United States Department of Agriculture

Forest Health Highlights in Oregon - 2020

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Pacific Northwest Region
Forest Health Protection

Oregon Department of Forestry
Forest Health Program

FOREST HEALTH HIGHLIGHTS IN OREGON - 2020

Joint publication contributors:

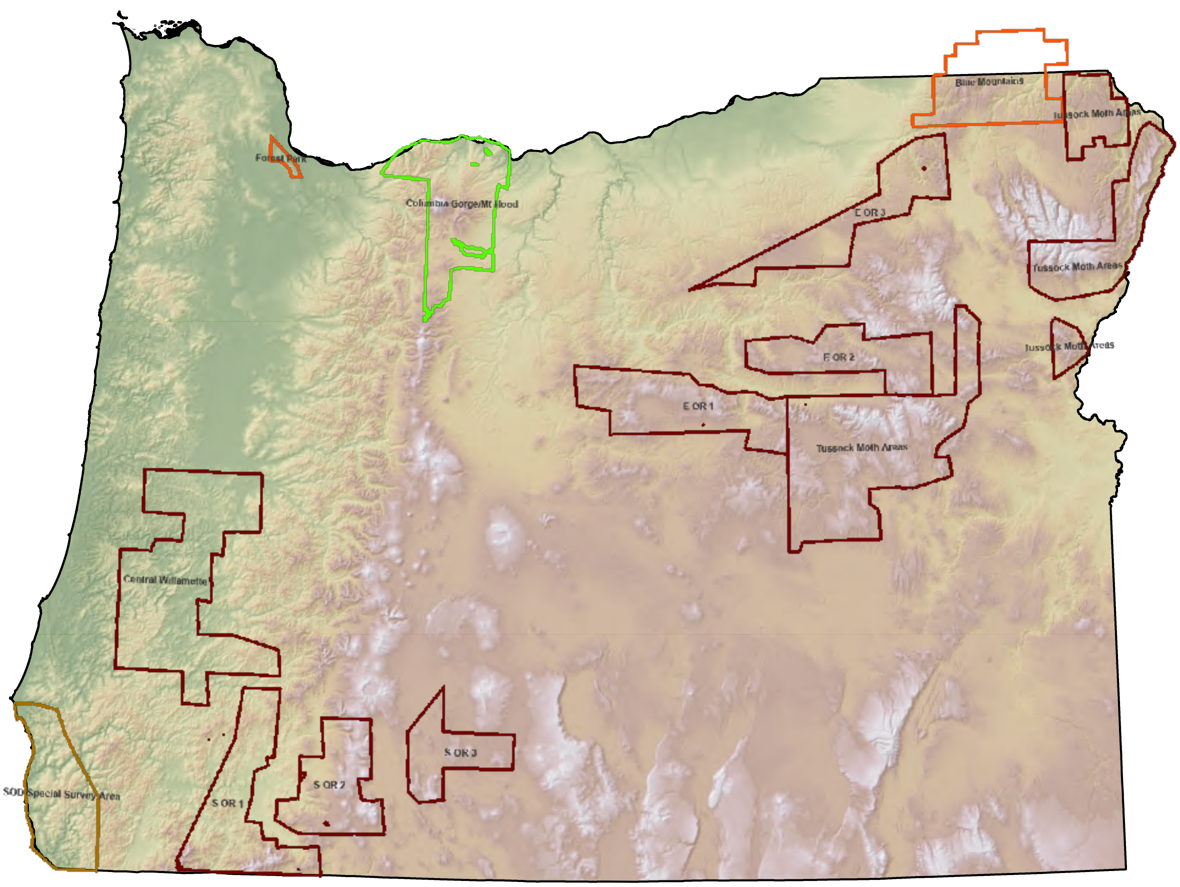
Christine Buhl
Wyatt Williams
Danny Norlander

Oregon State University

Gabi Ritokova
Stephen Calkins

Karen Ripley
Sarah Navarro
Zack Heath
Ben Smith
Justin Hof

Cooperative Aerial Survey: 2020 target areas



Map above: COVID-19 safety precautions limited surveys and field investigations during 2020. The above outlined areas were identified as high priority based on known abiotic stress, or insect and/or disease activity. Data were collected for these high priority areas using Scan and Sketch, our new alternative surveillance strategy (pg. 8) as opposed to regular aerial observation.

Front cover: *2020 Wildfire season: Holiday Farm active fire in Lane County (Marcus Kauffman, ODF), Beachie Creek fire burned area in Marion County (Wyatt Williams, ODF) and evidence of bark beetle attack in living, fire-damaged pine (Christine Buhl, ODF).*

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LANDOWNER RESOURCES

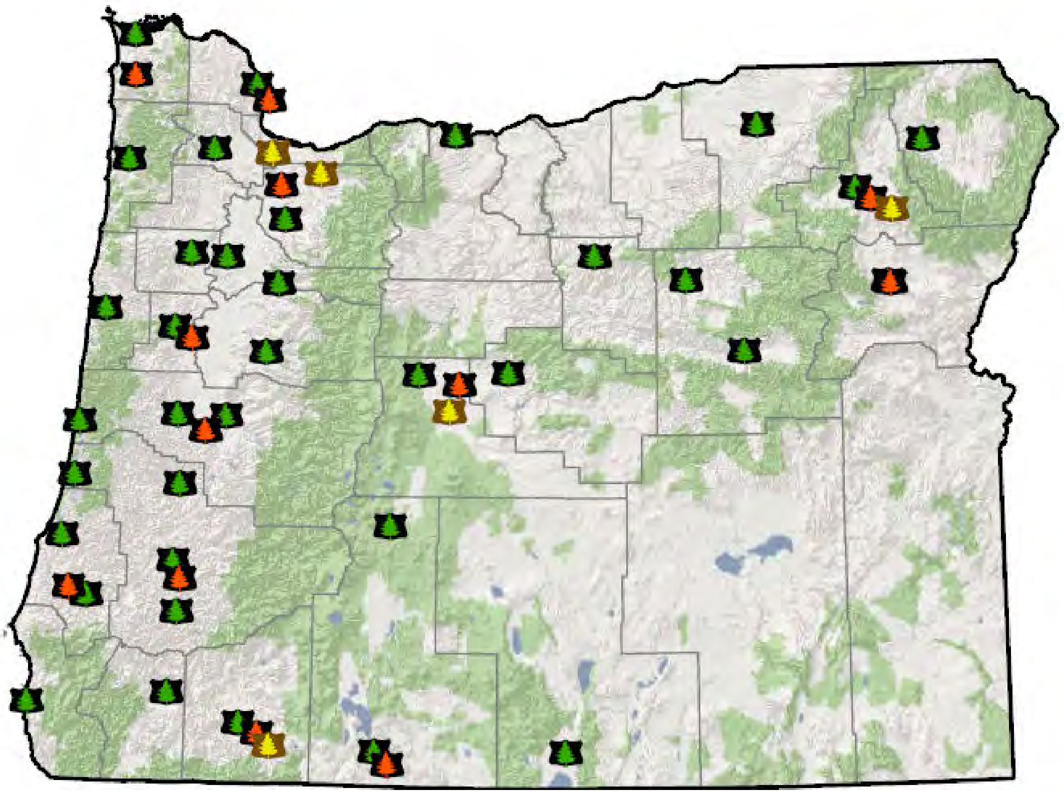


Figure 1. Map of ODF (black badge with green tree), USFS (brown badge with yellow tree), and OSU (black badge with orange tree) unit offices.

OREGON DEPARTMENT OF FORESTRY (ODF) RESOURCES:

Connect with your local ODF stewardship forester to get stand management guidance, diagnose and troubleshoot issues and learn about incentive programs: https://tinyurl.com/ODF-forester

Connect with the ODF Forest Health team to diagnose and manage abiotic stressors, insects, diseases, weeds and other invasive species. Visit the ODF Forest Health website for fact sheets and training videos: https://tinyurl.com/odf-foresthealth

USDA FOREST SERVICE (USFS) RESOURCES:

(Federal agencies and Tribes only) Connect with USFS Forest Health Protection specialists to diagnose and manage abiotic stressors, insects, diseases, weeds and other invasive species: https://www.fs.usda.gov/goto/r6/foresthealth

OREGON STATE UNIVERSITY (OSU) FORESTRY EXTENSION SERVICE RESOURCES:

Connect with your local OSU Forestry Extension agent to get stand management guidance and to diagnose and troubleshoot forest health issues: https://tinyurl.com/OSU-forester

FORESTRY IN OREGON

Forestry has a long and storied history in the Pacific Northwest, especially in Oregon, which at 30 million acres is second only to Alaska in total acreage of forestlands. This number has remained unchanged since 1953. Almost 50% of Oregon is forestland. These forests take many forms, from the family forest that is handed down across generations, to large tracts of productive industrial land, to untouched wilderness. Oregon offers a diversity of forests ranging from mossy, rain-drenched coastal ecosystems to arid ecosystems of central Oregon to reliably snow-covered high elevations along the Cascades and northeast ranges (Fig. 2).

Figure 2. Diversity of Oregon forests (Christine Buhl, ODF).

Oregon's forests cover approximately 30 million acres and consist of federal (60%), private (35%), state (3%), tribal (1%), and other public (1%) ownerships.

Oregon strives to ensure that timber production does not come at a cost to our natural resources and was first to create laws regulating forest practices. The Forest Practices Act (OAR 629, Est. 1971) guides private landowners on how best to manage their forestlands to preserve ecosystem functioning and sustainability while utilizing this renewable resource. There are also certification processes (Sustainability Forestry Initiative, American Tree Farm System, Forest Stewardship Council) in place to help consumers identify products grown and harvested under specific standards.

In recent years Oregon forests have been pushed to the limit due to climate change, but they also offer the opportunity of carbon capture. Fallout from climate change includes shrinking tree species ranges, increased wildfire intensity, and accumulation of stressed and pest-susceptible trees. We can't slow climate change overnight but we can mitigate its toll on our forests by promoting their resilience, which starts with improving forest health:

- Know the genetic lineage of your seed source. Do you have Douglas-fir from a dry or wet site?
- Stay within your seed zone as much as possible. It may be okay to go outside of seed zones slightly if necessary (east-west 1-2 zones, north-south 1 zone, from down slope (but not up)). Updated seed zone maps: http://www.forestseedlingnetwork.com/resources/seed-zone-maps/oregon-maps/seed-zone-post-options-(species-dependent)/new-zones.aspx
- Plant species/cultivars in the right microclimate (soil type, soil moisture range, sun exposure, etc.).
- Plan stand density that can tolerate climate change and extreme weather events. Discuss spacing with ODF, OSU or other forestry consultants to account for a warming climate, inconsistent precipitation, and realistic pre-commercial thinning and harvest timelines.
- Manage fuels. Reducing intensive wildfire risk prevents fire-damage and beetle-susceptible trees.
- Know what major insects and diseases occur on your tree species (pg. 34) and how to prevent or mitigate them through improving tree health.

2020: YEAR IN REVIEW

2020 was a hard year for forestry, COVID-19 presented challenges that reduced in-office availability, group gatherings, and delayed or canceled some field and survey projects that could not be conducted solo or safely in groups. Despite this we accommodated by:

1) Moving from in-person to virtual meetings and trainings, some of which were recorded and will be available for viewing in perpetuity.

2) Shifting away from aerial survey to utilizing new tools such as evaluation of satellite imagery and use of imagery analysis software, which will better prepare us for inevitable evolution into more technologically advanced methods for collecting these data.

3) Collaborating across agencies to assist with in-kind labor to ensure that monitoring efforts continued for 2020/21.

Other challenges in 2020 included a record wildfire season and budget cuts, which put further strain on our ecological and economic resources. Although the sudden wildfire occurrence near the end of the season tested our resources, it also pulled us together to determine what we can do better to prevent catastrophic wildfire and how to recover from it.

Lastly, 2020 reminded us that to take this opportunity to evaluate the inequity of resource access and distribution for some underserved populations and communities.

Figure 3. Holiday Farm fire destruction (Jason Pettigrew, ODF).

FOREST HEALTH SUMMARY

Insects, diseases and abiotic disturbance agents cause significant tree mortality, growth loss, and damage in Oregon forests each year. Many of these insects and diseases are native and are always present on the landscape but only become a problem when populations increase, often due to a buildup of trees stressed by some other primary stressor. In recent years a primary stress on trees has been hot droughts, which weaken trees and make them less tolerant or resistant to insects and diseases.

Normally, native insects and diseases can play a critical role in maintaining healthy, functioning forests by weeding out unhealthy trees, contributing to decomposition and nutrient cycling, and creating openings that enhance forest diversity and wildlife habitat.

A healthy forest is never totally free of insects, diseases, and other disturbances.

Western Oregon is characterized by high rainfall and dense coniferous forests along the Pacific coastline, the Coast Range, and western slopes of the Cascade Range. Eastern Oregon largely consists of lower density, semi-arid forests and higher elevation desert. Oregon forests are primarily dominated by conifers such as Douglas-fir, true firs, western redcedar, western hemlock, lodgepole and ponderosa pine, among others. The most abundant hardwoods are bigleaf maple, red alder, Oregon white oak, and black cottonwood.

This report highlights major agents of damage or mortality in Oregon forests over the past year and provides updates on chronic issues. Much of this information is typically obtained from aerial surveys but due to COVID-19 restrictions these surveys were conducted for a smaller portion of the state and consisted of analysis of high-resolution imagery (Scan and Sketch) as opposed to visual observations from a plane.

Because of this change in our methods we cannot fairly compare 2020 data with that from previous years. Instead we rely on our ground reports, trapping and other monitoring programs to bring you a summary of forest health topics that were important in 2020 and may guide management in 2021.

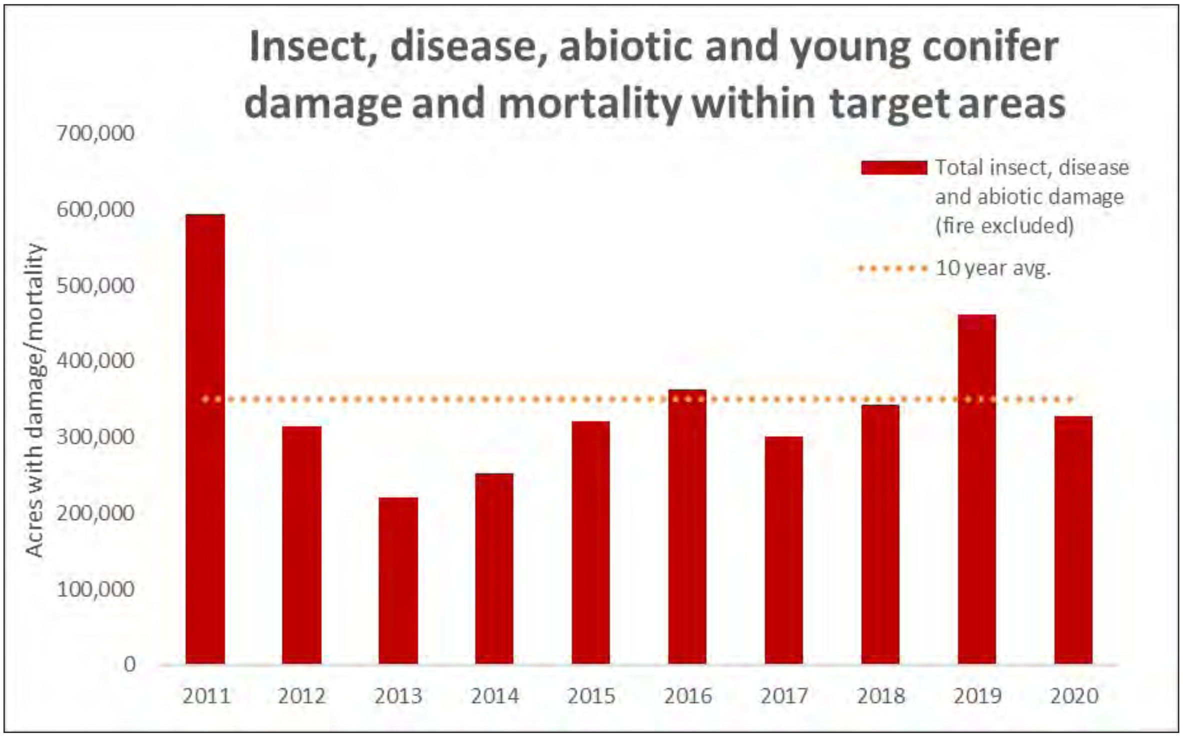


Figure 4. Tree damage and mortality were collected across 11,200,000 acres via Scan and Sketch (pg. 8). The table above shows 2011-2019 ADS-collected data "trimmed" to the same acreage footprint as the 2020 Scan and Sketch-collected data to produce a rough comparison for trend analysis. Note the metric is acres "with" not "of" damage because undamaged trees are often intermixed within a mosaic of damaged and dead trees.

Comparisons of survey data collected each year but trimmed down to the same footprint areas mapped in 2020 (Figs. 4 and 6), resulted in a 30% decrease in acres with damage in 2020 relative to 2019. Additionally, damage in 2020 was just below the 10-year average for damage within these areas. The caveat to making this comparison is that data were collected using a different survey method in 2020 than what was used in previous years. Another caveat in looking at the 2020 data is that the coverage area is reduced from the typical coverage area of all forested portions of the state, meaning that concentrated areas of damage in non-surveyed parts of the state could have been missed in 2020. However we also rely on ground reports which helps to fill in this knowledge gap. Ground reports come from our ODF and USFS Forest Health staff as well as foresters from both agencies and OSU who have unit offices and coverage areas throughout the state (pg. 1). We also rely on ground reports from public and private landowners and land managers, and other members of the general public. Site visits can provide more information to form a narrative around what is happening on the landscape.

Damage trends from a combination of aerial surveys (Fig. 5) and site visits on the ground indicate that drought stress is one of the main causes of tree dieback and decline. And often the final blow is from bark beetles that opportunistically take out stressed trees. At normal population levels, bark beetles can often help remove struggling trees to allow healthier trees to dominate. Landscape-level stress conditions from hot droughts produce a pulse of susceptible trees to feed these insects and may result in a population outbreak that allows beetles to spill over into healthier trees and overwhelm their defenses. Another widespread stressor that sets the stage for tree damage and mortality is root disease which can go unchecked for years because it is hard to verify from aerial surveys; instead relying on intensive ground surveys.

In recent years the highest levels of tree mortality have been detected in true fir which is growing in areas that either have unchecked root disease or are becoming marginal due to hot droughts. Often these true fir are finished off by fir engraver beetles but the initial cause of root disease or poor site quality under drought conditions is what needs to be addressed in management. True fir, particularly at hard to access higher elevations, is also under threat from balsam woolly adelgid. This invasive insect went unchecked for many years due to our inability to find an efficacious control and has since established in the west making eradication unfeasible.

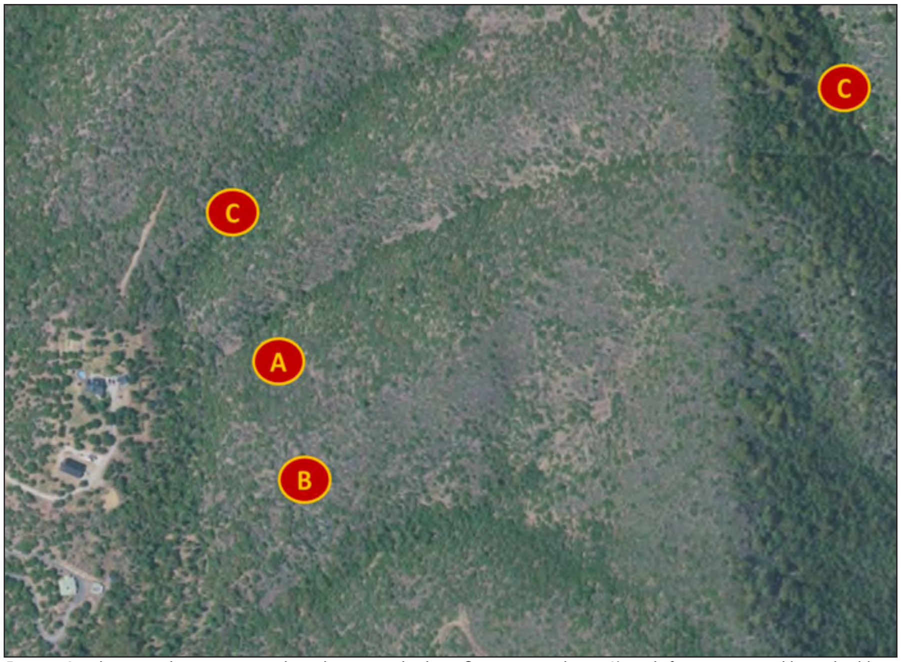
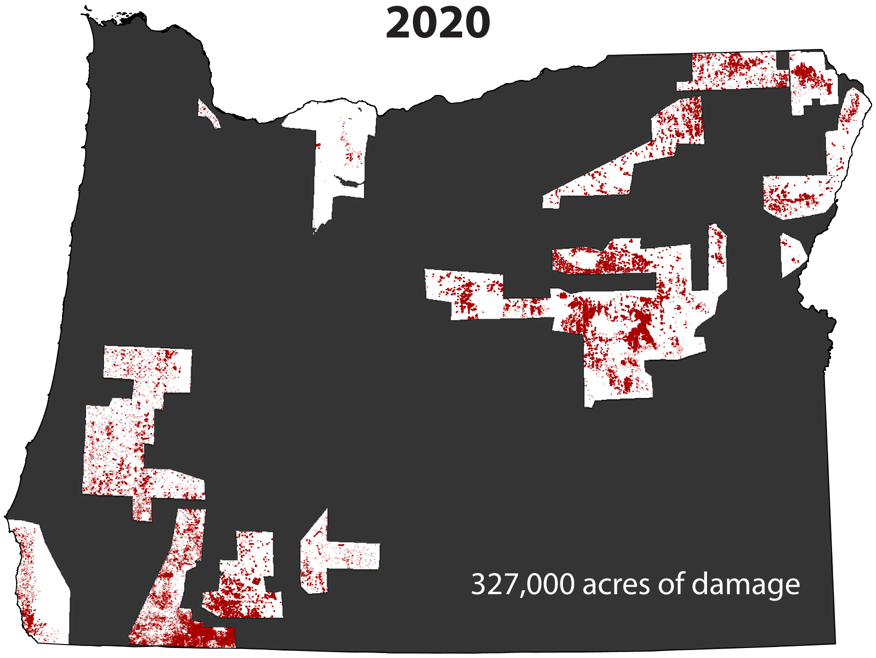


Figure 5. Aerial imagery showing patterns driven by topography that influence tree resilience: A) north-facing aspects yield more healthy trees versus B) more sun-exposed south-facing aspects, and C) moist and shaded draws can improve growth of some species. Various other topographic features and soil types affect how much moisture is received and retained and shape the micro climate of a site.

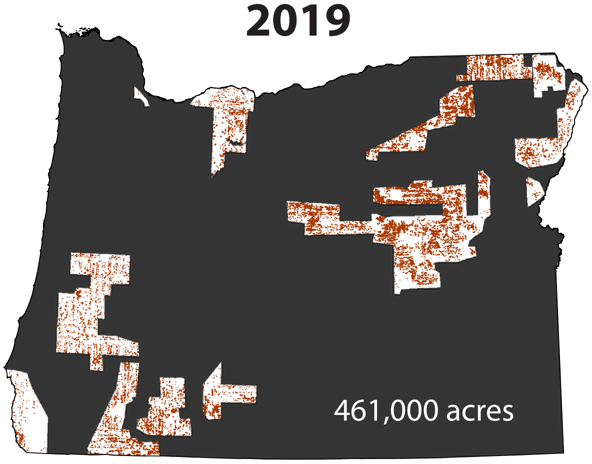
Douglas-fir is perhaps the second most at-risk tree due to our widespread planting of this essential timber crop species in areas that can no longer support it, due to persistent hot droughts. From the Willamette Valley through the southwest part of the state, this species is struggling in areas where it historically thrived. Many of our tree species are predisposed to abiotic stress that must be addressed by re-evaluating where we are putting them on the landscape to assure that their needs are met by future conditions.

FOREST DAMAGE AND MORTALITY MAPS

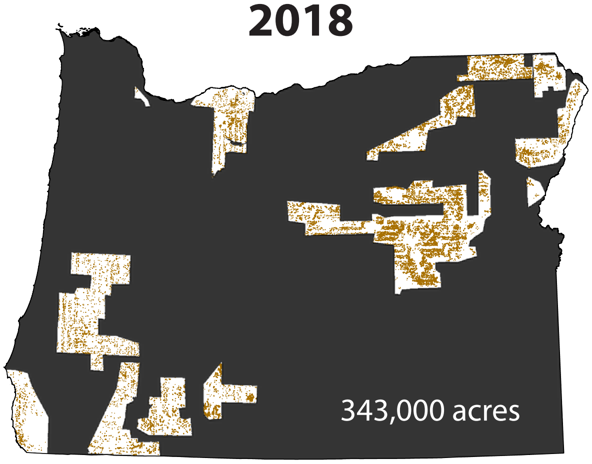
2020



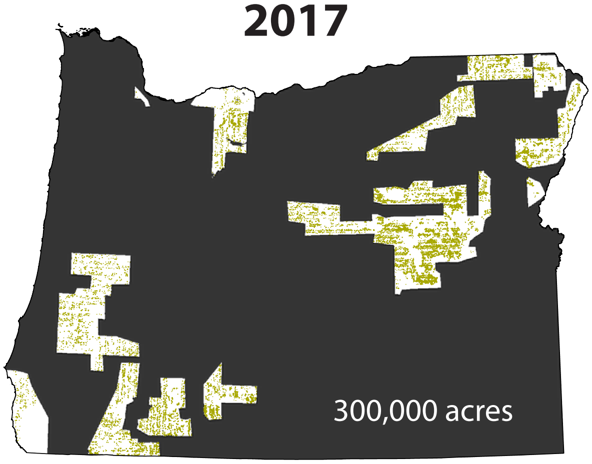
2019



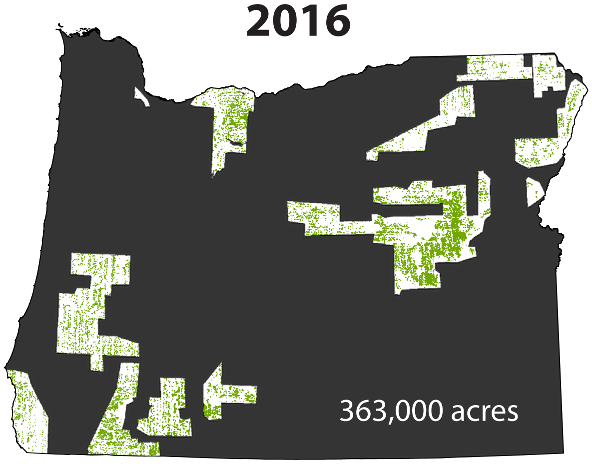
2018



2017



2016



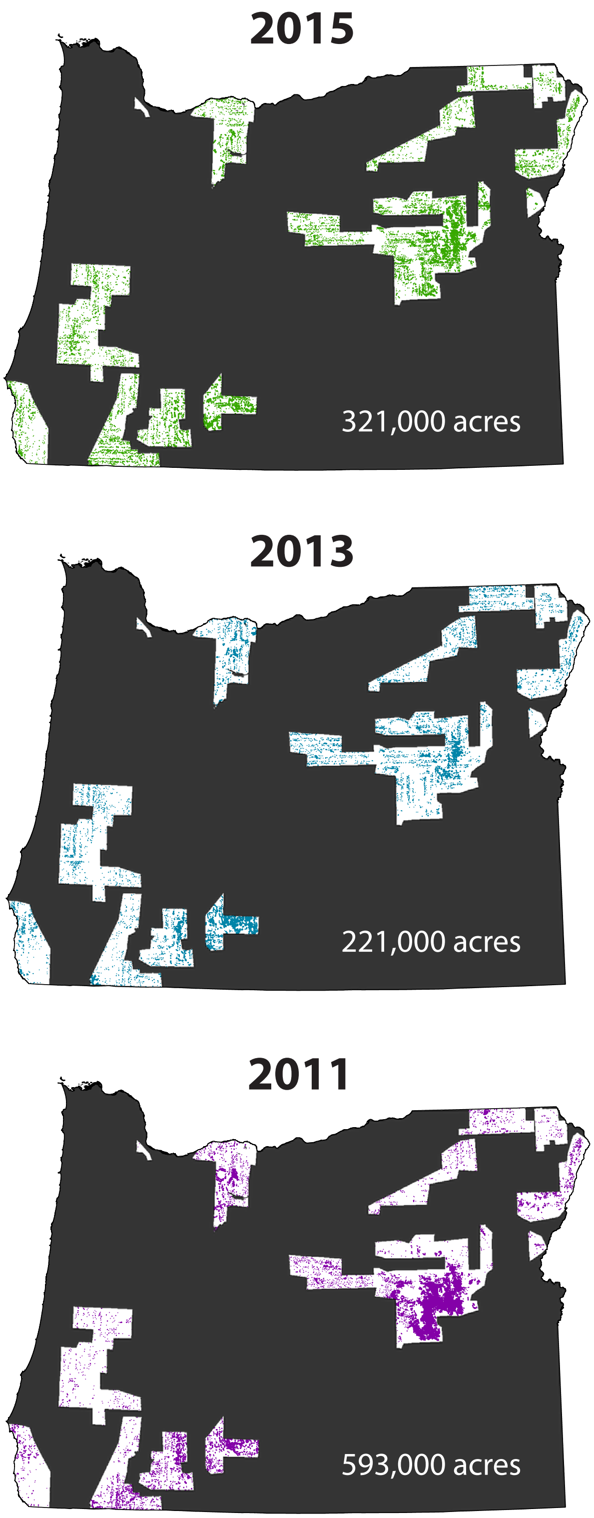


Figure 6. 10-year damage trend from aerial survey program "clipped" to 2020 target areas for comparison. Note, 2020 data were collected using the "scan and sketch" method which involves identification of damage via aerial imagery on the computer versus 2011-2019 data which were collected via visual observation of damage from airplane flights. Because of these differences in data collection methods, 2020 data should not be used as a direct comparison with previous years although 2020 observations are useful to locate and estimate current year damage.

SURVEYS, MONITORING AND OTHER PROJECTS

The Oregon (and Washington) forest aerial survey program began in 1947 and is the oldest in the country. This survey is conducted by ODF and USFS Forest Health staff and consists of a general survey that covers all forested parts of Oregon each year (about 28 million acres), as well as annual or periodic special surveys targeting specific agents such as sudden oak death, Swiss needle cast, Pandora moth, oak looper, gorse, etc. In total, the agencies survey 35 million to 41 million acres in a given year. Some years this intensive effort must be adjusted from the statewide wall to wall coverage model due to budget deficits and other unforeseen circumstances such as COVID-19. Regular aerial surveys flown in small planes were canceled in 2020 to protect the health and safety of survey staff. An alternative data collection method called "Scan and Sketch" was developed. With this method a surveyor visually scans high resolution orthoimagery and marks areas of damage using the same Digital Mobile Sketch Mapping (DMSM) tablets that are used in survey planes. Developing and conducting this method took time so we adjusted the area mapped from statewide to smaller priority areas across the state (Fig. 7). We used damage detection software (LandTrendr and Forwarn), historical and current ground knowledge of damage hot spots to determine priority areas for Scan and Sketch. LandTrendr and Forwarn detect damage based on light reflectance of vegetation. They can't detect smaller changes and therefore can't yet be used to fully automate damage detection but are useful for identifying large problem areas. Orthoimagery used for Scan and Sketch was obtained from both WorldView satellite and National Agriculture Imagery Program (NAIP) with acquisition dates between July and October 2020.

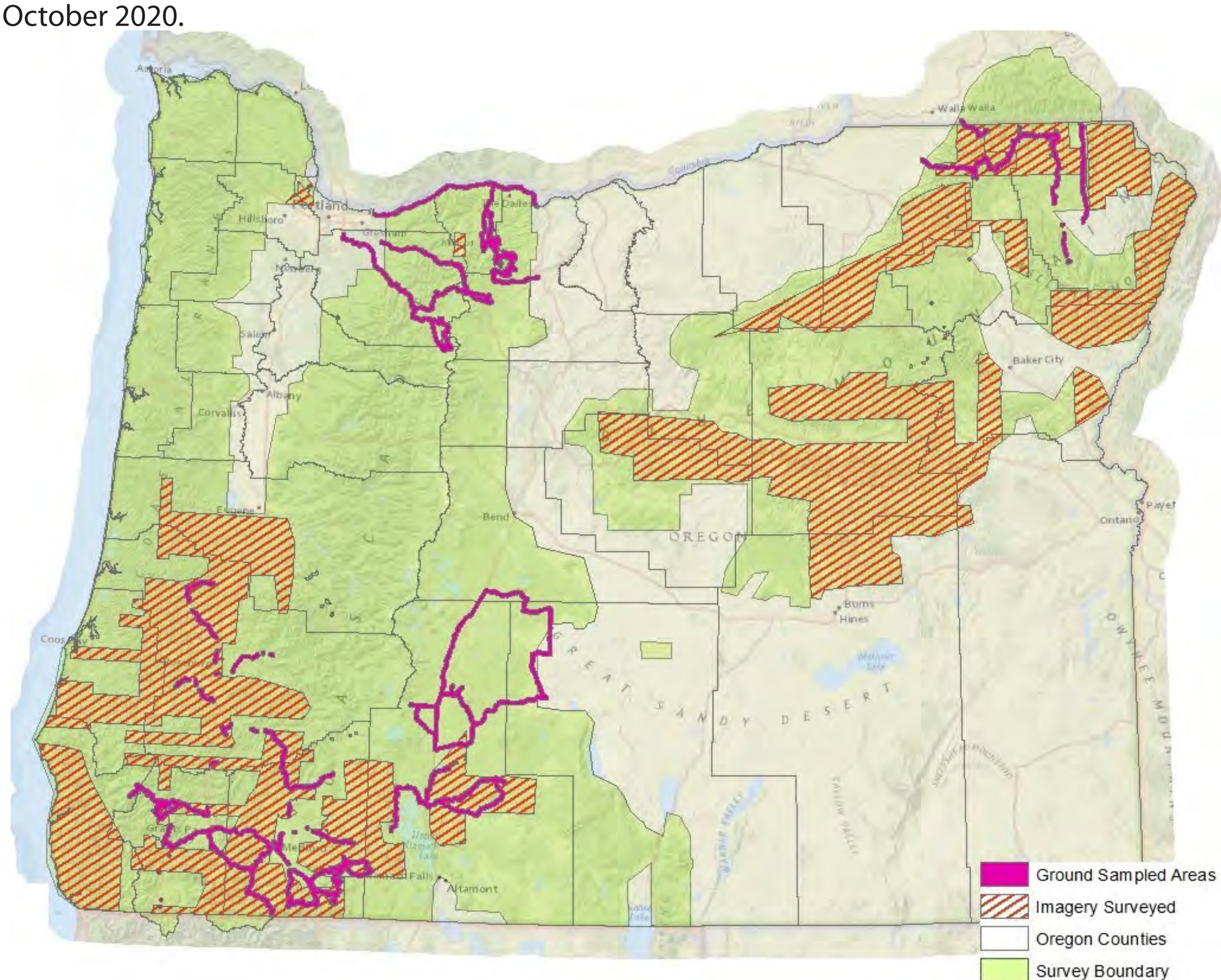


Figure 7. Map of areas surveyed for insect, disease and abiotic damage in 2020 via Scan and Sketch and ground surveys.

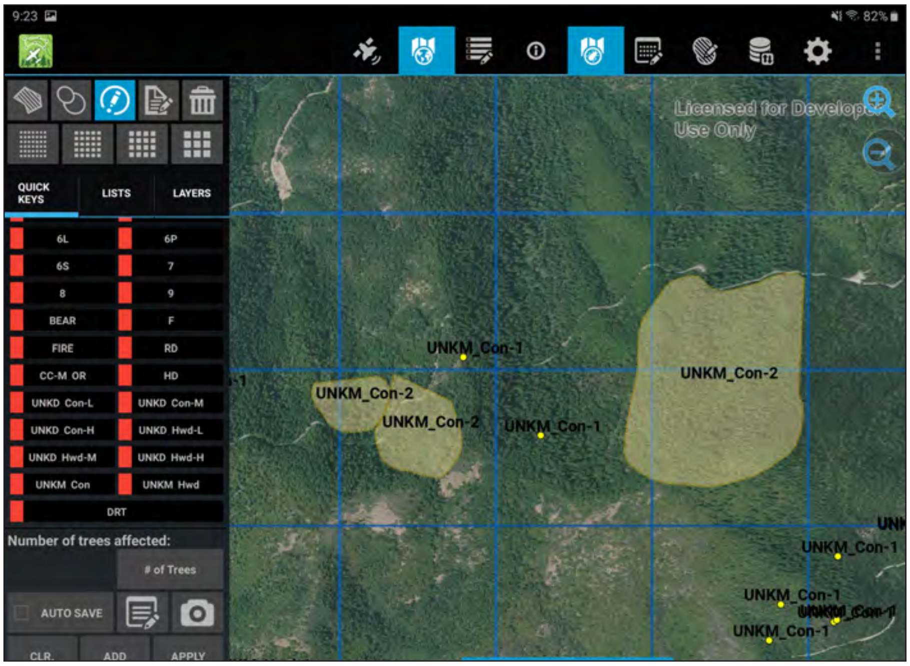


Figure 8. Screenshot of tablet view showing: tools for marking damage areas and designating agents on the left, blue lines indicating 1 mile swaths, points and polygons of damage drawn over imagery.

During Scan and Sketch, imagery is viewed in 1 mile swaths and manually scrolled through systematically on the tablet and damage is marked for single trees (points) or larger acreages (polygons) (Fig. 8). Surveyors are not in a moving plane so they can spend more time analyzing imagery and can also revisit imagery as needed. This allows a higher level of accuracy for placing on the map where damage is located and the area that it covers. It also allows for closer inspection of symptoms for more accurate agent identification, although that also depends on the resolution of the imagery. This method can also be conducted from any location at any time, which reduces travel expenses and can be started and stopped at any time to fit with staff schedules.

Difficulties with this method are that the imagery must be of high quality, collected when symptoms are present (spring to early fall), and can be expensive or unavailable for the whole state each year. Additionally, Scan and Sketch can take a long time depending on how long it takes to determine the causal agents. This is greatly dependent on the resolution of the imagery because it is a static, 1-dimensional view of the damage. The same issue is encountered in a plane due to the angle of the sun, clouds, etc. although planes can make circles to give the surveyor a view of damage from a different perspective.

Figure 9. Imagery quality in terms of lighting and resolution are important for determining tree type and agent. Red trees are easier to find in the image to the left versus the right.

Accurate agent identification was difficult for the 2020 Scan and Sketch effort due to low imagery resolution (Fig. 9). Damage agents were assigned when host and symptoms were visibly clear or could be estimated based on ground knowledge or previous year data for the area. If agents couldn't be determined areas were marked as "unknown damage". For most of these areas surveyors are familiar with the primary agents at work, although questionable signatures marked as "unknown" are followed up on for site visits.

SURVEYS, MONITORING AND OTHER PROJECTS

Every 3 years the National Agricultural Imagery Program (NAIP) acquires aerial photography of the continental U.S. during "the agricultural growing season", which varies by state. A goal of NAIP is to provide digital orthoimagery to the government and public within one year of its acquisition. Fortunately, NAIP imagery is free, is of sufficient resolution and quality to depict forest damage, and Oregon was scheduled for NAIP acquisition during 2020. ODF also acquired other high-resolution imagery to complement the NAIP imagery to conduct the special sudden oak death (SOD) survey in southwest Oregon. A new SOD detection was found using the NAIP imagery which was a testament to the ability of Scan and Sketch to pick up even small areas of damage.

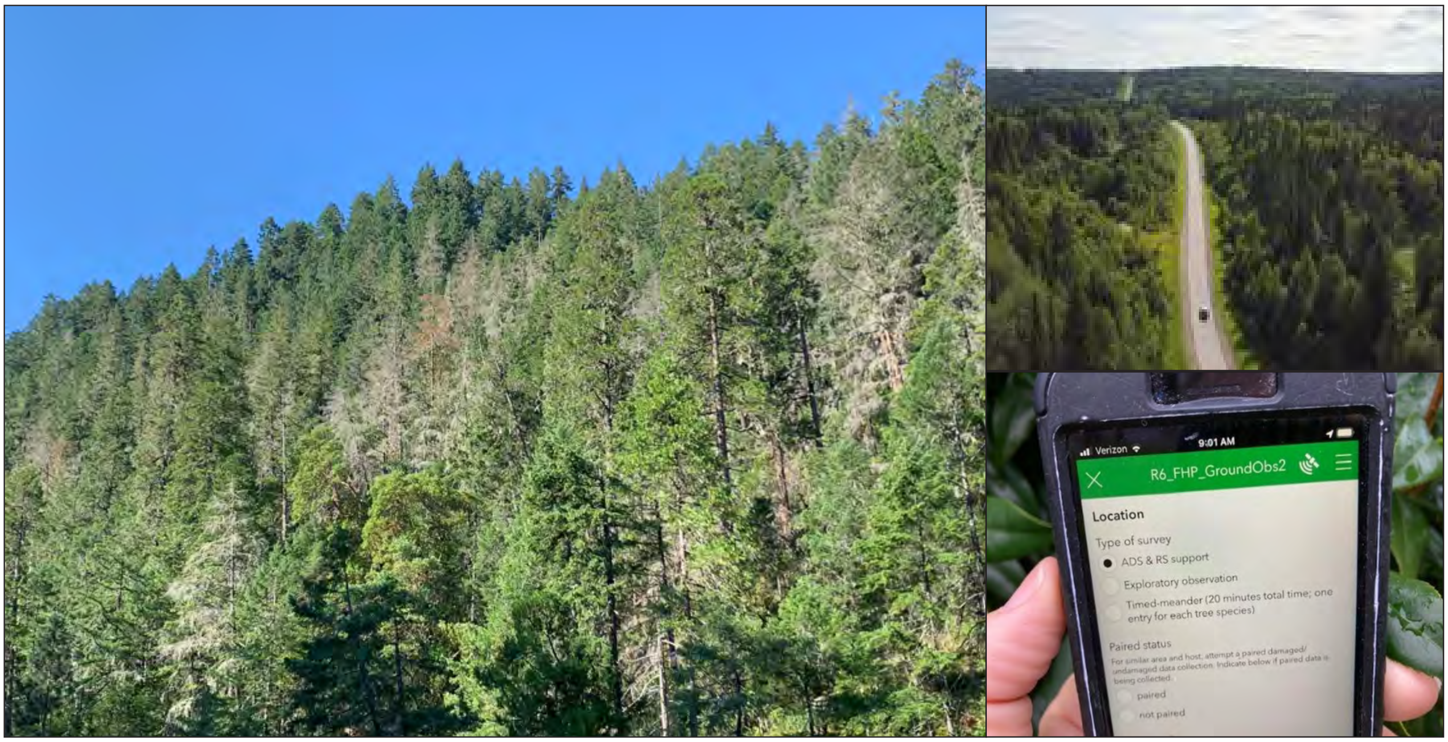


Figure 10. Roadside survey in southern Oregon where several dead Douglas-fir were identified among healthier Douglas-fir and ponderosa pine as well as skeletons of trees that died in previous years (left; Christine Buhl, ODF), often seeing trees from the road was difficult due to inability to get closer or see out over the tree line. Damage from ground surveys was logged into DMSM or Survey123 (right bottom; Karen Ripley, USFS) when possible.

In addition to Scan and Sketch, ground or "dashboard" surveys were conducted from roadsides and logged into DMSM or Survey123 (Fig. 10). These ground surveys covered about 766, 000 acres, but don't include acres assessed for technical assistance visits, other monitoring projects, and targeted ground checks. Aside from providing metrics, ground surveys provide narratives of what is happening on the ground to improve current, local knowledge of conditions to better advise landowners and managers.

Although we hope to resume aerial surveys in 2021, the Scan and Sketch method will remain a valuable tool for moving our survey program into the 21st century.

Aerial survey raw data and maps:
https://www.fs.usda.gov/detail/r6/forest-grasslandhealth/insects-diseases/?cid=stelprd3791643

Western redcedar dieback monitoring

From Oregon through western Canada, western redcedar (*Thuja plicata*) has been dying in areas where it should be thriving, such as along streams and within closed canopies. The cause for this sometimes sudden and expanding dieback is currently unknown. Insects and diseases known to attack western redcedar are typically secondary, meaning that they are not direct tree killers but are opportunistic pests and can only attack dead and dying redcedar. Redcedar can even tolerate endemic levels of bark beetles and stem rots for many years. These known pests are not always found in dieback pockets nor have novel pests been observed.

The predominant theory for this sudden mortality is that these trees are being impacted by a changing climate that includes increasing average temperatures and drought stress in the form of reduced and inconsistent precipitation. Even shaded sites along streams are at risk due to higher than usual average temperatures and reduced stream flow. Western redcedar is sensitive to slight changes in climate and, in some areas, may be crossing the lower limits of where they can thrive, which may eventually result in a range shift.

In 2020 a new USFS-funded monitoring project began in Oregon and Washington to map the distribution of western redcedar dieback and determine the cause(s) of dieback. Preliminary data are being collected by ODF, Washington Department of Natural Resources, USFS, and various natural resource agencies. Additional funding is being sought for further investigation (e.g., soil sampling, tree ring analysis, tree water use efficiency, etc.) by researchers at multiple universities in both states. Agencies in Alaska, Idaho and Canada are also part of this collaborative.

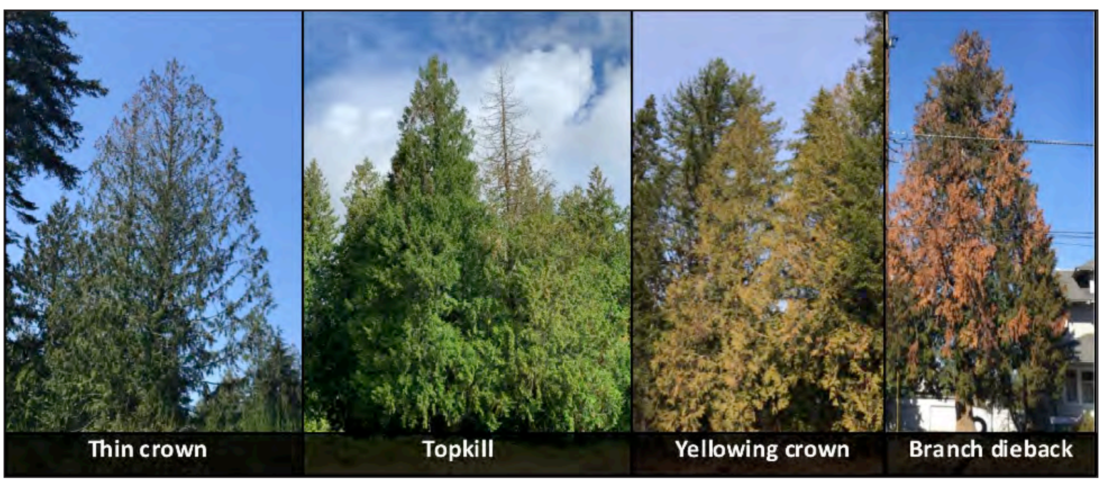


Figure 11. Western redcedar dieback symptoms (Christine Buhl, ODF).

Symptoms of western redcedar dieback (Fig. 11) are hard to see during aerial surveys so we also rely on ground reports of potential sites. Report locations containing multiple western redcedar trees exhibiting dieback symptoms to:

(Oregon) Christine Buhl, ODF Entomologist, christine.j.buhl@oregon.gov
(Washington) Melissa Fischer, WADNR Entomologist, melissa.fischer@dnr.wa.gov
(Washington) Betsy Goodrich, USFS R6 Pathologist, anne.goodrich@usda.gov

Fact sheet: https://www.oregon.gov/odf/Documents/forestbenefits/TreeDeclinesRedcedar.pdf
GIS Dashboard: https://tinyurl.com/WRCDashboard
Storymap: https://tinyurl.com/WRCStorymap

SURVEYS, MONITORING AND OTHER PROJECTS

Hazard Tree
Pathologists with ODF and the USFS evaluate tree hazards and provide trainings on an annual basis to ensure that trees at risk of failure, due to root and stem rots or other defects, are removed to protect those working and recreating in the woods. ODF annually assesses state forest lands for hazards in recreation areas and assists Oregon Parks and Recreation Department with hazard tree training to ensure that state parks have trained staff available to identify hazard trees.

Bark beetle landowner incentives cost share program
Each year, federal funds are allocated for bark beetle prevention and mitigation treatments such as thinning, pine slash management, and anti-aggregation pheromone application. Some of these funds are applied on federal lands and others are allocated to ODF for non-federal landowners at a 1:1 match. In 2020 1,950 acres were treated on federal lands and another 236 acres were treated on non-federal lands across 11 private ownerships. This cost share may also be applied for removal of living trees that were recently damaged by wildfire to prevent infestation by bark beetles. More info: https://www.oregon.gov/odf/AboutODF/Pages/GrantsIncentives.aspx

Douglas-fir tussock moth trapping
This ongoing monitoring trap system (est. 1979; Fig. 12) detects increases in moth numbers and can predict building outbreaks or determine status of current outbreaks in eastern Oregon. More on Douglas-fir Tussock Moth (DFTM) on page 24.

Figure 12. DFTM trap (Christine Buhl, ODF).

Exotic Woodborer Monitoring
During 2016-2018, a special survey for exotic, invasive woodborers across 12 sites along the Columbia River corridor was conducted cooperatively by the Oregon Departments of Forestry and Agriculture. A new record for North America, the exotic ambrosia beetle (*Xyleborus monographus*), also known as the Mediterranean Oak Borer, was detected in an ODF trap at Chinook Landing Marine Park, Multnomah County, in June 2018. In its native range of Europe, this exotic beetle is known to cause injury to white oaks. Also beginning in 2018, forest health professionals in California have reported *X. monographus* attacking and killing valley oaks (*Quercus lobata*) and blue oaks (*Q. douglasii*) in Napa, Sonoma and Sacramento counties. ODF Forest Health assisted the Oregon Department of Agriculture in delimiting trapping in 2019 for *Xyleborus monographus* in the vicinity of Chinook Landing Marine Park near the city of Troutdale. The 2019 trapping effort at Chinook Landing Marine Park did not yield any *X. monographus*. Additional ODA trapping in 2020 (16 sites around Chinook Landing and 12 sites at wineries - suggested by the association with wine country in California) did not catch any additional *X. monographus* beetles.

Oregon Forest Pest Detector program
Since 2013, the USDA-funded Oregon Forest Pest Detector (OFPD) program, coordinated and led by Oregon State University Extension Forestry, has trained arborists, landscapers, park workers and other professionals to identify the early signs and symptoms of priority invasive forest insects (http://pestdetector.forestry.oregonstate.edu). Using a combination of online presentations, face-to-face seminars and field training courses, over 500 professionals have been trained as "First Detectors" of emerald ash borer, Asian longhorned beetles and other exotic forest insects. The OFPD works with the Oregon Invasive Species Council to utilize the Oregon Invasive Species Online Hotline reporting system (https://oregoninvasiveshotline.org) to log a report and picture of potential invasive species while in the field. The overall goal is to detect key forest invaders early in their invasion when eradication is still feasible. Due to statewide closures of campgrounds and state offices and other complications surrounding COVID-19, as well as the 2020 Oregon fire season, the OFPD was put on pause until 2021.

Forest Pollinator Projects

Over 600 species of native, wild bees occur in Oregon, many of which can be found in forests (Fig. 13). There are many interagency efforts to increase our understanding and enhance and conserve habitat for native, wild bees and other pollinators on forest landscapes:

Figure 13. Pollinator forage in southern Oregon forest understory (Christine Buhl, ODF).

New publication with guidance on enhancing forest bee habitat: https://woodlandfishandwildlife.com/publications/insect/forest-bee-pollinators

New rule in Forest Practices Act, Wildlife food plots (ORS 527.678), that allows a small portion of timberland to be allocated toward habitat enhancement for wildlife without rezoning (https://www.oregonlaws.org/ors/527.678). Look for pollinator-specific guidance from ODF soon.

A silver lining for forests damaged by intensive wildfire, is that wildfire replicates an early seral forest stage which is attractive to forest bees. Opening the canopy increases light exposure to germinate forage plants and increase thermal environments, and burning clears ground debris to expose soil for ground-nesting bees. Consider opportunities during post-wildfire reforestation to also provide pollinator habitat (flowering plants, and exposed soil and stem and wood cavities for nesting).

The Oregon Bee Project (OSU, ODA, ODF) maintains the Oregon Bee Atlas, a voluntary wild bee monitoring program that collects data on bee presence, abundance and diversity across the state. Many private forest landowners are involved in this effort. More information: https://www.oregonbeeproject.org/bee-atlas

Learn more about forest pollinator topics and become a Woodland Pollinator Steward through OSU Extension's new program: https://extension.oregonstate.edu/pollinator-stew-ard#:~:text=The%20OSU%20Pollinator%20Steward%20Program,or%20creating%20new%20pollinator%20habitat

House Bill 2531 was passed in 2021, and formally includes Departments of Forestry, Fish and Wildlife and Transportation in pollinator protection efforts conducted by OSU and ODA. This multi-agency program (Oregon Bee Project est. 2015) works to enhance bee health and habitat through outreach, pesticide training, research and landowner projects. ODF voluntarily joined this effort in 2016.

Forest Health education

OSU Tree School courses moved to an online format this year with the help of Oregon Forest Resources Institute. All courses and materials can now be viewed for free at any time: https://extension.oregonstate.edu/tree-school/tree-school-online-class-guide

Forest health-specific courses include:

Forest insect pests: https://tinyurl.com/TreeSchool-insectpests

Forest bees: https://tinyurl.com/TreeSchool-bees

Forest diseases: https://tinyurl.com/TreeSchool-diseases

ABIOTIC AGENTS

Climate and weather are often primary contributors to tree health and forest conditions. Events that stress trees reduce growth and decrease their ability to defend themselves or rebound from insects, diseases and additional stressors. Healthy trees are able to defend themselves from insects and disease with pitch and compartmentalization, which are forms of mechanical and chemical defenses. Attacking insects get stuck in or drowned by pitch, or are repelled by the chemical compounds it contains. Similarly, pitch is a defense against some fungi by sealing wounds that can be entry points for spores, compartmentalizing diseases to prevent their spread among tissues, or reducing virulence by containing antimicrobial chemicals.

HEALTHY TREES = RESILIENT TREES

Climate change One of the major reoccurring stressors in Oregon forests has been ongoing drought (Fig. 14) as a result of climate change. Oregon has a diversity of forest ecosystems due to variations in latitude, elevation, topography, and proximity to the ocean and mountains (rain shadow effects). All these factors play a role in determining the impacts of altered temperatures and precipitation (rain and snow) levels. Additionally, soil and ground cover type, local water use and watershed dynamics can place different pressures on water storage capacities. Tree stocking levels influence the competition among trees for the availability of water resources. Some tree species have strategies to tolerate drought better than others.

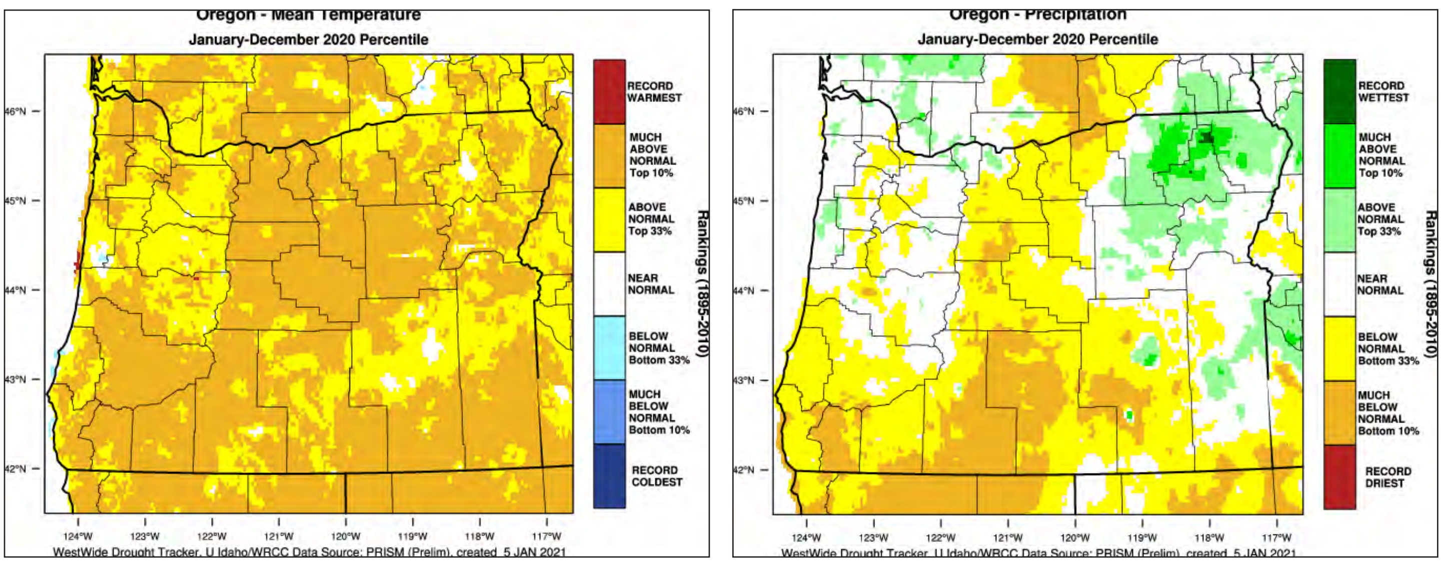


Figure 14. Average temperature and precipitation levels from January-December 2020, relative to the average normal based on 115 years spanning from 1895 to 2010 (Western Regional Climate Center).

There are many climate change models for the Pacific Northwest and most echo the same prediction: warmer average temperatures resulting in warmer winters and longer summers; more erratic precipitation events; and winter precipitation in the form of rain rather than snow. The fact that we are experiencing a change is not unprecedented. Earth experiences naturally alternating periods of cooling and warming and we are currently in a warmer phase. However, the rate that change has been occurring is extreme. Temperatures have already risen an average of 1.0 – 2.0°F along the west coast over the last 60 years and are predicted to increase by an average of 5.0°F by the 2050's and 8.2°F by the 2080's (Fig. 15). In relation to forestry, many of these climate change projections predict change well within the span of a stand rotation or two. Therefore management decisions such as species mix and densities must be made in anticipation of these projections.

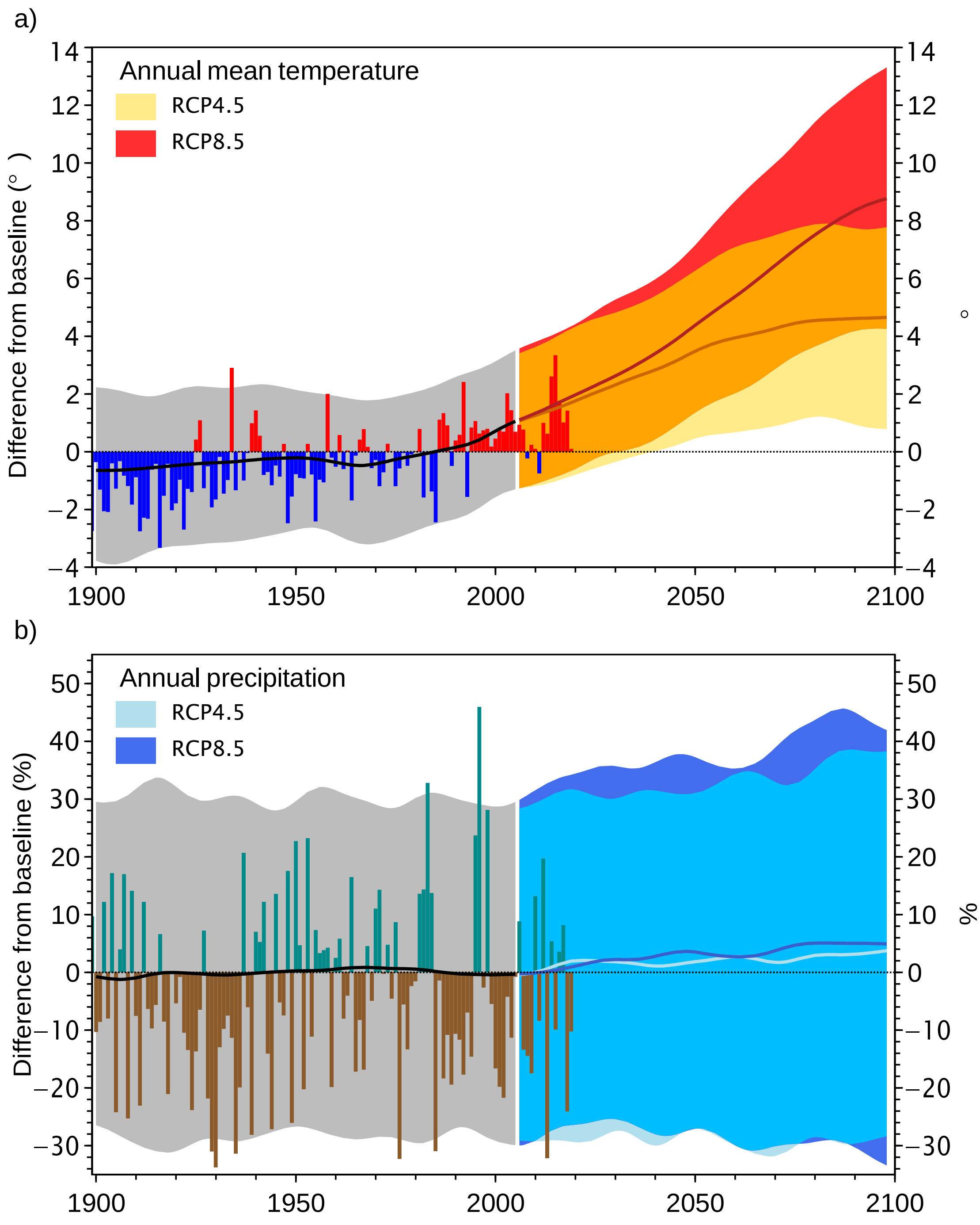


Figure 15. Observed, simulated and projected changes in Oregon's mean annual (a) temperature (°F) and (b) precipitation relative to 1970-1999 baseline. Colored bars are the observed values (right axes) for 1900-2019 from the National Centers for Environmental Information, and how much they differ from the baseline (left axes).Solid lines are mean values of simulations from 35 climate models for the 1900-2005 period which were based on observed values (black lines) and the 2006-2099 period for two future scenarios (colored lines; RCP 4.5 is less and RCP 8.5 is more extreme). Shaded areas indicate the range in annual temperature and precipitation for all models (Dalton, M., and E. Fleishman, editors. 2021. Fifth Oregon Climate
Assessment. Oregon Climate Change Research Institute, Oregon State University, Corvallis, Oregon. https://blogs.oregonstate.edu/occri/oregon-climate-assessments).

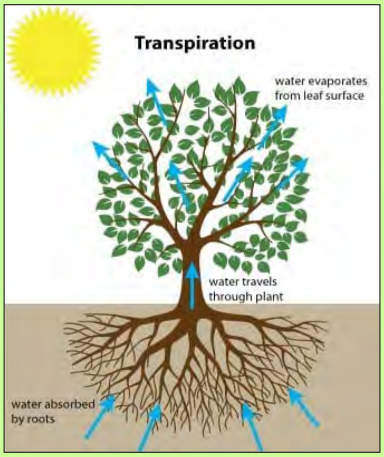
Drought

Droughts should not be simply defined by high temperature or low precipitation records. Timing and duration of these events must be taken into account to properly evaluate their impacts on trees. Damage and morality (Fig. 16) may not occur in trees for years after drought events and repeated droughts compound the stress even if there are "good" years between drought events.

How to manage for future drought stress:

- Plant: native species, seed sources local to your region, and species adapted to the various conditions and micro-climates (soils, aspect, sun or wind exposure, etc.) at your site. Pay attention to which species are doing well and where. Do not continue to replant with species that are struggling to survive or don't naturally regenerate.
- Maintain: thin trees early and leave enough space between trees to handle future droughts. Reduce competition from other competing plants especially grasses and invasive species. Do not fertilize during droughts because increased growth increases moisture requirements.
- Prevent and control: be aware of the major insects and diseases that occur in your tree species and in your region (pg. 34). Follow management guidance. Remove weak, injured or extremely stressed trees.

How do trees respond to drought?



To understand how drought affects trees and how they respond, one must understand some basic biological processes. Trees are actively pulling in water through roots and transporting it through a bundled network of straws (vascular tissues) to leaves that release moisture into the air via small holes (stomata). A common misconception is that roots are pushing moisture up throughout the tree. In reality this process is driven by the pull of moisture from leaves into the atmosphere. Dry or windy conditions result in lower atmospheric moisture which results in a greater pull of moisture from leaves to maintain water balance between leaves and the air. When stomata open they let in CO_2 which, when combined with sunlight and water, allows trees to make food during photosynthesis. When stomata close, as a mechanism of drought-tolerance to reduce water loss, starvation occurs due to the halt of photosynthesis.

During periods of low water availability, roots may die back, or grow closer to the surface in search for moisture, exposing them to compaction near the surface. Replacement of root tissues takes time, so even if moisture levels increase, there may not be enough root tissue biomass present to absorb enough of it. When soil moisture levels are low or roots are not present to obtain it, moisture continues to be lost through leaves. The upward pull through vascular tissues can create so much pressure that air pockets form and tubes within the tissues break. It takes time for these tissues to be rebuilt as the tree grows, so trees are left with reduced ability to translocate available moisture. Trees can withstand mild or infrequent droughts through a variety of moisture conserving techniques (premature leaf drop, stomatal closure, etc.), but prolonged or repeated droughts often result in mortality, sometimes years later.

Figure 16. Symptoms of drought: flagging (dying branches), thinning crown and stress cones, asymmetrical crown (from uneven foliage then twig and branch loss), topkill (note the progression of mortality) (Christine Buhl, ODF).

Climate change and drought resources:

- Keep up to date by subscribing to Oregon Water Resources Department's monthly drought summary email: https://tinyurl.com/drought-report
- Oregon Climate Change Assessment (comes out every two years): https://blogs.oregonstate.edu/occri/oregon-climate-assessments
- Information video on drought in forests: https://youtu.be/wHZ1G5wH4r8
- Help track the spread and intensity of drought by reporting drought impacts you observe through the National Drought Mitigation Center survey: https://go.unl.edu/cmor_drought

Storms

At the start of 2021, a late winter storm event occurred across much of the state, which caused strong winds, snow and ice to break and topple trees (Fig. 17). Blowdown of large-diameter Douglas-fir will invite infestation from Douglas-fir beetle in April 2021 and branch breakage and other damage to pine will invite Ips bark beetles. Following storms, landowners are advised to remove downed large Douglas-fir and/or apply MCH repellant; and remove and burn/chip 3-8" diameter pine material before April. ODF's bark beetle 1:1 cost share program can be used to cover costs of MCH or to remove, burn or chip damaged material to prevent bark beetle outbreaks.

Figure 17. Blowdown near Lyons, OR (Wyatt Williams, ODF).

Storm damage management: https://www.oregon.gov/odf/Documents/forestbenefits/Storms_2017.pdf
Cost share: https://www.oregon.gov/odf/AboutODF/Pages/GrantsIncentives.aspx

Wildfire

The 2020 fire season started off slowly and ended severely with many losing not only their forested stands but also their homes and towns. Ongoing droughts in southwest Oregon and a sudden wind event that swept the Willamette Valley in early September resulted in large and intense wildfires. The fallout from these fires included multiple days of hazardous air quality thick enough to block out the sun (Fig. 18), hillsides left bare and at risk for landslides, hanging trees creating hazards near structures and roads, and further loss of livihood and shelter during a time people have already been tested by impacts of COVID-19. The number of fires in 2020 was *just* below the 10-year average although the amount of acres burned was about 40% higher (Fig. 19). 2020 served a notice that climate change and fuel buildup can no longer be ignored and warrant appropriate action to reduce risks wherever possible.

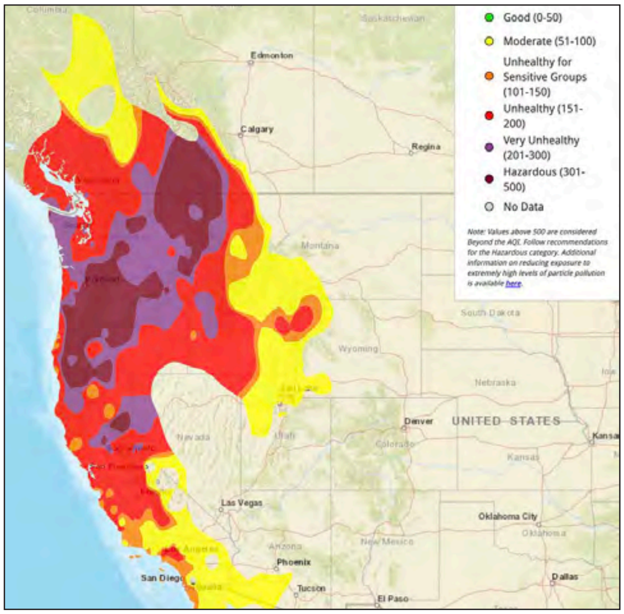


Figure 18. September 2020 air quality map following wildfires that ignited or expanded due to the 2020 Labor Day wind event (NOAA).

2020 statistics:

- 16 Federal Emergency Management Agency (FEMA) fires were declared in Oregon, relative to another busy fire season in 2018 when only 6 FEMA fires were declared in Oregon
- 89 of the fires met "large fire" criteria (at least 100 ac timber and 300 ac in grass or brush)
- Approximately 15 million board feet were lost to wildfire, or enough to build about 1 million houses
- As of October 2020 fire-fighting costs totaled $339,643,601
- During the peak of wildfire season over 9,250 fire fighters were at work putting out fires in Oregon and Washington
- ODF Protection still managed to keep 95% of fires at 10 acres or less (a statistic maintained since 2004 despite drought and heavy lightning years such as 2013 and 2018)

Wildfire recovery resources:

To assist with post-fire salvage and recovery efforts, the USFS produced a guidance document to determine the probability of tree mortality from fire injury. This document is a thorough culmination of many studies conducted locally over many years: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd814664.pdf

ODF also produced a shorter summary of this document: https://www.oregon.gov/odf/Documents/forestbenefits/post-fire-tree-mortality.pdf

- ODF "Help After Wildfire": https://www.oregon.gov/odf/fire/Pages/afterafire.aspx
- OSU Extension Fire Program info: https://extension.oregonstate.edu/fire-program
- OSU Extension wildfire webinars: https://extension.oregonstate.edu/fire-program/online-webinar-guide
- Oregon Statewide Wildfire Response & Recovery: https://wildfire.oregon.gov
- Make your home Firewise: https://www.nfpa.org/Public-Education/Fire-causes-and-risks/Wildfire/Firewise-USA
- Reduce risk of wildfire starts: https://keeporegongreen.org

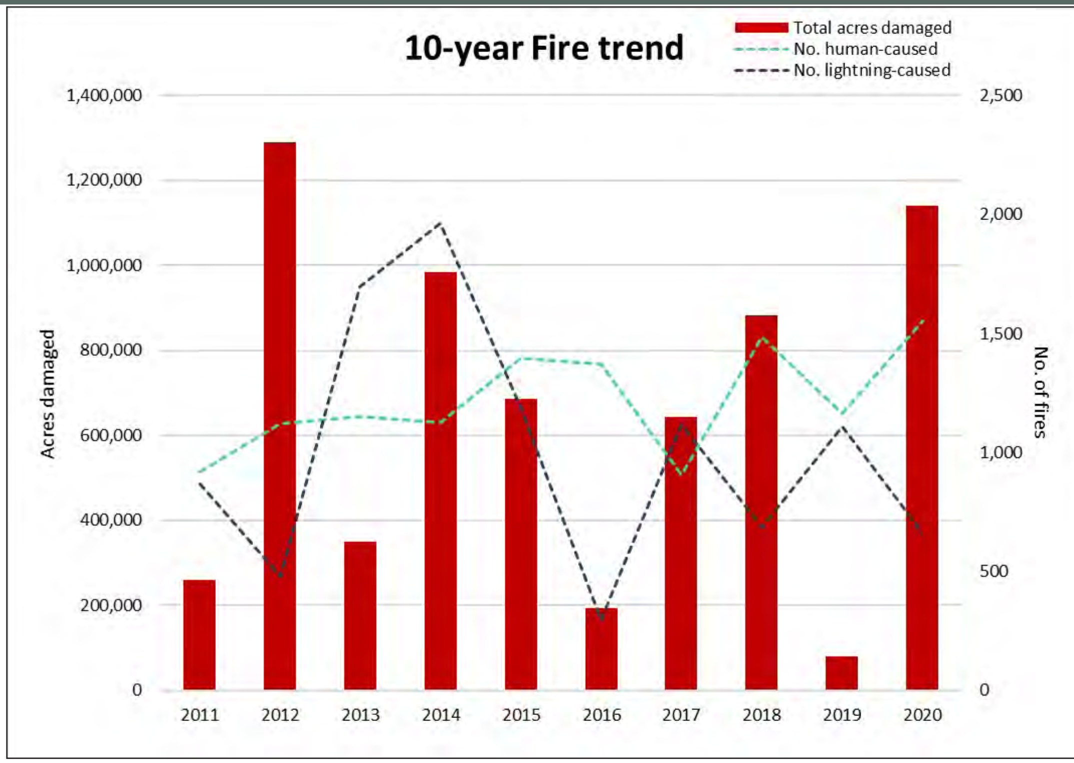


Figure 19. 10-year trends, across allownerships, in annual number of acres damaged by fires, and number of fire starts from human (green) versus lightning (blue) causes.

Figure 20. Less severe fire damage in thinned forest (top left Beachie Creek; Mike Cafferata, ODF), Patrick Stephenson, ODF, scouting (top right; Jordan Grimes, ODF), Rocky Top in Santiam State Forest (bottom left; David Capasso, ODF), smoke (bottom right; Tyer Ramos, ODF), Holiday Farm crew (center; Marcus Kauffman, ODF).

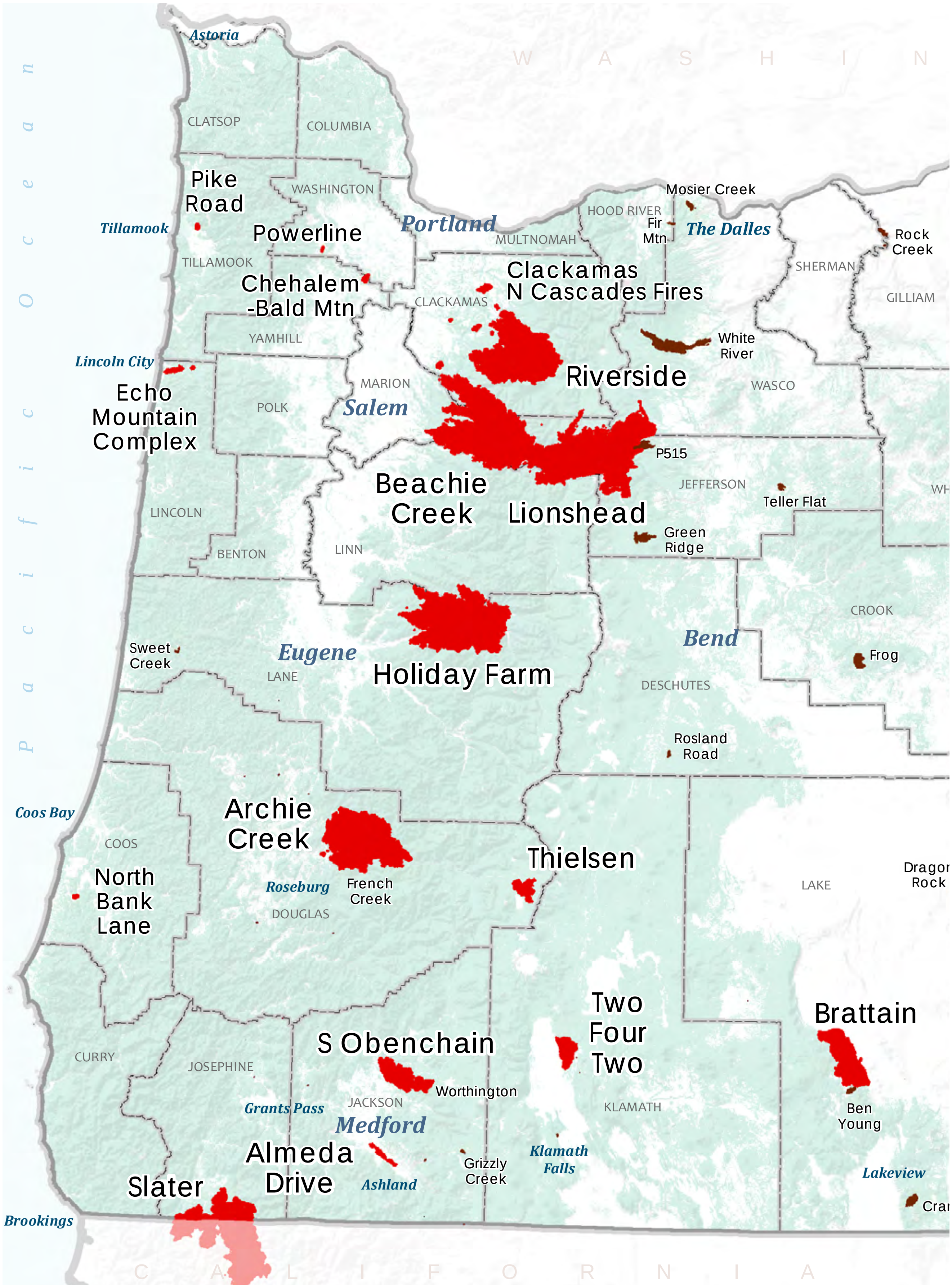


Figure 21. Map of statewide fire polygons. Fires that began before the 2020 Labor Day wind event are maroon and fires that started after the event are red.

Meacham Complex
Pendleton
UMATILLA
WALLOWA
Rock Creek
MORROW
HERMAN
E Fork Butter Creek
GILLIAM
La Grande
UNION
Steet Mtn
Laurel
Baker City
BAKER
WHEELER
Flat
GRANT
John Day
Baldy
Wickiup
CROOK
Frog
Indian Creek
Burns
2020 Oregon Wildfires
Wildfires After Labor Day
Wildfires Before Labor Day
Oregon Forests
0
50 Mi
0
75 Km
MALHEUR
Dragon Rock
AKE
Sodhouse
HARNEY
Neals Hill
Wildcat
Brattain
Ben Young
Lakeview
Crane
Anderson Crossing
WASHINGTON
IDAHO
NEVADA

FOREST INSECTS

Healthy trees are defended trees. Tree defenses include mechanical and chemical defenses in foliage and wood that prevent infestation, mitigate damage or kill insects. In order for trees to produce these defenses they must have their growth requirements met, sparing additional resources that producing defenses require. Droughts in particular especially impact defenses because trees require moisture for products such as sap which is a mechanical barrier that traps insects and also contains chemicals that are repellant or toxic to insects and fungal pathogens they may vector.

BARK BEETLES

Figure 22. Brown frass indicates bark beetle attack (left) and MCH pouch (right) (Christine Buhl, ODF).

Storms in 2019 caused major damage and blowdown of trees in the lower Willamette Valley. Blowdown of large-diameter (>12 inch) Douglas-fir trees is particularly attractive to **Douglas-fir beetle** (*Dendroctonus pseudotsugae*) which can infest blowdown the first April after the storm and build up to infest adjacent standing trees the second April. Outreach efforts to spread awareness to landowners about removal and/or application of inexpensive MCH (repellency pheromone) were increased (Fig. 22). Reports from treatment areas voiced success, noted by the absence of initial attack symptoms in blowdown in April 2020. Standing Douglas-fir trees in 2019 blowdown areas should be monitored for signs of infestation in April 2021. *More info:* https://www.oregon.gov/odf/Documents/forestbenefits/Douglas-fir-beetle.pdf and https://www.oregon.gov/odf/Documents/forestbenefits/MCH_2016.pdf

Figure 23. True fir finished off by fir engraver (ODF).

Fir engraver (*Scolytus ventralis*) continues to kill true fir growing in sites with increased drought stress or unmanaged root disease (Fig. 23) such as along Fremont-Winema and Ochoco National Forests and the Blue Mountains. *More info:* https://www.oregon.gov/odf/Documents/forestbenefits/FirEngraverBeetle.pdf

Ips bark beetles (*Ips pini* and *I. paraconfusus*) also continue to be a problem in stands of young, overstocked pine or wherever fresh pine slash has not been chipped or burned to prevent infestation. Note, verbenone (repellency pheromone) is not effective for Ips beetles for it has only shown some effectiveness for preventing mountain pine beetle in pure lodgepole pine stands. *More info:* https://www.oregon.gov/odf/Documents/forestbenefits/ips.pdf

Some areas in eastern Oregon are still experiencing pockets of **western pine beetle** (*D. brevicomis*) outbreaks in ponderosa pine and **mountain pine beetle** (*D. ponderosae*) has remained quiet except for some pockets such as around Mt. McLoughlin in south central Oregon. *More info:* https://www.oregon.gov/odf/Documents/forestbenefits/MountainPineBeetle.pdf and https://www.oregon.gov/odf/Documents/forestbenefits/Western%20Pine%20Beetle.pdf

WOODBORERS

There is a significant risk of **emerald ash borer** (EAB; *Agrilus planipennis*) to Oregon's riparian forests (Fig. 24). EAB has not yet been detected in Oregon or in other western states. In Oregon, a native and susceptible ash (*Fraxinus latiofolia*), grows widely across the western part of the state in riparian areas, in habitats occupied by threatened and endangered species and other rare species. Rapid mortality of this native tree caused by EAB is expected to cause changes in riparian plant communities, increase stream temperatures and alter food webs. Oregon ash is also grown by some tree farmers as a specialty niche crop for forest products or for conservation and restoration efforts. Pockets of ash often occur in areas unsuitable for our other native tree species and the loss of these stands would reduce the ecological and aesthetic value of these areas. If patterns follow eastern states, EAB will likely decimate this small but important market, as well as wild ash stands within approximately 10 years. Moreover, rapid ash mortality in Oregon's cities and urban forests will cause significant economic strain on local governments and property owners.

Figure 24. Feeding galleries from emerald ash borer under the bark of green ash (top), and emerald ash borer traps (bottom) (Wyatt Williams, ODF).

Multiple state and federal agencies have been surveying the state for EAB since 2008 and have not yet found evidence that EAB is in Oregon (Fig. 24). In 2020, due to complications surrounding COVID-19, no statewide survey was conducted.

In 2018, ODF Forest Health received funding from the USFS to collect and store seeds of Oregon ash for preventative efforts before the arrival of EAB to the state. The seeds will be stored in freezers for genetic conservation (USDA Seed Lab, Fort Collins) and resistance research (USFS Dorena Genetic Resource Center). In 2019, approximately 350,000 seeds were collected from over 100 mother trees across 12 populations in western Oregon. Because of the record-setting 2020 fire season and the impact on agency resources, ODF plans for collecting and storing another 600,000 seeds from an additional 200 mother trees were delayed until September-October of 2021, when seeds are mature.

For more on the risk and mitigation of EAB, visit Oregon's EAB Readiness and Response Plan:
https://www.OregonEAB.info

DEFOLIATORS

Our current **Douglas-fir tussock moth** (*Orgyia pseudotsugata*) outbreak in NE Oregon began in 2018 and began its decline in 2019 (Fig. 25). Outbreaks from this insect typically last 2-3 years before virus and natural enemies catch up to them. Because outbreak initiation was staggered among populations, some areas are closer to outbreak collapse than others. Ground reports indicated the most significant defoliation near Halfway although annual monitoring traps indicate a second year of population decline in nearby Wallowa-Whitman National Forest. *More info:* https://www.oregon.gov/odf/Documents/forestbenefits/douglas-fir-tussock-moth.pdf

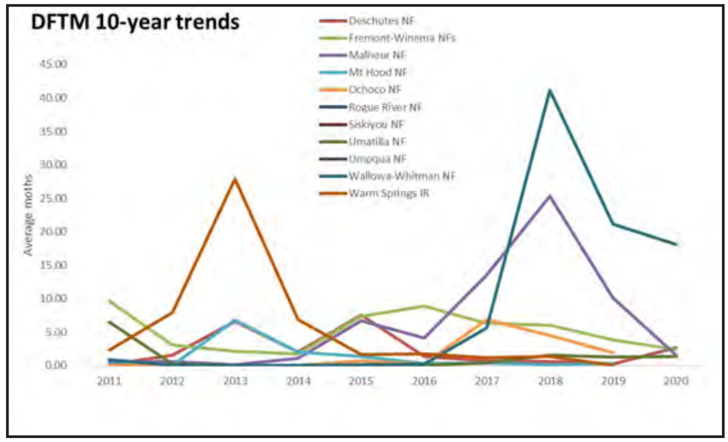


Figure 25. Defoliation from Douglas-fir tussock moth in eastern Oregon (left; Mike Johnson, USFS) and 10 year trap catch trends (right).

Trees defoliated by **Pandora moth** (*Coloradia Pandora*) in 2018 (feeding occurs in even years) in central Oregon are reported to be rebounding in 2020. Pandora outbreaks often collapse within 8 years; this outbreak is in year 6 and is showing signs of decline. Defoliation from other pine-infesting needleminers and sawflies was also reduced in 2019 damage footprints. *More info:* https://www.oregon.gov/odf/Documents/forestbenefits/Pandora_2017.pdf

Gypsy moth is an exotic defoliating insect that feeds on several hundred species of trees and shrubs, including conifers. If it were to establish in the western U.S., it has the potential to dramatically change forest management and ecology, and likely increase aerial pesticide use and timber harvest costs. European gypsy moth (EGM; *Lymantria dispar dispar*) is established in the eastern U.S. and is regularly detected in Oregon; Asian gypsy moth (AGM; *Lymantria dispar asiatica*) is not established in the U.S. but is occasionally detected in western states from overseas imports. All detections of both types of gypsy moth have been successfully eradicated in Oregon since monitoring began in the 1970s. Today, there are no established populations of gypsy moth in Oregon due to our effective early detection and rapid response system.

Since the 1970s ODA has been the agency responsible for surveying the state for gypsy moth, deploying approximately 15,000 traps annually. In the last several years, state funding for this large trapping program has been generated from the Oregon Lottery. In 2020, lottery fund revenues were significantly reduced due to measures taken to protect the public from COVID-19 (e.g. mandatory closures and restrictions of bars and restaurants). Therefore, ODA requested in-kind assistance from other agencies, including ODF, OSU, and Oregon Parks and Recreation.

In total, 25 ODF Stewardship Foresters, Forest Officers and other staff from Private Forests, State Forests and Protection divisions all contributed in placing 223 gypsy moth traps to monitor Eastern and Southern Oregon forests. ODA reported that external cooperators, like ODF, placed a total of 4,826 traps out of a statewide total of 21,463. Two European gypsy moths and one Asian gypsy moth were reported from the 2020 trapping season. None of the gypsy moths in 2020 were found in ODF traps. *More info:* https://www.oregon.gov/odf/Documents/forestbenefits/ODF%20Gypsy%20moth%20fact%20sheet%20Feb%202016.pdf

Damage in Oregon white oak is often observed along the Columbia River Gorge and in some parts of the Willamette Valley. This damage is typically from a complex of **oak-feeding leaf miners, galls**, etc. Sometimes gall insect infestations are compounded by damage from squirrels digging for grubs. Hot droughts can even become taxing on drought-tolerant species such as oak and result in early seasonal leaf drop. Because white oak drops its leaves each year and buds are not affected, even severe damage does not typically result in tree mortality. *More info:* https://www.oregon.gov/odf/Documents/forestbenefits/Oak_galls_2017.pdf

SAP-SUCKING INSECTS

The 2019 outbreak of the exotic but established **spruce aphid** (*Elatobium abietinum*) seems to have collapsed in 2020. Heavy outbreak areas were revisited and few aphids were found and noticeable defoliation was not observed in Sitka stands along the coast. It is likely that heavy rains in winter 2019 and catch up by natural enemies led to the collapse of this recent outbreak. Outreach efforts (presentations and articles) raised awareness that a tree heavily defoliated from spruce aphid can still bounce back and it is best to ride it out rather than to cut it. Data collection plots and a Survey123 form were created during the 2019 outbreak and will be used for future monitoring. *More info:* https://www.oregon.gov/odf/Documents/forestbenefits/Spruce_aphid_2017.pdf

EXOTIC PEST ALERT

Asian giant hornet aka "murder hornet" (*Vespa mandarinia*) is an exotic species that has not yet been found in Oregon. It was first reported in northern Washington in 2019 and again in 2020, and has been found in Canada in previous years. This insect is often mistaken for many other species that are found in Oregon such as cicada killers (Sphecidae), sawflies, bald-faced hornets and yellow jackets (Fig. 26). A feature that stands out in this insect is its size since it may reach 1.25 - 2 inches long. It also has a large yellow head. There is concern around this insect establishing due to its aggression toward honey bees. Additionally this insect creates large underground nets and due to its size and nest populations it can become a human health hazard.

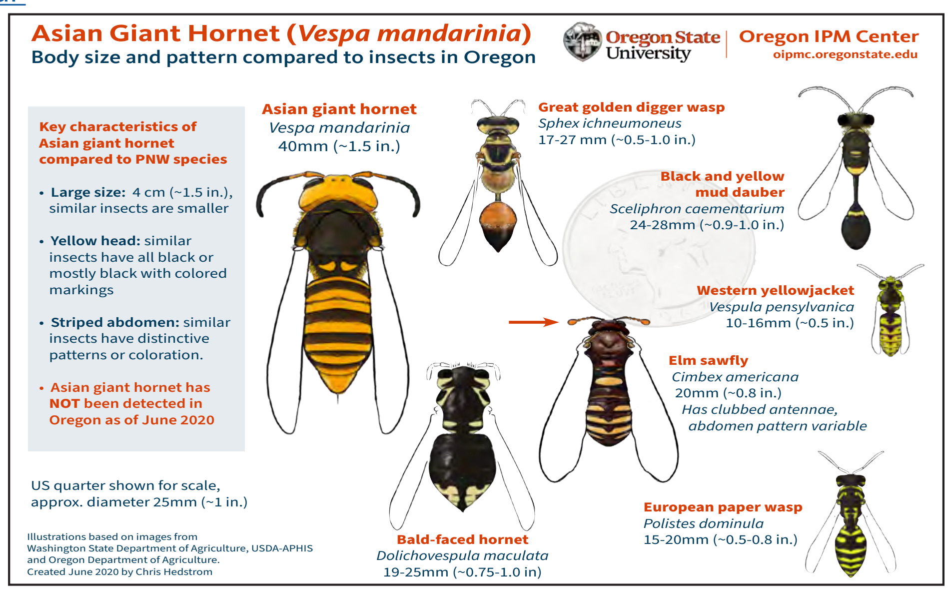


Figure 26. Asian giant hornet and look-alikes (Oregon State University publication EM 9297).

If you think you have found Asian giant hornet please report it to the Oregon Department of Agriculture: plant-entomologists@oda.state.or.us or 503-986-4636

More info:
Online identification form: https://oda.direct/InsectID
https://www.oregon.gov/odf/Documents/forestbenefits/asian-giant-hornet-1.pdf
https://www.oregon.gov/odf/Documents/forestbenefits/asian-giant-hornet-2.pdf

Sudden oak death (SOD), caused by the non-native invasive pathogen *Phytophthora ramorum*, is lethal to tanoak (*Notholithocarpus densiflorus*) and threatens this species throughout its range in Oregon. The disease was first discovered in coastal southwest Oregon forests in July 2001. Since then an interagency team continues to slow the spread of the pathogen through a program of early detection and treatments of infected and nearby host plants. Treatments include cutting and burning infected and potentially exposed host material. Spread of *P. ramorum* is managed through the designation of a SOD Generally Infested Area (GIA) and SOD quarantine area under the authorities of the Oregon Department of Agriculture (ORS 603-052-1230) and the USDA Animal Plant Health Inspection Service (7 CFR 301-92). These state and federal quarantines regulate the intrastate and interstate movement of host plant material outside of the quarantine area. Oregon regulations require infested sites on state and private lands to undergo eradication treatment. In late 2020, ODA expanded the GIA boundary to encompass areas within the SOD quarantine areas where the infestations were not treated from 2018 and 2019 due to reduced priority from resource constraints (Fig. 30).

Figure 27. Tanoak stem with girdling canker lesions (ODF).

P. ramorum spreads during rainy periods when spores produced on infected leaves or twigs are released into the air and are either washed downward or transported in air currents. The disease can be spread by humans transporting infected plants or infested soil. *P. ramorum* can kill highly susceptible tree species such as tanoak, coast live oak, and California black oak by causing canker lesions on the main stem (Fig. 27). Tanoak is by far the most susceptible species in Oregon, and the disease seriously threatens the future of tanoak. In order to monitor disease spread and detect new infestations, Oregon's SOD Program relies on multiple monitoring methods throughout the year, such as aerial surveys, ground based transects, and stream monitoring. With regional aerial surveys cancelled for 2020 due to COVID-19 safety concerns, SOD foresters at ODF and USDA Forest Service visually scanned 220,000 acres of high-resolution aerial imagery to detect dead tanoak trees (Fig. 28).

Since 2015, ODF has been aggressively treating all known EU1 infestations with large buffers of 300 - 600 feet. In Europe, the EU1 lineage kills or damages several conifer tree species and is considered more aggressive than the North American lineage (NA1). In 2020, ODF, USFS, and Bureau of Land Management completed treatments on 30 acres and over 700 acres of tanoak remain to be burned. To date, eradication treatments have been completed on more than 7,400 acres at an estimated cost of over $30 million. Outside of Oregon, *P. ramorum* is known to occur in forests only in California (16 counties) and two European countries. The origin of the pathogen is unknown.

Figure 28. Aerial photography showing the disease progression of sudden oak death from 2012 (left) to 2020 (right) (ODF. (right) from within the Generally Infested Area.

In 2019, ODF, USFS, and OSU staff planted several thousand tanoak seedlings grown from acorns collected from the southern Oregon coast marking the first out-planting to monitor for genetic resistance to *P. ramorum*. ODF staff collected tanoak acorns in 2016-2018 from tanoak trees both exposed to the disease, within the SOD GIA, and from areas free of disease, such as along the Rogue River. The acorns were sorted by family and grown at the Dorena Genetic Resource Center until ready for field and OSU lab testing. Monitoring of the out-planting continued in 2020; visual observations identified about 10% mortality among tanoak seedlings throughout the planting and visible SOD symptoms in about 20% of the seedlings (Fig. 29). Oregon's SOD Program is interested in finding potentially resistant tanoak trees in SOD infested areas and encourages local landowners to identify those trees using the TreeSnap App: https://treesnap.org

More info:
https://www.oregon.gov/oda/programs/PlantHealth/Pages/SODProgram.aspx
https://catalog.extension.oregonstate.edu/em9216
https://www.aphis.usda.gov/plant_health/plant_pest_info/pram
https://www.suddenoakdeath.org

Figure 29. ODF SOD Foresters participated in the 2020 International Year of Plant Health communication campaign with Beastie the Bug (https://beastiebug.eppo.int/) (Casara Nichols, ODF). They used the campaign to highlight the ongoing Tanoak Field Resistance Trial in Curry County.

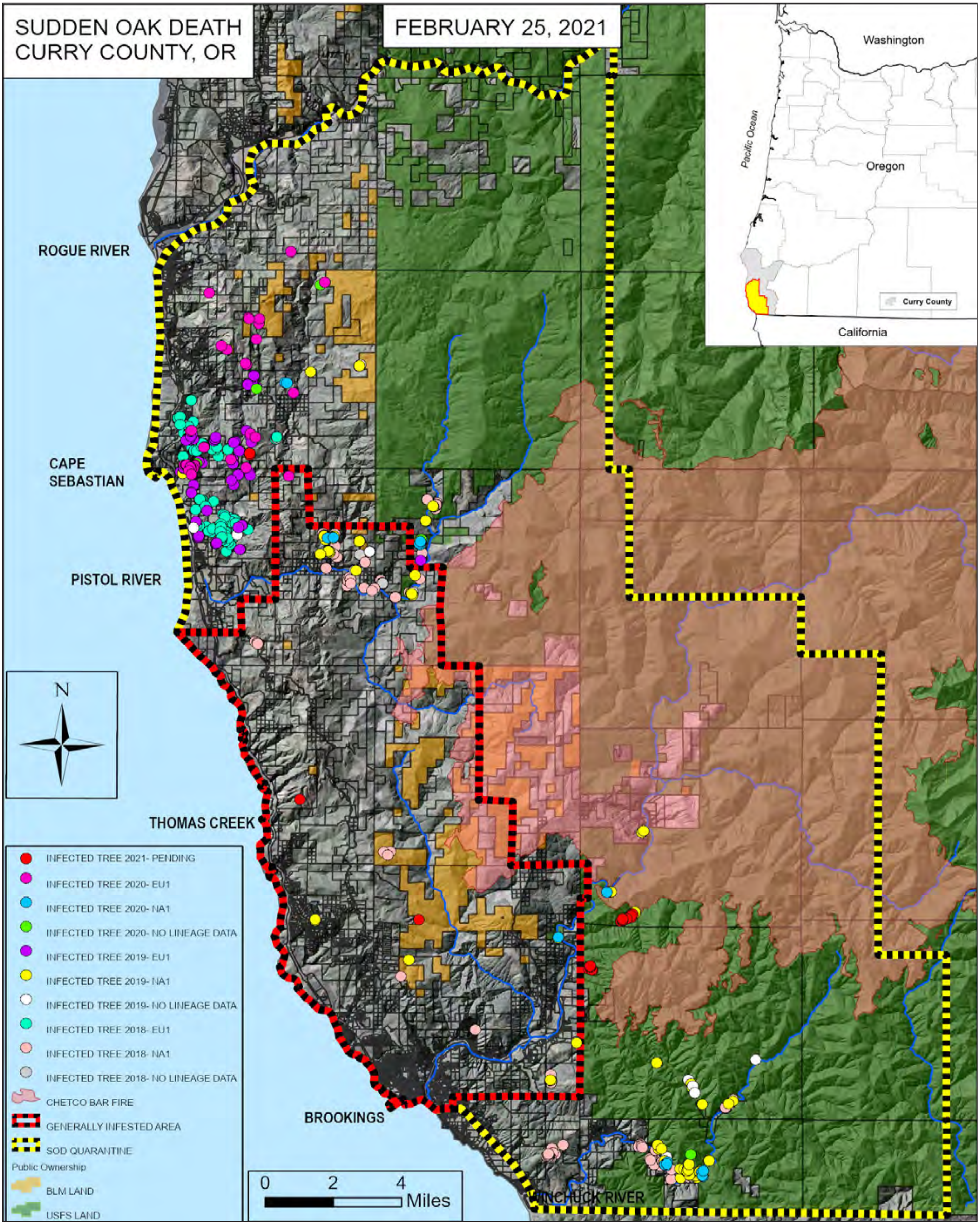


Figure 30. Map of SOD infection area (red) and quarantine area (yellow). EU1 and NA1 are two different lineages of P. ramorum. In Europe, the EU1 lineage kills or damages conifer tree species and is considered more aggressive than the NA1 lineage.

Port-Orford-cedar root disease, caused by the non-native pathogen *Phytophthora lateralis*, was first identified in the Port-Orford-cedar forests of southwestern Oregon in 1952 (Fig. 31). Since then this soil- and water-borne pathogen has been spread to many areas throughout the range of Port-Orford-cedar in southwest Oregon and northern California. In recent years, the ODF-USFS statewide aerial survey has mapped approximately 4,000 acres of Port-Orford cedar mortality per year (Fig. 32).

Figure 31. Dead, cinnamon-colored bark indicative of Port-Orford-cedar root disease infection (Alan Kanaskie, ODF).

Disease management emphasizes excluding the pathogen from areas where it does not yet occur and minimizing its spread in already infested areas. This is accomplished through road closures, limiting wet-weather access into stands with Port-Orford-cedar, washing equipment, sanitizing roadsides, and treating water used for fire-fighting and road maintenance (Fig. 32). Seed from disease-resistant Port-Orford-cedar is now being produced through a cooperative program between the USDA Forest Service, Bureau of Land Management, and Oregon State University. Planting resistant seedlings greatly improves opportunities for restoring this important tree species. Resistant Port-Orford-cedar seed is available to interested small woodland owners in Oregon through the ODF Seed Orchard: https://www.oregon.gov/odf/working/Pages/seed.aspx

Figure 32. Port-Orford-cedar root disease observed during aerial surveys (left; Michael McWilliams, USFS) and management sign (right) (Alan Kanaskie, ODF).

FOREST DISEASES

Swiss needle cast (SNC), a foliar disease affecting Douglas-fir in the Pacific Northwest, is caused by the native fungus *Nothophaeocryptopus gaeumannii*. The fungus is common where its only host, Douglas-fir, is grown. It has become particularly damaging to Douglas-fir forests on the western slopes of the Oregon Coast Range. The host-pathogen interaction is unique, because both the fungus and the host tree are native in the Pacific Northwest (PNW), where the disease originated.

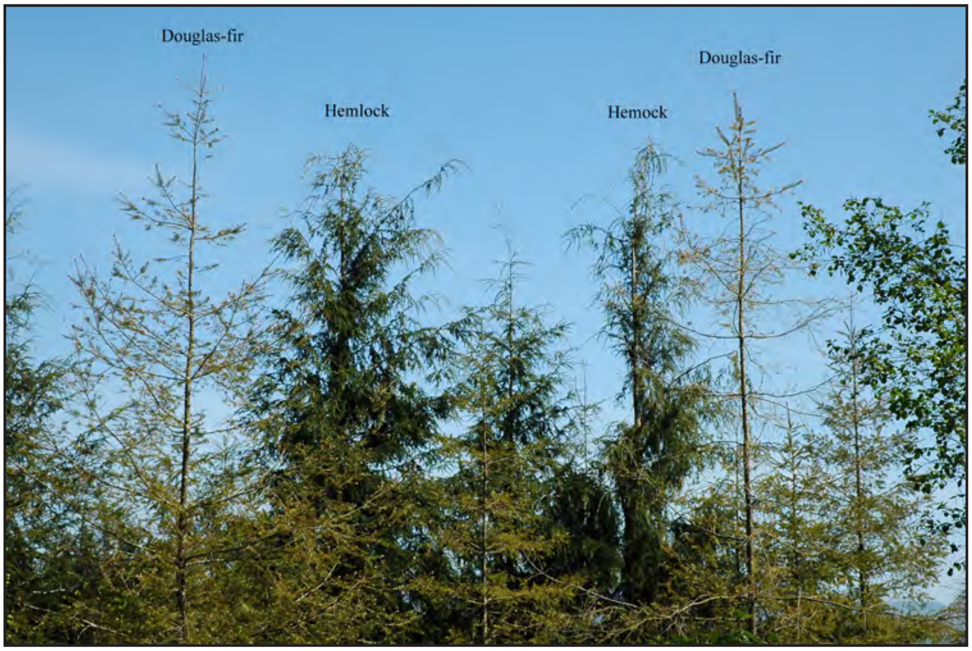
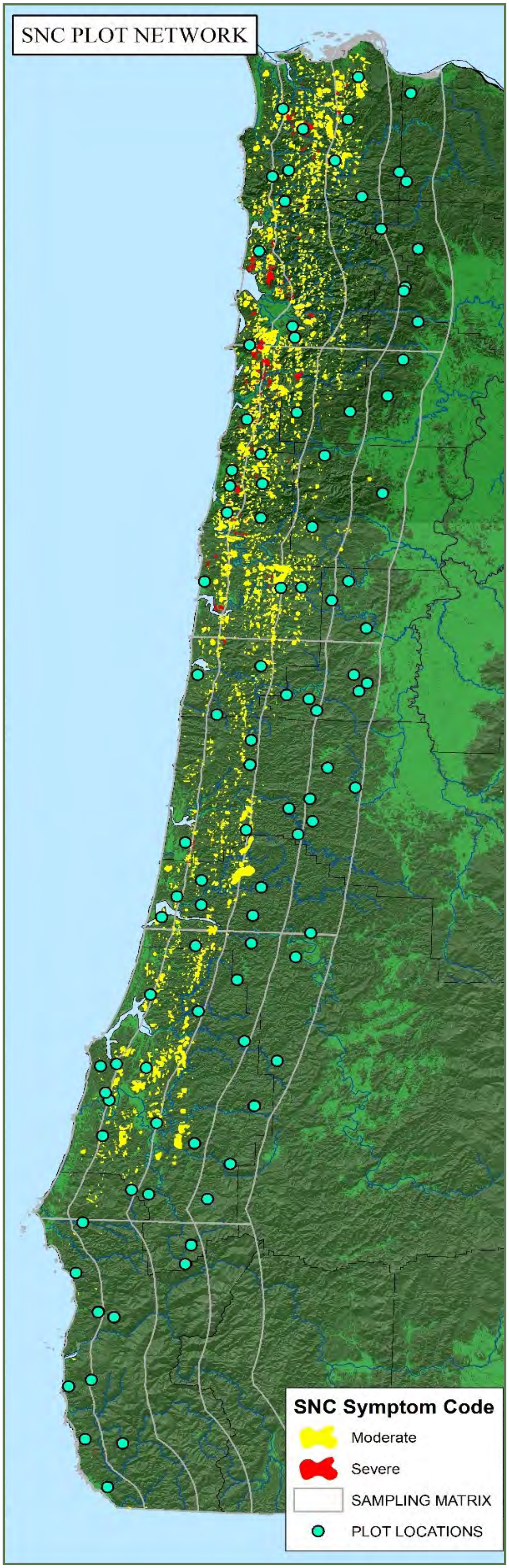


Figure 33. SNC causes foliage loss and sparse yellow crowns in Douglas-fir in Oregon's Coast Range. Low foliage retention can reduce tree volume growth by more than 50%. Western hemlock is unaffected (Alan Kanaskie, ODF).

Trees affected by SNC exhibit chlorotic foliage in the late spring and cast needles prematurely, resulting in sparse crowns. Disease severity and growth impacts are assessed using the number of years of retained foliage. Uninfected trees generally have a minimum of 3 years of retained foliage, and trees with severe infections may retain needles for less than 2 years (Fig. 33). SNC rarely kills trees but reduces diameter and height growth due to foliage loss. Previous analyses (1998-2008) have shown cubic volume growth losses exceeding 50% when only 1 year of foliage remains on the tree. Growth loss due to SNC in 10-70 year old Douglas-fir in the Oregon Coast Range is estimated at more than 190 million board feet per year. SNC also negatively alters wood properties and value, hinders the development of stand structure and wildlife habitat, and limits stand management options.

Over a 3-year period, starting in 2013, the SNC Cooperative (SNCC) at OSU established a 106-plot research network in 10-25 year old Douglas-fir stands (Fig. 34). The plots are distributed from the Oregon-California border to southwest Washington and 35 miles inland. The SNCC will collect data from these plots for at least 10 years. The first five-year period of plot re-measurement has been completed and has provided information about disease severity, growth loss and its geographic distribution on 102 surviving plots throughout the Coast Range. Analysis of these new data showed that the maximum cubic volume growth losses during the 2013-2020 period was ~35%. The lower maximum growth losses (relative to the 1998-2008 period) are thought to be due to a decrease in under-performing stands in the dataset/population because heavily infected stands have been harvested, particularly in coastal zones.

A special SNC aerial survey (Fig. 35) is conducted by ODF and USFS every other year (survey was annual until 2018). It was canceled in 2020 and 2021 due to COVID-19 restrictions but is planned to resume in spring 2022: https://www.arcgis.com/apps/MapJournal/index.html?appid=da5cda5003d24544b9231dbb8edf82fb



More information:

The SNCC has produced a silvicultural guide to assist land managers in decision making within SNC infected stands: http://sncc.forestry.oregonstate.edu/sites/default/files/SilvGuide_July2020.pdf

SNCC guide to decision-making in SNC-infected stands: http://sncc.forestry.oregonstate.edu/sites/default/files/SilvGuide_July2020.pdf

https://www.oregon.gov/odf/documents/forestbenefits/swissneedlecast.pdf
http://sncc.forestry.oregonstate.edu

Figure 34. Map (left) of SNC plot locations and SNC damage observed in Douglas-fir during the 2018 SNC aerial survey (left). The next aerial survey will take place in late spring of 2022.

Figure 35. During recent SNC aerial surveys, observers have noted that SNC infected Douglas-fir stands appear more brown with thin crowns (above top) compared to previous years when symptomatic stands appeared more yellow in color (above bottom) (ODF).

Western hemlock dwarf mistletoe (*Arceuthobium tsugense* ssp. *tsugense)* is a native, arboreal parasite, infecting western hemlock (Fig. 36) throughout its range, and several other conifers in western Oregon. Infection occurs in the boles and branches and predisposes trees to drought-related stress and reductions in height and diameter growth. Severe infections lead to top kill or whole tree death (Fig. 37). Branch infections cause swelling at the point of infection and a massive proliferation of branchlets and twigs, resulting in a witches' broom. Management historically focused on eradication to minimize merchantable timber losses. However, the unique forest structures produced by infections are important for many bird and arboreal mammals; witches' brooms can serve as nesting platforms, forage, and cover.


Figure 36. Western hemlock dwarf mistletoe (left) with female visibly ready to eject seeds (right) (Stephen Calkins, OSU).

In 2019, researchers from OSU climbed 16 mature and old age western hemlocks at the H.J. Andrews Experimental Forest, near Blue River, Oregon, to investigate the effects of dwarf mistletoe infection severity on the growth and structure of infected trees. Infection severity of selected trees ranged between uninfected and all branches infected. Trees were measured for occurrence of all dwarf mistletoe infections, mistletoe-caused deformities, branch and crown structural metrics, and sapwood area. Results suggest that shifts in crown structure and branch deformation, foliage amount, and foliage distal to infection, reflected a likely reduction of capacity for tree growth that coincided with a hypothesized increase in resource demand by dwarf mistletoe plants as infection severity intensified. *More info:* Calkins et al. 2020 https://doi.org/10.1111/efp.12664

Figure 37. Old growth forest at OSU's H.J. Andrews Experimental Forest infected by hemlock dwarf mistletoe (Katie Nicolato).

ODF has been a cooperator in the development of new control strategies for **Japanese knotweed** (*Fallopia japonica*), a noxious weed that grows rapidly and chokes out native plants along rivers and streams in northwest and southern Oregon (Fig. 39). In 2020, ODF Forest Health and ODF State Forests assisted Oregon State University researchers and Oregon Department of Agriculture locate sites on the Nehalem River for release of a new biological control agent, the knotweed psyllid (*Aphalara itadori*) (Fig. 38). The knotweed psyllid is an insect from Japan that feeds solely on knotweed. This insect was tested for several years in a quarantine facility at Oregon State University, and in 2020 was deemed safe for open field releases by the USDA. Included in the field sites selected by OSU researchers were a site on Tillamook State Forest and another on nearby private land. At both of these sites, the insects successfully established and produced a second generation. Introduction of this biocontrol agent shows promise for the development of a sustainable, eco-friendly control tactic for this damaging weed.

Figure 38. Knotweed psyllid (inset; CABI) and damage to knotweed (main; Joel Price, ODA)

ODF supports safe and proven biological control as part of a comprehensive Integrated Pest Management (IPM) program. This is especially important for Japanese knotweed, which is extremely difficult to control with chemical pesticides. Biological control also significantly reduces the amount of chemical pesticides being applied near streams and rivers.

Figure 39. Japanese knotweed along Siuslaw River near Mapleton (Wyatt Williams, ODF).

Japanese knotweed is one of the species on the state's official noxious weed list, a list comprising over 130 species of exotic pest plants deemed a "menace to the public". Over 30 of the weeds on this list occur in Oregon's forests. Two of these pest plants, Himalayan blackberry and Scotch broom, cost Oregon's forestland owners and farmers an estimated $80 million dollars annually. Oregon Department of Agriculture administers the noxious weed list, and has a robust program focusing on early detection and rapid response, as well as sound IPM strategies. ODF Forest Health supports and cooperates with the ODA Noxious weed program.

More info on noxious weeds in Oregon: https://www.oregon.gov/oda/programs/weeds/oregonnoxiousweeds/pages/aboutoregonweeds.aspx

IMPORTANT INSECT AND DISEASE PESTS

	DOUGLAS-FIR	TRUE FIR	PINE
INSECTS	 • Douglas-fir beetle • Douglas-fir tussock moth • Western spruce budworm • Flatheaded fir borer • Cooley spruce gall adelgid* • Douglas-fir pole & engraver beetles*	 • Douglas-fir tussock moth • Western spruce budworm • Fir engraver beetle • **Balsam woolly adelgid**	 • Ips beetles (pine engraver & California five-spined) • Mountain pine beetle • Western pine beetle (ponderosa only) • Pine butterfly • Black pineleaf scale • Sequoia pitch moth*
DISEASES	• Laminated root rot • Blackstain root disease • Armillaria root disease • Swiss needle cast • Rhabdocline needle cast • Douglas-fir dwarf mistletoe • Heart and stem decays	• Annosus root disease • Interior needle blight • Fir needle rust • Fir broom rust • Heart and stem decays	• **White pine blister rust** (5-needle pines) • Diplodia tip blight • Dothistroma needle blight • Western gall rust • Blackstain root disease • Armillaria root disease • Pine dwarf mistletoe

	TANOAK	WHITE OAK	MAPLE
INSECTS	• **Gypsy moth** 	• **Gypsy moth** • Oak looper* • Gall-making wasps & flies* • Leaf miners* 	• **Asian longhorned beetle** • **Gypsy moth** • Various defoliators* 
DISEASES	• **Sudden oak death** (*Phytophthora ramorum*) • Armillaria root disease	• Armillaria root disease • Inonotus trunk rot	• Tar spot • Ganoderma trunk rot • Armillaria root disease

*Secondary or aesthetic pests that are not typically tree-killers
BOLD: non-native, exotic insects and diseases

IN NATIVE OREGON TREES

HEMLOCK	SPRUCE	'CEDARS'	LARCH
 • Western hemlock looper	 • Spruce beetle • **Spruce aphid** • Cooley spruce gall adelgid*	 • Cedar bark beetles* • Amethyst borer* • Western cedar borer*	 • **Larch casebearer**
• Annosus root disease • Hemlock dwarf mistletoe • Hemlock needle rust • Heart and stem decays	• Spruce broom rust • Heart and stem decays	• **Port-Orford-cedar root disease** (POC only) • Cedar leaf blight (western redcedar only)	• Larch needle cast • Larch needle blight • Larch dwarf mistletoe

ALDER	ASH	POPLAR	MADRONE
• **Gypsy moth** • Western tent caterpillar* • Alder flea beetle* 	• **Emerald ash borer** • **Gypsy moth** 	• **Gypsy moth** • **Satin moth*** • Webworm* 	• **Gypsy moth** 
• Armillaria root disease • Nectria canker • Alder collar rot • Heart and stem decays		• Heart and stem decays	• Madrone leaf blight • Madrone branch dieback • Madrone stem cankers

Don't know your tree? ID here:

Oregon tree ID: https://oregonstate.edu/trees/name_common.html

FOREST HEALTH CONTACTS

Oregon Department of Forestry - Forest Health
2600 State Street, Salem, OR 97310
https://tinyurl.com/odf-foresthealth

Christine Buhl	Entomologist	(503) 945-7396	christine.j.buhl@oregon.gov
Vacant	Pathologist		
Wyatt Williams	Invasive Species Spec.	(503) 945-7472	wyatt.williams@oregon.gov
Vacant	Aerial Survey Spec.		

USDA Forest Service – Forest Health Protection Monitoring Program
1220 SW Third Avenue, Portland, OR 97204

Chad Davis	Region 6 Director	(503) 808-2340	chad.davis2@usda.gov
Karl Dalla Rosa	Region 6 Asst. Director	(503) 808-2913	karl.dallarosa@usda.gov
Iral Ragenovich	Entomologist	(503) 808-2915	iral.ragenovich@usda.gov
Karen Ripley	Entomologist	(503) 808-2674	karen.ripley@usda.gov
Blakey Lockman	Pathologist	(503) 808-2997	irene.lockman@usda.gov
Sarah Navarro	SOD Pathologist	(503) 808-2257	sarah.navarro@usda.gov

USDA Forest Service – Westside Oregon Service Center
Mount Hood National Forest, 16400 Champion Way, Sandy, OR 97055

Beth Willhite	Entomologist	(503) 668-1477	beth.willhite@usda.gov
Kristen Chadwick	Pathologist	(503) 668-1474	kristen.chadwick@usda.gov
Holly Kearns	Pathologist	(503) 668-1475	holly.kearns@usda.gov
Vacant	Aerial Survey Mgr.		
Justin Hof	Aerial Observer	(503) 668-1646	justin.hof@usda.gov

USDA Forest Service – Southwest Oregon Service Center
Medford Interagency Office, 3040 Biddle Rd, Medford, OR 97504

Laura Lowrey	Entomologist	(541) 858-6125	laura.lowrey@usda.gov
Josh Bronson	Pathologist	(541) 858-6126	joshua.j.bronson@usda.gov

USDA Forest Service – Central Oregon Service Center
Deschutes National Forest, 63095 Deschutes Market Road, Bend, OR 97701

Robbie Flowers	Entomologist	(541) 383-5788	robbie.flowers@usda.gov
Brent Oblinger	Pathologist	(541) 383-5701	brent.oblinger@usda.gov
Max Wahlberg	Fire Ecologist	(503) 319-9582	maximillian.wahlberg@usda.gov
Danny DePinte	Aerial Observer	(541) 840-2311	daniel.depinte@usda.gov

USDA Forest Service – Blue Mountains Service Center
3502 Highway 30, La Grande, OR 97850

Lia Spiegel	Entomologist	(541) 962-8580	lia.spiegel@usda.gov
Mike Johnson	Entomologist	(541) 962-8538	jay.m.johnson@usda.gov
Michael McWilliams	Pathologist	(541) 962-8510	michael.mcwilliams@usda.gov