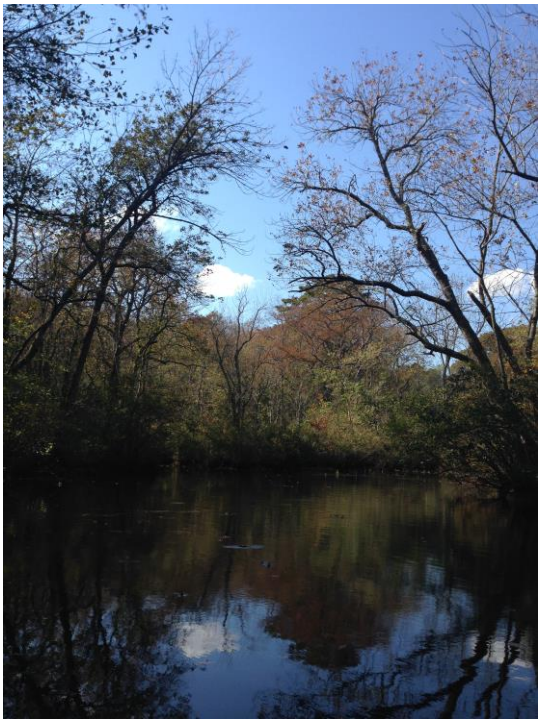
Maryland Protected Lands Plan

For the Management of
Emerald Ash Borer



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MARYLAND DEPARTMENT OF NATURAL RESOURCES

MARYLAND FOREST SERVICE

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EXECUTIVE SUMMARY

The emerald ash borer (EAB) has spread across the Western Shore and parts of the Eastern Shore of Maryland, since its discovery in Prince George's County in 2003. When ash trees become infested with EAB, they rapidly deteriorate and may snap, presenting a public safety hazard. Additionally, EAB presents a serious threat to some native ecosystems, affecting rare ash species and riparian forests. Maryland's protected lands represent important green infrastructure, while also receiving thousands of visitors each year. This plan outlines response measures for protecting against safety and ecological threats on the state's protected lands.

Assessment

To most effectively protect against public safety hazards, ash trees should be surveyed around developed areas on protected lands, where there is the greatest risk of injury due to falling trees. Areas with ecologically significant ash such as rare species, extensive ash stands, or riparian ash stands may also be inventoried.

Management

Management options for ash trees include biological control ("biocontrol"), silviculture, chemical treatment, removal, and replacement. Biocontrol efforts are carried out by the Maryland Department of Agriculture and are a potential tool in natural stands. Silviculture can improve stand health and reduce ash components in forests. Chemical treatment can be used for selective preservation of specimen ash trees. Trees that will not be treated but present a risk to public safety should be prioritized for removal. Where trees are removed or have died, replacement with a diversity of species will aid in better resilience to future health threats and maintain important canopy cover benefits.

Statewide Strategy

Maryland will pursue short term protection of specimen and seed trees through chemical treatment, with removals and replacements to mitigate safety hazards and maintain tree canopy cover. Long term efforts include biocontrol releases, integrated pest management approaches, contribution to genetic research including seed collection and lingering ash monitoring, and research on long term ecological impacts in wetland and upland ash forests.

PURPOSE STATEMENT

The purpose of this plan is to assist land managers across Maryland with planning for and managing EAB, to mitigate threats to public safety and ecosystem health. It lays out the strategy for Maryland Department of Natural Resources lands, and may help to provide guidance for management on federal, private, or other protected lands.

INTRODUCTION

Emerald Ash Borer Overview

Problem

Emerald ash borer (EAB), *Agrilus planipennis*, is a non-native, invasive, wood-boring beetle from Asia. It was first found in Michigan in 2002, and has since moved across the country, killing millions of ash trees (1). EAB girdles and kills all species of native ash trees by feeding on the phloem of the infested tree. Ash trees are typically infested for several years before they begin to show visible symptoms, but generally die within 2-3 years following the first outward signs of EAB (2). EAB is expected to cause close to 100% mortality in native ash trees unless treated with insecticides (3, 4).

Ash trees are a critical part of many healthy forests and communities. In addition to providing food for birds and mammals, ash trees are also the obligate host for 17 invertebrate species in Maryland (5). Ash trees are a common ornamental and shade tree, reducing energy costs in urban communities. Maryland's ash species primarily grow in riparian areas, where they filter sediment, nutrients, and pollutants from streams and rivers. Maryland has five species of native ash, including rare species and those in rare community types. The widespread mortality of ash trees at the hands of EAB could constitute a great loss for wildlife, urban communities, water quality, and biodiversity in Maryland.

Biology

The primary damage caused by EAB occurs in its larval stage, when it feeds on the phloem of ash trees, generally throughout the summer and fall. EAB follows a one or two-year life cycle, either overwintering under the bark of ash trees and pupating the following spring, or overwintering and maturing for two years prior to pupation. In Maryland, the beetles generally emerge from ash trees as adults beginning in May, but may continue to emerge through early summer. Following emergence, adults feed on ash leaves and mate. Females lay their eggs in bark crevices and between bark layers. When the eggs hatch, larvae immediately bore into trees, where the feeding and maturation process begins once more. Eggs hatch and begin boring approximately 4-6 weeks after adult emergence.

Status

EAB was first found in Maryland in Prince George's County in 2003. The Maryland Department of Agriculture and the Maryland Forest Service, with assistance from the US Department of Agriculture, attempted to eradicate EAB from the state. After removing over 40,000 ash trees, the beetle continued to spread throughout the state, and the regulatory focus switched from eradication to containment.

While EAB adults can fly up to 2-3 miles, the primary form of spread is human-assisted movement of infested wood products, including firewood. To combat the spread of EAB, the US Department of Agriculture has issued a federal quarantine restricting the movement of ash nursery stock, ash woody debris or green lumber, ash wood chips, and any species of hardwood firewood. The entire state of Maryland is under the federal quarantine. Ash products may be moved within the state and into neighboring states within the quarantine boundaries, but not across the quarantine boundary. Some states under the quarantine may have additional requirements for moving ash products, so individual states should be consulted if moving products across state lines.

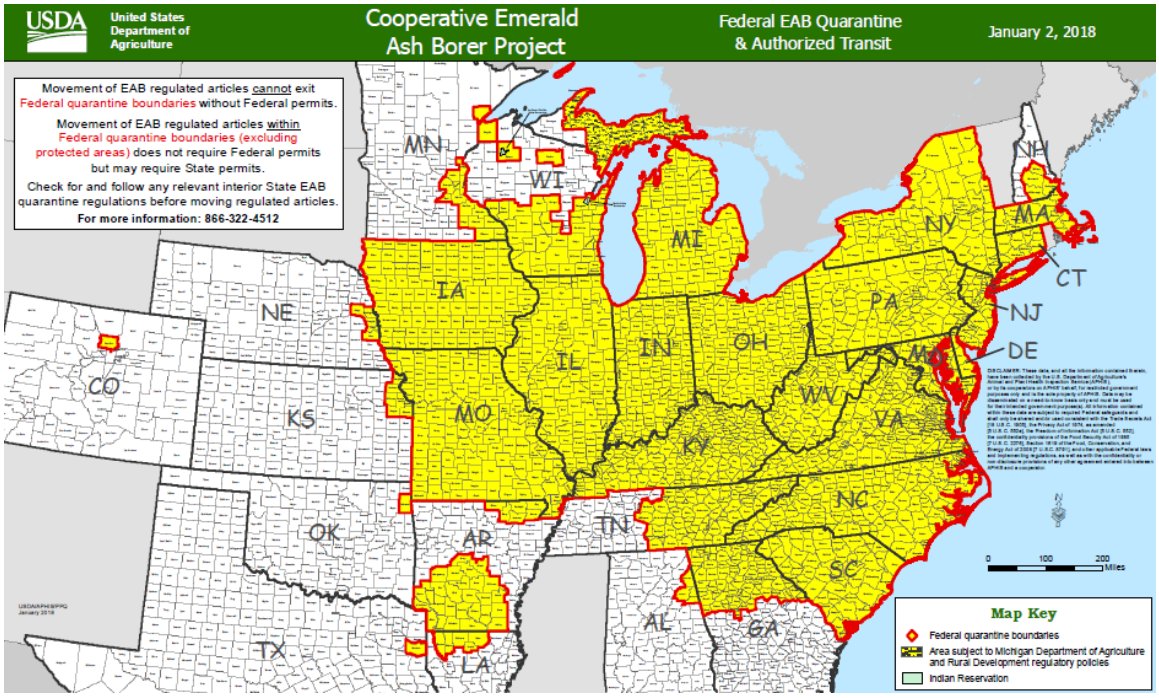


Figure 1. USDA Federal EAB Quarantine Map as of January 2, 2018 (6).

Ash Trees in Maryland

Ash trees (*Fraxinus spp*.) generally make up a modest component of Maryland's forests, averaging about 2% of the total volume of trees greater than 5 inches in diameter (7). However, there are some pockets of more dense cover. For example, on Maryland's Eastern Shore, the headwaters of rivers including the Nanticoke and Pocomoke contain stands composed of 50-100% ash trees of various species (8).

The majority of ash trees in Maryland are white ash (*Fraxinus americana*) and green ash (*Fraxinus pennsylvanica*). Maryland is also home to rare ash species: in Western Maryland, black ash (*Fraxinus nigra*) grows in several Montane-Piedmont basic seepage swamps, pumpkin ash (*Fraxinus profunda*) grows in forested wetlands and swamps on the Eastern Shore and in Southern MD, and small pockets of Carolina ash grow on the lower Eastern Shore (*Fraxinus caroliniana*) (9, 10).

Protected Lands Characterization

Maryland's protected lands include local, state, federal, and private properties and easements. Of this, the Department of Natural Resources manages over 480,000 acres including state parks, state forests, wildlife and fishery management areas, and other property types, the majority of which are forested (11).

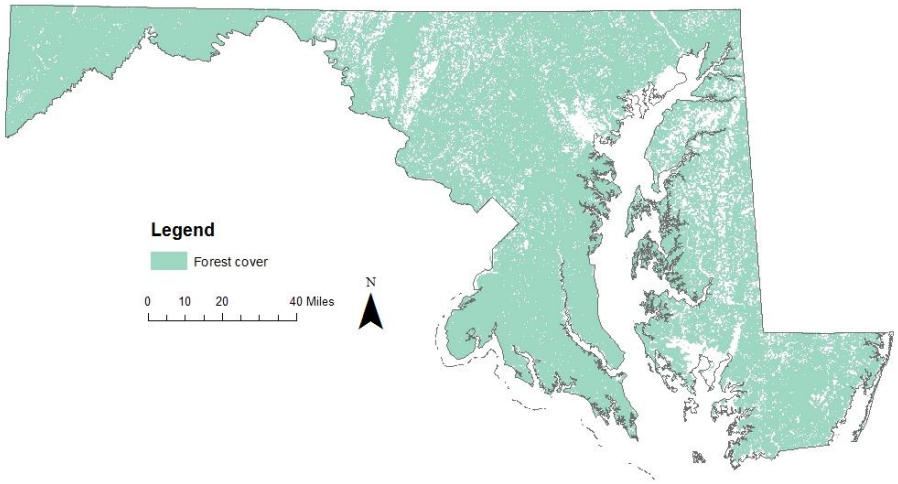


Figure 2. Maryland's forest cover at 10m resolution (12).

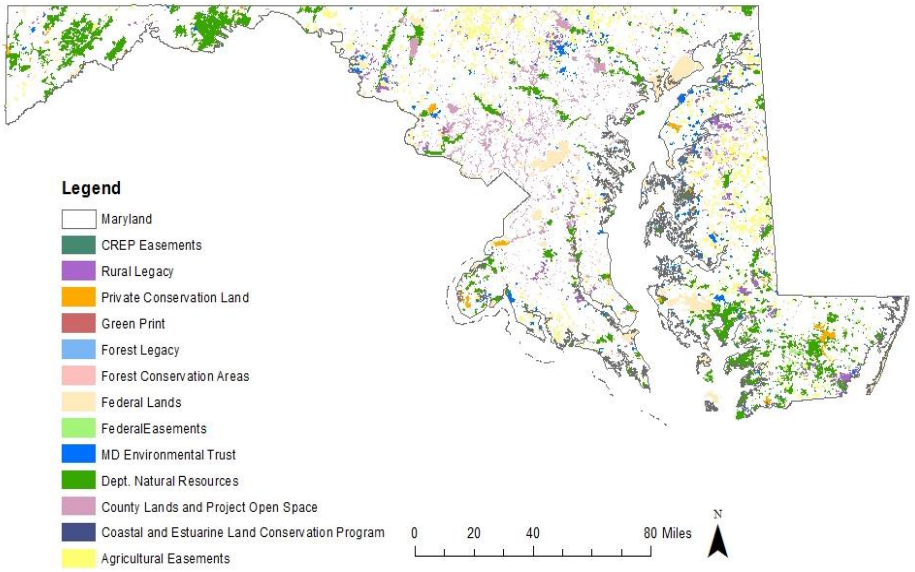


Figure 3. Maryland's protected lands (13-26).

PARTICIPATING UNITS AND RESPECTIVE ROLES

EAB management on protected lands will involve input from several agencies, each with their own authorities and expertise. Management on protected lands will primarily involve the Maryland Department of Agriculture, Maryland Department of Natural Resources, and University of Maryland Extension and Entomology. Non-state-owned land management entities may also use this plan as a tool for guiding management. The major roles for implementing the protected lands plan are as follows:

Maryland Department of Agriculture (MDA)

MDA is the primary state agency that handles regulation and quarantines of forest pests, pest control, and pesticide application. Its primary roles in EAB response on protected lands include the following:

a) Conduct biocontrol releases for the control of EAB, coordinating with federal partners.

b) Carry out surveys for the detection and delineation of EAB populations.

c) Coordinate with US Department of Agriculture- Animal and Plant Health Inspection Service (APHIS), the lead federal plant pest regulatory agency.

d) Review and coordinate chemical and biological control activities that meet federal, state, and local laws.

e) Provide guidance and expertise on EAB treatment activities across protected lands.

Maryland Department of Natural Resources- Forest Service (MFS)

MFS is responsible for the management of State Forests, and the lead state agency offering expertise in forest management.

a) Offer technical assistance on ash inventory and other planning activities.

b) Offer management advice for responding to EAB.

c) Coordinate response efforts between MDA, Wildlife and Heritage Service, and Park Service staff.

d) Identify priority areas for ash management on Forest Service lands.

e) Carry out management activities for EAB on Forest Service lands.

Maryland Department of Natural Resources- Wildlife and Heritage Service (WHS)

WHS is the primary state agency involved in the protection of rare and endangered populations in Maryland, including populations threatened by invasive species.

a) Identify areas with rare or threatened ash species across the state.

b) Coordinate seed collection efforts with regional seed banks including the Mid-Atlantic seed bank.

c) Manage the state's Wildlife Management Areas, including the coordination of ash management activities occurring on these lands.

Maryland Department of Natural Resources- Park Service (MPS)

MPS manages state lands including state parks, natural environmental areas, natural resources management areas, rail trails, and state battlefields.

a) Identify priority areas for ash management on Park Service land.

b) Implement management plans, including inventory, treatments, and removals, on Park Service lands.

c) Coordinate with the Maryland Conservation Corps to assist with EAB management activities, where applicable.

University of Maryland (UMD)

University of Maryland Extension offers expertise in education and outreach, while researchers in the Department of Entomology conduct biocontrol activities and monitoring.

a) Coordinate with state agencies and private groups to increase public awareness of EAB.

b) Provide educational outlets for information on EAB management through workshops, webinars, and other media.

c) Assist with identification and detection of EAB.

d) Research and monitor biocontrol efforts in coordination with MDA and US Department of Agriculture- Agricultural Research Service.

US Department of Agriculture- Agricultural Research Service (ARS)

ARS conducts research on agricultural problems across the country. This includes the Beneficial Insects Lab in Newark, DE, which leads research on current and potential biological control species.

a) Partner with MDA and UMD to conduct biocontrol releases and follow-up monitoring and research.

Non-State Land Management Groups

Non-state-owned protected lands include federal easements and parks, county protected lands, and private conservation areas, among others. These lands may include extensive ash stands and rare species, and provide recreational and educational opportunities for visitors. This plan may serve as a tool for these areas to:

a) Identify priority areas for management.

b) Develop management plans and implement management activities

MANAGEMENT OBJECTIVES

Public Safety

The girdling action of EAB causes ash trees to decline and deteriorate rapidly following infestation. Infested trees become prone to breaking and become a hazard near structures, roads, wires, or other high-traffic areas. In some protected areas, the primary management objective is to protect against this public safety threat. Targeting management activities in high traffic areas will maximize protection from public safety threats due to EAB.

Ecological Benefit

EAB threatens the ecological services provided by ash trees in urban, rural, and riparian forests. Preserving the ecological benefits provided by ash may be the primary management objective on some protected lands, and will help to guide management activities. Targeted management for rare species of ash, large trees, extensive ash stands, or ash growing in riparian buffers will maximize the ecological benefit of management activities.

INVENTORY AND ASSESSMENT

Inventories should be conducted as the first step towards developing a management plan. Inventories should include a basic assessment of the location, number, and condition of ash trees, as well as any additional factors necessary for making management decisions. The design for the inventory can best be guided by the two primary management objectives: protecting public safety and ecological benefits. Following inventory, the data collected can be used to develop management plans.

Public Safety

Focus Areas:

Inventories to assess ash should focus on areas with the potential for public safety hazards. These include parking lots, picnic areas, playgrounds, campgrounds, or other high traffic areas in protected lands. On Maryland Park Service land, existing hazard tree information may be helpful for establishing the location of dangerous ash trees in high traffic areas.

Methods:

Inventories are best conducted in a 75 ft buffer, or greater, around high traffic areas. Inventories of high use areas should include for each ash tree, at a minimum:

a) Location

b) Species

c) Diameter at breast height (dbh)

d) Condition

e) Additional factors such as tree height, potential targets, wire conflicts, signs of EAB presence, or other helpful notes for determining management approaches

An example inventory data collection sheet is attached in Appendix II.

Ecological Benefits

Focus Areas:

Ash trees which provide particular ecological benefits should be identified and assessed. These include rare species, large trees, extensive stands, or trees delivering an important ecological service, such as riparian area canopy cover and bank stabilization. Information from the DNR WHS Natural Heritage Community dataset may be helpful for identifying areas containing priority trees.

Methods:

Ecological priority trees should be identified and inventoried where they coincide with assessments for public safety. Additional ecologically significant ash should be inventoried, collecting the same basic data as listed above. In extensive ash stands, forest plot sampling may be a useful tool for inventory design, with locations of plots established randomly or systematically throughout an area.

MANAGEMENT OPTIONS

Biological Control

Background

Biological control, or "biocontrol," is a system that manages pest populations using a pest's natural enemies. Several natural enemies exist in EAB's native habitat in China and Russia. The U.S. Department of Agriculture has approved the release of four species of parasitoid wasps as biocontrol agents in the U.S.: *Oobius agrili*, *Spathias agrili*, *Spathius galinae*, and *Tetrastrichus planipennisi*. These wasps have co-evolved with EAB to effectively parasitize and kill the beetles at its various lifestages. *O. agrili* parasitizes EAB at its egg stage, while *S. agrili*, *S. galinae*, and *T. planipennisi* parasitize EAB at its larval stage.

The Maryland Department of Agriculture conducts releases of parasitoid wasps across Maryland, with follow-up studies conducted by the University of Maryland-Department of Entomology to establish the success of parasitoid survival and spread.

Use as a Management Tool

Biocontrol may be a useful tool in extensive ash stands, or areas where treatment is infeasible due terrain or management constraints. In areas such as inundated wetlands, where terrain poses a challenge to chemical treatment, biocontrol releases could be conducted to maintain healthy riparian forest function. Because Maryland's rare ash species tend to grow in riparian areas, biocontrol may also be a tool for protecting rare species.

Biocontrol populations are not yet well-established enough in Maryland to be used as a stand-alone method for protecting ash trees. Where biocontrol releases are planned, they may be coupled with treatments to protect select trees that are important for public safety, ecological function, or the preservation of future ash seed source.

Site Selection

To conduct a bio-control release, several site requirements should be met to encourage the success of the release. Potential sites should be:

a. Natural, wooded areas with no plan to harvest or develop within 5 years

b. 40 acres or larger

c. 25% or greater ash

d. Various ash tree size classes

e. In the early stages of infestation, with low to moderate levels of EAB population (27).

Silviculture

Silviculture can be a useful tool for capturing the timber value of ash trees, encouraging healthy tree regeneration, and creating conditions for healthy and diverse stands in the future. Stand improvements, such as thinnings, can improve tree vigor and make ash more resilient to stress from EAB. However, even healthy trees will eventually succumb to EAB during the initial wave of the infestation. Therefore, silvicultural practices may be used to reduce the ash component and increase species diversity prior to, or during, an infestation. The following are general guidelines for applying silvicultural treatments to ash stands:

a) If a stand is 10-100% ash, reduce the ash component through a pre-salvage or salvage harvest, where feasible, but maintain some trees for future seed source (<10% basal area).

b) If a stand is 10-100% ash and a harvest is not feasible, reduce the ash basal area prior to infestation to diversify the stand. This step will not be necessary once a stand becomes infested.

c) Encourage the regeneration of other species or replant where natural regeneration is not present.

d) Control invasive plants to ensure the success of native regeneration in gaps created by harvesting or mortality.

e) Maintain riparian buffers and follow forest buffer BMP's. Underplanting in riparian ash stands may help to maintain cover as ash trees die.

Chemical treatment

Chemicals and Application Methods

Several chemicals are used for the protection of ash trees against EAB: Emamectin benzoate, imidacloprid, dinotefuran, and azadirachtin. Emamectin benzoate has a 2-5 year residual in ash trees, and is applied as a trunk injection. While EAB populations are high across the state, the recommended treatment interval is every 2 years. Emamectin benzoate provides close to 100% protection of healthy ash trees, and is the most effective treatment method currently known for EAB (28). Imidacloprid has a one-year residual and may be applied as a trunk injection, soil injection, or soil drench. Dinotefuran also has a one year residual and may

be applied as a bark spray, soil injection, or soil drench. Azadirachtin has a 1-2 year residual and is applied as a trunk injection. Treatments may be conducted by licensed pesticide applicators.

The environmental impacts of these chemical treatments will be minimized with the use of trunk injections. Trunk injections place chemicals directly into the trunk of the tree, limiting the risk of contamination of soil and groundwater, nearby plants, and aquatic habitat. Because of the high cost to perform treatments (approximately $10/diameter inch), the goal for chemical treatments is to maximize effectiveness while minimizing off-target impacts. Trunk injections of emamectin benzoate are the recommended treatment option, offering the most effective control of EAB and limited contamination risk. In the riparian zones around any body of water, trunk injections will be the only method of pesticide application. The use of soil treatments will be avoided in all riparian areas.

Timing

Trees should be treated when EAB has been confirmed within 10-15 miles of a site, indicating that EAB will soon be, or may already be, present at the site (29). The 10-15 mile zone currently covers nearly the entirety of Maryland. Treatments should begin for any ash trees that have been selected for preservation in Maryland.

The preferred time of year to treat trees is in the spring, before adult EAB emergence. When treating with trunk injections of emamectin benzoate, the ideal time for treatment is mid-May to mid-June (29). Treatments occur most efficiently in mid-morning, when tree respiration is at its peak, and at periods with moderate temperature and soil moisture. If necessary, summer and fall treatments may be conducted. However, these treatments will fail to kill the current year's adult cohort before it lays its eggs. Treatments are also less effective during periods of drought, high heat, or dormancy.

If conducting a soil, bark, or foliar treatment, treatments should be conducted when there is no rain in the forecast. Rain will increase the likelihood of runoff, which could contaminate the area and decrease the amount of chemical taken up by the tree.

Tree Selection

Cost limitations make the treatment of entire ash stands infeasible. Individual trees should be selected for preservation, incorporating public safety interests and environmental benefits, according to management objectives. Where significant girdling from EAB has occurred, treatments may not be sufficient to save ash trees. Therefore, trees with greater than approximately 30% crown dieback should not be treated. To assist with prioritizing trees for treatment, consider the following elements:

a) Tree condition- full crown and few defects

b) Safety impact- trees within 75ft of high traffic areas

c) Environmental impact- riparian areas, seed source, or other factors

d) Size- large trees

e) Location- prominent

f) Special character- special historical, cultural, or aesthetic value

g) Rare species- black, pumpkin, or Carolina ash

h) Land manager preference

When inventorying a large number of trees, it may be helpful to assign a priority ranking for treatment to each tree. For example, a Priority 1 through 4 system may be used:

Priority 1: “Most important for treatment.” Excellent condition, prominent visitor location with high potential safety impact or particularly important value in natural areas (rare species, specimen/champion tree, etc.), and generally among the largest trees.

Priority 2: “Good additional trees to treat.” Good condition, less prominent visitor locations or lower potential safety impact, important ecosystem value, large trees.

Priority 3: “Trees to treat as funding or time allows.” Good condition with minimal form defects, less prominent visitor locations or lower potential safety impact, important ecosystem value in natural areas where other trees have already been chosen for treatment, and smaller but still sizeable (greater than about 10” dbh, depending on habitat).

Priority 4: “Do not treat.” Defects or wounds, low visitor or ecosystem value, small trees (less than about 10” dbh, depending on habitat).

Treatment for Visitor Safety

In areas where management objectives include maximizing public safety, treatments should be prioritized in areas where visitors remain stationary. The following is a general guideline for prioritizing treatment areas:

Priority 1) Campgrounds

Priority 2) Picnic areas

Priority 3) Buildings

Priority 4) Parking lots

Priority 5) Trails and roads

Treatment for Seed Source Protection

In natural areas containing ecologically important ash stands, treatments should be conducted to protect a future seed source for the area. Trees should be treated in clusters at a sex ratio of about 5 females: 1 male. The selected trees should be mature, dominant, and in good condition. For individually important trees such as champion or specimen trees, this seed source protection approach may not be necessary.

Data Collection

Where treatment occurs, a record of the data should be kept by the land manager, and a copy submitted to MFS to begin building a statewide database of ash treatment activities. A sample treatment data collection sheet can be found in Appendix III. At a minimum, the following should be collected for all treatments:

a. County

b. Site name

c. GPS location (latitude and longitude)

d. Species

e. Diameter

f. Tree condition

g. Date of treatment

h. Treatment material or chemical

i. EPA regulation #

j. Amount of chemical applied

k. Contact information for landowner/ land manager

Removal

Tree removals should be conducted where dead or dying trees pose a threat to public safety. Removals will be most necessary in the 75 foot buffer surrounding developed areas. Because of the potential for widespread mortality and decay, removals should begin promptly. This will allow land managers to schedule removals over time, decreasing the burden on budgets and staff time. Prompt removal will also prevent trees in poor condition from decaying and increasing the public safety hazard. Ash trees should be monitored regularly for decline, to minimize future risks to public safety.

To prioritize ash removals over time, criteria may be used to rank the necessity of removal:

Priority 1) Current hazard trees in developed areas.

Priority 2) Trees showing signs of EAB damage or other defects, which will increase the likelihood of future failure.

Priority 3) Other ash trees around high risk targets that will not be treated.

Replacement with Alternative Species

Approach

Where ash trees are removed or die from EAB, replacement will maintain the aesthetic and ecological value of our tree canopy. Replacement plantings should include a diversity of species so that future tree canopies are resilient to forest health threats, including future pests such as Asian longhorned beetle. Replanting could be useful in developed areas with sparse tree cover, riparian buffers, and stands with a high percentage of ash. Where natural regeneration of other tree species is present, replanting may not be necessary. Planting plans should go through the standard Stewardship Review Process to address any site-specific requirements or concerns.

Where trees are removed within the Critical Area, including within the Critical Area Buffer, they should be replaced with native species at a 1:1 ratio, according to Critical Area regulations.

Replacement may be done proactively through underplanting: a process in which trees are planted under ash canopies that will not receive treatment. As the ash canopy dies, regeneration will already be present. Underplanting could be particularly useful in riparian buffers to ensure that buffers are not lost with ash tree mortality.

Invasive Plant Control

As the ash trees in the canopy die, they will allow more light into the forest understory. This could create a favorable environment for invasive plant establishment. In areas with significant ash cover, planting or natural regeneration should be coupled with invasive plant control to ensure the survival of native trees.

Species Selection

When planting trees, consideration should be made to select appropriate species for site conditions, including soil moisture, sunlight, and future conflicts with wires or structures. Species should be planted where they are found naturally. Questions on natural distribution may be directed to WHS. Table 1 provides a list of potential replacement trees for several habitat types.

Species	**Stream Edge**	**Wetland**	**Woodland**	**Lawn**
Dutch elm disease resistant elms	X	X	X	X
Black gum		X	X	X
Hackberry	X		X	X
Overcup oak	X	X		X
Atlantic white cedar		X		
Tulip/Yellow poplar			X	X
Beech			X	X
Bald cypress	X	X	X	X
Swamp white oak	X	X	X	X
Swamp chestnut oak	X	X	X	X
Sycamore	X	X	X	X
Willow oak	X		X	X
Persimmon			X	
Sweet gum	X	X	X	X

Red maple	X	X	X	X
River birch	X			X
American linden			X	X
Sugar maple			X	X
Black walnut	X			
Red oak			X	X
Pin oak	X		X	X
White oak				X
American hornbeam			X	X

Table 1. List of potential replacement species by appropriate habitat type. "X" denotes site suitability (30, 31, 32).

MONITORING

Treatment and Removal

Treated trees should be monitored annually to establish the effectiveness of treatments. If trees decline despite treatment, removal and replacement may be required. All ash trees in high-use visitor areas should be continually monitored for decline and potential safety hazards. Ash trees in decline may become most noticeable in the spring, if they fail to leaf out.

Lingering Ash

Following the first wave of peak infestation by EAB, most untreated mature ash trees will die. However, in some stands, a few "lingering ash" have survived attack. Research is being conducted on these surviving trees to understand possible genetic or environmental causes for their resistance to EAB. To be considered a "lingering ash," surviving ash trees must be greater than 10 cm dbh (about 4 inches) in stands with greater than 95% mortality due to EAB. Ash stands should be periodically monitored, and any lingering ash should be reported to MFS for coordination of further research.

MARYLAND STATEWIDE STRATEGY

Short Term Management

Chemical Treatment

Chemical treatments are the preferred option for providing short term protection for ash trees across the state.

- **Treatment stages**

In areas with visitor safety concerns, such as State Parks, the first priority for treatment will include trees in high-use visitor areas. Upon further funding, treatments could include trails and roads, or ecologically significant trees in natural areas.

In areas where the primary objective is the protection of ecologically significant ash trees, the first priority for treatments are significant trees located in high-use visitor areas. Additional treatments should target extensive, riparian, or rare species stands, protecting specimen trees and future seed sources.

- **Funding**

  Limited funding has been secured through MFS for treatments on protected lands through 2019, through the US Forest Service Cooperative Forest Health Program and a Northeastern Area State and Private Forestry Landscape Scale Restoration grant. Funding will require 50/50 match from participating protected land groups.

Removal

To minimize potential public safety concerns, managers of protected lands will continue to assess both treated and untreated ash trees in visitor areas, particularly within 75 ft of amenities. Ash trees posing current or potential hazards will be removed in a timely manner.

Replacement

Where ash trees are removed, protected lands will seek to replace them with a diversity of species through natural regeneration and plantings, as required. In all areas where plantings occur, efforts should be taken to control impacts from deer and invasive plants.

Long Term Management

Biocontrol

Biocontrol is the primary long term approach for the management of EAB. MDA conducts biocontrol releases, partnering with DNR, UMD, and ARS. MDA will conduct annual releases of approved biocontrol species, with follow-up monitoring to evaluate spread, parasitism rate, and the role of natural predators. An MOU will be established between MDA and DNR, to allow timely releases of biocontrol agents on state lands.

Integrated Pest Management (IPM)

An IPM approach is being tested on protected lands combining paired treatment of larger specimen trees with biocontrol releases. This approach is being tested to establish the effects of maintaining seed source trees in the near term, while promoting long term protection from EAB through biocontrol parasitism.

Genetic Research

MD will participate in seed collection and lingering ash research, to contribute to long term restoration efforts. MFS will coordinate with other DNR agencies, MDA, ARS, and the US Forest Service on ash seed collection, with particular emphasis on collections from MD's rare species. MFS will also work to identify any lingering ash, coordinating with work in State Parks and other protected lands. If found, MFS will coordinate with MDA and researchers at APHIS, US Forest

Service, and universities including Ohio State University to distribute information for follow-up research.

Ecological Research

MD will work with researchers to investigate the long-term ecological impacts of EAB. Andrew Baldwin at University of Maryland is conducting a wetland ecology study, and Smithsonian Environmental Research Center is monitoring ecological changes in upland ash stands. Results from these studies will inform long term management and restoration in ash stands.

Timeline

- December 2015- draft Protected Lands Plan
- January/February 2016- establish treatment plans for MPS and a list of potential biocontrol release sites for Spring and Summer 2016
- May 2016- conduct treatments in Southern, Central, and Western MPS regions
- June 2016- conduct biocontrol releases in state parks and other protected lands, as specimens become available
- January/February 2017- Establish treatment plans for MPS for Spring 2017
- May 2017- conduct treatments in Eastern MPS region, and remaining areas in Southern, Central, and Western regions
- June 2017- conduct a second round of biocontrol releases on selected sites, with follow-up monitoring
- January 2018- finalize Protected Lands Plan

Treatments will be continued every 2-3 years until the initial wave of EAB mortality has passed After approximately 10 years, treatments may be spaced out to every 5 years, with annual monitoring between treatments. Biocontrol releases will be conducted for 3 consecutive years at each site, followed by new sites, as resources become available.

APPENDICES

I. Specifications for Treatment

The following is a list of suggested specifications for chemical treatment contracts:

a) Qualifications of contractor- MD licensed pesticide applicator

b) Treatment chemical- Emamectin benzoate, 4%

c) Treatment method- Stem injection

d) Applicator system- Arborjet Quick-jet, Arborjet Tree-IV, Rainbow IQ Tree Infuser, Rainbow Q-Connect

e) Identification of ash- Tree species and condition should be verified prior to treatment by applicators.

f) Diameter- diameter is measured at breast height, 4.5 feet above ground level. For trees with more than one stem, the diameter at breast height for each stem is measured: Diameter=$\sqrt{(dbh_1^2+dbh_2^2\ldots)}$

g) Application rate- Applications may be applied at the low to high application rates, as directed by the product label.

h) Injection site spacing- injection sites should be spaced evenly around the base of the tree, within 12 inches of the ground. Injection sites should be located every 4-8 inches.

i) Injection site depth- Holes should be drilled between 5/8" to 1-5/8" deep. Avoid drilling into diseased sections of stem.

j) Drill bit size- For Arborjet Quik-jet and Arborjet Tree-IV systems, 3/8" drill bits may be used with #4 plugs. Rainbow IQ tree infuser and Q Connect require 15/64" holes drilled with a high helix drill bit.

k) If used, plugs should be left in tree following treatment.

l) Contamination- material should not be allowed to puddle or run off-site.

m) Application timing- For maximum effectiveness, applications should be made in mid-spring, several weeks before expected adult emergence. Treatments should not be conducted during periods of drought or during a trees' dormant season. Treatments should be conducted while there is adequate soil moisture, and during mid-morning for the highest uptake rates.

II. Example Inventory Data Collection Sheet

Surveyor Names:						**Survey Date:**			
Survey Area:						**Sheet #:**			
Species	Latitude	Longitude	DBH (in)	Height (ft)	Crown dieback (%)	Condition (G,F,P,D)	Treatment priority (1,2,3)	Target risks	Notes

III. Example Data Collection Sheet for Insecticide Treatments

Emerald Ash Borer Suppression
Tree Injection Data Sheet

Page ____ of ____

County ____________ Date ____________

Site Name ____________ Section ____________ Crew Leader ____________

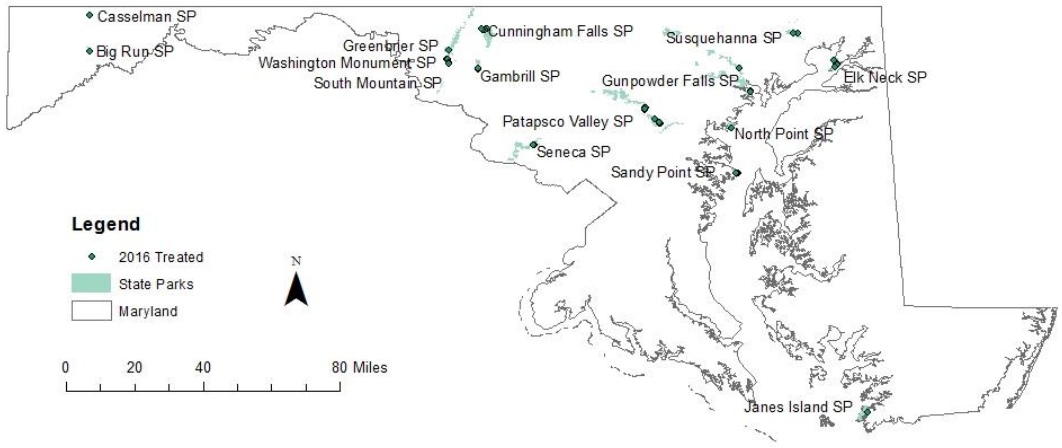
Weather conditions ____________ Insecticide ____________

Soil condition (Wet, moist) and Temp. ____________ EPA REG # ____________

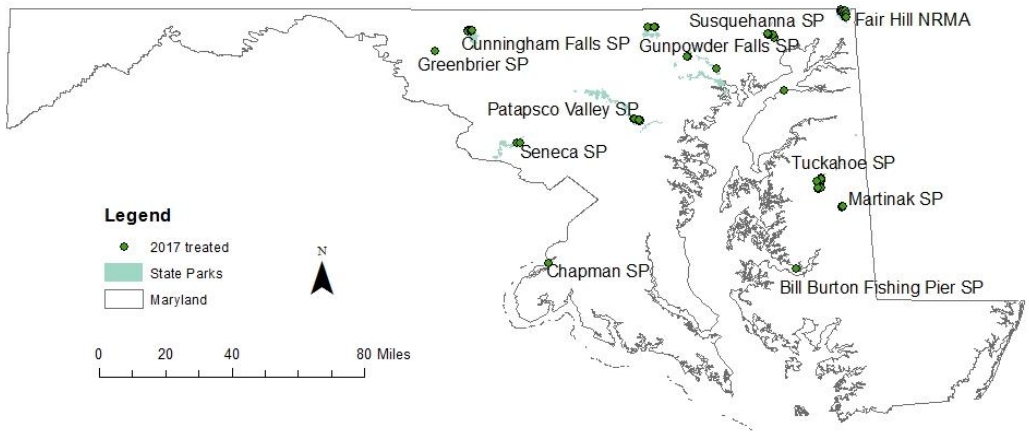
Tree #	Latitude	Longitude	DBH (In)	Condition (Good, Fair, Poor)	# Holes	TREE-age (ml)	Comments	Tree #	Latitude	Longitude	DBH (In)	Condition (Good, Fair, Poor)	# Holes	TREE-age (ml)	Comments	Start Time [1]	End Time [1]
Totals																	

1 - Start time for first tree, and end time for last tree at location

IV. State Park Treatments



Chemical treatments in Maryland state parks in 2016. 299 trees were treated in 15 state parks.



Chemical treatments in Maryland state parks in 2017. 306 trees were treated in 10 state parks.

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