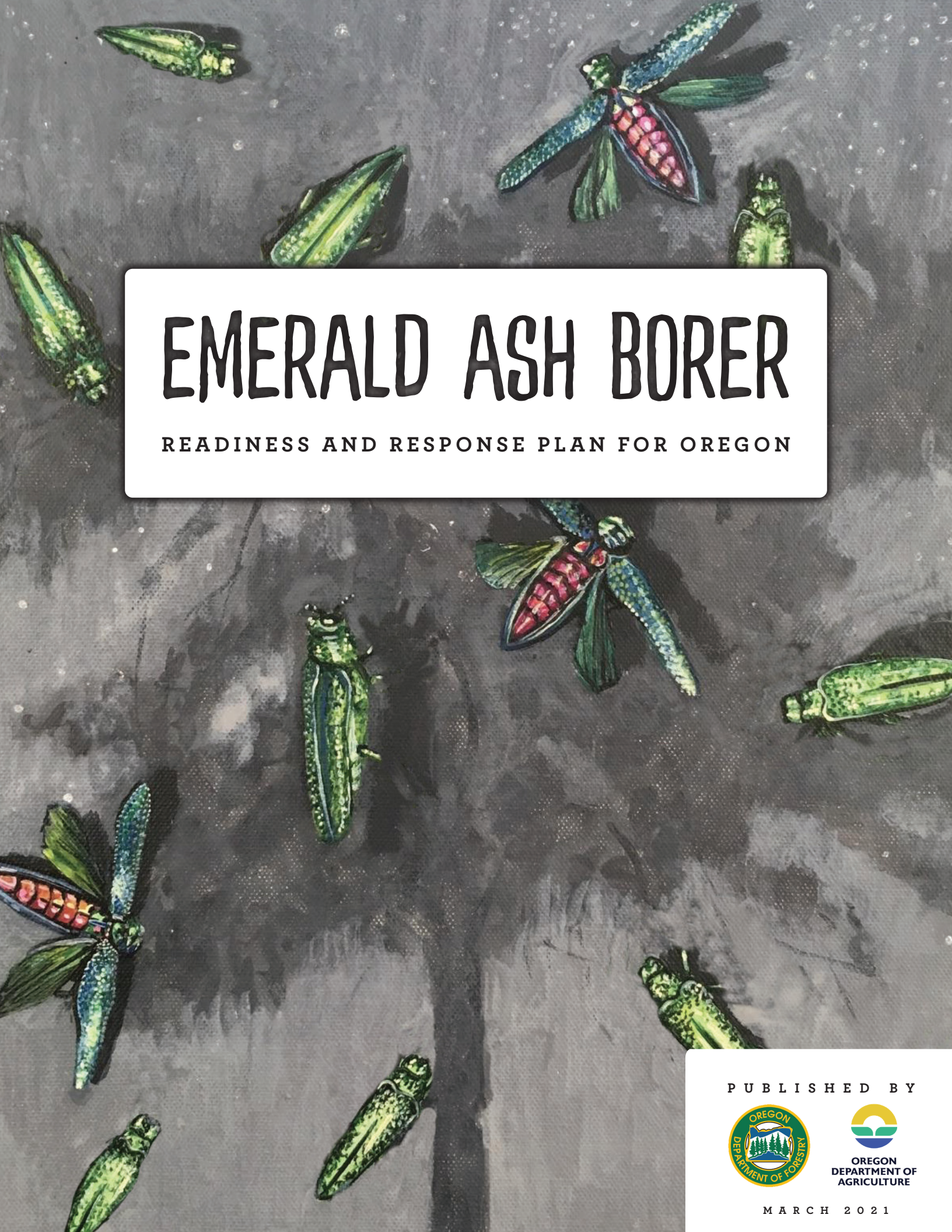

EMERALD ASH BORER

READINESS AND RESPONSE PLAN FOR OREGON

PUBLISHED BY

OREGON DEPARTMENT OF FORESTRY

OREGON DEPARTMENT OF AGRICULTURE

MARCH 2021

Authors & Acknowledgements

This Readiness and Response Plan for Oregon was made possible thanks to the considerable input and review that was provided by members of the EAB Advisory Committee and from potentially affected stakeholders throughout the state. We would also like to thank those outside Oregon that shared their experiences and lessons learned from living with EAB, as well as forestry and invasive species experts from our neighboring states (WA, CA, ID) who shared EAB planning updates with us.

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Printing of the document was funded by USDA Landscape Scale Restoration Grant (15-DG-11062765-715)

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I. PURPOSE STATEMENT

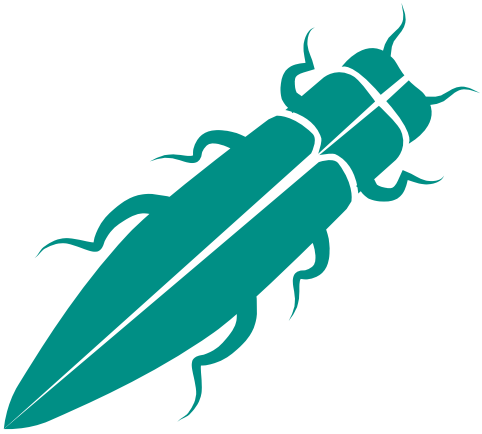
In Oregon, the establishment of emerald ash borer *(EAB)* could devastate whole habitat types, such as ash swales and sensitive riparian zones, as well as reduce urban forest cover. EAB has the potential to cause the local extinction of Oregon's native ash species. The loss of these trees could result in wide-reaching economic impacts, endanger important cultural resources, damage water quality and create direct human health impacts.

Strategies to cope with the introduction and spread of EAB must be identified and implemented prior to introduction and establishment to best protect Oregon resources. Thus, in preparation for the introduction of EAB, The Oregon Emerald Ash Borer Readiness & Response Plan *(plan)* was created to outline important steps, highlight tools and resources already available, and guide the state's approach to handling an EAB infestation at all stages. The Readiness & Response plan is organized into four main categories: Function & Role of Stakeholders, Readiness, Response, and Funding. Each of these four categories include the information and necessary resources to prevent and respond to an EAB introduction.

The Oregon Emerald Ash Borer Readiness & Response Plan was created through the collaborative efforts of a diverse group of stakeholders that would be actively involved and/or impacted by the introduction and establishment of EAB in Oregon. Plan development was initiated by the Oregon Department of Forestry *(ODF)* and the Oregon Department of Agriculture *(ODA).*

This plan will serve as a guide for the state of Oregon to actively prevent the introduction of EAB and to control and manage any EAB populations that could arrive in the future. The intent of this plan is to capture and elucidate community and stakeholder participation in prevention and readiness efforts, alongside an agency readiness and response plan. It is designed to serve as a tool in helping establish a framework for local EAB preparedness and community action by outlining major issues and providing guidance on how to address them. By fostering EAB resilient communities, this plan may serve as a model for protecting Oregon resources from other invasive forest pests. After feedback is received from stakeholders and user groups, an evaluation of the overall effectiveness of the Oregon plan will be included in future versions. This plan is a "living" document and will be updated as needed to ensure the information within remains accurate and up-to-date.

II. INTRODUCTION AND BACKGROUND



The emerald ash borer *(EAB)* beetle, Agrilus planipennis *(Fairmaire)*, possibly the most destructive forest pest in North America, is a wood-boring pest of ash trees. Since the original discovery in 2002 in the vicinities of Detroit, Michigan and Windsor, Ontario, EAB infestations have been detected in 30 states, with the westernmost infestation reported in Colorado. Native to parts of Asia, it is likely that EAB was transported to the U.S. in solid wood packing material. Considered a devastating non-native pest for its ability to infest all species of ash *(Fraxinus)* with mortality rates of up to 99%, EAB presents a significant threat to ash trees throughout North America. Recent research indicates that all 16 native species of ash in North America are susceptible to EAB infestation. No effective native predators or parasites have been encountered, and, unlike in its native range, EAB aggressively kills both stressed and healthy trees.

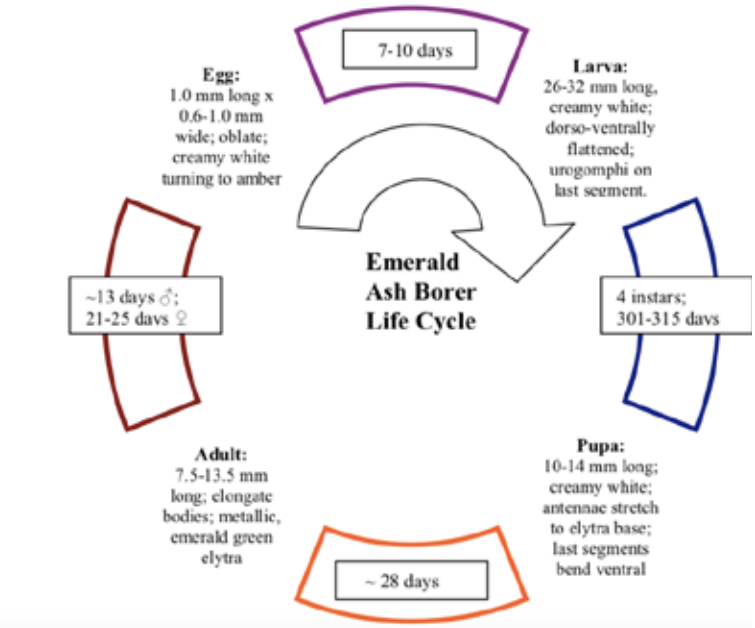
This pest will continue to infest and kill ash trees, harming urban forests and natural areas throughout North America. The primary host for EAB in North America are ash trees which are widespread in the United States, although white fringetree *(Chionanthus virginicus)* and cultivated olive trees *(Olea europea)* may also be at risk. EAB has already killed tens of millions of ash trees and threatens to kill most of the 8.7 billion ash trees throughout North America. Subsequently, the impact on ash in North American forests will be devastating.

Ash Creek is a tributary of the Willamette River. The image shows the creek in its lower reaches within the city of Independence, OR.
Photo credit: Finetooth (2016).

EAB presents a significant concern to the Pacific Northwest where Oregon ash *(Fraxiunus latifolia)* is abundant along riparian corridors in western Oregon and Washington, and where other ash species are widely used by cities and municipalities as good-fit street trees.

Biology and Life Cycle of EAB

EAB is a small *(1/2 inch-long)* metallic-green buprestid, or jewel beetle, that bores into ash trees, feeding on tissues beneath the bark, ultimately killing the tree. EAB is capable of infesting all ash trees in the genus Fraxinus. In its native range in eastern Asia, EAB is typically found at low densities and usually does not cause mortality in healthy native Asian ash trees. EAB is particularly attracted to stressed trees, meaning trees already in a weakened state from damage, such as broken limbs, lack of water, disease or fungal infection.



Emerald ash borer life cycle graphic.
From the USDA Emerald Ash Borer Program Manual (2015).

The EAB has four life stages: egg, larva, pupa and adult *(Figure 1)*. Research suggests that EAB goes through complete metamorphosis in either a one- or two-year life cycle. Low density EAB populations in healthy ash trees tend to complete a two-year life cycle while stressed trees supporting higher larval population densities tend to host a one-year life cycle. It is unknown exactly how the EAB lifecycle dynamics and behavior might respond to the Oregon environment.

Typically, adults begin to emerge in mid to late May with peak emergence in late June. Females usually begin laying eggs about 2 weeks after emergence. Adult EAB prefer to lay eggs on stressed ash, but will readily lay eggs on healthy trees as well. After 1-2 weeks of incubation, eggs hatch and the tiny larvae bore through the bark of the ash tree and burrow into the cambium layer. After feeding for several months, most EAB larvae will overwinter in the outer bark or outer layer of wood. With spring comes the onset of pupation and a new generation of adults will emerge in late

Emerald ash borer emerging from D-shaped exit holes.
Photo Credit: Debbie Miller, USDA Forest Service, Bugwood.org.

spring through D-shaped exit holes chewed in the bark. Adult beetles are capable of flight upon emergence but will spend most of the day feeding on ash leaves in the ash canopy. Within 1-3 weeks they will begin mating and laying eggs and the cycle will begin again.

While EAB are attracted to volatile chemical compounds released by stressed ash trees they are also capable of using those same volatiles to find ash trees when dispersed in mixed-species forests.

THE NORTHERN RESEARCH STATION OF THE US FOREST SERVICE CONDUCTED RESEARCH IN MICHIGAN ON EAB DISPERSAL ABILITY:

"We studied the dispersal potential of EAB using flight mills, which allowed us to measure the distance EAB adults flew. We found that mated females flew further than unmated females and males. The average distance flown by mated females was about 3 km, however, 20% flew >10 km and 1% flew >20 km. These findings demonstrate one of the reasons that eradication of EAB in North America has been unsuccessful."

Natural Areas, Wildlife and Water Quality

The establishment of EAB will likely devastate ash woodlands as well as riparian zones and has the potential to cause the extirpation of an entire species of native ash *(Fraxinus latifolia, Oregon ash).* The Oregon Conservation Strategy has identified Oregon ash as an important characteristic of deciduous swamps and shrubland as well as riparian habitats. The loss of these trees from an EAB infestation could further endanger wildlife that depend on forested wetlands.

In wetter parts of the Willamette Valley, ash is the predominant tree species and the loss of ash trees will likely result in significant changes. Ash provides important food and habitat resources along creeks and rivers where soils can be poorly draining and where seasonally high water-tables can exclude nearly all other tree species. In dense stands of Oregon ash, understory vegetation is often sparse, consisting primarily of sedges. The loss of ash trees caused by EAB mortality is expected to facilitate colonization by invasive plants and lead to once-forested areas becoming shrub- or grasslands. Standing and fallen dead ash biomass can alter soil pH, mineral concentration *(ash is an accumulator of calcium),* and soil moisture levels. The resulting changes in soil chemistry can affect rates of decomposition, nutrient, and water cycling, thus impacting nutrient resource availability for the remaining trees, while gaps in tree canopy can increase soil erosion, stormwater runoff and elevated stream temperatures.

Along sensitive riparian corridors, the resulting increase in water temperature, nutrient runoff and sediment load could be detrimental to Endangered Species Act *(ESA)* listed species *(Table 1; Figure 2).* In the Willamette River, fish species such as Upper Willamette River steelhead, Upper Willamette River chinook salmon, and the Willamette bull trout, as well as the recently delisted Oregon chub, could be imperiled by the effects of an EAB infestation. Other species of concern to the state of Oregon, including freshwater mussels like the winged floater and the Western ridged mussel, and populations of endemic caddisflies may also be negatively impacted by increased water temperature and sediment load.

Table 1. Oregon threatened and endangered species that will likely be impacted by widespread Oregon ash mortality caused by EAB.

Common Name	Scientific Name	State Status	Federal Status	Potential Impact of EAB
Columbian White-tailed Deer (Lower Columbia River population only)	*Odocoileus virginianus leucurus*		T	Some
Lower Columbia River Chinook Salmon	*Oncorhynchus tshawytscha*		T	Some
Lower Columbia River Coho Salmon	*Oncorhynchus kisutch*		T	High
Lower Columbia River Steelhead	*Oncorhynchus mykiss*	E*	T	Some
Oregon Coast Coho Salmon	*Oncorhynchus kisutch*		T	Some
Southern Oregon Coho Salmon	*Oncorhynchus kisutch*		T	Some
Upper Willamette River Chinook Salmon	*Oncorhynchus tshawytscha*		T	High
Upper Willamette River Steelhead	*Oncorhynchus mykiss*		T	High
Nelson's checkermallow	*Sidalcea nelsoniana*	T**		High
Peacock larkspur	*Delphinium pavonaceum*	E**	E	Some
Bradshaw's desert parsley	*Lomatium bradshawii*	E**	E	Some

** Listed under the Oregon Endangered Species Act (ORS 496.171 through 496.192)*
***Listed under Oregon endangered, threatened and candidate plants (OAR 603-073)*
+U.S. Endangered Species Act of 1973 (Public Law 93-205, 16 U.S.C. § 1531)

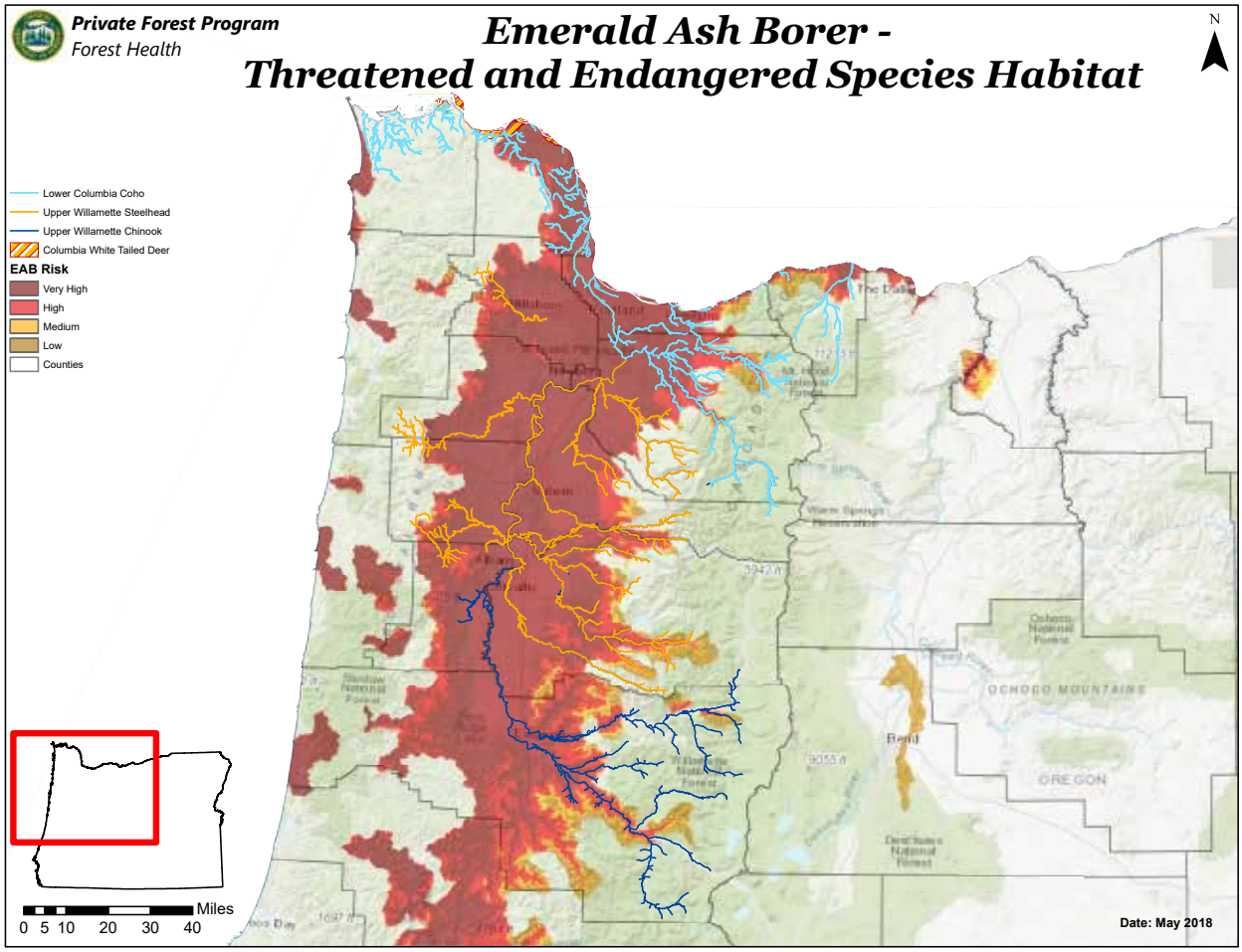


Figure 2. The EAB Threatened and Endangered Species Habitat map shows critical habitat that intersects with EAB risk and the distribution of wild ash in riparian areas of the state. The Threatened and Endangered species includes Lower Columbia Coho salmon (Oregon endangered species, federally threatened species), Upper Willamette Chinook salmon (federally threatened species), Upper Willamette steelhead (federally threatened species), and Columbia white-tailed deer (federally threatened species). Data is not shown for Nelson's checkermallow (Oregon threatened species).

Of the species addressed in the US Fish and Wildlife Service Recovery Plan for Prairie Species of Western Oregon and Southwest Washington, seven of them can be found in wet prairie habitats. Specifically, Nelson's checker-mallow, peacock larkspur, and Bradshaw's desert parsley can be found in Oregon ash swales, in native wet prairies on the edges of ash wetlands, or along streams in the Willamette Valley. The loss of riparian ash stands and swales may affect critical habitat that supports these and other species of concern. Although the effects of EAB-induced ash mortality may temporarily increase open prairie habitat to the benefit of these species, long-term ash loss can result in the establishment of invasive weeds and an increase in detrimental woody shrubs. Habitat destruction, isolation and fragmentation, invasion by non-native plant species, and succession are underscored in the recovery plan as the primary threats to prairie species. EAB-induced ash mortality could counteract this efficacy of existing restoration strategies.

Oregon ash trees also provide a direct benefit to wildlife. The winged fruit (also known as samara) of the ash are utilized as food by a variety of squirrels and mice, as well as birds such as grosbeaks, wood ducks, finches, and more. Many species of insects, including larval butterflies like the two-tailed swallowtail, feed on the leaves of Oregon ash, while twigs and leaves are eaten by deer and elk. The trees themselves are used as nesting sites for birds, roosting habitat for bats, drill sites for sapsuckers, and provide wood for beaver dams.

For all of the reasons listed above, native Oregon ash plays an important role in ecosystem restoration projects where the management goal is restoration of important wildlife habitats rather than mitigating impacts to a single species of concern. Similar incidental benefits hold true for aquatic wildlife as well, given that many large riparian habitat restoration projects include replanting ash. Not only would EAB induced tree loss cause ecological harm, but the loss of ash trees available for restoration projects could also have negative ramifications on the success of local restoration and mitigation efforts.

Economic Impacts

Emerald ash borer has already caused billions of dollars in damages to natural and urban areas in North America. Economic damages attributed to EAB infestations includes loss of ash trees as a source of timber and firewood, lost value of forested areas, lost value of urban tree canopy, costs incurred in removing diseased trees, and costs incurred by diminished trade/nursery industry attributed to EAB quarantine zones as well as the loss of ecosystem services.

While the nursery value of ash trees in Oregon is unknown, according to the Oregon Association of Nurseries plant finder, there are more than 40 growers/wholesalers/retail nurseries that carry one or more of approximately 20 different varieties of ash from rootstock to containers. If EAB is detected in Oregon, the infested areas could be placed under quarantine, meaning that selected materials, including ash nursery stock, will no longer be allowed to be moved out of infested areas and may need to be destroyed to reduce the chances of spreading EAB. According to the U.S. Department of Agriculture, National Agricultural Statistics Service, Oregon is consistently among the top three producers of nursery stock in the country. Due the state's prominence as a top exporter of nursery stock, EAB could have an impact on Oregon's nursery industry beyond just ceasing the sale of ash trees within Oregon. The 2016 ODA estimated value of Greenhouse & nursery products was $909,493,000.

Oregon ash is not considered an economically important timber species. It is not generally managed for timber production and its availability for harvest is restricted by regulations governing forestry practices in wetlands and riparian areas. However, it is moderately hard, machines well, has high impact resistance, and is utilized on a small-scale in tool and furniture making. It is also considered a desirable firewood species because it splits easily and has a high heat value, but because it is a non-durable wood species its value can quickly degrade post felling.

City trees, which include various ash species and other cultivated varieties (cultivars), provide various benefits that increase over the lifetime of the trees. Thus, management decisions that contribute to the long-term health and maintenance of the urban forest are considered a valuable investment. However, the cost of caring for the majority of urban trees falls on private property owners. Once infested trees die, they are quick to rot and become public-safety hazards. While

removal of infested trees can be a significant expense to private tree owners, it can cost cities tens of thousands of dollars to deal with an EAB infestation in a public park or along an ash-lined street. Additional costs incurred may also include loss of ecological services, a drop in property values, and the time and cost of replanting a comparable replacement. The loss of these shade trees will negatively impact both the property owner and the local community.

Ash trees lining a residential street in Portland.
Photo credit: Portland Parks & Recreation Urban Forestry

Investing public resources in prevention and slowing the spread of threats to the urban forest, such as EAB, will help reduce these costs, as will investments in research on EAB biology and management. Managers can assess the costs of prevention versus projected economic damage incurred by EAB as well as compare the costs of replacing infested trees with EAB-resistant species versus inoculation of full-size healthy ash trees.

More difficult to calculate is the economic value provided by the healthy ecological function of natural ash areas and the forested riparian corridors that ash provide, especially those adjacent to agricultural areas.

Urban and Community Forests

While Oregon ash is the only ash native to the Pacific Northwest, other species and cultivars of ash can be found within Oregon's urban forests, widening the impact of an EAB infestation. Extensive research has been conducted to assess the benefits provided by urban forests which include trees in densely populated areas in parks, on streets, and on private property. The benefits of urban forests include reduction of the urban heat island effect, filtering air pollution, increasing property values, reducing stormwater runoff, providing habitat for wildlife, improving human health, and providing aesthetic value.

While urban forests are complex, living resources that have many well-documented positive benefits, there are also costs associated with their management. Since city trees are an important component of a community's green infrastructure and livability, proactive planning for resiliency through increasing species diversity, tracking changes via tree inventories and canopy analyses, and investing in public education on how trees contribute to communities are important components for maintaining the overall health of our urban forests.

THE VALUE OF STREET TREES

Given that trees can increase property values by .08%, the median value of a mature ash tree would be $3,120 in Portland, OR or $2,192 in Eugene, OR. Values are based on the median value of a single family home in Portland, OR ($390,000) and Eugene, OR ($274,000) in June 2017.

Cultural Resources

EAB threatens the cultural heritage of indigenous communities that have traditional uses for Oregon ash. Ethnobotanical records report medicinal and ceremonial uses of ash (leaves, bark, twigs, and roots) in addition to the use of ash trees as fuel. Records and artifacts also show that ash wood was used in the construction of tools, such as poles, canes, and pipes. The Cowlitz used Oregon ash to make canoe paddles and digging sticks. The Karuk used the root fibers of ash trees to weave baskets. Traditional Costanoan tribal wisdom suggested Oregon ash sticks and leaves would repel venomous snakes.

Human Health & Safety

Direct threats to human health and safety from EAB encompass hazards caused by dead and rotting trees, including falling trees and tree limbs, both within cities and in natural areas. Indirect threats, while difficult to quantify, relate to the consequences of losing significant urban tree canopy. City tree canopy can positively impact human health by reducing the urban heat island effect, filtering air and water pollution, and improving human health and well-being. Studies conducted by foresters and epidemiologists with rapid loss of ash trees caused by the EAB in the Midwest suggest that the loss of trees was correlated with increased mortality related to cardiovascular and lower-respiratory-tract illness.

Trees marked for removal due to EAB infestation in Roeland Park, Kansas.
Photo credit: Ryan Armbrust, Kansas Forest Service, Bugwood.org.

III. FUNCTION AND ROLE OF STAKEHOLDERS

There are numerous state agencies that have invasive species functions and key responsibilities as outlined in the Emerald Ash Borer Readiness and Response Plan for Oregon. The following is a summary of general duties of the agencies and groups located within Oregon that may be involved in the eradication and management of emerald ash borer. See Appendix A for agency contact information.

Primary State Agencies

Oregon Department of Agriculture (ODA):

- Lead agency for the state of Oregon for quarantine and enforcement
- Conduct detection surveys of insects, pathogens and plants
- Implement emergency measures at the state level to prevent spread
- Provide laboratory support
- Provide information to the public and media
- Inspect and regulate movement of nursery stock
- Issue and review interstate plant movement permits
- Review international and interstate plant and plant pest movement permits issued by APHIS (Animal and Plant Health Inspection Service)
- Regulate pesticide registration and use
- Provide information to national pest reporting systems
- Administer state rules on intrastate movement of regulated materials
- Collaborate with the U.S. Department of Agriculture (USDA) and other state and local agriculture agencies
- Represent Oregon on national and regional plant boards
- Designate and regulate invasive plant and plant pest species
- Participate as appropriate in an incident command system

Primary State Agencies *(continued)*

Oregon Department of Forestry (ODF):

- Conduct annual aerial surveys of forest health conditions
- Cooperate with state and federal agencies on monitoring and detection surveys and limiting spread of pests
- Identify and control forest pests on state and private forestlands
- Educate forest industry and state land managers and landowners about forest pests
- Communicate with forest industry, managers, and landowners
- Advise and develop forest management protocols for state and private forestlands
- Seek and apply for special funding assistance through the USDA Forest Service or Natural Resource Conservation Service for established forest pests
- Assist with planning for solid waste disposal and or utilization strategies
- Participate as appropriate in an incident command system
- Provide technical assistance to impacted landowners

Oregon Department of Fish & Wildlife (ODFW):

- Assist with other agencies with pest surveys on state lands and share information
- Assist with public education about forest pests
- Cooperate with other agencies to manage forest pests on state lands
- Participate as appropriate in an incident command system

Other Principal Agencies and Partner Institutions

- USDA Animal and Plant Health Inspection Service (APHIS) Plant Protection and Quarantine:
- Maintain and fund Cooperative Agricultural Pest Survey (CAPS) program and surveys
- Provide final confirmation of pest identifications
- Provide pest traps and lures, if available
- Implement emergency measures at the federal level to prevent spread of pests
- Administer quarantines on interstate movement of regulated materials
- Provide international liaison services between individual states and foreign regulatory bodies
- Provide emergency funding for survey and response, as appropriate and available
- Develop and improve survey and control protocols and measures
- Provide survey data repository, if appropriate
- Participate as appropriate in an incident command system

Other Principal Agencies and Partner Institutions *(continued)*

USDA Forest Service (USFS), Forest Health Protection:

- Provide current information and technical assistance for detection surveys and control activities on federal lands
- Evaluate and develop new technologies for pest management
- Implement detection surveys, evaluation assessments, and control measures on federal lands
- Provide information and educational materials
- Coordinate interstate initiatives, as appropriate
- Provide funding through Cooperative Forest Health and other programs to state and private organizations
- Participate as appropriate in an incident command system

Oregon State University (OSU) Research and Extension:

- Share results of relevant research with state and federal agencies
- Conduct research on plant and plant pest biology, ecology, impact, and management
- Coordinate Oregon Forest Pest Detectors training programs
- Provide information through Extension, Master Gardener, Master Woodland manager and other programs
- Participate as appropriate in an incident command system

Oregon Invasive Species Council:

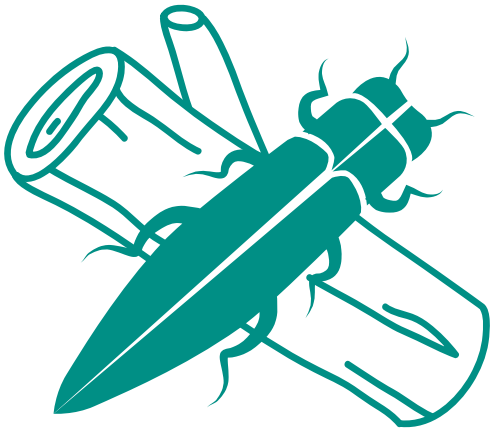
- Coordinate exchange of timely and relevant information among a diverse group of state, federal, local, and non-governmental entities
- Provide information to the public and media
- Manage the Oregon Invasive Species Online Hotline

Other Principal Agencies and Partner Institutions *(continued)*

City of Portland:

- Require permitting, removal, and replacement of infected trees in the city of Portland through authority of the city's tree ordinance
- Provide an inventory of ash trees, using existing street and park tree inventory data
- Promote the Oregon Forest Pest Detector program to City of Portland employees, contractors, and other networks
- Incorporate information on invasive pests into existing outreach efforts, including websites and education programs
- Cooperate with regional partners in planning and response
- Participate as appropriate in incident command system

IV. READINESS



Prior to the arrival of EAB, it is important for the state of Oregon to remain proactive and fully prepared for the arrival of EAB. This includes knowing where ash is located throughout the state, understanding how/where it is likely to be introduced, and identifying the required resources to deal with its aftermath, among other readiness actions. Readiness is broken down into four sections: Risk Assessment, Resilience, Resources for Response, and Detection.

A. Risk Assessment

Assessing and mapping where the greatest risk of EAB establishment is provides a starting point for understanding where in Oregon the economic, environmental, and social impacts of an infestation would be most felt. The risk that a pest such as EAB becomes established in a new location requires an assessment or evaluation of several factors including the risk of EAB being introduced (risk exposure) and the abundance of ash trees in the exposed location. Risk assessments provide information that can be used to maximize the efficacy of both early detection and rapid response efforts. By identifying areas of high risk, outreach campaigns and citizen monitoring efforts can also be targeted to these areas.

1. Distribution of Oregon Ash in Natural Areas

Native Oregon ash distributions have been modeled by ODF and can be used to facilitate targeted detection and control efforts in both wild and managed natural ash habitat (Figure 3; Figure 4). Additional EAB Risk Maps by region can be found in Appendix B.

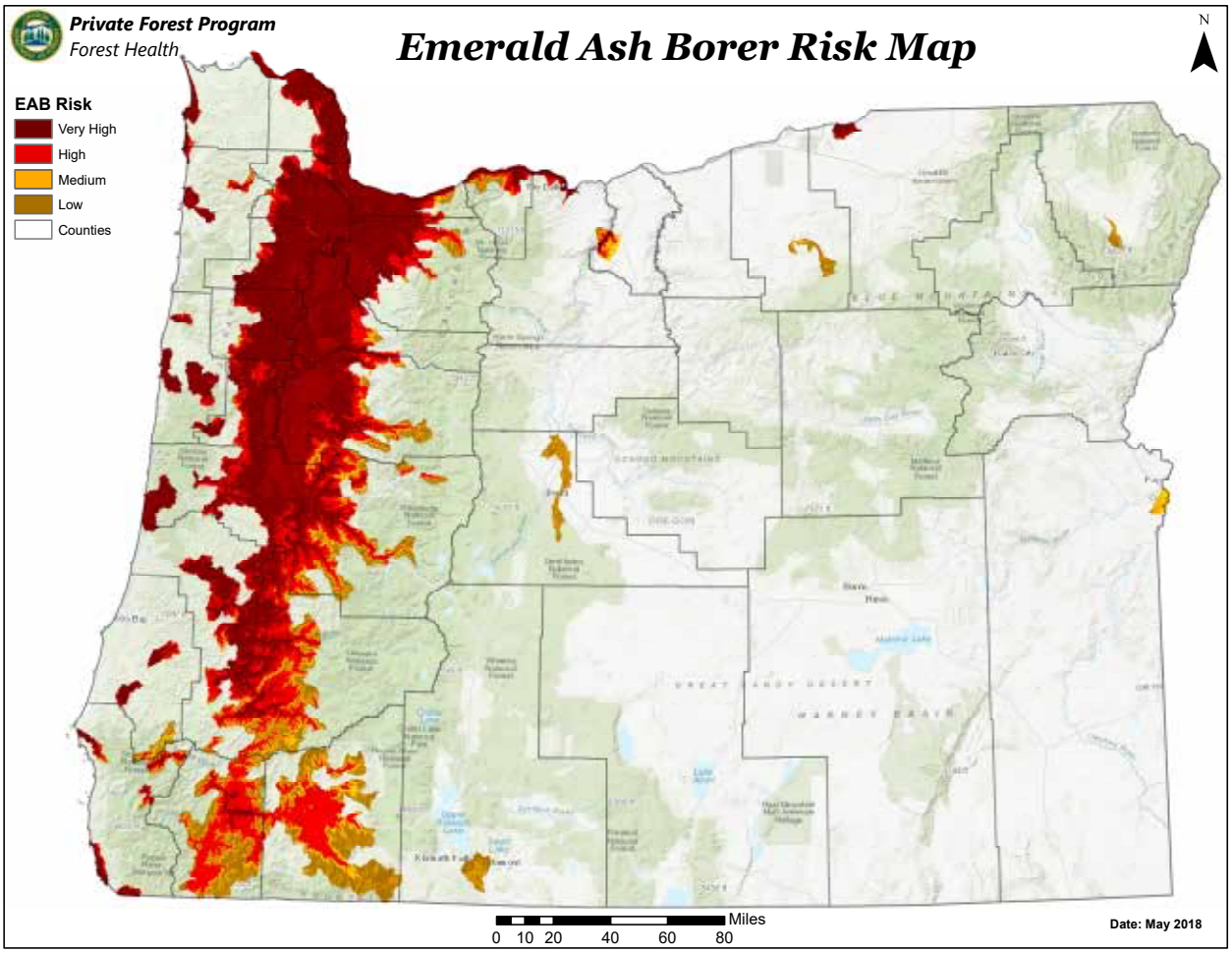


Figure 3. Risk for emerald ash borer *(EAB)* is mapped based upon known occurrences of ash *(Fraxinus sp.)* at the local watershed level (hydrologic unit code 12, or HUC-12) in Oregon. Point data for Oregon's two wild, naturalized species of ash, Oregon ash *(F. latifolia)* and green ash *(F. pennsylvanica),* were used to create the map. Data on ash distribution originated from two sources: the Oregon Plant Atlas, a product of the Oregon Flora Project, and emerald ash borer surveys conducted by the Oregon Department o f Forestry. EAB risk categories were determined based on the frequency distribution of ash by elevation above sea level and corresponding human activities associated with known pathways of EAB introduction and establishment: Very high: ≤1,000' above sea level, High: 1,000 to ≤2,000', Medium: 2,000 to ≤ 2,500', and Low: >2,500'.

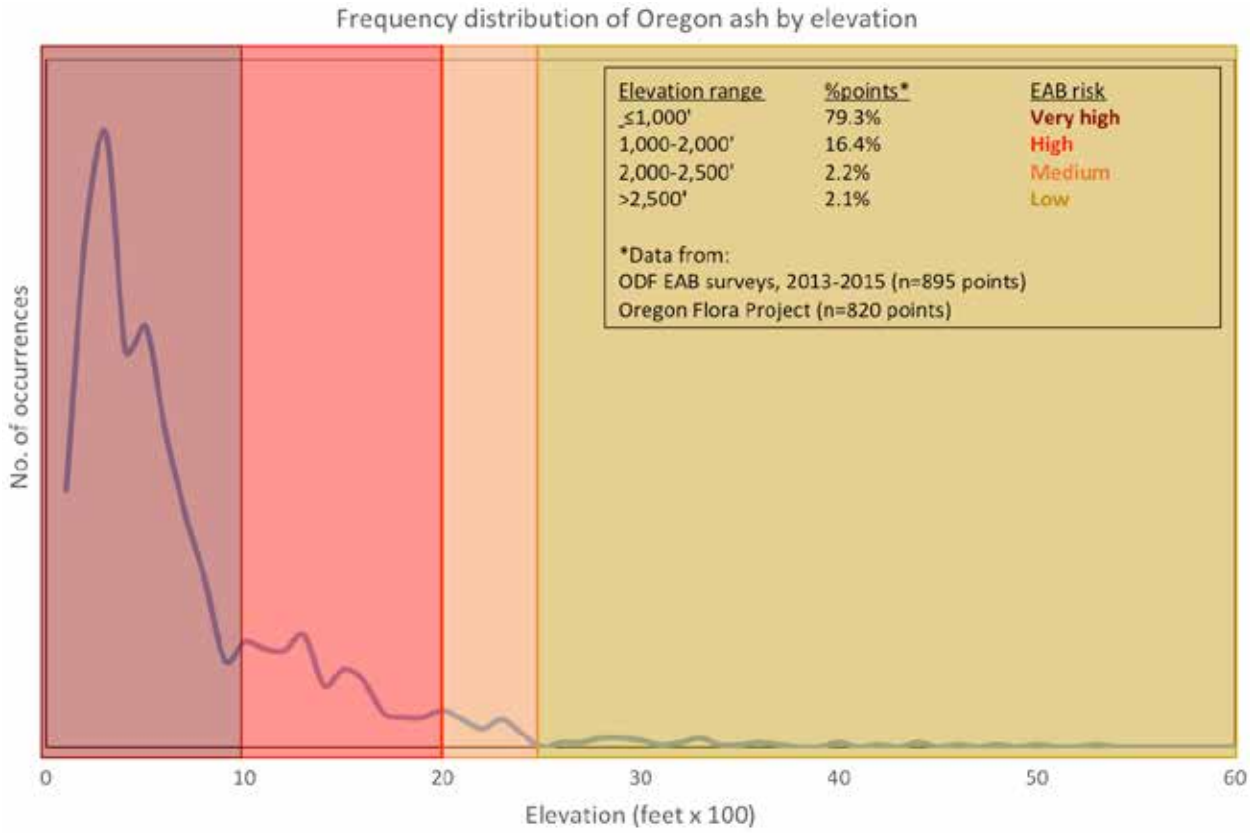


Figure 4. This figure depicts the distribution of wild, naturalized ash (Oregon ash, *Fraxinus latifolia,* and green ash, *F. pennsylvanica)* by elevation and corresponding risk of EAB introduction and establishment. Data on ash distribution originated from two sources: the Oregon Plant Atlas, a product of the Oregon Flora Project (820 points), and emerald ash borer surveys conducted by the Oregon Department of Forestry (895 points). EAB risk categories were determined based on the frequency distribution of ash by elevation above sea level andv corresponding human activities associated with known pathways of EAB introduction and establishment: Very high: ≤1,000' above sea level, High: 1,000 to ≤2,000', Medium: 2,000 to ≤ 2,500', and Low: >2,500'

INFESTATION TIMELINE

Since ash often do not show symptoms during the first years of an infestation, EAB can go unnoticed for several years after it is introduced. Cities already dealing with EAB have estimated that EAB was present for 2-3 years before detection. As local populations enter the fourth year post-establishment, EAB larval densities build high enough to cause rapid mortality of ash trees. Previous studies have suggested that ash populations in forested sites can go from healthy to nearly 100% mortality of mature trees within 6 years of an infestation.

2. Map the Risk of Imported Firewood Transported by Out-of-State Recreationists

The primary interstate pathway by which EAB is thought to be moved long-distances is via the transport of infested firewood by the general public. Using zip codes of out-of-state campers, the risk of potential infested materials movement into federal, state, and private campgrounds has been modeled. These models can help determine the highest risk areas based on locations where native ash distributions and visitors from EAB quarantine areas coincide *(Figure 5)*.

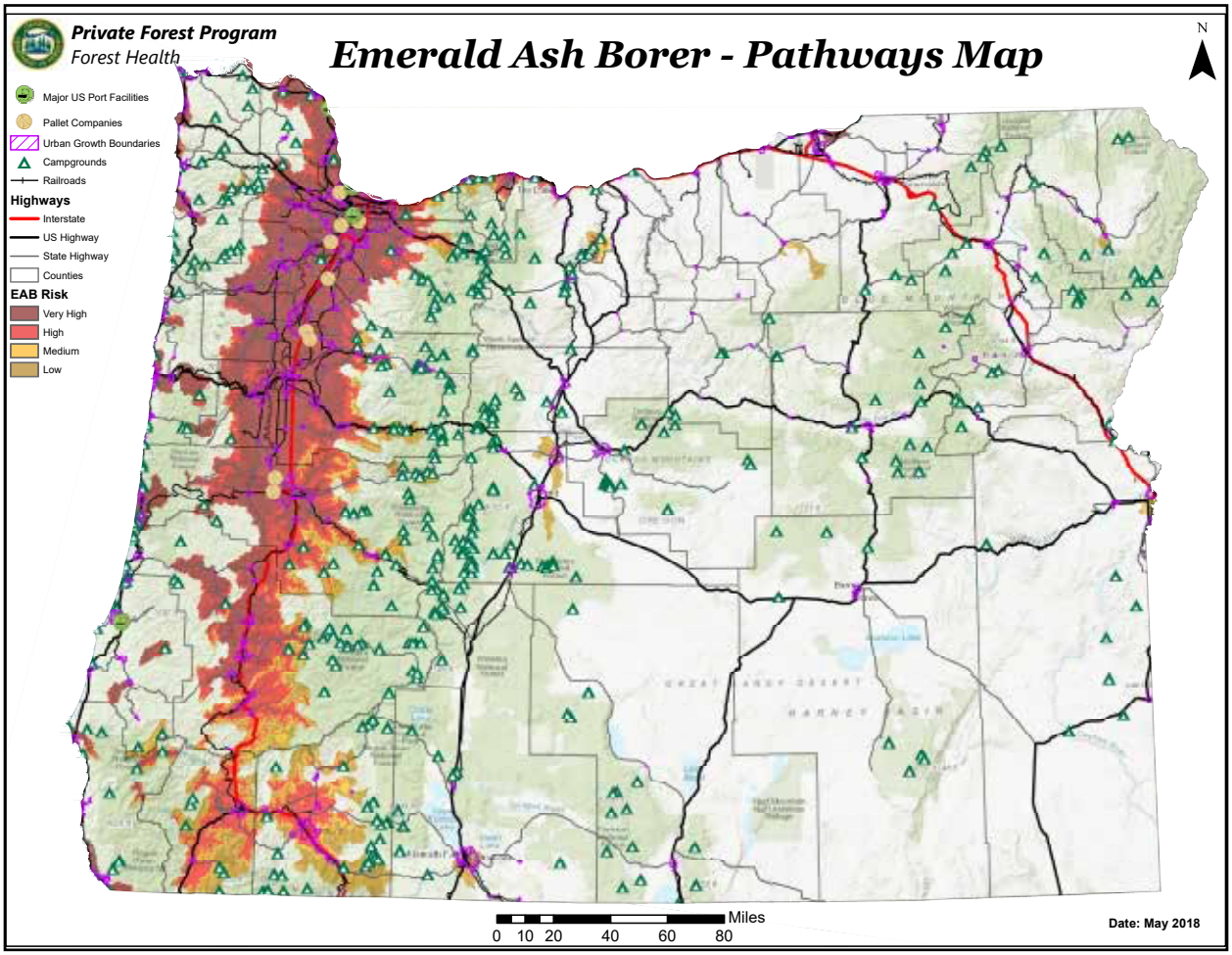


Figure 5. The EAB Pathways map shows all state and federal campgrounds, major U.S. ports facilities, and pallet companies, as well as major railroads and highways – all known pathways for movement of emerald ash borer.

3. Educate groups and industry with high risk of introduction

To increase vigilance for EAB and awareness for how it is transported, recreationalists such as out-of-state game hunters, mushroom hunters, and other backcountry user groups should be provided information on how to not only positively identify EAB, but also ways to decrease the chance of transporting EAB. Additionally, those primarily using wood heat for their homes as well as specialty mills and hobby woodworkers should also be aware of the risk of importing ash from quarantine or near-quarantine areas. Educating local nurseries should also be a priority to ensure they are aware of the potential introduction of EAB through nursery stock.

4. Complete Urban Tree Inventories for Oregon Ash and Other Ash Species

Ash trees can be common in urban and suburban areas. Urban tree inventories allow managers to identify those urban forests that are more vulnerable to invasion and subsequent extensive tree loss, as well as identify high-value urban trees *(such as designated heritage trees)* that may merit protection via prophylactic measures. A list of cities that have completed tree inventories can be found in Appendix C. Tree inventories should be updated and/or refined as appropriate to maintain current inventory data on ash.

5. Estimate the Cost of an EAB Infestation

The estimated cost of an EAB infestation can be calculated using existing tools such as Purdue University's "Emerald Ash Borer Cost Calculator" or the "Emerald Ash Borer Planning Simulator". These tools can provide an estimate of the costs of different EAB management options for specific, high-risk areas such as municipalities.

B. Resilience

The capacity of an ecological system to buffer itself against disturbance is known as resilience. The more biodiversity in urban forests, the more resilient it will be to costs incurred by pests, pathogens, and increasing climate stressors. If managed sensibly, diversity can act as an important buffer against catastrophic tree loss via pests, such as EAB, in forested systems.

EAB RESILIENT COMMUNITY

Prior to a major disturbance, communities can preemptively manage their urban forests in a manner that promotes resilience. A model EAB Resilient Community will have the following components completed, or will have a plan in place to address each:

- **Up-to-date Urban Tree Inventory**
- **Biodiverse urban tree canopy**
- **EAB Prevention Plan and accompanying efforts**
- **Education and outreach**
- **EAB monitoring** *(formal and informal reporting)*
- **EAB Response Plan**
- **Emergency fund**
- **Native ash seed storage** *(if applicable)*

1. Discourage Planting of At-Risk Species

Municipal street tree resources across Oregon recommend planting Oregon ash as well as a variety of other ash species and cultivars. With the growing threat of EAB, municipalities are encouraged to revise their lists with the goal of increasing urban street tree biodiversity. Municipalities should also consider the removal of susceptible *Fraxinus* species and other EAB hosts currently established *(Table 2)*.

For restoration projects located in high risk areas and where ash is heavily used, managers may want to minimize percent ash planting in order to bolster EAB resiliency. Managers may also consider alternative species because of the potential devastation to ash trees after the arrival of EAB.

STREET TREE RESILIENCE THROUGH DIVERSITY

Urban forest species diversity is evaluated using the 10-20-30 rule. This rule recommends that urban tree diversity be composed of no more than 10% of one species, 20% of one genus, or 30% of one family. However, pests with broad host ranges can leave urban areas highly vulnerable to catastrophic tree loss and result in significant long-term costs for removal and replacement of dead and diseased trees. A new 5-10-20 goal has been undertaken by many temperate urban areas in order to bolster the resiliency of urban forests.

For example: According to the City of Portland's 2016 Street Tree Inventory, Ash *(Fraxinus spp.)* represents approximately 4.2% of all street trees in Portland. At under 5% of city-wide street tree diversity, *Fraxinus spp*. are well within the progressive urban forestry guidelines for protecting the urban forest from catastrophic harm from plant pests and pathogens. However, with more than 9,000 ash street trees, the impact of EAB on the urban forest would still be profound, with homeowners potentially incurring considerable costs.

Table 2. Wild and cultivated ash species *(Fraxinus spp.)* in Oregon. Source: Oregon Department of Forestry, 2017.

Latin Name	Common Name	Origin	OR wild populations	OR cultivated/ urban	USDA zones
Fraxinus latifolia Benth.	Oregon ash	OR, WA, CA	●		7–9
Fraxinus pennsylvanica Marshall	green ash	eastern U.S.	●	●	3–9
Fraxinus americana L.	white ash	eastern U.S.		●	4–9
Fraxinus angustifolia Vahl	narrow-leafed ash	Eurasia		●	6–9
Fraxinus excelsior L.	European ash	Europe		●	4–7
Fraxinus nigra Marshall	black ash	eastern U.S.		●	7–10
Fraxinus nigra Marshall	flowering ash	Eurasia		●	6
Fraxinus quadrangulata Michx.	blue ash	eastern U.S.		●	4–7
Fraxinus uhdei (Wenzig) Lingelsh.	shamel ash	Central America		●	8–10
Fraxinus velutina Torr.	velvet ash	Southwestern U.S		●	7–10

**Ash species in bold font are the most common planted and wild ash in the state. Less common species of ash may also be rarely encountered.*

Photo Credit: Kew Gardens.

2. Native Ash Seed Collection and Storage

Collecting and storing native ash seed is essential to preserve the genetic diversity of Oregon ash in preparation for the threat of infestation, and the potential for finding EAB resistance and/or replanting if a successful control measure is found.

To access ash seed collection resources, visit The National Seed Laboratory webpage for Ash. Developing partnerships with local or regional entities for seed collection and storage efforts should also be explored to combine resources and collect from culturally significant ash sources.

ASH SEED COLLECTION

While discussing lessons learned with states already dealing with EAB, Michigan shared that they regret not collecting seeds from their native ash and they have now lost native seed diversity as a result.

Seed collection of native ash for nursery cultivation and use in local restoration projects has already been conducted locally in Oregon. For instance, in 2015 Metro crews planted 42,000 ash trees at Smith and Bybee Wetlands Natural Area that had been grown from seeds collected in summer 2013. Scholls Valley Native Nursery nurtured them for two years in preparation for planting. These efforts can be combined with seed storage guidance to create a viable seed collection of native ash diversity for future use in post-EAB restoration efforts.

3. Pre-emptive Removal of Ash

Since EAB are more strongly attracted to stressed ash, inventoried trees can be prioritized for removal by condition. The cost of pre-emptive tree removal can be estimated above *(see section V. A. 4. "Estimate the Cost of an EAB Infestation").* Municipalit ies may also wish to strike a balance between inoculation and preemptive replacement. If preemptive removal will be conducted, it should be implemented by the time the EAB infestation is within 100 miles *(see also "Integrated Pest Management for Emerald ash borer" Appendix D).*

Guidance for proper disposal should be developed and/or utilized and appropriate ash disposal sites should be identified prior to any removal. More information on wood disposal can be found below in section V. C. 3. "Wood Waste Disposal & Treatment".

POOLING RESOURCES AT THE NEIGHBORHOOD SCALE

For areas with a large number of urban ash that need to be treated or removed, one potential option for landowners to save money is for neighbors to pool together and accept bids from arborists to treat several trees in one area. Arborists may be willing to offer a better price if they are able to treat and/or remove multiple trees in one area at the same time.

C. Resources Needed for EAB Response

Carefully planned treatment, removal, and/or disposal of possibly infested ash is a critical component of containing the spread of EAB. Response actions must consider the origin of the EAB infestation in order to effectively treat, remove, and dispose of ash, and to avoid further spread. Prior to any response, it will be important to determine and clearly communicate who is ultimately responsible for ash treatment and removal in terms of urban, residential, and natural ash locations throughout the state.

1. Pesticide Use and Applicators

Systemic pesticides, such as imidacloprid, dinotefuran, or emamectin benzoate, are most commonly used as a protective treatment against EAB infestation, although they can be used to treat EAB infested trees that still retain >50% of their canopy. Preventive chemical treatments for healthy, uninfested trees can be initiated when known EAB infestations are within 10-15 miles *(see also "Integrated Pest Management for Emerald ash borer" Appendix D).* For more information please visit Insecticide Options for Protecting Ash Trees from Emerald Ash Borer. Certified pesticide applicators can also be found through the Oregon Department of Agriculture's Pesticide Licenses search engine.

2. Tree Removal Resources

When considering tree removal, you will want to utilize qualified arborists and landscape contractors located within your region. Information that can help find and choose qualified arborists near you is available through Pacific NW ISA: Find an Arborist.

3. Wood Waste Disposal & Treatment

Fenced disposal sites can be located on public or private land, with the caveat that the specific location will have to be identified based on proximity to where EAB was first detected, as to not encourage spread of the infestation. The size of the site will be dependent on potential wood volume, proximity to other yards and merchandising activities that will take place and can range from 3 to 10 acres. Treatments to eliminate EAB from these materials include, but are not limited to:

Chipping:

Wood, brush, and stump grindings must be chipped or ground down to a size of no more than 1" in two dimensions *(two of the three measurements- length, width, depth- must be 1" or smaller).* Typical chippers used in tree care operations will not reliably create chips that meet this specification. Chippers equipped with a 1" screen will assure compliance.

Debarking:

At minimum, a complete removal of bark is required. The removed bark *(and any removed wood)* must be chipped down to a maximum size of 1" by 1" in 2 dimensions.

Heat:

Wood must be heated according to established pest or disease specific BMPs. For regulated pests and diseases, the wood temperature must reach 160 degrees F for 75 minutes in the center of the piece.

Ash logs in chipping yard in Southeast Michigan.
Photo Credit: David Cappaert, Bugwood.

D. Detection

Early detection, coupled with rapid response, can stop the spread of new and emerging invasive species before they become established, making it one of the most cost-effective methods for controlling invaders. Early detection of wood boring pests such as EAB is critical to the success of efforts to eradicate the invaders, isolate the infestation, and minimize its impacts to urban and natural areas. Unfortunately, EAB is notoriously difficult to detect and trees may not develop signs for up to four years after the initial infestation.

1. Develop and Support Strategic Detection Trap Surveys

Building capacity for early detection efforts can be done by increasing the number and types of EAB surveys, increasing the efficiency of trapping and other survey methods, prioritizing high-risk areas, training individuals already working in high-risk areas *(such as arborists),* and increasing outreach to the general public in high-risk communities. Early detection capacity can be prioritized and/or expanded across agencies, stakeholders, and communities.

Effectively locating early detection efforts relies on analyzing the sources and pathways with the greatest potential for EAB importation into the area *(campgrounds & recreation areas, nurseries & garden centers, and high-traffic shipping & receiving centers).* Focusing early detection activities in areas where out-of-state firewood and nursery stock are transported is the most effective and cost-efficient strategy. Methodologies and strategies should be adjusted as EAB trapping technology and science advances. Priority targeted survey techniques are outlined below *(see also "Integrated Pest Management for Emerald ash borer" Appendix D).*

Visual Survey:

Looking for the outwardly visible signs and symptoms of EAB. Can also include inspection of nursery stock or firewood .

Professional Assessment:

Arborists contracted to closely examine tree canopies in a given area. Branch sampling or other closer assessment may be made.

"Trap Tree" System:

Artificially wounding *(girdling)* trees to increase stress and make them more attractive to EAB. Requires expendable ash trees, and thus may not be practical.

Attractant-Baited Traps:

Set and monitor Purple Prism Traps *(PPTs).* Surveys can be conducted over a larger area and at considerably less expense than other methods. When purchased in bulk, the purple prism trap and lure *(z-3 hexanol)* can be purchased for under $7.00 per unit. See 2018 EAB Trapping Protocols from USDA APHIS PPQ for more information.

Visual signs and symptoms of EAB infestation include canopy thinning (left), epicormic sprouting (right), and woodpecker damage.
Photo credit: Joseph O'Brien, USDA Forest Service, Bugwood

Purple Prism Trap (PPT).
Photo Credit: Kenneth R. Law, USDA APHIS PPQ, Bugwood.org

2. Support and Expand the Oregon Forest Pest Detectors Program

Oregon Forest Pest Detectors (OFPDs) are volunteers that help prevent the damaging impacts of invasive forest pests by monitoring for and reporting potential infestations. Typically, participants already have some baseline knowledge of tree/insect identification and are likely to encounter an infestation as part of their work. Forest Pest Detectors could be: arborists, foresters, landscape contractors, cargo distribution center employees, neighborhood tree volunteers, state park and campground personnel, OSU Extension volunteers, watershed council members, and others in the restoration community. Utilization and support of this program will increase the number of highly-trained EAB detectors. Ways to support the OFPD program include ensuring there is adequate funding for training, increasing the number and locations of trainings *(especially within EAB high-risk areas),* creating incentives that encourage professional trainings, and making the OFPD training program a requirement for campground staff and/or ISA members.

Wyatt Williams from the Oregon Department of Forestry shows a group of OFPD participants insect galleries on samples of ash bark at a field training. Photo Credit: Amy Grotta, Oregon State University Extension Service.

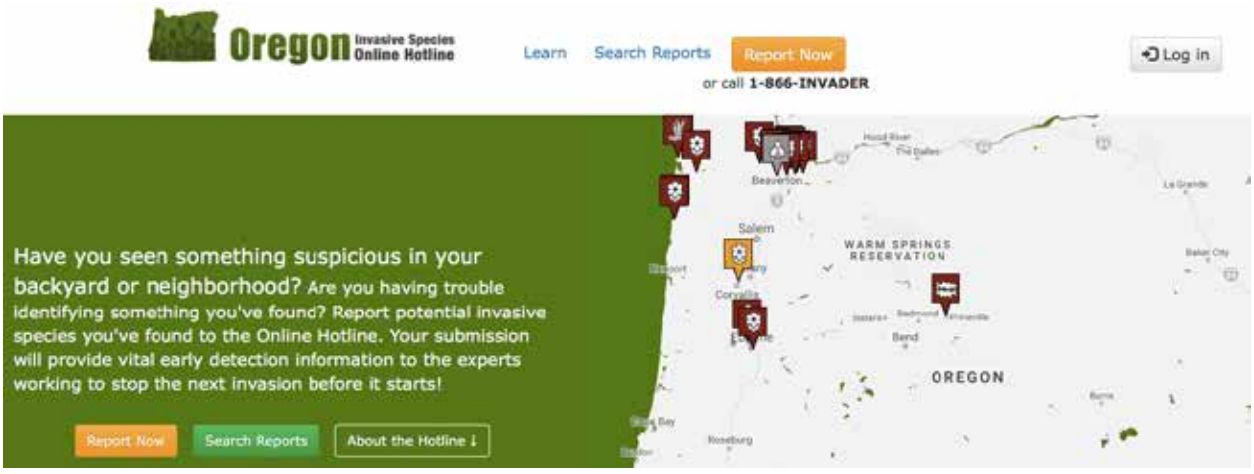
3. Public Engagement

In addition to educating groups of the public that are most likely to unintentionally introduce EAB into Oregon *(campers, out-of-state game hunters, mushroom hunters, etc.)*, these groups should also be encouraged to get involved in detection efforts. This includes active vigilance of EAB and other forest pests when in Oregon, spreading the word to others within their network, and taking the initiative to report any suspected sightings.

4. Reporting

When the presence of EAB is suspected, specific steps must be taken swiftly to ensure the possible detection is responded to in an appropriate and timely manner. Anyone submitting a report should be prepared to give a detailed description of the sighting, including the signs/symptoms observed and the exact location of the ash tree(s). Agency personnel will promptly investigate the suspected EAB infested ash. Below are the required actions if/when EAB is suspected:

> **Agency professionals must immediately contact Oregon Department of Agriculture Insect Pest Prevention & Management (ODA-IPPM) in the event EAB is suspected by emailing plant-entomologists@oda.state.or.us or calling 503-986-4636 / 1-800-525-0137.**
>
> **Members of the general public, conservation groups, volunteers, city workers, or other entities doing surveys are encouraged to report all suspected EAB sighting to the Oregon Invasive Species Hotline by calling 1-866-INVADER or by going to oregoninvasiveshotline.org.**



Screenshot of the Oregon Invasive Species Online Hotline, where users can submit suspected sightings of EAB.

5. Collection, Identification and Verification

It is important that the collection and submission of specimen(s) follow Oregon Department of Agriculture-Insect Pest Prevention & Management (ODA-IPPM) guidelines to ensure specimen quality is not compromised. Contact ODA-IPPM directly to ensure proper collection methods are utilized (plant-entomologists@oda.state.or.us). Specimen(s) collected from suspected ash will be sent to ODA-IPPM for identification at:

Oregon Department of Agriculture
Insect Pest Prevention & Management
635 Capitol St NE
Salem, OR 97301

If the inspection of the collected specimen results in a positive identification, the specimen will then be forwarded to USDA's Systematic Entomology Laboratory (SEL) for further confirmation. The steps laid out in (4) Reporting and (5) Collection, Identification, and Verification must be taken each time EAB is suspected in a new county or region of the state.

V. RESPONSE

Once EAB arrives, swift response actions will be necessary to lessen the overall impact to the state. An understanding of designated agency roles and adherence to thorough communication and coordination of collaborative efforts are key to successfully responding to an introduction of EAB. Response is broken down into eight sections: Stakeholder Actions, Communications Plan, Local Coordination, Investigation, Quarantine/Regulation, Management, Wood Waste/ Utilization, and Restoration & Replanting.

A. Stakeholders Convene to Create Specific Plan

ODA will take the lead in the event of an EAB detection in Oregon and will work together with ODF, OSU Extension, ODFW, USFS, APHIS, local governments, and entities in the detection zone to immediately determine a preliminary plan of action. Items to be addressed will include:

- Identify missing partners that should be at the table
- Identify a communications team to develop a communications plan
- Review details about the detection
- Review existing information on the pest and identify information gaps
- Develop plans for a delimiting survey
- Develop proposals for regulatory activities
- Quarantine determination and boundaries
    - Review State and Federal processes and timing
- Identify staffing and resource needs
- Finalize Incident Command structure and staffing for:
    - Planning and Finance
    - Operations
    - Communications
- Develop Response Team and Utilization Task Force

For more information on the general response, structure, and components necessary to create a preliminary plan of action in the event of an EAB introduction, see the Oregon Department of Agriculture's Plant Health Emergency Response Plan.

B. Communications Plan

In the event of an EAB introduction, efficient communication will be essential to garner the resources and assistance necessary to control the infestation. The primary agencies involved in the detection and announcement of an EAB infestation will compose a unified message to release to the media and interested parties. Communication between locally affected area(s) and their neighboring municipalities as well as between Oregon and neighboring states will be required in an effort to prevent the natural and anthropogenic spread of EAB.

- Develop a communication plan
    - See the Kansas Emerald Ash Borer Readiness and Response Plan for an example of an EAB communications plan
- Identify the Public Information Officer for all media contacts
- Set up contact personnel and website resources for the public in order to address questions and provide more information
- Inform the public
    - Submit a press release *(a sample press release can be found in Appendix E)*
      Host local resident meetings, visit affected residents, or use other outreach techniques to share information as soon as possible and to ensure all local residents are aware of the detection and the actions that will follow
    - Utilize social media to inform and communicate with the public

C. Coordination with Local Government, Landowners, and Tribes

Schedule an emergency meeting with local and tribal government representatives, landowners, regulated industries, utility companies, recreational areas, and others within the affected areas. See Appendix F for a preliminary list of potential outreach groups and collaborative partners. A Community Checklist *(below)* may be useful to discuss possible management actions with community representatives:

- Educate yourself, community staff, and community volunteers on the pest and its potential effects. Go to the Emerald Ash Borer Information Network and USDA APHIS Emerald Ash Borer websites and contact professionals for the most up to date information.
- Convene a Task Force of community decision makers, community volunteers, and agency individuals that can help evaluate potential decisions.
- Gather pertinent street tree and community owned tree documents: Inventories, maps of trees in your community, and applicable ordinances.
- Determine your level of risk: How many susceptible trees do you have? Who is responsible for their management? What is their condition?
- Determine your management strategies: Removal, replacement, treatment with pesticides, or a combination of actions.
- Determine your timeline for implementing management.
- Evaluate your budget for conducting management actions and identify other possible funding sources.
- Determine who will be executing the management: Community staff/employees? Contracted arborists and pesticide companies?
- Create a plan for dealing with/capitalizing on wood waste.
- Determine whether your community will assist with privately owned trees.
- Develop a dissemination plan for community residents and businesses concerning EAB and your decisions.
- Monitor public and private trees for signs and symptoms of EAB infestation

EXAMPLE INVASIVE SPECIES OUTREACH: JAPANESE BEETLE

The largest infestation of Japanese beetles ever found in Oregon was detected in 2016 in the area of Cedar Mill and Bethany of Washington County, Oregon. In response, the Oregon Department of Agriculture (ODA) prioritized public education and outreach efforts as well as consistent communication and coordination between agency professionals, affected landowners and business owners, and landscaping crews in order to maximize support of eradication efforts and lessen the likelihood of transporting Japanese beetle out of the treatment zone. Learn more about this 5-year project here:

http://www.japanesebeetlepdx.info

The Oregon Department of Agriculture team talking with residents of the treatment area during one of the many outreach events in 2017.
Photo credit: Jessica Riehl.

D. Investigation

A delimiting survey and dendrochronology techniques will provide information on EAB population density and dispersal as well as how long EAB has been present. This information can help guide planning and management strategies. Depending on the extent, severity, and age of the infestation, goals of the response efforts could range from complete eradication to slowing the spread of EAB to new areas.

1. Origin and Dissemination

Investigate not only the location and possible pathway of original infestation, but also the likelihood that additional introductions could occur through the same path. Dendrochronology techniques could also be utilized to identify the timeline of the infestation. Trace forward and trace back movement of infested material and associated commodities.

2. Spread

If the infestation is relatively geographically contained and was established within the last three years, then eradication efforts can likely proceed. However, if the infestation is across a large area and/or has been established for four or more years, then quarantine and containment efforts should be enacted in order to slow the spread of EAB to other parts of the state.

3. Delimitation

Determine the extent of the EAB infestation to provide information necessary to make quarantine determinations and establish quarantine boundaries.

E. Quarantine/Regulation – Enforcement and Compliance

If an EAB infestation is detected within four years of arrival, there are several actions that can be taken in an effort to eradicate EAB from Oregon including pesticide treatment and preemptive tree removal. In the event that EAB cannot be eradicated, municipalities within the state of Oregon should shift their focus to managing and containing the local EAB infestation to prevent further spread to nearby areas. Containment efforts follow Emerald Ash Borer Program Manual established by USDA or from research conducted by state or federal agencies.

As of January 14, 2021, interstate movement of EAB-infested materials and products is no longer prohibited by the U.S. Government (USDA Docket APHIS-2018-0056). There are currently no federal restrictions in the movement of ash firewood, nursery stock, or other items across the United States. Under Oregon Administrative Rule, Chapter 603 Division 52, Oregon Department of Agriculture can impose its own quarantine for emerald ash borer which could prohibit items from other states infested with emerald ash borer as well as establish control areas in Oregon if EAB were to establish in the state.

See Appendix G for a list of applicable state and federal quarantine laws and regulations.

EAB infested ash tree removal in Pennsylvania.
Photo credit: Pennsylvania Department of Conservation and Natural Resources- Forestry, Bugwood.org

F. Management

1. Tree Removal for Containment and Local Eradication

Tree removal can be conducted on both infested and uninfested host trees. There may be opportunities where selective removal of trees can remove "stepping stone" trees to protect vulnerable ash population *(i.e. hinder the ability of EAB to spread).*

2. Long Term Management: Biocontrol

Due to the long life cycle of trees and the large number of ash trees and species throughout North America, it will be many years before we know if biological control *(biocontrol)* can effectively protect ash species against EAB. However, biocontrol has been used for over 100 years in the U.S. and has successfully controlled similar invasive insect pests such as gypsy moth, winter moth, ash whitefly, and eucalyptus longhorned borer.

Four species of hymenopteran parasitoids are approved for release as biocontrol agents of EAB in the U.S. and others are currently under consideration. The four approved species are Oobius agrili, Spathius agrili, Tetrastichus planipennisi, and Spathius galinae. It will be important to evaluate these biological control options, specifically in reference to their performance in Oregon ash and common urban street trees in the state.

BIOCONTROL OF EAB

In 2007, Massachusetts released parasitic wasps to kill EAB. One important lesson learned was that the phenology of EAB needs to be considered and compared to that of the parasitoid *(i.e. whether it has a 1 or 2 year life cycle and whether its life cycle lines up with that of EAB).* **Another lesson learned was that there is no "one-size-fits-all" parasitoid. For example, one of the wasps that established well in the North was unable go through thick bark** *(aka large trees),* **while another wasp was much larger and could go through thick bark, but did not seem to establish well. However, there is a new parasitoid species from Russia on the horizon that came out in Spring 2018 and is better synchronized with EAB in the North.**

When selecting release sites, there are specific characteristics to consider in order to ensure the highest probability of establishment. For example, natural areas, at least 40 acres in size, with ash density 25% or higher, that are difficult to manage by tree removal or insecticide treatment and are proximal to areas where EAB is being managed *(such as urban areas),* are good candidates for biocontrol release sites.

Information about EAB biocontrol can also be found at the USDA Forest Service's Biological Control of the Emerald Ash Borer and protocols for EAB biocontrol use in Oregon can be found in Emerald Ash Borer Biological Control Release and Recovery Guidelines.

Spathius galinae, a parasitoid wasp from Russia, has been approved for release to help control the emerald ash borer.
Photo credit: USDA and University of Delaware.

SLOW ASH MORTALITY (SLAM)

In 2008, researchers in Michigan set out to evaluate unsuccessful EAB eradication and quarantine efforts and wound up creating a pilot field project that proposed using a combination of response tools to slow the onset and progression of ash mortality. SLow Ash Mortality (SLAM) is a site-based approach that integrates different management options based on the characteristics of an infested site and seeks to increase the success of EAB responses within the urban tree canopy. SLAM management options include girdling and debarking ash trees, prophylactic insecticide treatment, and selective ash removal. Over a 10-year horizon, simulations showed that annual treatment of 20% of ash trees protected 99% of trees after 10 years, and the cumulative costs of treatment were substantially lower than costs of removing dead or severely declining ash trees.

G. Wood Waste Disposal/Utilization

The EAB response team can convene a Utilization Task Force to identify wood disposal and/or utilization options, investigate resources that are available, and develop best management practices for handling wood waste.

1. Marshalling Yards

Wood collection or marshalling yards have proven to be an effective way to collect infested wood harvested by various groups into one accessible location where it can be sorted, processed, treated, and merchandised. These yards will also play a regulatory role by enabling state and local officials to contain large amounts of affected material and inspect finished products efficiently. Partners, such as ODOT, will play in important role, providing expertise in site locations, equipment, etc.

2. Biofuel, Woodworkers, Landscaping (chips), and Others

The recommended options for utilizing properly treated wood waste include lumber products *(with no bark present),* chipped wood waste for landscaping, trail surfaces, bedding material for farmers, or a carbon source for compost piles. Wood waste can also be used as boiler fuel in a boiler equipped with the appropriate air pollution control equipment *(consult individual boiler owners for required fuel specifications),* or as firewood for wood burning stoves and outdoor campfires *(residential outdoor wood fired boilers are not recommended due to their heavy release of fine particulate matter pollution).*

VI. FUNDING

Eradication and program expenses are often covered by the state with funding through cooperative agreements with USDA APHIS and/or USDA Forest Service. These agencies may provide emergency funds for selected pest management activities and/or for restoration, above any base-level funding for pest detection and surveys. State emergency funds can also be requested by the responsible state agencies. If eradication efforts fail and the pest becomes well established, annual costs for control will likely be incurred by the towns, cities, communities, and landowners. Sources of federal and state funds for control of established populations are uncertain and may be partially dependent on the pest of concern.

Since funding sources are not guaranteed, affected communities should look into multiple sources of potential funding. Actions that could generate funds for EAB detection efforts include implementing a firewood tax, increasing campground fees, or charging students of the OFPD training program, which is currently offered at no charge. Below is a preliminary list of potential partners who could assist in finding and securing funds for control activities:

Preliminary list of potential partners that may provide assistance in finding and securing funds for control activities:

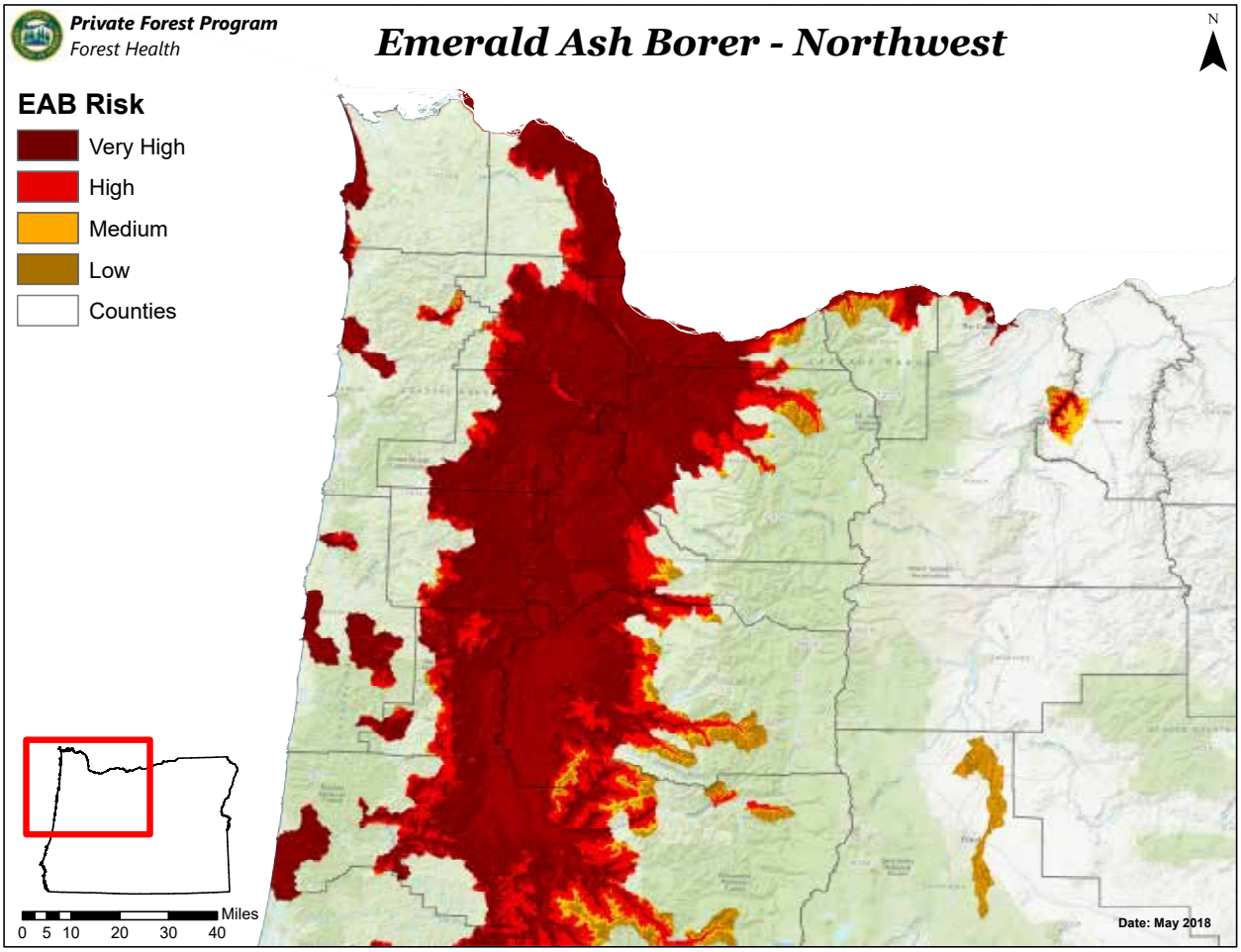
- **APHIS**
- **Forest Service**
- **EBoard**
- **Oregon Invasive Species Council-Emergency Account**
- **Oregon Forest Industries Council**
- **Office of Emergency Management**
- **League of Oregon Cities**
- **Association of Oregon Counties**
- **Marine Board**
- **Bureau of Land Management (BLM)**
- **Oregon Watershed Enhancement Board (OWEB)**
- **State Parks**
- **FEMA**
- **Nature Conservancy**
- **Audubon Society**
- **Builders Association**
- **Oregon Association of Nurseries - Emergency Account**
- **Cost sharing with neighboring municipalities**

VII. APPENDICES

A. Stakeholder group contact info

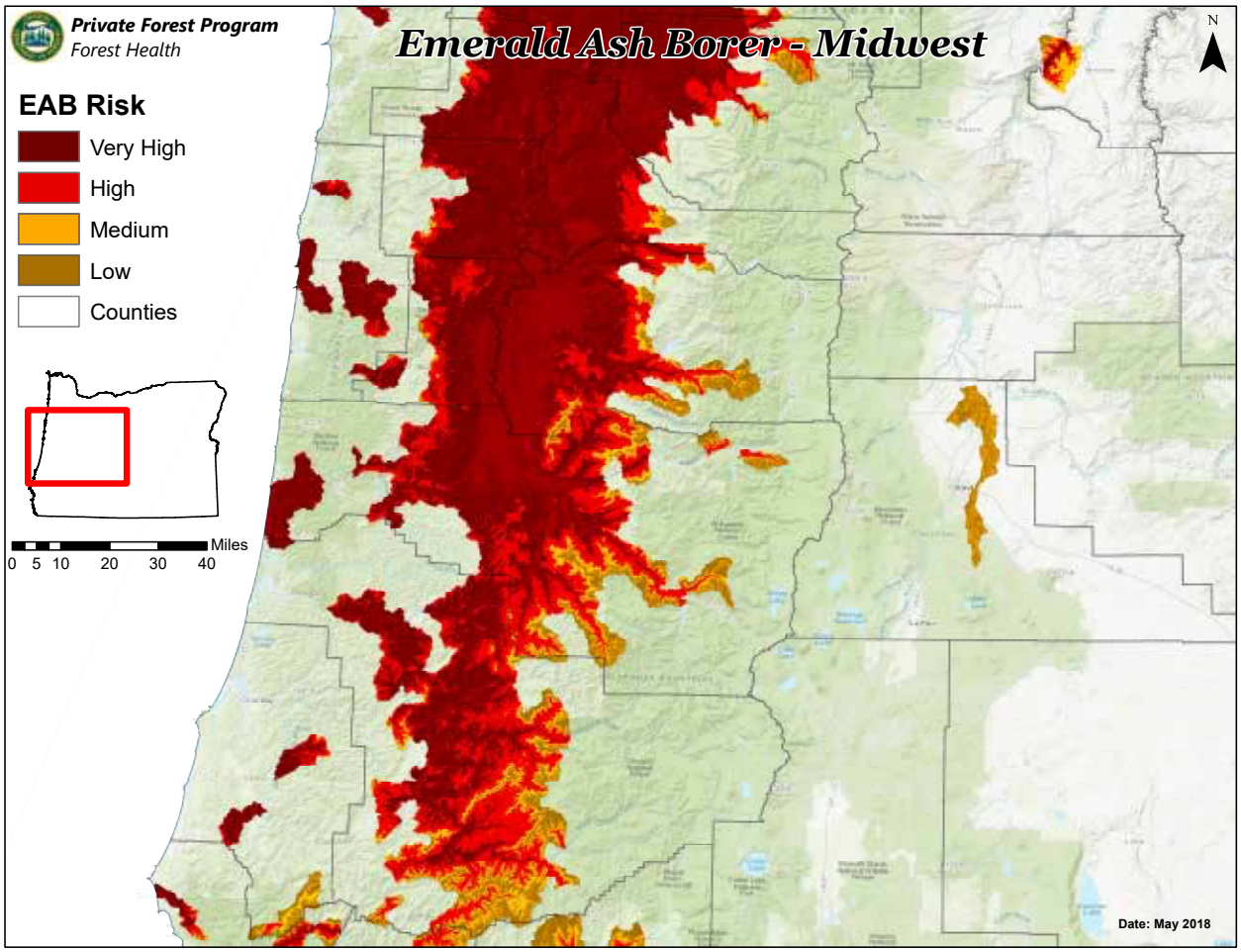
Agency	Title	Phone
Oregon Department of Agriculture	IPPM Program Manager	503-986-4663
Oregon Department of Forestry	Forest Health Program: Invasive Species Specialist	503-945-7472
Oregon Department of Fish and Wildlife	Aquatic Invasive Species/ Wildlife Integrity Coordinator	(503) 947-6308
USDA APHIS	State Plant Health Director	503-326-2814
US Forest Service	Forest Entomologist / Forest Health Monitoring Coordinator	503-808-2674
Oregon State University	Extension Forester	503-397-3462
Oregon Invasive Species Council	Coordinator	971-998-0573
City of Portland: Portland Parks & Recreation Urban Forestry	Botanic Specialist I	503-823-1650

B. EAB Risk Maps by Region



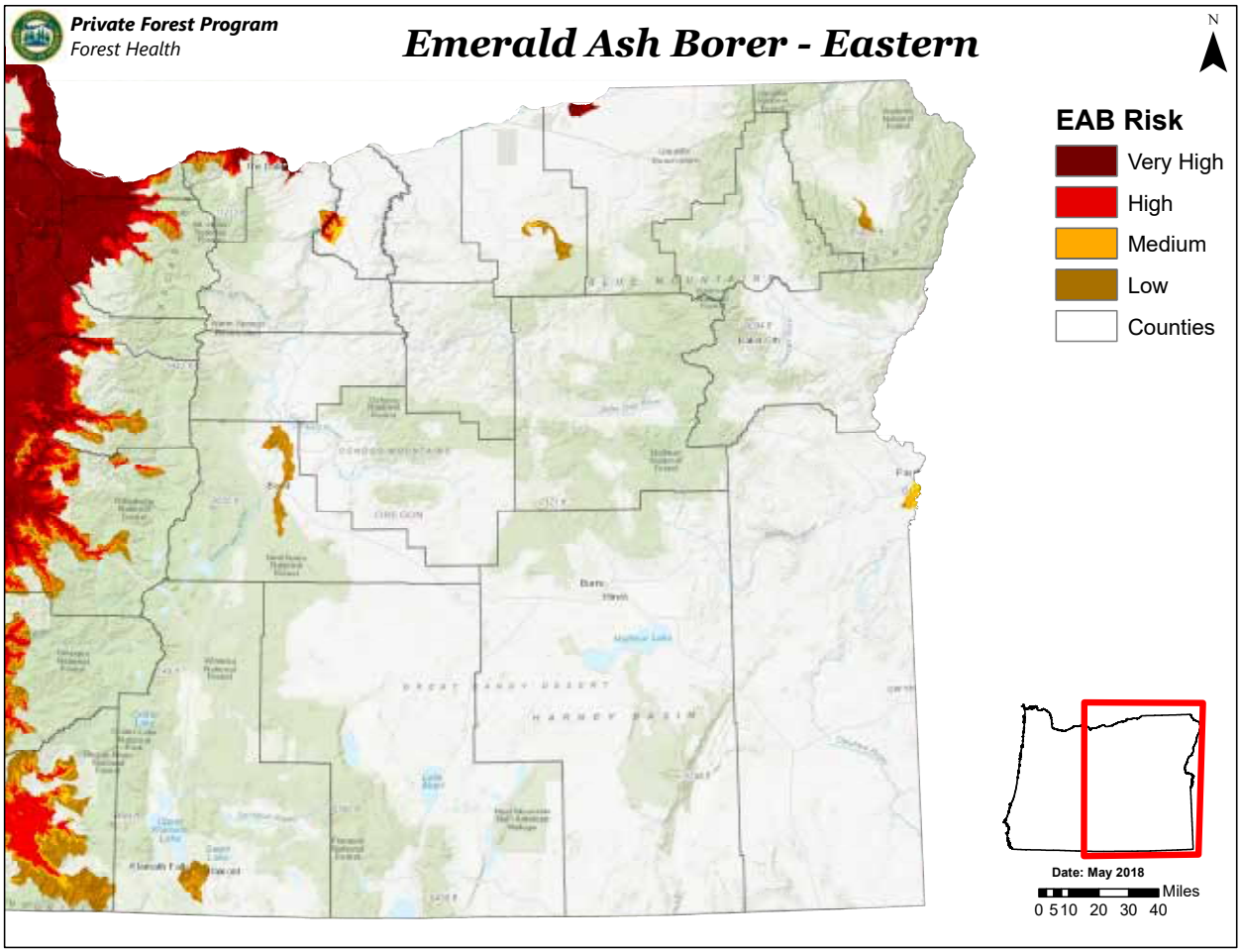
Risk for emerald ash borer (EAB) is mapped based upon known occurrences of ash (Fraxinus sp.) at the local watershed level (hydrologic unit code 12, or HUC-12) in Oregon. Point data for Oregon's two wild, naturalized species of ash, Oregon ash (F. latifolia) and green ash (F. pennsylvanica), were used to create the map. Data on ash distribution originated from two sources: the Oregon Plant Atlas, a product of the Oregon Flora Project, and emerald ash borer surveys conducted by the Oregon Department of Forestry. EAB risk categories were determined based on the frequency distribution of ash by elevation above sea level and corresponding human activities associated with known pathways of EAB introduction and establishment: Very high: ≤1,000' above sea level, High: 1,000 to ≤2,000', Medium: 2,000 to ≤ 2,500', and Low: >2,500'. The EAB risk map is shown in four regional maps for the state of Oregon.

B. EAB Risk Maps by Region *(continued)*



Risk for emerald ash borer (EAB) is mapped based upon known occurrences of ash (Fraxinus sp.) at the local watershed level (hydrologic unit code 12, or HUC-12) in Oregon. Point data for Oregon's two wild, naturalized species of ash, Oregon ash (F. latifolia) and green ash (F. pennsylvanica), were used to create the map. Data on ash distribution originated from two sources: the Oregon Plant Atlas, a product of the Oregon Flora Project, and emerald ash borer surveys conducted by the Oregon Department of Forestry. EAB risk categories were determined based on the frequency distribution of ash by elevation above sea level and corresponding human activities associated with known pathways of EAB introduction and establishment: Very high: ≤1,000' above sea level, High: 1,000 to ≤2,000', Medium: 2,000 to ≤ 2,500', and Low: >2,500'. The EAB risk map is shown in four regional maps for the state of Oregon.

B. EAB Risk Maps by Region *(continued)*



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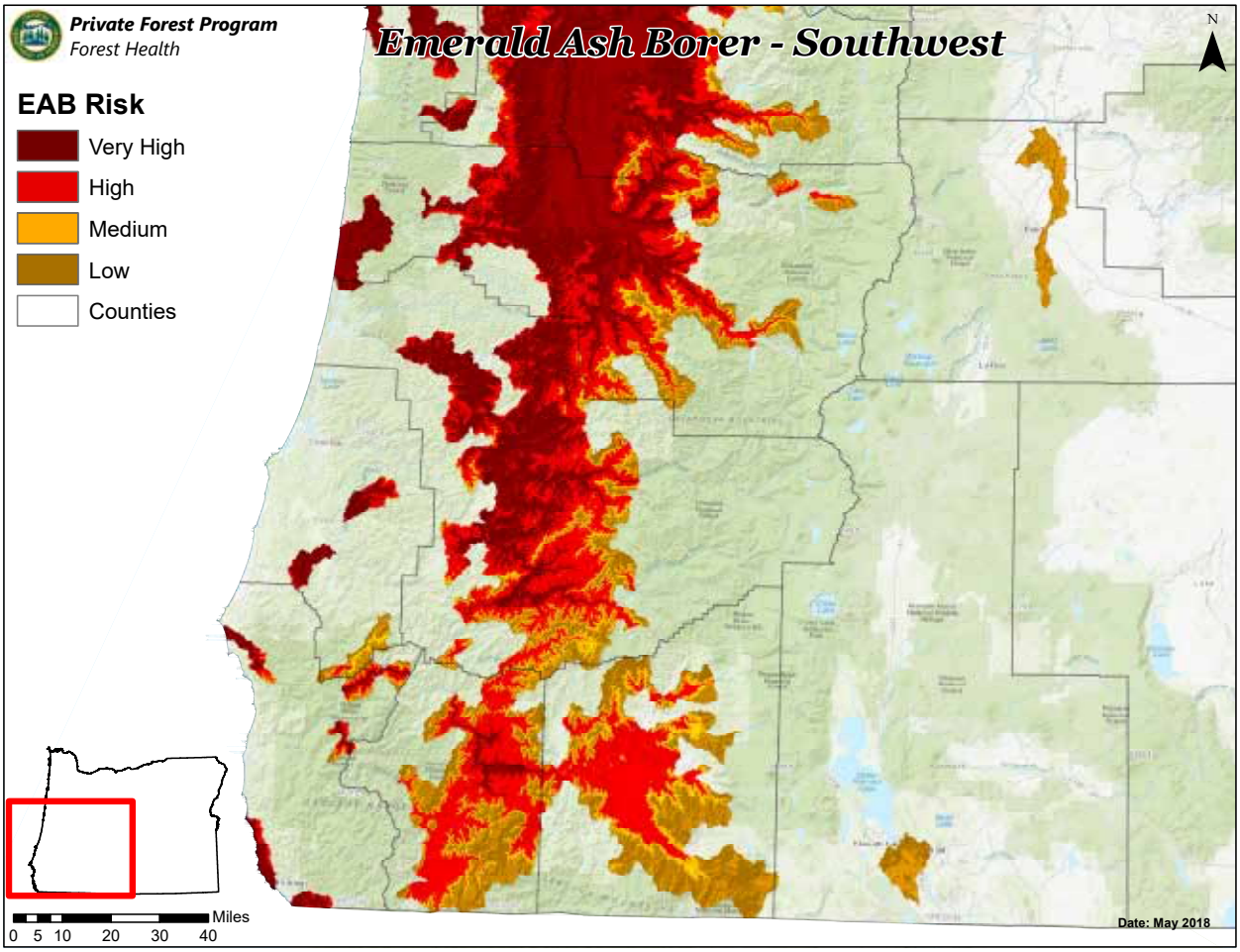

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C. List of Oregon Cities with Tree Inventories

Some city inventories may only include city parks and/or street trees. It is recommended that cities work toward complete community-wide inventories and update information at regular intervals as appropriate to ensure accurate information is available.

City Name
Albany
Baker City
Beaverton
Canby
Cannon Beach
Corvallis
Cottage Grove
Dallas
Dayton
Durham
Eagle Point
Estacada
Eugene
Grants Pass
Gresham
Jacksonville
La Grande
Madras
Malin
Metolius
Milwaukie
Portland
Salem
Sandy
Sisters
St. Paul
Sunriver
Tillamook
Tualatin
Turner
Wilsonville
Woodburn

D. Integrated Pest Management (IPM) recommendations for EAB

IPM is a holistic strategy of pest prevention or pest reduction that incorporates economic, ecological, and social values while minimizing impacts and risks to human health, non-target organisms, and the environment. Acceptance of some level of resource loss is central to IPM ideology. Thresholds, either economic or environmental, are established before arrival of the pest and serve to trigger an appropriate management response. The IPM process involves continuous monitoring for the pest in question, understanding the pest's biology and opportunities for control, and responding with an appropriate array of IPM tactics after thoughtful review of ecological and economic consequences of doing so. IPM control tactics include chemical, biological, mechanical, and cultural methods, as well as the option of "doing nothing," or waiting until conditions are more favorable for control to be employed. See Table 3 for available IPM tactics and optimal timing for each. Record keeping, follow-up monitoring and maintaining a flexible response to current pest conditions are keys to success for IPM.

Six step process to decision-making in IPM:

1. Identify the problem or pest with awareness that more than one stressor may be present
2. Determine the severity of the problem
3. Assess management options
4. Select and apply one or more options
5. Measure the efficacy of options applied
6. Record the results; monitor, and follow-up

Table 3. Table of actions and thresholds for common EAB IPM tactics.

IPM Tactic	Action	Threshold/Timing
Monitoring	Trap surveys/trap trees	Annually; Trapping season May-Aug
	Visual surveys	Annually; Reports filed to Hotline
Cultural Control	Promote local firewood	Continuous
	Inventory/document ash in cities	Continuous; best done May-Sept when leaves are on trees
	Remove ash from city street tree lists	Ongoing
	Pre-emptive removal of ash	When nearest confirmed EAB is 100 miles in proximity; dry/debark/use wood ASAP
Mechanical Control	Tree removal and chipping	Active EAB infestation or invasion front (10-15 miles from known EAB population)
	Tree burial or incineration	Active EAB infestation or invasion front (10-15 miles from known EAB population)
Biological Control	Request/release agents from ODA/APHIS	Active EAB infestation or invasion front (10-15 miles from known EAB population)
Chemical control	Systemic insecticides	Active EAB infestation or invasion front (10-15 miles from known EAB population)
	Foliar sprays	Not recommended

Common tactics for emerald ash borer IPM:

Monitoring:

- Purple prism traps, coated with insect-trapping adhesive and baited with lures Z-3-hexenol and Manuka oil, are placed 3-10 m high in ash trees before and during peak adult flight period.
- Girdled "trap trees" – ash trees that have been intentionally killed by mechanical girdling – can be left in place, or bolts of freshly-cut ash stems can be hung in ash canopies or placed in other areas to monitor for attacks by EAB adults.
- Visual monitoring for EAB symptoms on trees and the insect itself are made by the public, private tree care professionals, government natural resource workers, and others. Report suspected findings of EAB to the Oregon Invasive Species Online Hotline: oregoninvasiveshotline.org
- State and federal agencies conduct monitoring surveys for EAB, contingent upon funding. Current quarantine maps for EAB in the United States can be found on the web at
- www.emeraldashborer.info. However, once EAB has been found in a county, surveys by regulatory agencies typically end. Thus, quarantine maps may not adequately reflect the current distribution of EAB.

Cultural control:

- Prevent the spread of EAB by not moving infested firewood, logs, or nursery stock
- Inventory urban forests to understand risks and costs associated with EAB-killed trees.
- Consider omitting or reducing susceptible host tree species (Fraxinus spp.) from lists of approved tree species for community or neighborhood plantings. Plant resistant or non-host tree species.
- Once EAB is nearing close proximity (e.g. 100-200 miles) consider pre-emptive removal of healthy ash trees to spread removal costs across several years. See tool to estimate cost of ash tree removal in IPM References and Further Reading section below.

Mechanical control:

- Timely removal of EAB-infested trees and chipping the infested material to small size – less than 1" on each of two sides
- Burial or incineration of infested wood material if chipping is not possible

Biological control:

- Release and monitor biocontrol agents in areas that are infested with EAB. Since 2007, the U.S. Department of Agriculture has been actively importing and researching several species of EAB parasitoids – insects that feed and develop exclusively on EAB – in attempts to provide population control after EAB has been established in an area. The egg parasitoid, Oobius agrili *(Encytridae),* and the larval parasitoids, Tetrastichus planipennisi *(Eulophidae),* Spathius agrili, and S. galinae *(Braconidae),* have been approved for release. Native parasitoids *(Phasgonophora sulcata and Atanycolus spp.)* have also been shown to attack EAB. Imported biocontrol agents for EAB can be requested through the U.S. Department of Agriculture. See IPM References and Further Reading section below.
- Increase or promote habitats for woodpeckers, which are generalist predators but have been shown to consume up to 30% of EAB larvae in severely infested areas in the eastern U.S.

Chemical control (Table 4):

- Pesticide applicators must read, understand and follow all label directions for pesticides. The pesticide label is the law. Pesticide labels and registrations change frequently, and it is the responsibility of the pesticide applicator – whether professional or home owner – to follow the directions on the label. See Oregon Department of Agriculture Pesticide Program in the reference section for latest regulatory information on applying pesticides.

- Some insecticides, such as neonicotinoids, have been implicated in decline of pollinators. The latest information on safety and legal use of insecticides in Oregon can be found through the Oregon Department of Agriculture Pesticide Program.
- Chemical control options, regardless of delivery system or active ingredient, are only effective when less than 50% of the canopy of an infested tree has been killed by EAB. If the tree has over 50% canopy mortality, it will likely not be able to recover and should be mechanically removed and disposed of properly.
- Trees with trunks greater than 15" diameter at breast height should be treated by a professional applicator.
- Healthy, uninfested trees can be preventively treated with pesticides and protected from EAB when known EAB infestations are within 10-15 miles. Chemical treatments that begin too early waste money and increase the risk of affecting non-target organisms.
- The most effective insecticides for EAB are systemic, meaning they are transported throughout the tree's vascular system. These systemic insecticides, which target both adults and larvae, should be applied in mid-April through May, before the peak flight of adult EAB *(late May through June).* Drought stress greatly inhibits the uptake of systemic insecticides. Supplemental watering, beginning a month or more in advance of treatment, may be needed to increase effectiveness of chemical application.
- Depending on the active ingredient and the particular product, systemic insecticides for EAB can be applied through soil drenching, soil injections, basal bark sprays, or direct injections into the tree itself. Some of these application techniques require specialized equipment and a professional pesticide applicator license.
- Broadcast foliar sprays target adults and are less desirable than systemic insecticides due to the larger volume that needs to be applied as well as the chance for drift and associated non-target effects.
- Systemic insecticides can provide >95% protection against EAB but must be reapplied every 1-3 years. Broadcast foliar sprays must be reapplied every year.

Table 4. Chemical control options for EAB.

Delivery	Active ingredient	Chemical class	Level & extent of control	Applicator	Target
Trunk injection	emamectin benzoate	Macrocyclic lactone	Excellent, 1-3 yrs	Professional	Larvae or adults
	imidacloprid	Neonicotinoid	Very good, 1-2 yrs	Professional	Larvae or adults
	azadirachtin	Botanical	Very good, 1-2 yrs	Professional	Larvae or adults
Soil drench or soil injection	imidacloprid	Neonicotinoid	Good, 1 yr	Home owner or professional	Larvae
	dinotefuran	Neonicotinoid	Good, 1 yr	Home owner or professional	Larvae
Trunk spray	dinotefuran	Neonicotinoid	Very good, 1 yr	Home owner or professional	Larvae or adults
Broadcast foliar spray	bifenthrin	Pyrethroid	Fair, 1 yr	Home owner or professional	Adults
	carbaryl	N-methyl carbamate	Fair, 1 yr	Home owner or professional	Adults
	cyfluthrin	Pyrethroid	Fair, 1 yr	Home owner or professional	Adults

IPM References and Further Reading:

Cost calculator for determining control measures by community or neighborhood:
http://int.entm.purdue.edu/ext/treecomputer/

Log a report of suspected EAB in Oregon:
https://oregoninvasiveshotline.org/

U.S. Department of Agriculture EAB monitoring and biological control program:
https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/emerald-ash-borer/ct_emerald_ash_borer

Academic research on EAB chemical control guidelines:
http://www.emeraldashborer.info/documents/Multistate_EAB_Insecticide_Fact_Sheet.pdf

Oregon Department of Agriculture Pesticide Program:
http://www.oregon.gov/ODA/programs/Pesticides/Pages/default.aspx

E. Sample Press Release

Contact: Jane Doe, <title here>, XXXXXXXXXX

EMERALD ASH BORER FOUND IN <City/Location>, MEETING PLANNED

<City/Location>, OR. –

Emerald ash borer (EAB), an exotic beetle that infests ash trees, was recently discovered in the <City/Location> area. EAB is now considered the most destructive forest pest ever seen in North America and has the potential to create billions of dollars in damages nationwide if not dealt with. The <municipality> is sponsoring an EAB informational meeting on <date, time> at the <meeting location> (<street address>). The public is invited. EAB specialists from <education/information resource> and regulatory specialists from the Oregon Department of Agriculture will be on hand to explain what EAB is and how it will be handled <City/Location>.

"This pest is very destructive, and people should know what to look for and what to do if they find it," says <name, title>. "We will provide information on identifying the pest, the signs and symptoms of EAB infestation, what treatment options are available, and tree species that are good options for replacing ash trees. There will also be information from an Oregon Department of Agriculture representative on EAB regulations and quarantine measures."

For more information, call <Name> at XXXXXXXXXX. Additional EAB information can be found at the EAB Web site: www.oregoneab.info.

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F. Outreach Groups and Collaborative Partners

The following list includes groups, agencies, institutions, and businesses that may be impacted by the arrival of EAB in Oregon and/or might be interested in receiving and sharing important information related to pre- and post-arrival actions. This is by no means an exhaustive list and is intended only to be a starting point for planning outreach and collaborative efforts.

Asplundh	Oregon Invasive Species Council
Association of Oregon Counties	Oregon Association of Loggers
Audubon Society of Portland	Oregon Association of Nurseries
Beyond Toxics	Oregon Department of Agriculture
Burns Paiute Tribe	Oregon Department of Environmental Quality
City of Albany	Oregon Department of Fish & Wildlife
City of Ashland- City Risk Manager	Oregon Department of Forestry
City of Central Point	Oregon Department of Transportation
City of Eugene: Parks & Open Spaces	Oregon Farm Bureau
City of Eugene: Emergency Management Program	Oregon Forest & Industries Council
City of Medford: Parks and Recreation	Oregon Forest Research Institute
City of Portland	Oregon Health Authority
City of Portland: Urban Forestry Commission	Oregon Interactive Corporation
City of Salem: Parks and Recreation	Oregon Office of Emergency Management
City of Salem: Risk Manager	Oregon Parks & Recreation
Clackamas County: Urban Lumber Program	Oregon Pest Control Association
Clean Water Services	Oregon Refuse & Recycling Association
Coast Fork Willamette Watershed Council	Oregon Small Woodlands Association
Confederated Tribes of Coos, Lower Umpqua & Siuslaw	Oregon State Beekeepers Association
Confederated Tribes of Grand Ronde	Oregon State University
Confederated Tribes of Siletz	Oregon State University Extension
Confederated Tribes of the Umatilla Indian Reservation	Oregon Stream Protection Coalition
Confederated Tribes of the Warm Springs Reservation of Oregon	Oregon Tree Farm
Coos Forest Protective Association	Oregon Watershed Enhancement Board
Coquille Indian Tribe	Pacific Northwest ISA
Coquille Watershed Association	Partnership for the Umpqua Rivers
Covanta - Marion County	PDX Ecologists Unite
Cow Creek Band of Umpqua Indians	Portland Bureau of Transportation

Cow Creek Band of Umpqua Tribe of Indians	Portland Community College
Department of State Lands	Siuslaw Watershed Council
Douglas Forest Protective Association	Society of Municipal Arborists
Eugene Water & Electric Board	Soil and Water Conservation Commission- Deschutes area
Forest Park Conservancy	Soil and Water Conservation Commission- Lower Willamette area
Friends of Trees	Soil and Water Conservation Commission- northern coast area
Greenbelt Land Trust	Soil and Water Conservation Commission- southern Oregon area
Harney County Watershed Council	Soil and Water Conservation Commission- Upper Willamette area
Hood River Soil & Water Conservation District	Southern Oregon Beekeepers Association
Intertwine Alliance	Tillamook Bay Watershed Council
Keep Oregon Green	Tillamook Forest Center
Klamath Tribes	Trees Inc. (Roseburg)
Klamath Watershed Partners	Tualatin Hills Nature Park
League of Oregon Cities	Tualatin River National Wildlife Refuge
Lower Rogue Watershed Council	Tualatin River Watershed Council
Luckiamute Watershed Council	University of Oregon (Exterior Maintenance Customer Service)
Metro	Upper South Fork John Day Watershed Council
Mid-John Day Watershed Council	US Fish and Wildlife Service
Middle Deschutes Watershed Council	USFS Portland
National Firewood Association	USGS
Necanicum Watershed Council	West Multnomah SWCD
Network of Oregon Watershed Councils	Weyerhaeuser
NOAA Fisheries- West Coast	Xerces Society
Northwest Center for Alternative Pesticides	

G. State and Federal Laws for Invasive Species

USDA APHIS

The Plant Protection Act of 2000 (7 U.S.C. 7701 et seq) as amended by the Noxious Weed Control and Eradication Act of 2004 (P.L. 108-412).

USDA Forest Service

Wyden Amendment (P.L. 109-54, Section 434)

USDA APHIS and Forest Service

Executive Order 13112

OR Revised Statutes for Forest Invasive Species

ORS Chapter 527 Insect and Disease Control; Forest Practices
ORS Chapter 561.510 to 561.600 – Quarantine Powers (ODA)
ORS Chapter 569 – Weed Control
ORS Chapter 570 – Plant Pest and Disease Control; Invasive Species
ORS Chapter 571.038 Plant Pest and Disease Emergency Response Fund
ORS Chapter 571.560 Inspection for pest, disease and weed control
ORS Chapter 634 – Pesticide Control

OR Department of Forestry Administrative Rules for Forest Invasive Species

OAR 629-025- 0040 General Forest Recreation Rules (Weed Free Forage)
OAR 629-051- 0210 Management and Control Actions (Forest Insects and Disease)
OAR 629-051- 0220 Costs of Control (Forest Insects and Disease)
OAR 629-051- 0230 Introduced Pests (Forest Insects and Disease)

OR Department of Agriculture Administrative Rules for Forest Invasive Species

OAR 603-010- 0055 Feral Swine
OAR 603-052- 0075 Quarantine; Chestnut Blight
OAR 603-052- 0114 Quarantine; Dutch Elm Disease and Elm Yellows Phytoplasma
OAR 603-052- 0120 Quarantine; Oak Wilt Disease

OAR 603-052- 1080 Firewood Restrictions To Prevent Transport Of Invasive Species

OAR 603-052- 1200 Quarantine; Noxious Weeds

OAR 603-052- 1205 Weed-Free Tree Seedling Nurseries

OAR 603-052- 1230 Quarantine: Phytophthora ramorum

OAR 603-054- 0027 Notification of Imported Trees and Shrubs

OAR 603-056- 0205 Prohibited and Restricted Noxious Weed Seed

OAR 603-057- 0001 to 603-057- 0425 Pesticide Control

OAR 609-010 Oregon Invasive Species Control Account

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