E1634 (Revised April 2025)

Emerald Ash Borer

Biology and Integrated Pest Management in North Dakota

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The Emerald ash borer (EAB), *Agrilus planipennis*, is an invasive, metallic, wood-boring beetle (Coleoptera: Buprestidae) that is a major cause of ash tree decline and mortality in the Midwest. This highly destructive pest attacks only species of ash (*Fraxinus* spp.).

Emerald ash borer was introduced to North America accidentally in the mid-1990s and was detected first in southeastern Michigan in 2002. Unlike native borer insects, which typically only attack trees already in decline, EAB attacks both stressed and healthy trees. Emerald ash borer has been responsible for killing hundreds of millions of ash trees since its arrival in the U.S.

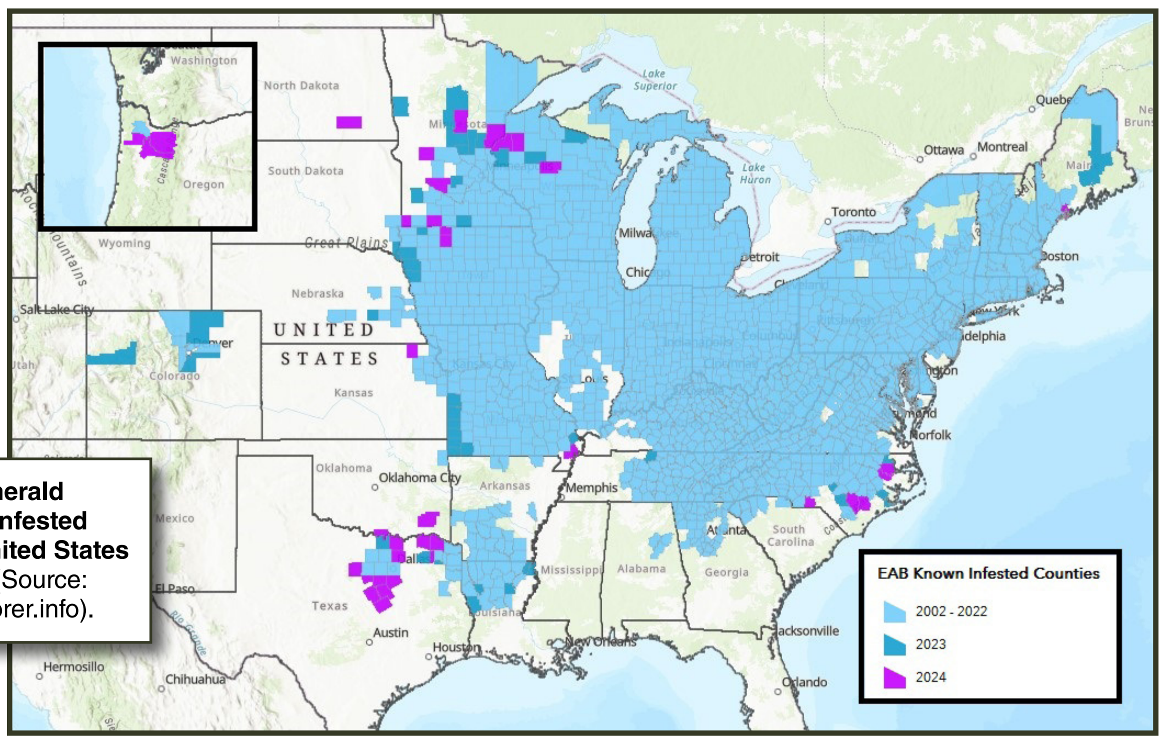

Figure 1. USDA emerald ash borer known infested counties in the United States as of March 2025 (Source: www.emeraldashborer.info).

Cover photograph – Emerald ash borer adult (L. Bauer, USDA Forest Service Northern Research Station, Bugwood.org)

Distribution

Emerald ash borer is native to Asia, where it can be found on several species of ash and is not considered a pest. Emerald ash borer most likely was transported to North America as larvae or pupae embedded in ash pallets, crates or packing material transported by cargo ships. As of March 2025, EAB has spread to 37 states (Figure 1) and six Canadian provinces. **The first North Dakota detection of EAB occurred in late August 2024 in LaMoure County near Edgeley. Adult beetles were trapped on prism traps and larvae were confirmed tunneling in nearby ash trees**. Information on EAB's most current distribution can be found at **www.emeraldashborer.info**.

NDSU EXTENSION

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Identification

Figure 2. Size of emerald ash borer adult compared with a penny (H. Russell, Michigan State University, Bugwood.org)

Adults are recognized as metallic, wood-boring beetles (Family Buprestidae) by their short saw-toothed antennae, blunt head and elongate yet compact body with metallic coloration.

The adult EAB is distinguished from other North Dakota Buprestidae by its size (about ½ inch or 13 millimeters [mm]), overall metallic green with coppery reflections on the pronotum (shieldlike body segment behind the head), and the bright metallic red of the upper surface of the abdomen (Figures 2 and 3).

The elytra (hard front wing covers) and membranous hind wings must be spread apart completely to view the dorsal surface of the abdomen. The abdomen projects beyond the elytra as a blunt-ended spine.

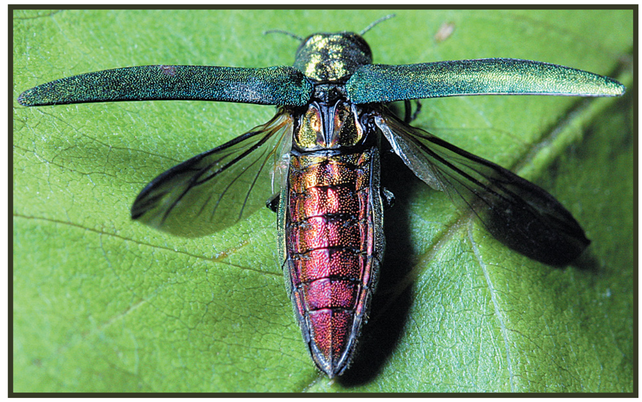

Figure 3. Emerald ash borer adult (D. Cappaert, Bugwood.org)

Eggs are oval to round, less than 0.039 of an inch (1 mm) in diameter, and although white when laid, they rapidly turn red-orange (Figure 4). Because eggs are laid in bark crevices, they are not readily observed.

Figure 4. Emerald ash borer egg (H. Liu, Michigan State University, Bugwood.org)

Larvae create characteristic serpentine tunnels beneath the bark of their host ash trees (Figure 5). Tunnels curve at near right angles so that the tunnel length, as measured in a straight line from start to end point, is less than half of the actual total tunnel distance through the wood.

EAB larvae (Figure 6) are recognized by their enlarged and flattened pronotum, elongate body shape with abdominal segments one to seven trapezoidal, abdominal segment eight bell-shaped, and the last abdominal segment round with two spines (urogomphi, Figure 7).

Figure 5. Serpentine tunnel created by emerald ash borer larva (G. Fauske, NDSU)

Figure 6. Emerald ash borer larva (Pennsylvania Department of Conservation and Natural Resources – Forestry Archive, Bugwood.org)

Figure 7. Comparison of prepupa of emerald ash borer (left) and red-headed ash borer (right). Circle shows two spines (urogomphi) on emerald ash borer larva (G. Fauske, NDSU)

Table 1. Larvae of ash-boring insects in North Dakota: comparison with emerald ash borer.

Character	Emerald ash borer		Red-headed ash borer	Carpenterworm	Ash/lilac borer	Ash bark beetles
	Larva	Prepupa	Larva	Larva	Larva	Larva
Length (late instar)	0.71 inch (18 mm)	0.51 inch (13 mm)	0.39 inch (10 mm)	3 inches (75 mm)	0.59 inch (15 mm)	0.12 inch (3 mm)
Shape	thin and wormlike	thick and wormlike	thick and wormlike	caterpillarlike	caterpillarlike	grublike
Thoracic legs	absent	absent	present	present	present	absent
Prolegs	absent	absent	absent	present	present	absent
Urogomphi	present	present	absent	absent	absent	absent

Overwintering larvae excavate a deeper chamber at the end of their tunnel and take on a compact appearance, with body segments somewhat telescoped together. At this point, they are called prepupae. A comparison of common wood-boring ash insect larvae is provided in Table 1.

Pupae have the characteristic shape of the adult beetle, with short, serrate antennae and blunt spine at the tip of the last abdominal segment (Figure 8). Newly formed pupae are white.

As the beetle within develops, the pupa takes on the adult form. When the adult emerges, the pupal exuvia (shed skin) remains in the pupal chamber. By contrast, two other common ash-boring insects, ash/lilac borer (*Podosesia syringae*) and carpenterworm (*Prionoxystus robiniae*), have the pupal skin partially or mostly extruded from the adult exit hole. Buprestids of the genus *Agrilus*, such as EAB, leave D-shaped emergence holes (Figure 9).

Figure 8. Emerald ash borer pupa (K. Law, USDA APHIS PPQ, Bugwood.org)

Figure 9. D-shaped emergence hole of emerald ash borer (D. Miller, USDA Forest Service, Bugwood.org)

Life Cycle

The EAB is a holometabolous insect, meaning it undergoes complete metamorphosis. The EAB has four life stages: egg, larva, pupa and adult. The life cycle of the EAB is completed in about one to two years. In northern states, such as North Dakota, larvae are expected to take two years to mature and complete development due to the colder climate and shorter growing season.

Females can lay 60 to 90 eggs in their lifetime. They deposit individual eggs on the bark surface or in bark cracks and crevices from mid-May through July. Eggs hatch one to two weeks later.

Larvae bore into the tree by chewing into the inner bark and cambium, creating serpentine (S-shaped) galleries. Larvae feed during the summer, usually from late June through October. These galleries increase in size as the larvae grow and feed. Larval galleries have been found in trunks and branches measuring as small as 1 inch in diameter.

When EAB larval densities are high, the tree's water and nutrient flow can be interrupted, causing crown dieback and death during a two- to five-year period, depending on the tree's size and relative health.

Larvae overwinter in a small gallery and pupate in early spring (April or May) of the following year. Based on the degree day (DD) accumulations, adults first emerge at 450 to 550 DD (using a base temperature of 50 F or 10 C), which in North Dakota is from mid-June through mid-July. Peak emergence is at 900 to 1,100 DD, from mid- to late July. Research indicates that winter temperatures colder than minus 30 F will cause about 98 percent mortality of EAB larvae. However, larvae found on the south side of trees often were not dead due to heat from sun in winter. In areas with harsh winter climate, the spread of EAB and time it takes to kill a tree is expected to be longer.

Adults live for only three to six weeks and feed on foliage for one to two weeks prior to mating. Foliar feeding by EAB adults causes little damage to the ash tree (Figure 10). They mate and repeat the life cycle.

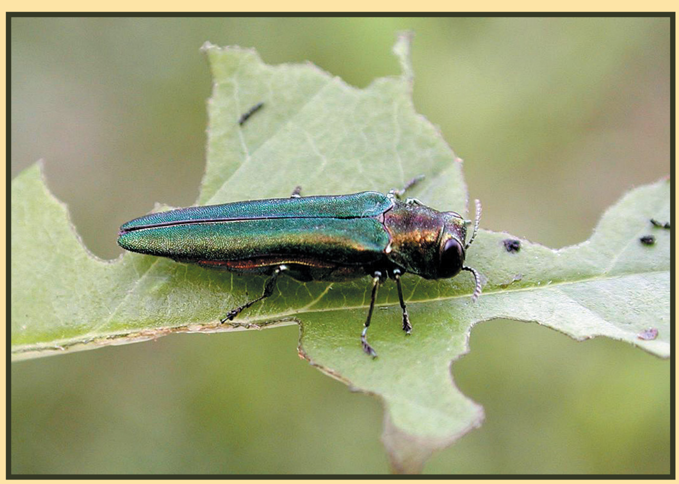

Figure 10. Emerald ash borer adult feeding on an ash leaf (D. Miller, USDA Forest Service, Bugwood.org)

Potential Hosts

Emerald ash borer attacks and kills all of the North American ash species in native woodlands, shelterbelts and urban forests.

In North Dakota, the most common ash species is green ash (*Fraxinus pennsylvanica*, Figure 11). Black ash (*F. nigra*, Figure 12), Manchurian ash (*F. mandshurica*) and white ash (*F. americana*) are uncommon in urban areas; however, these species also are susceptible to EAB, although Manchurian ash does have some level of resistance to this pest.

Note that EAB will infest healthy and unhealthy ash trees, large and small (down to 1 inch or 2.54 centimeters [cm] in diameter), and all of the named cultivars. Mountain-ash (*Sorbus* spp.) is not susceptible to EAB because it is not a true ash tree.

Figure 11. Green ash tree (N.D. Tree Handbook, NDSU)

Figure 12. Black ash tree (N.D. Tree Handbook, NDSU)

Damage

The vast majority of damage comes from feeding by the larvae in the phloem tissue, just under the bark. EAB larval galleries (Figure 13) also can extend into the sapwood. This feeding behavior damages the vascular system of the tree, blocking water and nutrient transport.

Figure 13. Larval galleries of emerald ash borer (S. Katovich, USDA Forest Service, Bugwood.org)

Visible symptoms of damage are dieback of the tree crown (Figure 14) and excessive sprouting (epicormic branches) along the main stem of the tree (Figure 15). However, these symptoms are unlikely to be seen during the first year of infestation. Instead, dieback probably will be observed only in trees that have been infested for three years or longer.

Figure 14. Dieback of tree crown (J. Zeleznik, NDSU)

Figure 15. Epicormic branching from tree attacked by emerald ash borer (Michigan Department of Agriculture, Bugwood.org)

INTEGRATED PEST MANAGEMENT of Emerald Ash Borer

Keep in mind that environmental stress and diseases, such as ash yellows, commonly are responsible for symptoms similar to EAB infestation. Woodpeckers are attracted to EAB-infested trees, and excessive pecking damage by woodpeckers may be another visible symptom of EAB presence (Figure 16).

The potential economic cost incurred by EAB is enormous. The most basic expenses will be those of tree removal and replacement. Finding a **qualified** contractor who holds a North Dakota contractor's license and has **liability insurance** for tree removal is important.

Beyond removal and replacement, the loss of benefits provided by ash trees will be enormous and expensive. Shelterbelts protect farmsteads, fields and livestock from harsh, drying winds in the summer and they capture snow in the winter, acting as living snow fences along highways and around many communities. In urban EAB-infested areas where ash trees have been destroyed, the loss of shade/protection from ash trees has resulted in increased costs associated with summer air conditioning and lawn watering, and home heating in the winter.

Figure 16. Woodpecker damage on emerald ash borer-infested tree (G. Fauske, NDSU)

Integrated pest management involves pest monitoring and the use of multiple control strategies (cultural control, plant resistance, biological control and pesticides) to mitigate losses from insect pests.

Monitoring and Surveying

Several methods are being used in survey efforts for EAB. Large purple prism traps (Figure 17) are used in government-sponsored survey programs for EAB and are very visible to the public in parks and recreation areas.

Prism traps are pre-coated with an insect-trapping adhesive. Lures are attached to the trap and are effective in the field for 20 days as an attractant. The chemical component of the lure has gotten better in recent years but still has room for improvement. Prism traps are hung over sturdy branches in the mid to lower canopy of ash trees of at least 8 inches (20 cm) in diameter before EAB emergence is expected.

Figure 17. Purple prism trap used for surveying for emerald ash borer (K. Law, USDA APHIS PPQ, Bugwood.org)

In addition to the prism traps, girdled "trap trees" also have been used for locating EAB, but this method is time-consuming and, therefore, expensive. Other traps that have been developed included green funnel and prism traps, but these are not widely used in the U.S.

Simple visual monitoring by the general public is also critical because the trapping materials and techniques have not been perfected yet. If you suspect that EAB is in your ash trees, contact one of the organizations listed at the end of this publication.

Cultural Control

One of the main cultural methods for preventing the spread of EAB is **NOT MOVING INFESTED FIREWOOD, LOGS OR NURSERY STOCK** to uninfested areas. Much of the rapid spread of EAB outside of its original detection sites near Detroit, Michigan, was due to direct, human-assisted movement of these products. Larvae of EAB are hidden underneath the bark of living trees or boards cut from infested logs where they can be transported easily into non-EAB-infested areas.

Another cultural control method is **TIMELY REMOVAL OF EAB-INFESTED TREES** and then chipping the trees to a small size - less than 1 inch (2.54 cm) - on each of two sides or burning the trees that were removed. This will kill EAB and help prevent further spread. Many cities are proactively removing and replacing diseased or unhealthy ash trees. This has been done to increase diversity of tree species with new plantings to prepare for the arrival of EAB.

Plant Resistance

In North America, all native species of Fraxinus are susceptible to EAB, although some species are preferred more than others. For example, blue ash (F. quadrangulata) is a less-preferred species. Researchers are identifying and developing ash trees that are genetically resistant against EAB in North America. Current research focus on the the Oregon ash (*F. latifolia*), which has an important niche in the Pacific Northwest forests.

Ash trees in the native range of EAB may be more resistant because their natural defenses have co-evolved throughout time. Researchers have observed that ash trees native to Asia have reduced larval tunneling and only stressed trees (for example, from drought) are colonized. Researchers also are studying Asian ash species as a possible source of resistance genes against EAB. Identification of resistant ash genotypes is important for reforestation and maintaining a market demand for ash in the nursery industry.

INTEGRATED PEST MANAGEMENT of EAB

Biological Control

Biological control involves the use of natural enemies (predators or parasitoids) to control insect pests naturally. Biological control primarily is being targeted at EAB in forests. The EAB has no known predators other than woodpeckers that occasionally feed on larvae and kill about 30 to 50 percent of large EAB larvae.

In 2007, three species of hymenopteran parasitoids (wasps) from China were released for biocontrol of EAB by the U.S. Department of Agriculture (USDA) Forest Service and USDA's Animal Plant Health Inspection Service (APHIS). Two introduced parasitoids, *Spathius agrili* (Braconidae) and *Tetrastichus planipennisi* (Eupelmidae, Figure 18), attack EAB larvae. The other introduced parasitoid, *Oobius agrili* (Encyrtidae), parasitizes EAB eggs. In 2015, an external larval parasitoid, *S. galinae* (Braconidae), was released from Russia.

Two of the released parasitoids, *O. agrili* and *T. planipennisi*, are established and are being widely released. However, *S. agrili* remains unconfirmed in northern areas. *Spathius galinae* does reproduce in northern areas.

In addition, researchers are surveying extensively for indigenous natural enemies of EAB. A native wasp, *Atanycolus* sp. (Braconidae, Figure 19), has been found parasitizing EAB larvae in Michigan. Another native solitary wasp, *Cerceris fumipennis* (Crabronidae), captures buprestid beetles, including EAB, as prey and provisions its ground nest with the beetle prey as food for its developing young. This solitary wasp also is used as a biosurveillance tool for the detection and survey of EAB populations.

Parasitism of EAB eggs by *O. agrili* was observed to be near 22 percent. For *T. planipennisi*, larval parasitism was at 20 percent in young ash trees and 50 to 80 percent in ash saplings, and it is spreading rapidly in all EAB-infested parts of North America. Researchers are optimistic that a combination of introduced and native parasitoids will help reduce EAB densities below a tolerance threshold so that ash trees can survive in the forest ecosystem.

Figure 18. Eulophid wasp, *Tetrastichus planipennisi*, of emerald ash borer (D. Cappaert, Bugwood.org)

Figure 19. Braconid wasp, *Atanycolus cappearti*, of emerald ash borer (D. Cappaert, Bugwood.org)

Insecticide Control

Research has demonstrated that insecticides can protect individual ash trees from EAB effectively. Insecticides are recommended **only** if the EAB infestation is within 15 miles (24 kilometers), or the ash trees are in an EAB-infested (or quarantined) area.

Making insecticide applications when EAB has not been detected in your area is a waste of time and money. Trees that show more than a 40 percent canopy decline are not likely to recover from EAB damage and should not be treated with insecticides. The guidelines in the position statement by the North Dakota Department of Agriculture, North Dakota Forest Service and NDSU Extension Service on the use of insecticide treatment for EAB should be followed. Visit the following website for the position statement:

www.ndda.nd.gov/eab

Four types of insecticide applications are available for controlling existing infestations and/or preventing EAB infestations (Table 2):

- Soil-applied systemic insecticides
- Trunk-injected systemic insecticides
- Basal trunk sprays of systemic insecticides
- Broadcast foliar sprays applied to trunk, main branches and foliage

Results of efficacy testing are available at www.emeraldashborer.info. The insecticides available for the homeowner are limited, so tree care professionals may be needed for the application of insecticidal control of EAB.

When using any pesticide, remember to **ALWAYS READ, UNDERSTAND AND FOLLOW ALL CURRENT LABEL DIRECTIONS.**

Soil-applied Systemic Insecticides

Systemic insecticides are applied to the soil as a drench or through an injection technique, absorbed by the roots and then translocated throughout the tree.

The best timing for soil injection and drenches is likely early to mid-May in North Dakota. A fall application also can be made as an alternative timing, but generally is not as effective.

Insecticide uptake and translocation may take up to four to six weeks in trees with trunks smaller than 12 inches (30.5 cm) diameter. Larger trees with trunks greater than 12 inches (30.5 cm) in diameter require more time for uptake, so treatment should be initiated earlier.

Application Method	Active Ingredient	Example of Trade Name(s)	Professional (P) or Homeowner (H) Use	Life Stage L - larvae A - adult
Soil-applied systemic	imidacloprid	Bioadvanced – Tree and Shrub Protect	P or H	L
	imidacloprid	Bonide – Tree & Shrub Insect Control	P or H	L
	imidacloprid	Compare & Save – Tree & Shrub Drench	P or H	L
	imidacloprid	Fertilome – Tree & Shrub Drench	P or H	L
	imidacloprid	Imidashot DF	P or H	L
	imidacloprid	Merit (75WP, 75WSP, 2F)	P or H	L
	imidacloprid	Xytect (2F,75WSP)	P or H	L
	dinotefuran	Safari 20 SG	P	L
	dinotefuran	Zylam Liquid Systemic	P or H	L
	dinotefuran	Transtect 70WSP	P or H	L or A
Trunk injection	emamectin benzoate	Tree-Äge G4, Tree-Äge R10	P	L or A
	emamectin benzoate	Tree-Äge	P or H	L or A
	emamectin benzoate	Mectinite	P or H	L or A
	emamectin benzoate	Arbormectin	P or H	L or A
	imidacloprid	IMA-jet 10	P or H	L or A
Trunk injection	dinotefuran	Safari 20 SG	P	L or A
Systemic trunk spray	dinotefuran	Zylam Liquid Systemic	P or H	L or A
	dinotefuran	Transtect 70WSP	P or H	L or A

Table 2. Insecticides registered in North Dakota for control of emerald ash borer by professionals and homeowners.

Larger trees also may require two different treatment techniques for effective EAB control. Homeowners trying to treat trees larger than 15 inches (38 cm) in diameter should consider having a professional treat their trees because higher rates and multiple applications may be necessary for effective EAB control.

For soil drenches, only a bucket or watering can is needed for application. Any mulch or leaf debris should be removed before applying the soil drench because imidacloprid binds to organic materials.

Soil injections place the insecticide near the root zone 2 to 4 inches (5 to 10 cm) below the soil surface and about 18 inches (46 cm) from the trunk near the highest density of tree roots. Specialized equipment is needed to perform soil injections, and applications primarily are conducted by professionals.

Soil drenches/injections should be applied when soils are moist but not saturated or extremely dry. When droughty, water the soil around the base of the tree prior to application.

Although soil-applied systemic insecticides have demonstrated effective control of EAB in some studies, results have been inconsistent. Some university studies of soil-applied systemic insecticide have shown poor control due to differences in pest pressures, tree sizes and other conditions in field.

Trunk-injected Systemic Insecticides

Trunk injections are available for use by tree professionals and homeowners (most products), (Figure 20 and 21).

Trunk-injected insecticides are used frequently in situations in which soil treatments are not practical due to saturated soil conditions, porous sandy soils or other sensitive environments.

The recommended treatment timing is when the ash leaves are starting to emerge but before EAB eggs hatch, usually mid-May to mid-June. Although trunk injections are absorbed quicker than soil treatments, they still require three to four weeks to translocate throughout the tree.

Trunk injections should be performed when temperatures are not hot (greater than 90 F or 37 C) and soil conditions are not dry. Morning is typically the best application time.

One of the negatives of using this technique is that it wounds the tree, which can affect the tree's long-term health. However, researchers found that a single injection of emamectin benzoate applied mid-May or early June provided excellent (greater than 99 percent) control of EAB for at least two years, even under high pest pressures.

Imidacloprid trunk injections resulted in less insect mortality and varying degrees of EAB control. Overall, trunk-injected emamectin benzoate provided the highest level of EAB control when compared with other insecticide products and application techniques.

Figure 20. Trunk injection for control of emerald ash borer
(D. Cappaert, Bugwood.org)

Figure 21. Mauget capsule injection for control of emerald ash borer
(D. Cappaert, Bugwood.org)

Basal Trunk Sprays of Systemic Insecticides

Dinotefuran, a systemic insecticide, is labeled for bark sprays for control of larval or adult stages of EAB. Applications are made to the lower 5 to 6 feet of the trunk using a regular garden sprayer. Dinotefuran penetrates the bark and then is translocated throughout the tree.

Studies found that efficacy of basal trunk sprays of dinotefuran were variable and similar to trunk-injected imidacloprid. Efficacy was better and control was more consistent on smaller trees than on larger trees.

Broadcast Sprays Applied to Trunk, Main Branches and Foliage

Insecticides can be sprayed on the trunks, branches and foliage to kill EAB adults as they feed on foliage and newly hatched EAB larvae before they bore into the tree. This technique does not kill larvae already feeding internally in the tree.

Broadcast sprays are generally NOT recommended because of low efficacy and toxicity to beneficial insects, including pollinators, parasitic wasps and predators.

What to Do if You Suspect EAB

If you suspect that your ash trees are infested with EAB, official confirmation is critical. Individuals from the following organizations or agencies are able to help you determine if EAB is infesting trees:

North Dakota Forest Service
701-231-5138

North Dakota Department of Agriculture
701-328-4765 or 701-220-0485

NDSU Extension
701-231-8143

NDSU Plant Diagnostic Laboratory
701-231-7854

Local city forester

Local county Extension agent

Note that other insect pests, diseases or stresses can cause dieback of tree crowns and sprouting along the main stem. True confirmation of EAB can come only by locating insects and having them identified by experts. Suspected larvae and adults of EAB will be forwarded from the North Dakota Department of Agriculture to experts at the USDA-APHIS for official confirmation.

For additional information on EAB, visit the following:

Websites:

www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/emerald-ash-borer

www.emeraldashborer.info

www.ndda.nd.gov/eab

www.dontmovefirewood.org/

www.ndda.nd.gov/firewood

www.hungrypests.org

www.pesttracker.org/pest/inahqja

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