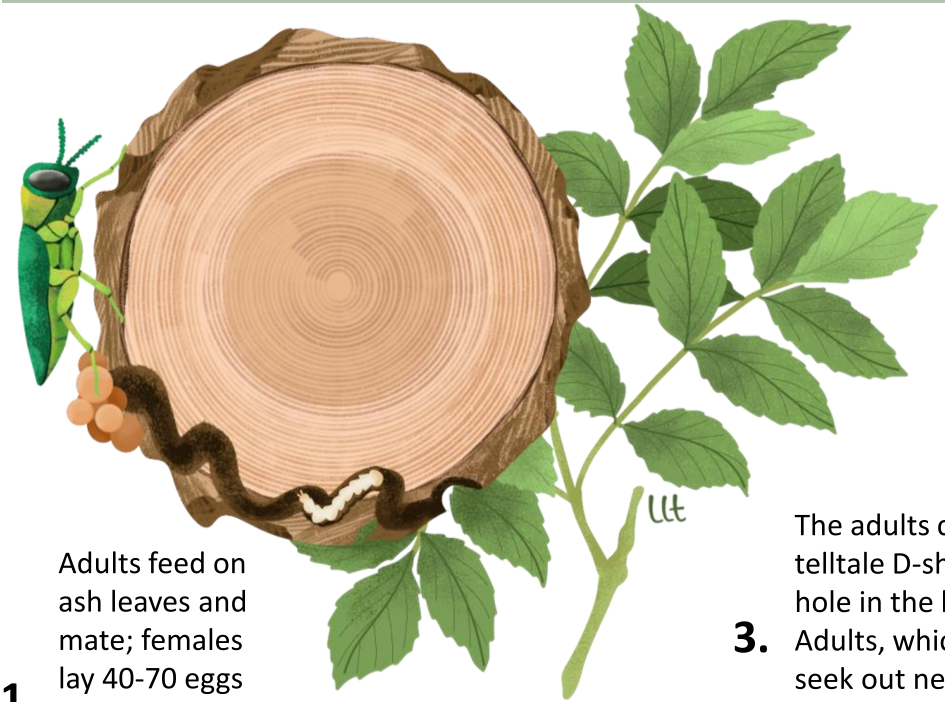
Regional Invasive Species & Climate Change
Management Challenge

Northwest RISCC Management Network

Managing the Threat of Emerald Ash Borer Invasion in a Changing Climate

Summary: In June 2022, the emerald ash borer (*Agrilus planipennis*; "EAB") was discovered in Forest Grove, OR, marking its first appearance west of the Rocky Mountains. Forest managers fear for the future of Oregon ash (*Fraxinus latifolia*) and at least 8 other tree species found only in western North America. Climate change may broaden the threat of EAB invasion[1] and requires climate-smart, proactive management to sustain healthy forests.

- Native to Asia
- First detected in U.S. in Michigan (2002), now present in at least 35 states & 5 provinces
- Infects all 16 species of N. American ash
- Primary cause of nationwide ash decline, with widespread economic impacts



1. Adults feed on ash leaves and mate; females lay 40-70 eggs on the bark of trees about 3-4 weeks before dying.
2. After hatching, the larvae bore into the tree to feed, creating S-shaped tunnels in the cambium. They remain for 1-2 years, then pupate into adults.
3. The adults chew a telltale D-shaped exit hole in the bark. Adults, which can fly, seek out new trees and start the cycle again.

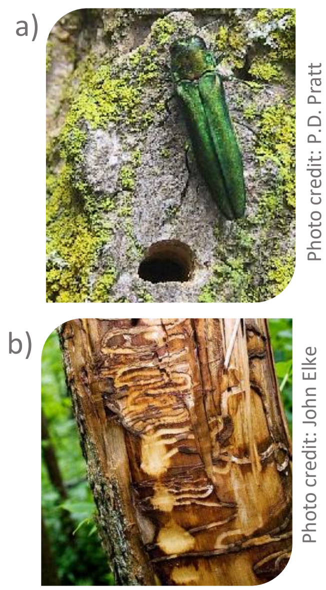


Fig. 1. (a) Adult EAB and exit hole.
(b) EAB tunnels in the trunk of a tree.

EAB invasion presents a significant threat to the Pacific Northwest where endemic Oregon ash and other ash tree species are abundant along riparian corridors in western Oregon and Washington. **Ash species provide important food and habitat resources along streams, rivers, and wetlands** where soils can be poorly draining and where seasonally high water-tables can exclude nearly all other tree species.

Loss of ash caused by EAB mortality → Dead ash biomass alters soil chemistry & soil moisture levels → Changes in soil chemistry can alter decomposition rates, nutrient & water cycling → Gaps in tree canopy can increase soil erosion, stormwater runoff, & stream temperatures & lead to invasion meltdowns[2] → Altered community composition & function[3]

Managing the Threat of Emerald Ash Borer Invasion in a Changing Climate

In Search of Climate Refugia

- EAB life cycle requires strong seasonality, with a long, cold winter season.
- Climate change could limit the southward invasion range if warming is enough to constrain EAB life cycle and survivorship.[4]
- Some ash species can survive increased temperatures of 3.5°C - 4.1°C, suggesting potential resilience to climate warming[5] and refugia from EAB in the southern portion of species ranges (but more information on refugia is needed).
- The entire North American range of ash species is invadable by EAB[6] but shifts in invasion range could be limited by the northern extent of ash (and ash densities), locations of potential ash refugia, return intervals of extreme cold events, and control measures.[4,7]
- Mid-winter warming events can cause a reduction in EAB cold tolerance ("deacclimation") and may limit survival and range expansion if followed by severe cold snaps (as expected under climate change).[8] However, evidence of extreme phenotypic plasticity in temperature tolerance suggests EAB may have great potential to withstand temperature extremes and variability.[6]
- Within the range of Oregon ash, minimum winter temperatures *do not* reach the supercooling points (i.e., coldest temperature at which EAB can no longer resist hard-freezing and die) reported from Canada and the Eastern U.S (**Fig. 2**).
    - Reported EAB supercooling points range from -35.3°C to -25°C.[8,9,10]
    - Most of North America, including the U.S. Northwest and southern British Columbia, does not experience extreme cold events frequently enough to kill EAB.[7,11]

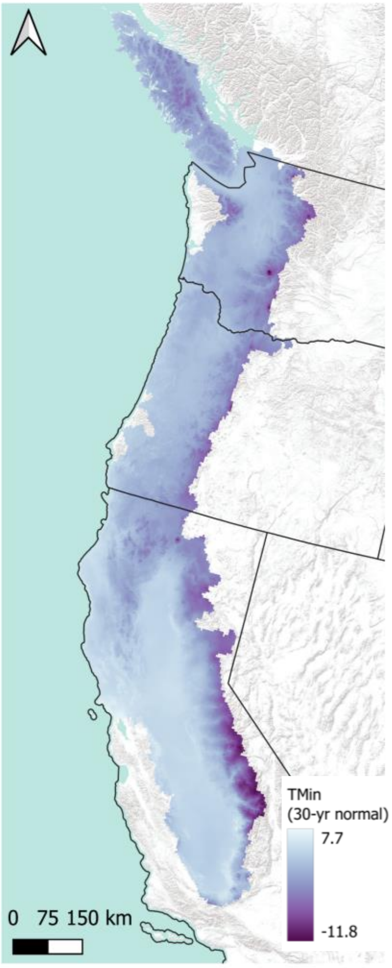
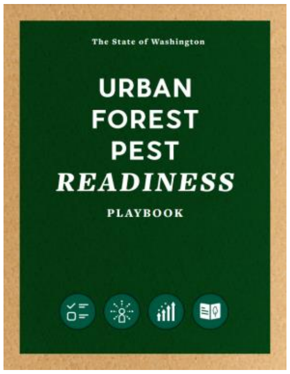


Fig. 2. 30-year normals of minimum winter temperatures (analyzed using PRISM downscaled climate data).

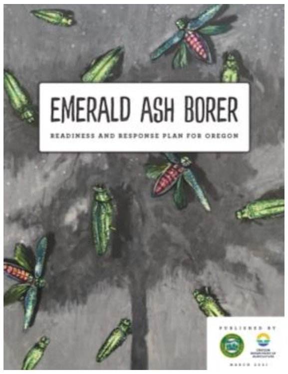
Climate-Smart Solutions

Oregon Dept. of Forestry is collecting 1 million seeds of Oregon ash to capture genetic diversity and support future breeding and provenancing programs.[12]
Other potential strategies include:

- Planting climate-adapted replacement species.[13,14,15]
- Deploying biological control agents (e.g., parasitoids) informed by host-parasite dynamics under climate change.[16,17]
- Identifying climate refugia for ash where either ash/EAB phenology or distribution is mismatched.
- Employing a risk matrix to evaluate relative threat of climate change to EAB invasion and identify ash species that need to have strategies developed, be evaluated further, or monitored.[18]
- Climate-informed Early Detection & Rapid Response (EDRR).[19]



https://invasivespecies.wa.gov/projects/pest-ready/



https://www.oregon.gov/odf/Documents/forestbenefits/eab-readiness-and-response-plan-for-oregon.pdf

References: [1] Olson *et al* 2021; [2] Simberloff & Von Holle 1999; [3] Grinde *et al* 2022; [4] Liang & Fei 2014; [5] Steiner *et al* 2021; [6] Duell *et al* (2022); [7] Cuddington *et al* 2018; [8] Sobek-Swant *et al* 2012; [9] Crosthwaite *et al* 2011; [10] Venette & Abrahamson 2010; [11] DeSantis *et al* 2013; [12] https://www.fs.usda.gov/nsl/GeneticConservation_Ash.html ; [13] Iverson *et al* 2016; [14] Palik *et al* 2021; [15] Looney *et al* 2017; [16] Gould *et al* 2020; [17] Duan *et al* 2020; [18] Iverson *et al* 2012; [19] Pontius & Hallett 2014

Authors: Lindsey L. Thurman (USGS NW Climate Adaptation Science Center); Deborah A. Rudnick (EcoAdapt). Illustrations by L. Thurman.