough bark has been removed already or removing some bark to enlarge the hole left by a woodpecker (see How to Confirm EAB for more information on insect tunneling in ash).

Some characteristics make it apparent that the woodpeckers were foraging on native insects and not EAB. Native insects typically infest trees that are in obvious decline, or they may infest discrete areas of trees in decline such as dead branches, areas around wounds or near large pruning cuts. The occurrence of one of these factors is an indicator that the insects being predated are native insects and not EAB. Another indicator is the appearance of the holes left behind by woodpeckers. Wood in areas where native insects have been active is often stained dark in color, either from the decline of the tree or from organisms introduced by the insects. As a result, the woodpecker holes over these galleries will also appear dark. In contrast, EAB can generally be found tunneling in healthy trees and in wood that is not stained dark. As a result, woodpecker holes over EAB galleries will often appear light in color with the white wood visible through the woodpecker hole. EAB does not tunnel deeply into the wood of a tree like some native insects do, so large, deep holes in the wood can be excluded as indicators of EAB.

Bark Cracks – Another early EAB visual symptom in the canopy of ash trees are bark cracks. As the tree is initially attacked, the tree tries to heal around the larval gallery area and keep growing. As the branch continues to grow it forms callus tissue around the gallery and the bark will begin to crack open. When the crack becomes large enough you may be able to see the gallery with a pair of binoculars.

***Note on removing bark**

Removing bark from a healthy area of a tree destroys food and possibly water conducting cells (if the outer wood is also damaged) in that area of the tree and also provides an entry point for pathogens. Areas in trees where insects have tunneled and woodpeckers have created holes through the bark have already sustained this injury and removing an additional small amount of bark will probably not add significant injury. However, bark missing from trees will attract the attention of other people who may not appreciate this argument and so you should never remove bark from a tree that you do not have authority or permission to sample in this way.

If an EAB gallery is present, bark should come off the tree relatively easy when pried up. This is due to how EAB feeds under the bark. If you are having to struggle to remove the bark, the damage is likely not caused by EAB

Note on Binoculars

While the light colored patches of inner bark are generally noticeable to the naked eye, determining whether or not woodpecker-created holes are present may require binoculars. Binoculars with greater magnifying power work better, but keep in mind that as viewing power increases the sensitivity of the view to movement also increases (it's hard to hold the binoculars steady enough). The MDA has had good success with binoculars offering 16 power (images magnified 16 times). The light gathering ability of binoculars is important as well, and generally the more light the better. Binoculars are generally labeled with both values, for instance, 10 x 20. This means that the binoculars will magnify images 10x and the diameter of the objective lens is 20 mm (wider lens = more light). The trade-off is that binoculars with greater power and light gathering ability will generally be bigger and heavier and more difficult to use.

There are characteristics associated with EAB in addition to woodpecker feeding damage and bark cracks, which can be seen while conducting a visual survey. While these things may in fact be present, they are not valuable indicators of EAB as they may be caused by many different things or are extremely difficult to see.

Canopy Thinning – Canopy thinning is typically a symptom that occurs after woodpecker damage and bark cracks can be seen, usually around the fourth year a tree is infested. The top canopy will have a general thinning to it, not a leafless branch.

Epicormic Sprouting – Epicormic sprouting is often seen on ash trees that are stressed in general. However, sprouting within the lower canopy of the tree is often seen with EAB infestations. This is the least reliable visual symptom for EAB.

Loose splitting bark

"D"-shaped Exit Holes – Unless you are working in the canopy of the trees, you will not see "D"-shaped holes until much later in the infestation. There are also many native insects attacking ash trees that make oval shaped holes of similar size. Looking for "D"-shaped exit holes is not a good use of your time when conducting visual survey.

How visual survey can be beneficial to managing urban environments:

Visual survey is an efficient way to detect EAB before impact to the canopy occurs. This is also the most economical method to find EAB. The MDA has observed that visual survey takes about 20 percent of the time it takes to branch sample a given area. The MDA has also noted that the difference of EAB detection between branch sampling and visual survey is rather small. Branch sampling can detect EAB at a lower density when no outward symptoms are present; however, in most cases trees infested with EAB will have some visual symptoms. It is also important to note that trees in an infested area will have varying degrees of EAB density, meaning that some trees are likely be at the level where woodpeckers have begun to forage and feed on EAB. Depending on the management goals, the value of knowing where EAB is may outweigh knowing exactly how many trees are infested in that area. For these reasons, if the goal is to detect EAB before canopy decline with the least amount of resources and time, visual survey is the best method to use.

How visual survey can be beneficial to managing woodlots and forested environments:

Management options are limited in woodlots and forest stands. Outside of biological control of EAB and cold mortality, there is no practical way to protect trees in these environments as EAB gradually spreads. As a result, the main goal for these areas will be to remove or harvest ash trees before they succumb to EAB and become hazardous. Visual survey will allow for the detection of EAB before this happens so that infested trees can be removed earlier and labor costs can be spread out over time.

BRANCH SAMPLING

Branch sampling is a technique that can be used to identify EAB infestations in trees that are free from external symptoms - making it the most sensitive method for EAB detection. This detection method involves removing two healthy limbs from ash trees and removing the bark to look for the presence of EAB larvae or feeding galleries. While branch sampling is sensitive and capable of early detection, it is very labor intensive and the results may not justify the added labor over other methods. Branch sampling can also be used to aid in estimating the density of an EAB infestation; however, this information may not be pertinent to managing the infestation.

How to process a branch sample:

Bark needs to be removed carefully down to the sapwood where EAB feeds. The best way to do this is by peeling the bark off in thin layers from the outer bark through the inner bark. The most common mistake when removing the bark from a branch sample with a draw knife is to not go deep enough. If the sample was recently cut this can be distinguished by a thin layer of moisture that is present when you reach the correct depth, as well as a change in texture.

A tree can be identified as positive when an EAB gallery or larva is uncovered. Depending on one's management goals, determining the density of EAB in a sample could be important. This is done by calculating the surface area of each sample and the amount of EAB galleries present. If the goal is to simply determine if a tree is infested, peeling can stop once one gallery is found. This can save time. It is important to note that other insects can leave feeding galleries, but the serpentine "s" gallery is unique to EAB in ash trees.

Things to consider before branch sampling:

- Is there enough staff time available for such work? Is there storage space available for the samples? Are there potential student worker/intern resources available?
- Keep in mind that sampling 50 trees will create 100 branches that will need to be peeled and documented for presence of EAB.
- Estimate of labor hours needed to sample 50 trees and peel 100 branches = 50 hours
- Intensity level of EAB Infestation in area (low, moderate or high)?
- If known, is it worthwhile in terms of potential management outcomes? If infestation levels are already moderate to high in the surrounding area, then the potential to positively impact management may be too late or the resources may be better used on future management rather than detection.
- Will results lead to targeted management?
- Are the results going to be used to influence the way a specific location is managed?
- Targeted removals or insecticide treatments? If no, then branch sampling may not be worth the time and resources as it won't impact forest management objectives.

Define area to be sampled:

To begin preparing your branch sampling plan, decide the following:

Define the geographic area being targeted for sampling:

- Entire city – EAB is not known to be in area or adjacent communities.
- High risk neighborhood(s) based on – proximity to nearby infestations, ash density, or types of businesses (areas with wood products, land clearing and firewood industry).
- High value areas – areas where ash is highly valuable to canopy coverage.
- County level – Parks, campgrounds, main travel corridors, high ash density, proximity to nearby infestations, etc.

Define the intensity of sampling:

Example: Grid based approach – create a grid using ArcGIS based on the intensity of sampling to be completed. (ex: place ½ mile x ½ mile grid over entire city) modify it until desired level of sampling is reached based on available staff resources.

Other Options:
Spot sample ash trees while performing other work such as trimming or removals. Have employees take a closer look while doing other work in the canopy of ash trees. This can be accomplished by peeling away bark if woodpecker damage or bark splits are noticed while pruning or removing a tree. Take a picture or collect a representative sample of the damage.

Recommended characteristics when selecting trees to sample:

- Open grown, semi-mature trees
- 8-20 inch DBH
- Two branches per tree from mid-crown (cut branch at the base)
- Branches are minimum of 2-3 inches diameter (4-5 inch diameter preferred)
- Branches have rough bark opposed to smooth bark
- Branches are taken from the south/southwest facing side of tree if possible (part of tree that receives the most sunlight)
- Branches are a minimum of 20 inches in length (30-40 inch lengths are best size for handling when peeling)

* Remember that the goal of branch sampling is to detect EAB, not to prune the ash tree. Take the best branches possible based on the criteria listed above and consider the tree being sampled as sacrificial to the goal.

Timing of branch sampling:

October 1 through April 1

*not recommended to fell, trim or sample ash trees during the summer due to risk of spreading EAB through movement of infested materials.

Tools/Equipment needed for this method:

- Bucket truck/pole saw/rope saw
- Chainsaw/ hand saw
- Drawknife
- Pocket knife
- Table vice/other with ability to hold branch in place

How branch sampling can be beneficial to urban environments

Branch sampling can be a valuable tool if finding EAB early will direct how the infestation is managed. For example, a management plan may involve insecticide treatments of healthy ash in an area once EAB is discovered. Branch sampling has the potential to detect EAB before the canopy is impacted resulting in a greater number of trees where treatments are viable.

** It is important to note that while branch sampling is the most sensitive tool available for detecting EAB, it is only 75% accurate. There is still a 25% chance that the sampling results will produce a false negative if the branches sampled happen to not contain EAB galleries even though the tree is infested*

How branch sampling can be beneficial to woodlots and forests

Due to the large labor costs compared to visual survey and the management goals associated with these

environments, branch sampling is not often the most practical method of detection. Resources would be better spent on planning for tree replacement and tree removal once EAB is detected with visual survey.

BIOSURVEILLANCE

Smoky winged beetle bandit wasp, Cerceris fumipennis, is a native, stingless wasp that preys on EAB and other similar beetles. The University of Minnesota Extension is working to use this wasp to detect EAB by monitoring wasp colonies and collecting beetle prey from the wasps. Beetles are intercepted from the wasps or found near nests by volunteers during the summer months.

For more information on this program visit: **www.myminnesotawoods.umn.edu/eab/waspwatchers/**

PURPLE TRAPS

Trapping for EAB involves placing prism traps in the canopies of ash trees during the EAB flight season. Traps contain a lure to attract EAB and are coated in a sticky substance. Adult EAB flying around the canopy get stuck to the outer surface of the trap. The US Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) coordinates the placement of traps in counties that are not infested with EAB. These traps are useful on a state or county level but are not designed to detect EAB in a way that will help manage the insect and forest.

Minnesota municipalities on average have 20.3% ash in their urban forest, with percentages ranging from 0.2 to 59.6 based on a 2010 MN DNR Community Tree Survey. There is no stopping EAB from

Management Tactics for Municipalities

spreading to every municipality in Minnesota; however, actions can be taken to slow EAB's spread through a city and manage the ash resource. There are a variety of management options available which can be combined to cater to each individual municipality with or without EAB infestations. Management options include best management practices, surveys, removals, chemical treatments, outreach, and reforestation. The MDA encourages municipalities to manage EAB; however, it is not a requirement.

Best Management Practices (BMPs)

The MDA has prepared Best Management Practice (BMP) recommendations for when to perform work on ash trees. It is recommended that no work be completed on ash trees during the EAB Active Period: May 2 – September 30. This helps reduce the risk of EAB spreading during transportation, and will provide habitat for EAB adults to lay eggs that will be destroyed during the dormant period. Note that trees damaged in storms or hazardous trees can be removed at any time to prevent damage to property or persons.

If possible, perform maintenance on or remove ash trees during the EAB Dormant Period: October 1 – May 1.

For more information on EAB BMPs visit **www.mda.state.mn.us/eab**

Ordinances

The Shade Tree Pest Control Ordinance can be applied to EAB infested trees. Please remember that the MDA does not require municipalities to enforce any ordinance. More information on preparing a Shade Tree Pest Ordinance can be found on the League of Minnesota Cities website **www.lmc.org**.

Municipalities that enforce a Shade Tree Pest Ordinance will condemn trees that have a visible EAB gallery, an EAB larvae, or an EAB exit hole. Some municipalities allow private property owners to treat condemned trees if they are lightly infested and still have a healthy canopy.

Visual Survey

The MDA and the University of Minnesota (U of M) have determined through a three year study that visual survey is the most time and cost efficient way to find EAB infested trees at varying population densities is through visual survey in the late winter and early spring. The study compared three survey techniques used in the field; visual survey for woodpecker damage, purple prism traps, and branch sampling. They found that visual survey took 12-24 minutes to find a positive tree compared to 3.5-3.6 hours by branch sample and 4.3-5.4 hours by purple prism trap. With basic training, municipality staff

can easily identify EAB infested trees using a pair of binoculars to look for woodpecker damage. (See Detection Methods: Visual Survey for more information)

Removals

The MDA and the U of M also determined that removing trees with EAB woodpecker damage showed a larger decrease in the beetle production per removed tree in a four year study in the Twin Cities Metro. By removing ~ 63% of the total ash trees in the study area over four years, there was a ~54% reduction of the cumulative number of beetles produced. Only removing EAB woodpecked trees will allow fewer removals over a longer time period which can buy time for other management strategies to be implemented and place less strain on budgets.

Examples of removal options: poor quality ash trees, EAB woodpecked public ash trees, EAB woodpecked private ash trees, ash trees regardless of quality or EAB, hazardous/dead ash trees.

Insecticide Treatment

Insecticide treatments can be started before EAB is in the area, after an initial detection in the municipality or after a tree is lightly infested. When treatments are applied correctly they will protect the tree from EAB and they will need to be repeated. Trees that have 50% or more of the canopy in good health are candidates for chemical treatment. Any ash tree that is not treated can be infested by emerald ash borer and die.

There are many options available to chemically treat trees which are described in the Insecticide Options for Protecting Ash Trees from EAB produced by the North Central IPM Center. Note that certain chemicals require a Pesticide Applicator License from the MDA.
www.extension.umn.edu/garden/insects/find/emerald-ash-borer/docs/ncbipm_eab_insecticide_bulletin_2nd_ed_may_2014.pdf

A homeowner version of treatment options is available at **www.mda.state.mn.us/eab**.

Municipalities can perform insecticide treatments in–house or contract with a private company. Municipalities working with a contractor have the potential to offer private property owners the municipality's discounted rate. A free permit is typically issued by municipalities when private residents pay for the treatment of public ash trees on their property. In some cases, in-house treatment rates can be lower than contracted rates. One municipality was able to get their in-house treatment rate to $4.77 per diameter inch, which included licensing, wages, benefits and equipment costs. Contracted treatment rates vary but are typically around $6.00 per diameter inch.

Insecticide treatments can be used to maintain the current tree canopy while waiting for reforested tree species to grow or removals can be planned. This prevents widespread ash mortality that may overwhelm the municipality's available resources.

Examples of treatment options: public boulevard trees, public park trees not in forested areas, private treatment of public trees, private property trees at contracted rate.

Combinations

Many municipalities are combining management tactics by removing unhealthy (non-EAB infested) ash, removing EAB infested ash showing woodpecker damage, and chemically treating healthy mature trees. Below are examples of management activities at cities in Minnesota. Again, the MDA does not require municipalities to perform any management of EAB.

MANAGEMENT ACTIVITY EXAMPLES			
REMOVAL	City A	City B	City C
Poor quality public trees	Yes	Yes	Yes
Public woodpecked boulevard trees	Yes	Yes	Yes
Public woodpecked park landscape trees	Yes	Yes	Yes
Public woodpecked forestland trees	Only hazards	Only hazards	Only hazards
Private woodpecked trees (Shade Tree Pest Ordinance)	Within a specific distance of adjacent property		Yes
CHEMICAL TREATMENT	City A	City B	City C
Mature public boulevard trees	In-house		Contract, high-value
Mature public park landscape trees	In-house		Contract, high-value
Mature forestland trees			
Private mature trees			Contract rate
Privately funded public boulevard trees	Yes		Yes
Private mature trees lightly infested	Yes		Yes

Do Nothing

Municipalities do have the option to do nothing; however, dead ash trees become hazardous and will eventually require removal to ensure public safety.

Outreach Efforts

Educating citizens should be considered by every municipality even if they are not actively managing EAB to prevent spread. Movement of infested wood is a leading cause of EAB traveling long distances in short periods of time. EAB adult beetles do not travel a significant distance each year on their own, but a person can easily move infested firewood hundreds of miles in a day.

Examples of outreach efforts: tree signs/wraps, water bill inserts, postcard mailings, press releases, posters, educational tables at municipal functions, or presentations at public meetings.

Reforestation

Species diversity is essential in reforestation efforts to prevent widespread mortality from future pests. A guide to recommended trees for Minnesota by region can be found on the My Minnesota Woods website. **www.myminnesotawoods.umn.edu/2008/11/recommended-trees-for-minnesota-by-region/**

Tree sales are another way to reforest the urban canopy through private residents purchasing wholesale priced trees and shrubs. Tree sales are run by counties, cities, non-profits, gardening groups, soil and water conservation districts or other entities. The sales typically take place in the spring and can be comprised of bare root, container or air pot trees and shrubs. Trees purchased through the sales are typically planted on private property; however, some cities allow plantings in the public boulevards. Depending on the entity holding the sale, residents may also purchase trees and donate them to a municipal park.

Management Tactics for Woodlots and Forested Areas

Minnesota has a vast number of ash trees outside of urban environments located in woodlots and forested regions of the state. Biological control is one practical landscape-level management option. There is no way to stop EAB from spreading throughout the state or a way to protect all of these trees. Although it may take many years for EAB to spread, if you have ash trees on your property, it is time to start planning for a future with fewer ash trees. However, planning ahead and managing the ash resource before EAB arrives will help keep your forest healthy and resilient.

For more information on managing ash in a forested setting visit: **www.myminnesotawoods.umn.edu/2011/07/emerald-ash-borer-and-your-minnesota-woodlands/**

Biological Control

Biological control of EAB was initiated in Minnesota in 2010 and remains the most practical landscape-level management option. Three parasitoid wasp species are being released in Minnesota. Two species attacks the larval stage of EAB under the ash bark. The other species kills EAB eggs that are laid in bark crevices. These wasps are small like gnats and do not harm humans. They were selected by the US Department of Agriculture's Animal and Plant Health Inspection Service (APHIS) and Forest Service and tested extensively to ensure that they will not negatively impact other species or the environment. APHIS rears these biological control agents at a specialized facility in Brighton, MI and provides them to states with EAB infestations. Program implementation includes EAB detection, site assessment, and parasitoid release and recovery.

Assessment of EAB Infestation

Not all sites fit the criteria for biological control. Once an EAB infestation is positively identified, several activities need to be completed to determine if biological control is viable:

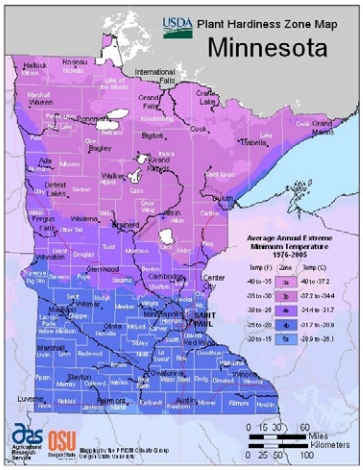
- Perform a delimit survey of the infestation to identify the perimeter of where symptoms are visible.
- Gauge the intensity or pest pressure in the area based on severity of EAB symptoms throughout the identified visibly infested area. Low to moderate EAB densities are recommended for potential sites. It is important that there are enough EAB for the parasitoids to feed on and there are enough living ash trees to sustain the populations over time.
- Identify forested areas on public or private land within the visibly infested area where removal and/or treatment of infested ash trees will not be feasible. Size and composition of forest should be at least 40 acres and at a minimum include 20% ash of varying size class. Ideally, the site would be greater than 25% ash and connected to other woodlots.

Coordination

After a viable biological control site is identified, coordination by the MDA with local natural resource managers, property owners and the USDA EAB Parasitoid Rearing Facility are necessary. At each site, one has to obtain permission, guarantee access and ensure other management objectives won't interfere with implementation. Special permits may be necessary depending on the ownership and designation of land. Long-term site access is important for follow-up monitoring of ash health and documenting parasitoid establishment.

EAB Cold Hardiness

Parasitoid Recovery



After parasitoids have been released, it is important to recover some to confirm that populations are overwintering and reproducing. There are multiple ways to recover parasitoids from release sites.

For more information on biological control of EAB in Minnesota; including parasitoids, release sites and recovery locations, visit MDA's biocontrol webpage:
www.mda.state.mn.us/plants/pestmanagement/eab/eabbiocontrol.aspx

The MDA, the US Forest Service, and the University of Minnesota partnered to study the winter hardiness of EAB larvae. Minnesota had a very cold "polar vortex" winter during the study period and an article was written regarding the effects on EAB titled "Cold snap is no snow day for emerald ash borer management" on January 31, 2014.

Article Summary

Emerald ash borer (EAB) causes problems when it becomes very abundant in an area. Populations grow slowly until they reach a "tipping point" after which they can grow very rapidly – killing many trees in a short time (1-3 years). We have found that some EAB larvae begin to freeze and die when temperatures within trees reach -20°F and that survival is very unlikely when temperatures reach below –30°F. In areas where the coldest winter temperature is generally warmer than -20°F, cold mortality is unlikely to have much or any impact on the population increase of EAB. In areas where the coldest winter temperature is generally between -20°F and -30°F, cold mortality may delay the increase of EAB to levels that kill trees, but EAB should still be expected to reach tree-killing levels. In areas where the coldest winter temperature is generally colder than -30°F, cold mortality may have a major impact on population increase of EAB – perhaps to the point of constraining populations below tree-killing levels. We cannot confirm this right now, but we are working to answer this question. Winter mortality should slow EAB population growth in these areas but it is probably not enough to justify changing management plans. EAB populations will likely recover and should still be expected to grow to tree-killing levels.

The entire article can be viewed at:
www.nrs.fs.fed.us/disturbance/invasive_species/eab/control_management/cold_hardiness/bp-EAB-and-extreme-cold.pdf