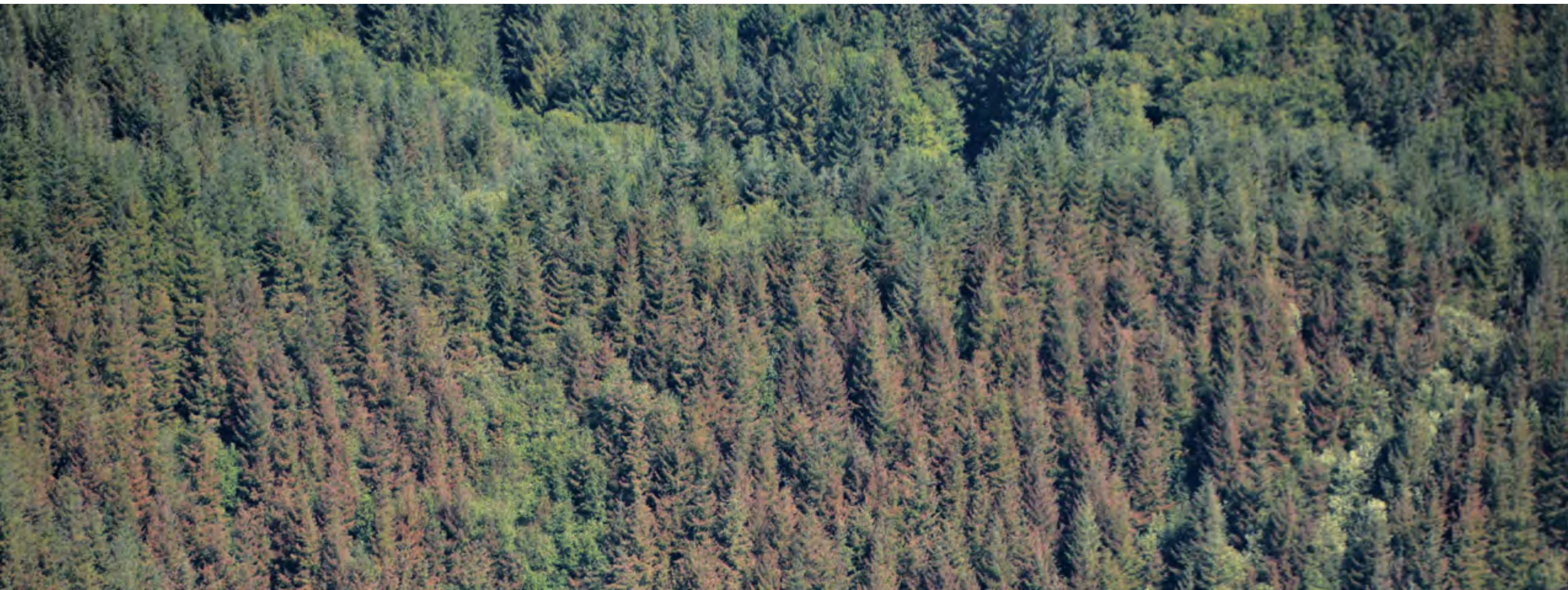
Forest Service
United States Department of Agriculture

Oregon Department of Forestry
Forest Health

Pacific Northwest Region

Forest Health Highlights in Oregon - 2021



FOREST HEALTH HIGHLIGHTS IN OREGON - 2021

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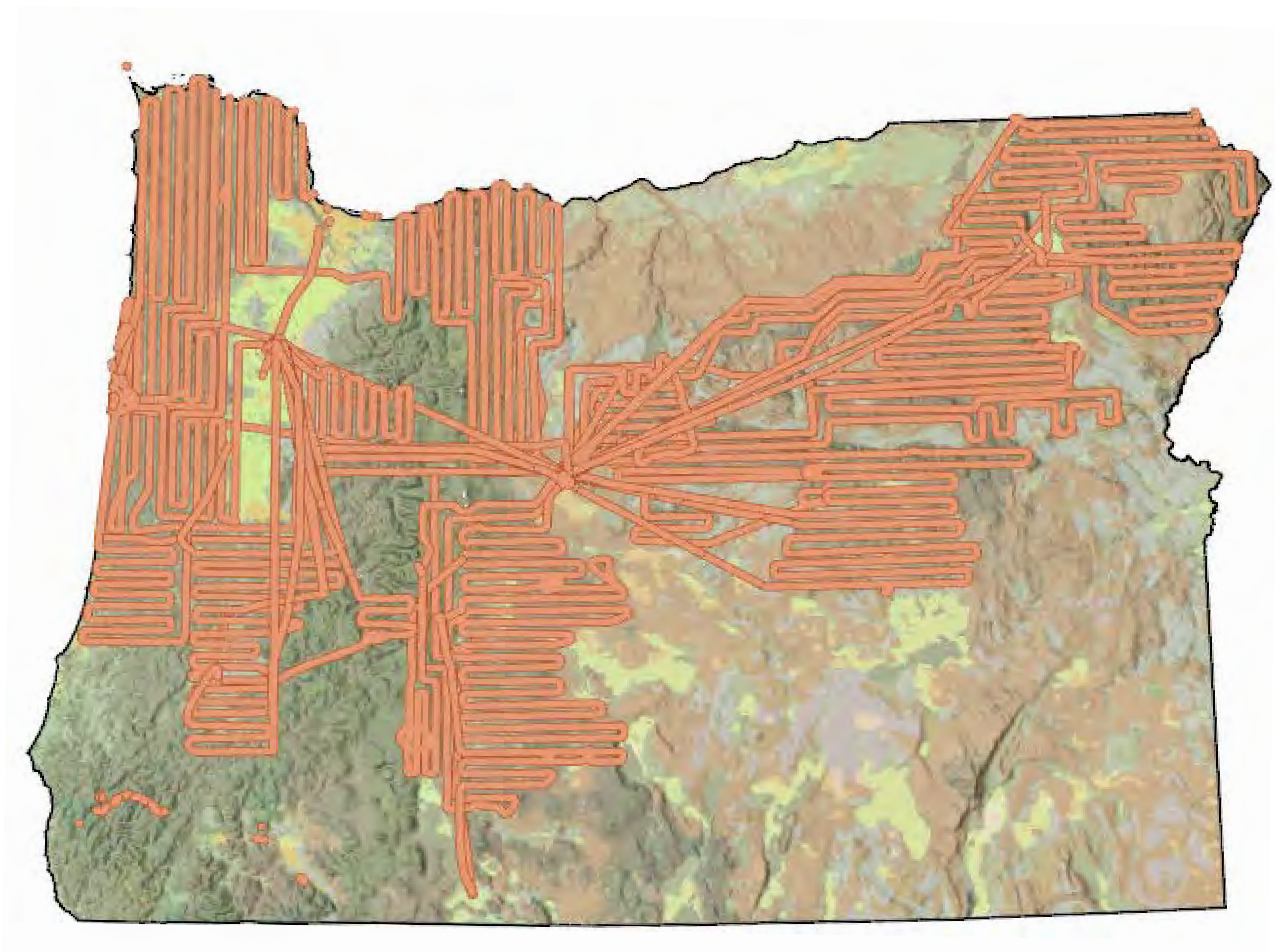
Cooperative Aerial Survey: 2021 coverage area



Map above: *Aerial survey flightlines of the 2021 forest health data collection coverage area. The typical general survey coverage area includes about 28 million acres but was reduced to about 25 million acres in 2021. Parts of southwest Oregon and the Cascades weren't covered in 2021 due to wildfire, COVID-19 complications and staff shortages.*

Front cover: *Heat dome damage observed during aerial survey east of Newport (Danny DePinte, USFS).*

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LANDOWNER RESOURCES

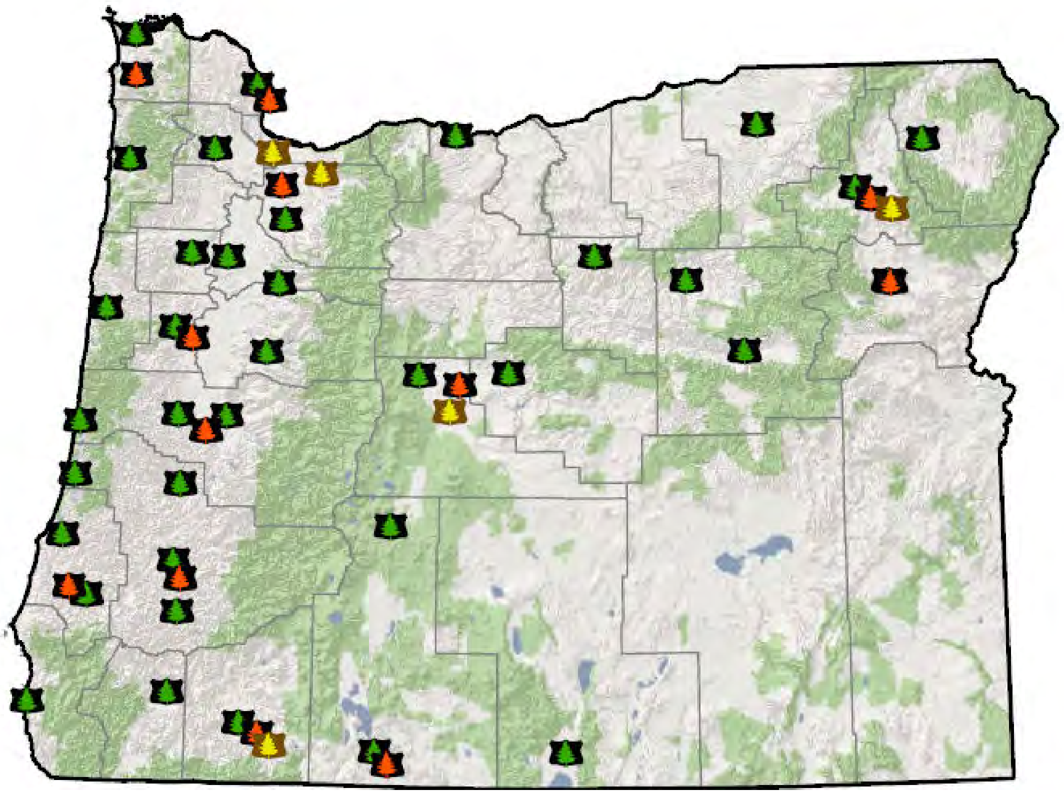


Figure 1. Map of ODF (black badge with green tree), USFS (brown badge with yellow tree), and OSU (black badge with orange tree) unit offices.

OREGON DEPARTMENT OF FORESTRY (ODF):

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):

(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:

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 almost 50% forestland. These numbers have remained unchanged since 1953. These forests take many forms: family-owned forests that are handed down across generations; large tracts of productive industrial land; and 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 mountain ranges (Fig. 2). Oregon's forests consist of federal (60%), private (35%), state (3%), tribal (1%), and other public (1%) ownerships.

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

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 landowners on how best to manage their forestlands to preserve ecosystem function and sustainability while utilizing this renewable resource. There are also certification processes (Sustainability Forestry Initiative, American Tree Farm System, Forest Stewardship Council) available 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. Ensuring that trees have the best chance for success results from a healthy start and promoting ongoing resiliency:

- Know the genetic lineage of your seed source. E.g., 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: https://tinyurl.com/seedzone
- 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 unnatural wildfire risk prevents fire-damaged and beetle-susceptible trees.
- Know what major insects and diseases occur on your tree species (pg. 32) and how to prevent or mitigate their impacts by improving tree health.

2021: YEAR IN REVIEW

2021 was again a difficult year for forestry but a lot of lessons were learned and plans came together for improving future resiliency and preparedness. COVID-19 impacts continued to present challenges. We navigated this hardship with increased literacy in remote technologies such as virtual and recorded meetings and trainings, which reduce geographic barriers, time constraints, and unavailability, and generally allow for greater flexibility.

Other challenges in 2021 included another intensive wildfire season and a record-setting heatwave (Fig. 3). Multiple interagency committees and working groups have developed post-fire recovery plans that establish necessary connections, improve resource availability, and reduce response times. Although we have become accustomed to ongoing hot, dry conditions, the heat wave / heat dome event was novel. We do not know what the long-term impacts of this event will be, although natural resource agencies and local universities acted quickly to understand the cause, quantify the amount of damage, and initiate discussions about how to predict and respond to this type of event in the future.

Figure 3. Landscape-level damage from heat dome in late June 2021 (Danny DePinte, USFS).

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. They are always present on the landscape but only become a problem when populations increase, often enabled by a buildup of trees weakened by some other primary stressor. In recent years a major stress for trees has been hot droughts, which make trees 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 fir, 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.

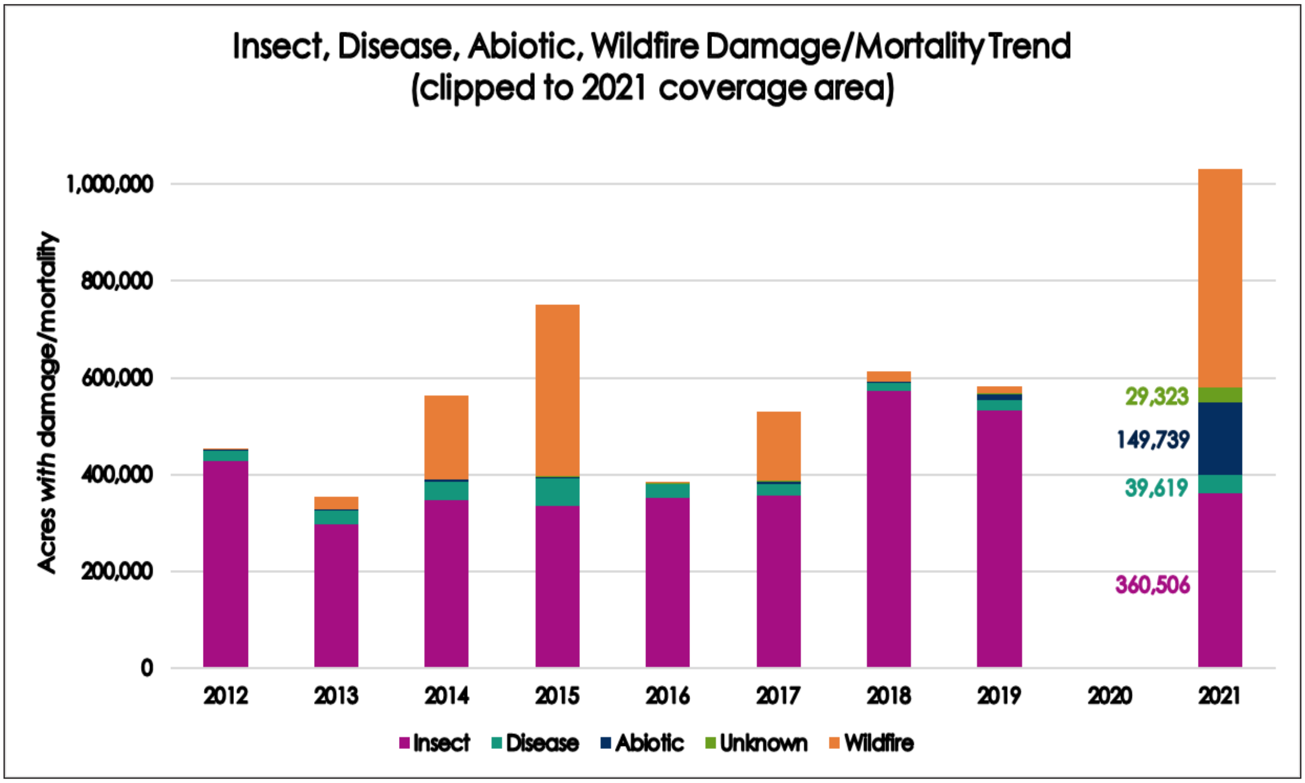


Figure 4. Tree damage and mortality were collected by aerial detection surveys (ADS) across 24,800,000 acres in 2021. For more accurate, direct comparison of annual totals, the table above shows ADS data from 2012-2021 that were confined to the geographic areas we were able to cover in 2021. Data from 2020 are not directly comparable and were excluded because they were collected across a much smaller geographic area and collected via a different method (Scan and Sketch, see the 2020 Forest Health Highlights: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd947558.pdf).

The metric is acres "with" not "of" damage because undamaged trees are often intermixed within a mosaic of damaged and dead trees. Damage/mortality from some agents such as many diseases (e.g., root diseases, Swiss needle cast) is not shown here because it is either difficult to identify via aerial survey or is captured in specialty aerial or ground surveys covered elsewhere in this report. Wildfire damage/mortality (data obtained from Northwest Interagency Coordination Center) is an influential factor on current and future forest health conditions and is shown, in addition to other forms of abiotic damage, for comparison. Wildfire totals shown here are also confined to the 2021 survey area. See pg. 16 for the full statewide wildfire totals and trends.

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 and ground surveys.

In addition to aerial surveys, we collect data via ground checks, traps, and reporting from ODF and USFS Forest Health staff, as well as foresters from both agencies and OSU which have unit offices and coverage areas throughout the state (pgs. 1 and 31). We also rely on ground reports from public and private landowners and land managers, and other members of the public. Site visits can provide more information to form an awareness of what is happening on the landscape.

Damage trends (Fig. 4) observed from data obtained from a combination of aerial surveys (Fig. 5) and site visits indicate that drought stress is one of the main underlying causes of tree dieback and decline, often followed by subsequent attack by opportunistic insects such as bark beetles. Many of our bark beetle species are native and, at normal population levels, bark beetles are not major tree killers. Landscape-level stress conditions from hot droughts produce a pulse of susceptible trees to feed these insects and may result in a beetle population outbreak that allows individuals 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 and delineation relies on extensive ground surveys. Many of our tree species are predisposed to abiotic stress and where we are putting them on the landscape must be re-evaluated to assure that their needs will be met in spite of increasingly changing future conditions.

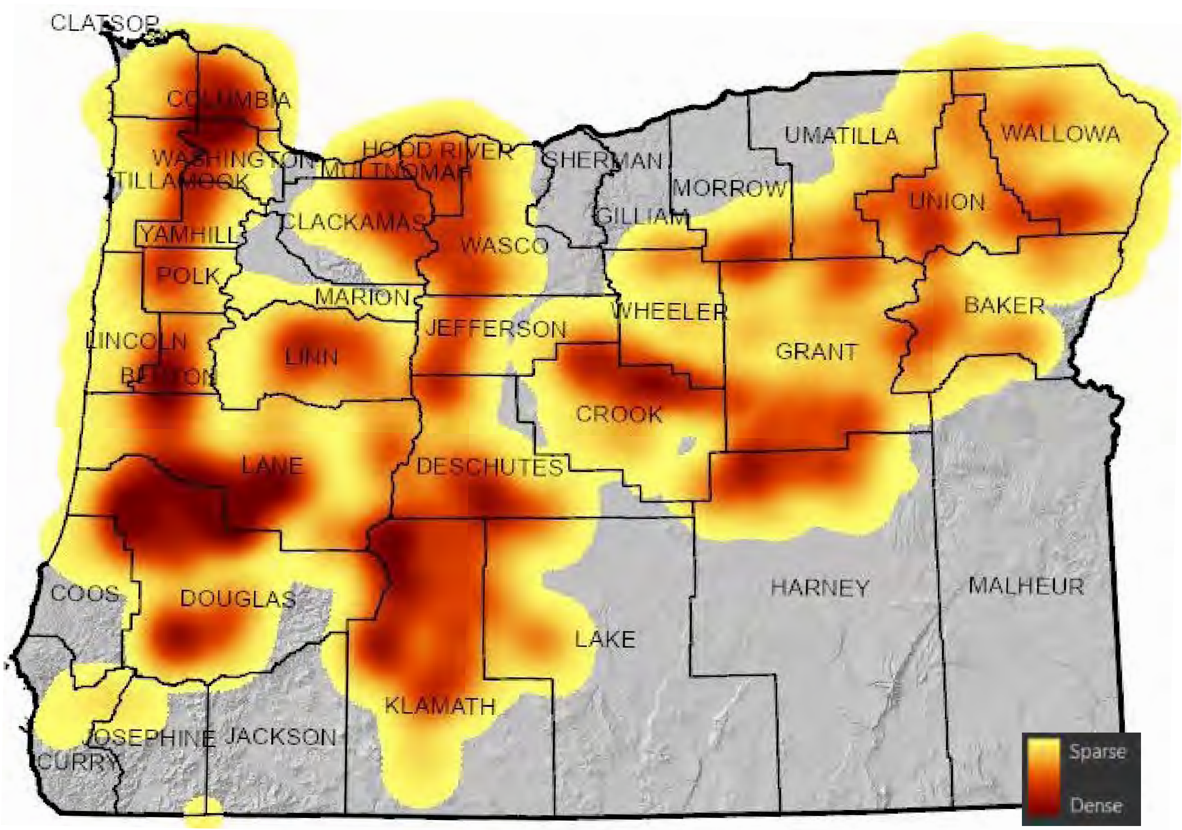


Figure 5. "Heat map" indicating areas of highest damage/mortality as caused by insects, diseases and abiotic (excluding wildfire) agents as identified by the 2021 aerial survey.

SURVEYS, MONITORING AND OTHER PROJECTS

Aerial Detection Survey (ADS)

The USFS and ODF cooperatively conduct forest health surveys each year to detect and appraise insect infestations, disease conditions, weather, and climate-related and man-made stressors affecting trees. Together we monitor the forests of Oregon to determine detrimental changes or improvements that occur over time. Aerial detection surveys are currently the most efficient and economical method of collecting and reporting timely data on forest disturbances across State, Private, and Federal lands. In Oregon (and Washington), this annual aerial survey began in 1947 and is one of the oldest continuous forest health aerial surveys in the nation. Trained specialists from each agency ride in low flying aircraft and conduct surveys through a process called sketch-mapping. With technical experts looking out each side of the plane, the extent of the observable damage on a forest is drawn on a digital map. Then each area of forest damage is given a severity rating and assigned a probable cause of the damage based on the observer's training, complementary ground surveys, local knowledge, and the best available science.

In a typical year, the general forest health survey covers roughly 28 million acres to assess most insect, disease and abiotic agents that can be identified from the air. Additional surveys are periodically flown for damage agents like Swiss needle cast, sudden oak death, and pandora moth. Separate surveys are necessary because the damage these other agents cause peaks outside of the summer general survey season and may be only periodic. With the addition of these special surveys our agencies typically monitor 35 million to 41 million acres each year. As we all know, 2020 and 2021 were not typical due to the COVID-19 pandemic. To keep staff safe from infection, no aerial surveys were completed in 2020. Instead, efforts were focused on visually scanning high-resolution imagery of Oregon to map damage rather than observing damage directly from a plane (summary of Scan and Sketch on pgs. 8-10 of 2020 Forest Health Highlights: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd947558.pdf). Aerial survey resumed in 2021.

The 2021 Oregon aerial survey started on June 28th and ran through September 22nd. During the 2021 survey, we resumed regular data collection from an aircraft using tablets running Digital Mobile Sketch Mapper software to collect data on the health of treed areas. We completed aerial survey across approximately 80% of our normal coverage area. This reduction in survey area was due to COVID-19 complications, smoke from wildfires, and staff shortages. Additionally, we used high resolution imagery to supplement the quality of data collected. Geospatial data collected with these systems are stored in a Regional and National Insect and Disease Survey (IDS) database and made available to the public. A variety of forest health data products are available online for downloading or to interact with, including regional Insect and Disease Detection Survey Maps, IDS Geospatial Data, and IDS Acre Summaries: https://tinyurl.com/FHAerialSurvey

Drought conditions affected most of Oregon by the end of June and the effects on the forest were noticeable during our June-September survey timeframe. Drought often serves as a catalyst for insect and diseases to take advantage of weakened trees. Additional abiotic damage appeared the last week of June during the heat dome event. Approximately 230,000 acres of heat scorched trees were mapped by the aerial survey effort in the Pacific Northwest with most of the damage occurring on Oregon's Coastal Range. Some saplings were killed outright by the heat dome event and foliage on older trees was shed prematurely. The observed damage within trees occurred mostly on their west and southern sides. Furthermore, this pattern continued at the landscape scale with the heat damage being more severe on west and south aspects. Southern- and western-facing aspects face the highest intensity of thermal heat, due to the position of summer sun later in the day, and are thus more at risk of heat damage.

Data trends (Fig. 6) of forest damage and mortality (Fig. 7) are impacted by the reduced extent of survey efforts in 2020 and 2021. Although those years appear to show less damage, in reality, they simply have less data. Given these caveats with forest damage trends, we can still share what information was collected. Based on aerial detection survey data, the historical trend in forested acres with mortality in Oregon has been slightly increasing over the past ten years. Most of the mortality observed in Oregon in 2021 was attributed to bark beetle feeding, often following precursor stressors, namely ongoing damage from hot droughts, which weaken tree defenses and allow opportunistic insects to infest and build their populations to epidemic levels. When looking at areas of mapped damage, it is important to understand the metric is acres *with* damage and not *of* damage (i.e., not all the trees in the indicated areas experience mortality or defoliation; polygons drawn during surveys often include a mosaic of damaged and undamaged trees). The severity levels of the associated damage indicate how bad the damage is, based on the percent of trees affected within each area of forest disturbance. Additional information about severity level of damaged areas can be found on quadrangle maps: https://www.fs.usda.gov/detail/r6/forest-grasslandhealth/insects-diseases/?cid=fseprd997700

Figure 7. Tree damage (left) versus tree mortality (right) (Christine Buhl, ODF).

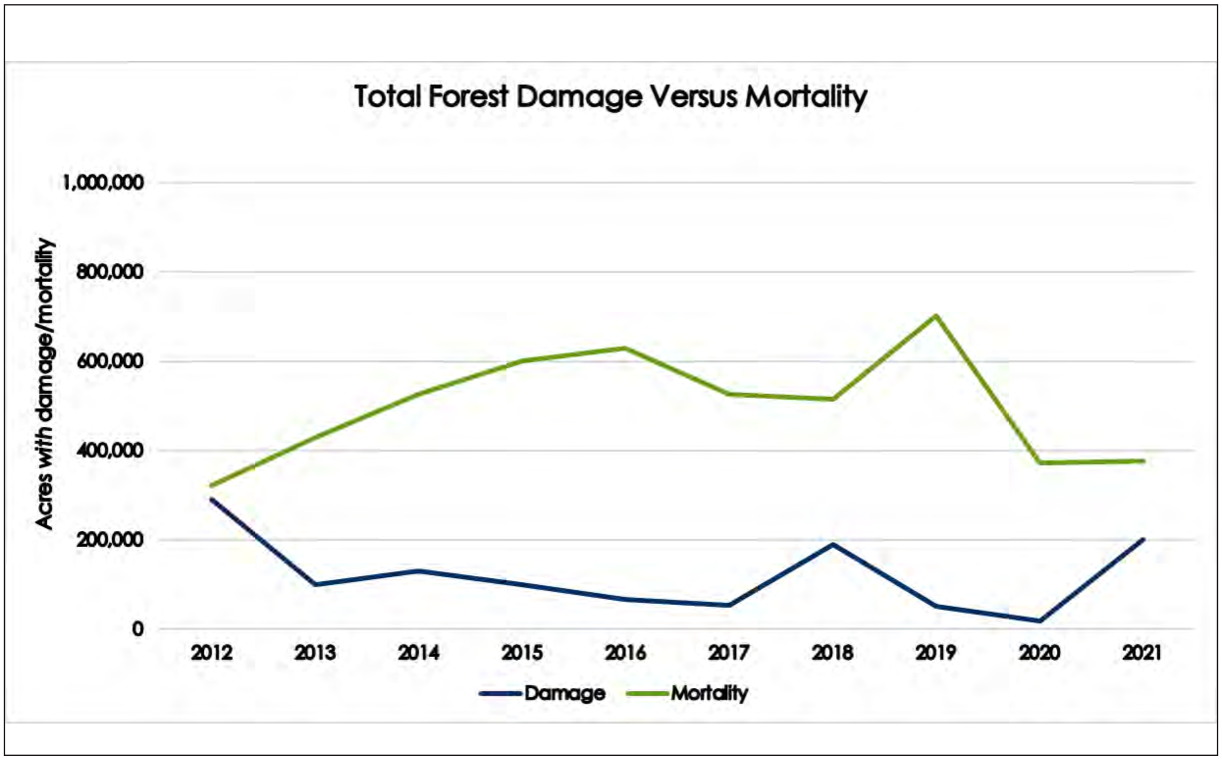


Figure 6. Trends in forest damage (defoliation, topkill, branch or stem breakage) versus mortality caused by insects, diseases, and abiotic agents (excluding wildfire). Note years 2020 and 2021 collected data from smaller areas than in previous years and likely under-represent totals across the same coverage area as previous years.

SURVEYS, MONITORING AND OTHER PROJECTS

Hazard Tree

Pathologists with ODF and the USFS evaluate tree hazards and provide regular trainings 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 the 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 2021, USFS applied bark beetle mitigation treatments on 1,447 acres on federal lands and ODF added another 357 acres across 22 non-federal ownerships. This cost share program may also support removal of living trees that were recently damaged by wildfire to prevent their subsequent infestation by bark beetles. Apply for cost share funds on non-federal lands: https://tinyurl.com/ODFcostshare

Douglas-fir tussock moth (DFTM) trapping

This ongoing monitoring trap system (est. 1979; Fig. 8) detects increases in moth numbers and can predict building outbreaks or determine status of current outbreaks of DFTM in eastern Oregon. More on DFTM on pg. 23.

Figure 8. DFTM trap (Christine Buhl, ODF).

Oregon Forest Pest Detector program

Since 2013, the USDA-funded Oregon Forest Pest Detector (OFPD) program, coordinated and led by OSU 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 beetle, 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 submit a report and photograph 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. The success of OFPD has been the result of in-person training at field courses where students can test their knowledge on trees that have been simulated with false insect attack symptoms. Additionally, the in-person training offers hands-on experience with tree and insect samples and a chance to have Q&A dialogue with course instructors and participants. Due to statewide closures of campgrounds and state offices and other complications surrounding COVID-19, as well as the 2020-2021 Oregon fire seasons, the OFPD has been significantly impacted. In 2019 and 2020, COVID-19 policies prevented in-person training. However, in April 2021, ODF and OSU hosted a OFPD training in Ontario in partnership with technical specialists from USFS-Boise and the Idaho Department of Lands that focused on emerald ash borer (*Agrilus planipennis*, a pest of ash) and the eastern 5-spined engraver beetle (*Ips grandicollis*, a pest of pine).

Forest Health education

OSU Tree School courses are now available online with the help of Oregon Forest Resources Institute;
All courses: https://extension.oregonstate.edu/tree-school/tree-school-online-class-guide
Forest insect pests: https://tinyurl.com/TreeSchool-insectpests
Forest bees: https://tinyurl.com/TreeSchool-bees
Forest diseases: https://tinyurl.com/TreeSchool-diseases

Forest Pollinator Projects

Over 800 species of native, wild bees occur in Oregon, many of which can be found in forests (Fig. 9). There are many interagency efforts to increase our understanding and enhance and conserve habitat for native, wild bees and other pollinators on forest landscapes.

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

The Forest Practices Act Wildlife Food Plots rule (ORS 527.678) allows a small portion of timberland to be allocated toward habitat enhancement for wildlife without re-zoning (https://www.oregonlaws.org/ors/527.678). Landowners may formulate plans with the ODF entomologist and their local ODF stewardship forester: https://tinyurl.com/ODF-forester

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, exposed soil, and stem and wood cavities for nesting).

More information on enhancing forest bee habitat: https://woodlandfishandwildlife.com/ publications/insect/forest-bee-pollinators

Learn more about forest pollinator topics and become a Woodland Pollinator Steward:
https://extension.oregonstate.edu/pollinator-steward

Figure 9. Pollinator foraging (top) and ground nest openings (bottom, circled) in forest understory (Christine Buhl, ODF).

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

Western redcedar dieback monitoring

From Oregon through Canada to Alaska, western redcedar (*Thuja plicata*) has been dying (Fig. 10) 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 opportunistic pests and can only attack dead and dying trees. Redcedar can 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 reduction or shift. Sites with microclimates that are less preferable for western redcedar (e.g., soils with lower water-retention capacity, south-facing or high sun-exposure, high density of trees and other plants competing for moisture) are especially prone to losing this Species. A shift to more drought-tolerant species is suggested. Species such as incense cedar, redwoods or sequoias, Willamette Valley pine, Oregon white oak, etc. may be good options for these locations.

In 2021, ODF, Washington Department of Natural Resources, and USFS continued year two of a project to map the distribution of western redcedar dieback in Oregon and Washington and determine its cause(s) through patterns and relationships emerging from tree and stand data, cross-referenced with climate data. Also in 2021, researchers at Washington State University conducted more intensive dendrochronology assessments to determine whether variations in annual ring growth were associated with western redcedar dieback.

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

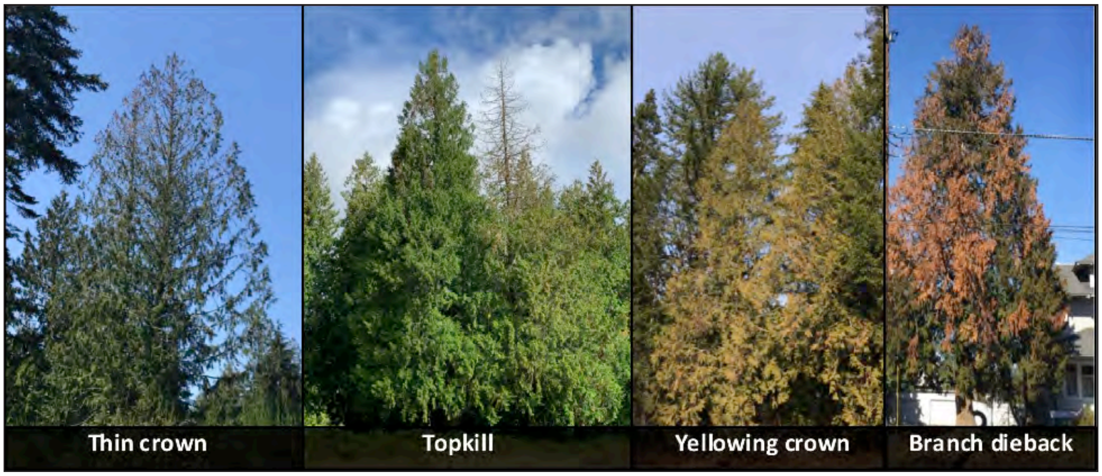


Figure 10. Western redcedar dieback symptoms (Christine Buhl, ODF).

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 (e.g., Climate change and insect pests: https://www.youtube.com/watch?v=TIlH8UftdqE&ab_channel=NorthwestNaturalResourceGroup).

Healthy trees can defend themselves from insects and diseases 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. Trees alter the physical and anti-microbial properties of tissue around diseased areas, creating compartments that prevent additional spread.

HEALTHY TREES = RESILIENT TREES

One of the major reoccurring stressors in Oregon forests has been ongoing drought because 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 temperature 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.

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 at which that change has been occurring is extreme. Additionally, El Niño and La Niña are natural occurrences that further affect temperature and precipitation. 2021 is the second year of La Niña, which, in the Pacific Northwest, usually manifests as cooler and wetter than normal winter conditions. 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. 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 density must be made in anticipation of these projections.

Changing climate also means increasing frequency and/or intensity of storm events. In 2020/2021 a late winter storm event created strong winds, snow, and ice which broke and toppled trees (Fig. 11). In early winter 2021 bouts of heavy rains swept across the northern part of the state and contributed to landslides and flooding. These large influxes of winter precipitation are more damaging than helpful for trees, when soils may already be saturated. Trees benefit from long and slow drinks of water as they grow in spring in summer.

Figure 11. Severe tree damage in mid-Willamette Valley (Wyatt Williams, ODF).

Drought

Other than the 2021 heatwave event (pg. 14), it is tempting to think temperature and precipitation levels for much of 2021 were returning to normal. However, almost every county in Oregon experienced above average temperature and below average precipitation for the entire year (Fig. 12). It is also tempting to assume that La Niña conditions in the Pacific Northwest (cooler, wetter weather and more snowpack in the mountains) will resolve damage done by ongoing hot droughts. But La Niña is a temporary circumstance and it takes more than a year or two of slight temperature reductions and increased precipitation for forest recovery following years of declining conditions.

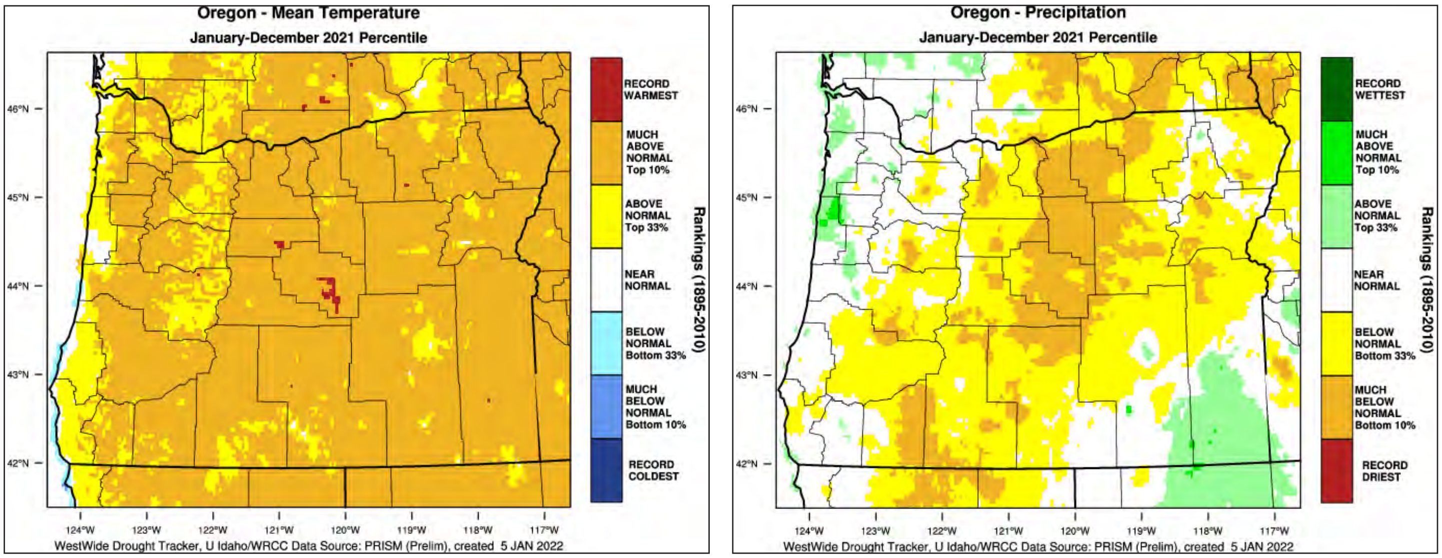


Figure 12. Average temperature and precipitation levels from January-December 2021, relative to the average normal based on 115 years spanning from 1895 to 2010 (Western Regional Climate Center).

In 2021, drought conditions accelerated after March. Oregon averages about 10.58 inches of rain from March through August statewide, but in 2021 received only 4.91 inches during this timeframe. Water basins in central Oregon and the Klamath region were hit particularly hard. Total snowpack (SNOTEL data) was above average in the north Cascades but not the south Cascades, and snowpack melted earlier than normal. Reduced precipitation contributed to a higher evaporative demand index which drives the drying of wildfire fuels. Intensive wildfires once again in southern Oregon can be directly linked to persistent hot drought conditions.

Since the U.S. drought monitor began weekly drought classifications in 2000, Oregon has had only two D4 rankings ("exceptional drought" - which is the highest ranking). The second D4 ranking was in 2021 and covered 27% of Oregon. 2021 also received the most extensive D3 ("extreme drought" – which is second highest ranking) across the state. Precipitation in Oregon ranked 16th lowest out of the last 127 years. In 16 out of the last 22 years Oregon has received below average precipitation and the last two years have been well-below normal. Temperatures also spiked across the state and exceeded 90°F for 24 days in Portland, 41 days in Salem, 74 days in Medford, 57 days in Redmond, and 61 days in Burns.

How are trees impacted by drought?

Water is collected by roots and transported throughout the tree via a network of straws (vascular tissues) then released from pores in leaves (stomata) into the atmosphere. Dry or windy conditions can increase water loss. Drought stress can strain or collapse vascular tissues or cause dieback of roots. It can take many years for trees to rebuild these tissues during which time they have fewer tissues to actively collect and transport water for the tree. Trees combat drought by closing stomata to reduce water loss to the atmosphere, but this stops photosynthesis which starves the tree and is thus only a short-term solution. Trees may also prematurely drop leaves to reduce the amount of tissues that both need and release moisture, which also reduces photosynthesis. Reduced photosynthesis reduces both growth processes and resources allocated toward defense which makes trees less resilient to other stressors such as insects, diseases, mechanical damages, etc. For most trees, there are no long-term drought tolerance solutions and prolonged or repeated droughts often result in mortality, sometimes years later (Fig. 13).

Figure 13. Symptoms of drought (left to right): flagging (dying branches), thinning crown and stress cones, asymmetrical crown (from uneven foliage then twig and branch loss), and topkill (note the progression of mortality) (Christine Buhl, ODF).

How to manage for future drought stress:

1. 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 where. Do not continue to replant with species that are struggling to survive or don't naturally regenerate.
2. 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.
3. Prevent and control: be aware of the major insects and diseases that occur in your tree species and in your region (pg. 32). Follow management guidance. Remove weak, injured or extremely stressed trees.

Climate change and drought resources:

- Oregon Water Resources Department's monthly drought summary email: https://tinyurl.com/drought-report
- Oregon Climate Change Assessment (published every two years): https://blogs.oregonstate.edu/occri/ oregon-climate-assessments
- Drought impacts on forests and pests: https://youtu.be/wHZ1G5wH4r8
- National Drought Mitigation Center drought symptoms reporting survey: https://go.unl.edu/cmor_drought

Heat wave / Heat dome

In 2021 Oregon experienced an anomaly that has been termed a "heat dome" resulting in a multi-day record level heat wave across the state. Portland broke its previous all-time record high temperature (107°F in August 1981) with a new high of 108°F on June 26th. That record was broken the next day at 112°F and again, by reaching 116°F on June 28th. For comparison, the all-time temperature record across the U.S. is (of arguable validity because measurement methods have varied over the years) 134°F in July of 1913 in Death Valley, California.

Impacts of this heat wave were immediately apparent in vegetation across the state from backyards to forests. The heat damaged trees so severely because it was extreme, happened quickly, and persisted over multiple days. Therefore, trees were unable to adjust to such a significant temperature change. Damage was manifested as scorched foliage. The greatest intensity of damage (Figs. 14 and 16) appeared on the:

- Youngest and most succulent foliage, often at branch tips
- South- and west-facing aspects and along exposed forest edges where solar radiation was most intense
- Trees along roads where thermal radiation heated trees from below
- Coastal trees and trees in other areas that are unaccustomed to higher temperatures, or that develop sensitive young foliage later in the season which coincided with the heatwave

Figure 14. Scorch was highest in young foliage and in trees along roadsides due to radiant heat from pavement (Christine Buhl, ODF).

Aerial (Fig. 15) and ground surveys were able to map some of this damage. Although whole crowns were not affected and often buds were left intact, many trees prematurely shed scorched foliage which will impact photosynthesis (and thus growth and defenses) in subsequent years. We also do not know how much this event resulted in damage to other tissues such as roots and vascular tissues. We will not know if this event will result in direct tree mortality until spring 2022 or beyond. Meteorologists have attempted to understand how this anomaly occurred but have determined it would have been virtually impossible without climate change (Philip et al. 2021 & [https://www.worldweatherattribution.org/western-north-american-extreme-heat-virtually-impossible-without-human-caused-climate-change.](https://www.worldweatherattribution.org/western-north-american-extreme-heat-virtually-impossible-without-human-caused-climate-change) It is predicted that this was a 1/1000-year event, although those odds get worse with changing climate, and will likely occur again sometime in the future. Forecasting is especially difficult because our climate continues to change rapidly.

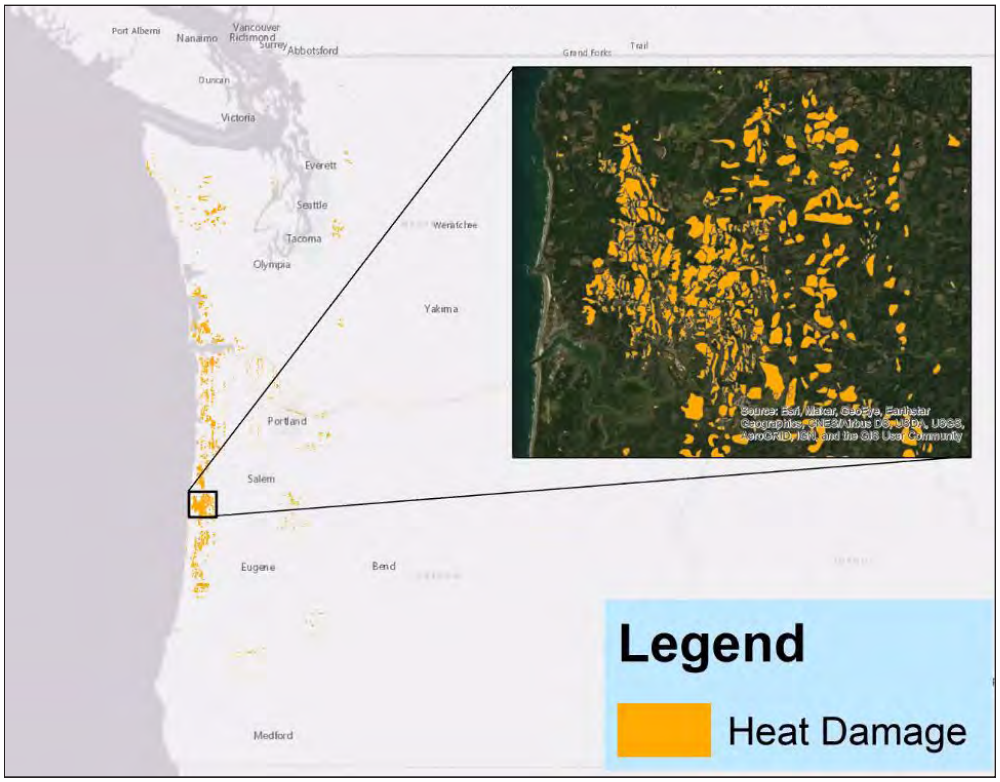


Figure 15. Example of some of the heat damage observed and mapped during the 2021 aerial detection survey (Danny DePinte, USFS).

Figure 16. On a landscape level (left) and within trees (right), scorch damage was most apparent on south- and west-facing exposures which experienced the greatest intensity of solar radiation (Danny DepInte, USFS).

Wildfire

Despite a 40% reduction from 2021 relative to 2020 (and being 3% below the 10-year average) of total acres damaged by wildfire across all ownerships (Fig. 18), Oregon experienced one of the largest wildfire complexes in recent history with the Bootleg fire in Klamath and Lake counties. This fire was ignited by lightning in a particularly drought-stressed part of Oregon on the Fremont-Winema National Forest. It burned more than 413,000 acres over 39 days and was the third largest fire in Oregon's recorded history. In contrast, 94% of ODF wildfires were kept at 10 acres or less, in large part due to early detection from heat detection monitoring from Forward Looking InfraRed (FLIR) cameras affixed to survey planes.

Figure 17. Wildfire creeping up a hillside (Kyle Kaupp and Jason Pettigrew, ODF).

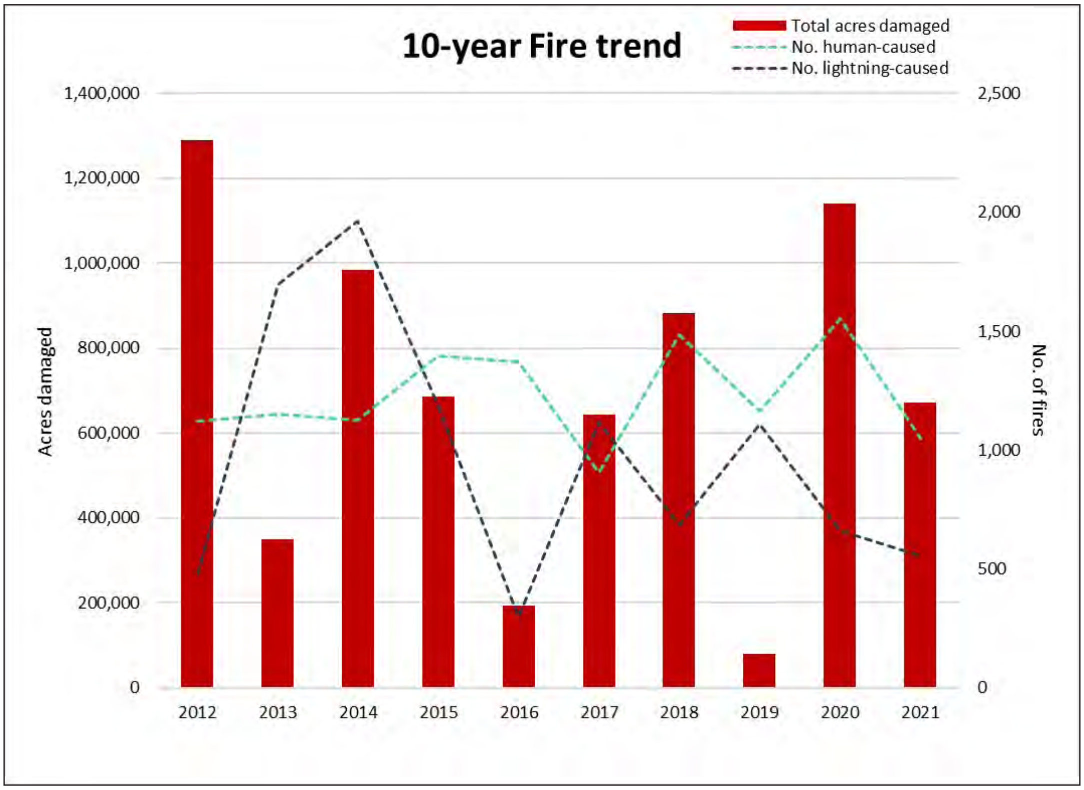


Figure 18. 10-year wildfire trends, across all ownerships.

More information:

- Post-fire mortality estimation guide (summary): https://tinyurl.com/ODFpostfire
  Post-fire mortality estimation guide (full): https://tinyurl.com/postfireguide
- ODF fuels reduction cost share program: https://tinyurl.com/ODFcostshare
- 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
- ODF KOG Reduce risk of wildfire starts: https://keeporegongreen.org

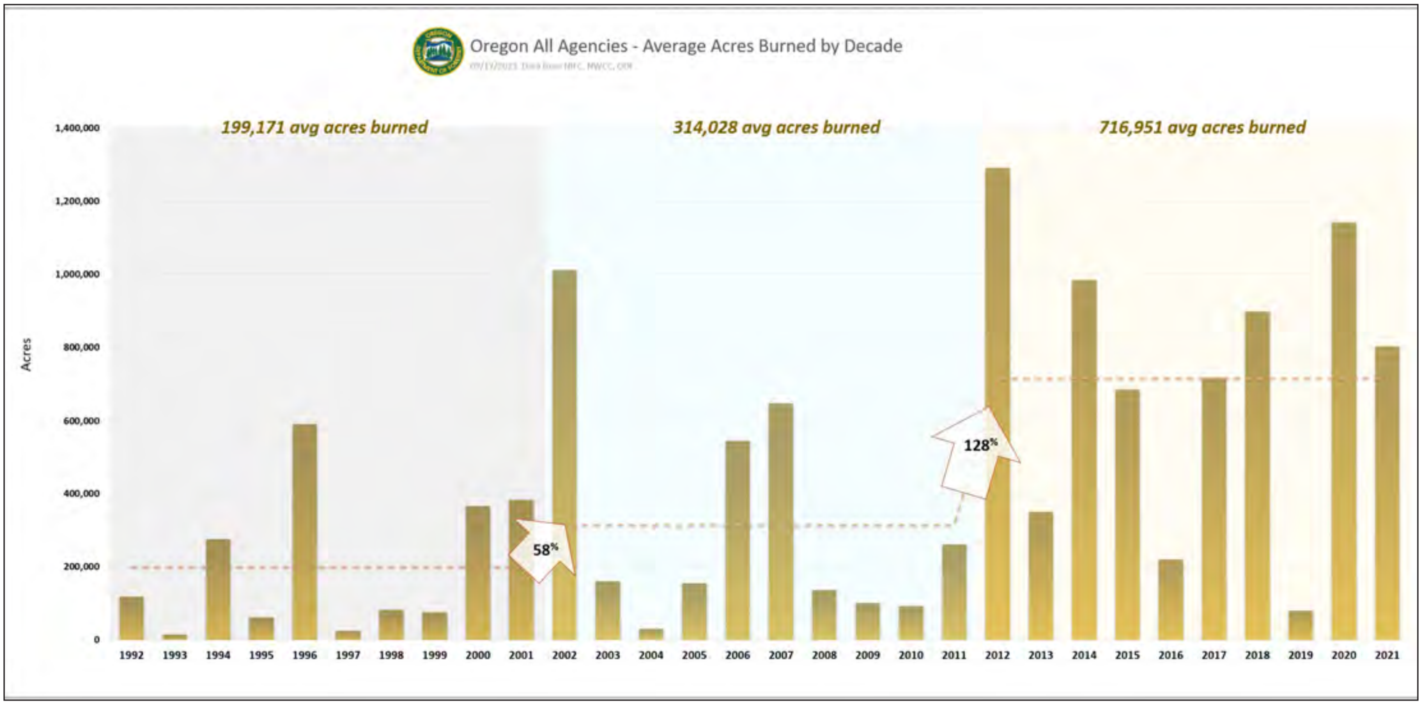


Figure 19. Annual number of acres burned in Oregon across all ownerships (1992-2021), grouped by decade to indicate increasing trends (Teresa "TzA" Alcock, ODF).

Figure 20. Patton Meadows fire (left, Tyson Schultz) and smoke from 413,000 acre Bootleg fire (right, Tyler Ramos, ODF).

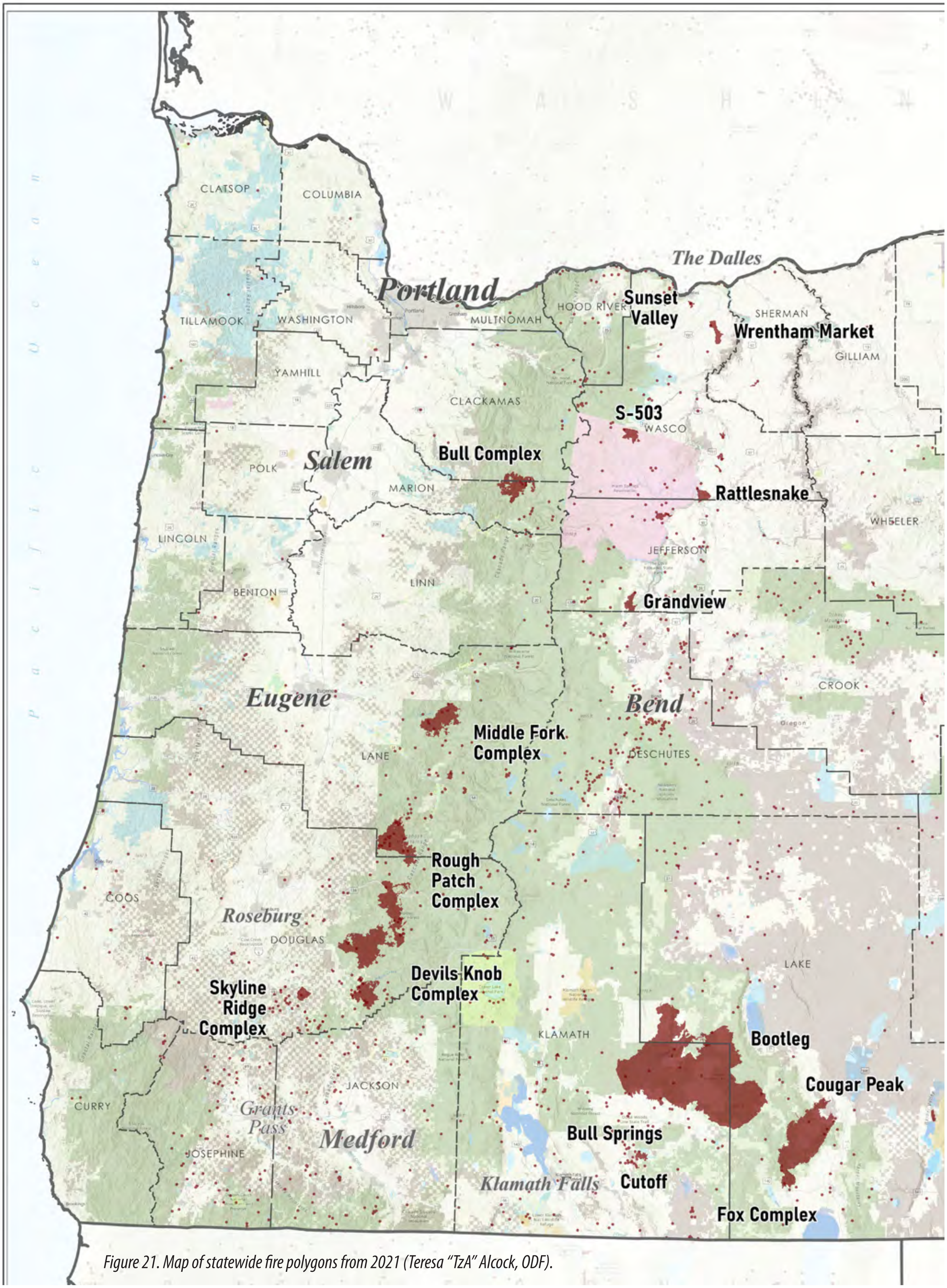
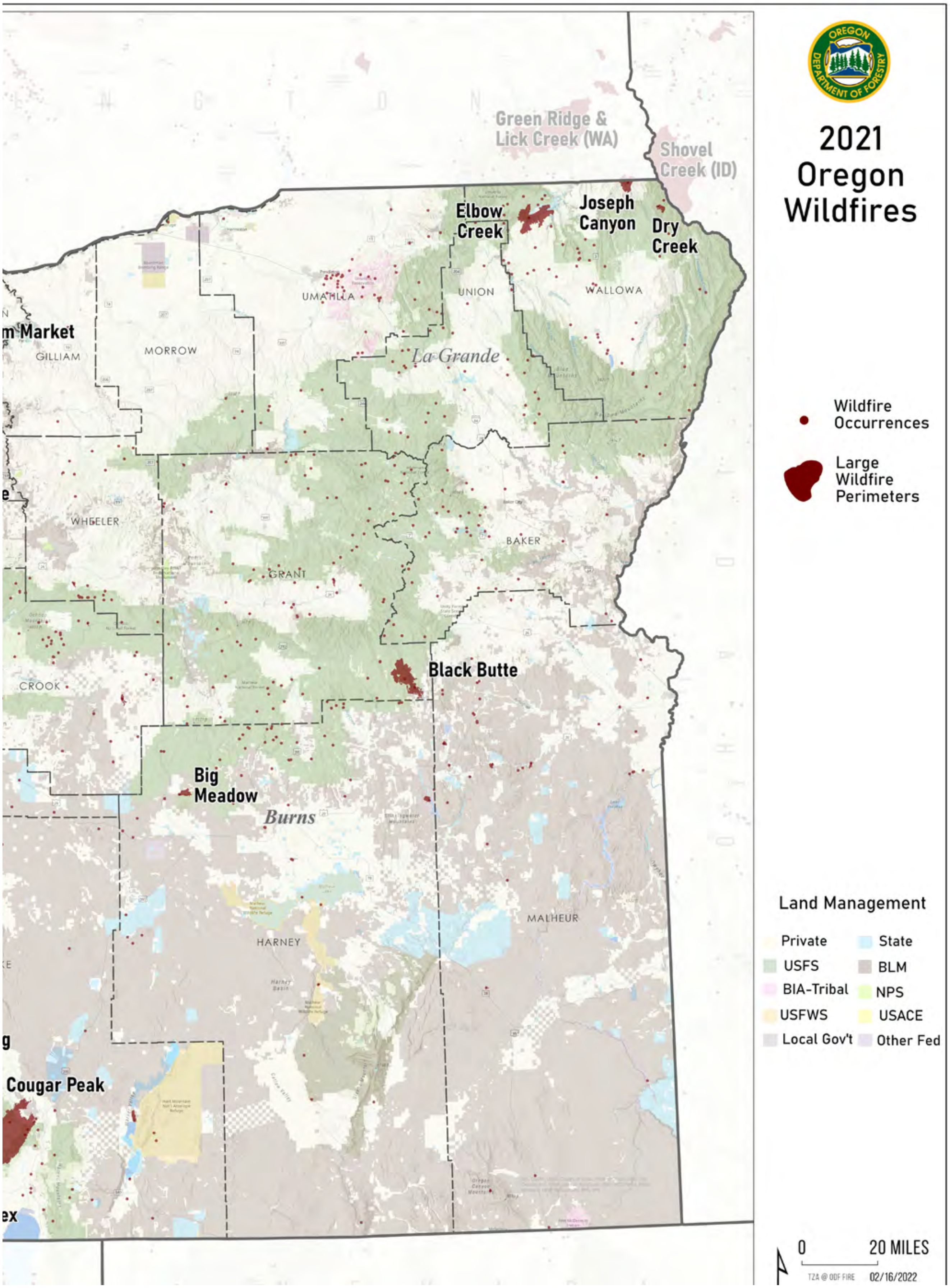


Figure 21. Map of statewide fire polygons from 2021 (Teresa "TzA" Alcock, ODF).


2021 Oregon Wildfires
Wildfire Occurrences
Large Wildfire Perimeters
Green Ridge & Lick Creek (WA)
Shovel Creek (ID)
Elbow Creek
Joseph Canyon
Dry Creek
UMATILLA
UNION
WALLOWA
MORROW
GILLIAM
La Grande
WHEELER
GRANT
BAKER
CROOK
Black Butte
Big Meadow
Burns
HARNEY
MALHEUR
Cougar Peak
Land Management
Private
State
USFS
BLM
BIA-Tribal
NPS
USFWS
USACE
Local Gov't
Other Fed
0
20 MILES
TZA @ ODF FIRE
02/16/2022

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. For trees to produce these defenses they must have their growth requirements met, sparing additional resources that producing defenses require. Droughts, in particular, impact defenses because trees require moisture for tree sap, their main defense, which acts as a mechanical barrier that traps insects and also contains chemicals that are repellent or toxic to insects and the microbes and fungal pathogens that insects may vector.

Beetles

Within the area of the state aerially surveyed in 2021 we observed beetle-caused mortality (Fig. 22) on about:

- 148k acres of true fir, attributed mostly to fir engraver
- 122k acres of pine, attributed to mountain pine beetle, western pine beetle, and Ips beetles
- 58k acres of Douglas-fir, attributed mostly to Douglas-fir bark beetle and flatheaded fir borer

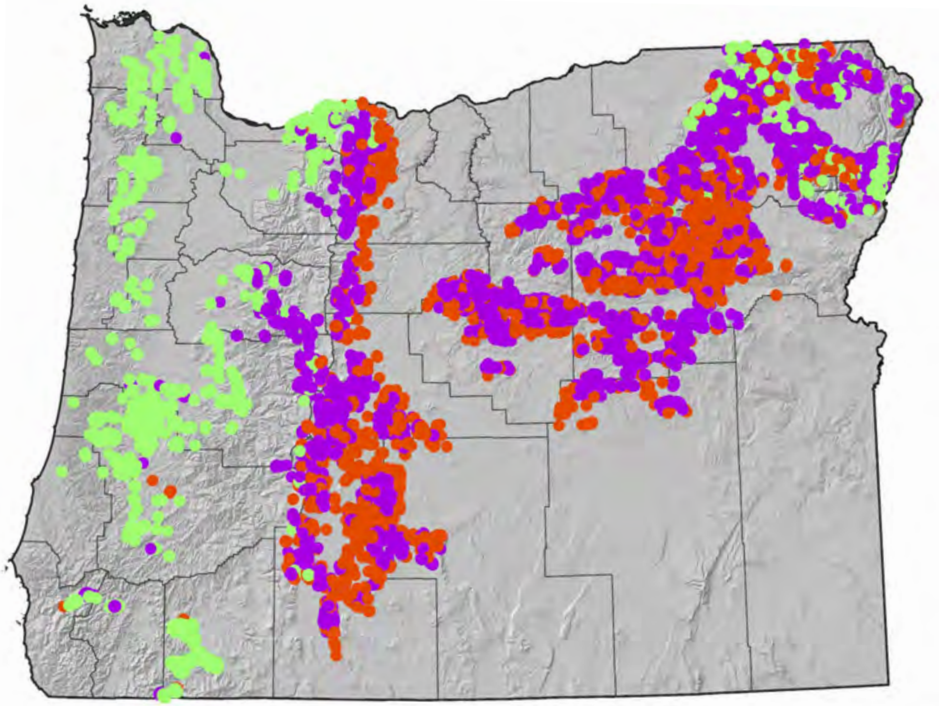


Figure 22. Beetle-caused mortality in true fir (purple), pine (red), and Douglas-fir (green).

All the above insects are native and widely present on the landscape at endemic levels. They are, however, opportunistic on stressed or damaged trees and their populations can build into unnaturally large levels that may spill over into healthier trees. In recent history, the statewide ongoing hot drought has predisposed trees to infestation and mortality from these beetles. Other landscape-level stressors such as storms and wildfires also damage trees and increase susceptibility to pests.

Figure 23. MCH pheromone packet that reduces Douglas-fir beetle aggregations (Christine Buhl, ODF).

The primary methods of management or mitigation of these pests is preventative because control measures are far too expensive or not efficacious at the stand-level. To reduce pest susceptibility, management strategies should target enhancement of tree resiliency to drought and wildfire by reducing stand density and fuels buildup. Other suggested prevention strategies are to prevent beetle population buildup by managing root diseases (e.g., alternate species, buffer cuts, etc. in root rot pockets), destroying pine slash to prevent Ips (*Ips* spp.) outbreaks, and applying MCH anti-aggregant pheromone (Fig. 23) in wildfire or storm-damaged areas to prevent Douglas-fir beetle (*Dendroctonus pseudotsugae*) outbreaks. These strategies are far more effective than attempting to control the insect pests directly. Cost share funds are available for bark beetle prevention and mitigation treatments such as thinning, pine slash management, and anti-aggregation pheromone application. Cost share for fuels reduction is also available. Apply for cost share funds on non-federal lands: https://tinyurl.com/ODFcostshare

More information:
Slash management:
MCH: https://www.oregon.gov/odf/Documents/forestbenefits/MCH_2016.pdf
ODF Insect pest guide: https://www.oregon.gov/odf/Documents/forestbenefits/InsectPestDiagnosis.pdf
ODF forest pest fact sheets and videos: http://tinyurl.com/ODF-ForestHealth

Are beetles still present?
Bark beetles infest only living trees and cycle very quickly, so it is important to recognize the signs and symptoms (Fig. 24) of current infestation when planning sanitation efforts. Sanitation can be useful at smaller scales, but be advised, it is hard to stay ahead of outbreaks through this method alone.

When bark beetles enter a tree, they kick out brown (not white) sawdust or "frass". If the tree has enough moisture to produce sap, there may be small, individual pitch drops, streams, or tubes depending on the tree species. Adult offspring then chew their way out of the tree, leaving many tiny perfectly round exit holes about the size of the tip of a ballpoint pen. If you peel back the bark, you will see that these holes do not penetrate the wood. Bark beetles girdle only the outside of sapwood and they have leave intricate gallery patterns that are usually repeated along the bole. Often, by the time a tree's foliage has turned red, the bark beetles have already matured and left.

Figure 24. Left to right: bark beetle frass, pitch streams, pitch tubes, and bark beetle exit holes (Christine Buhl, ODF).

Defect
Salvage logging has increased in recent years following intense and widespread wildfires. For trees that are being removed for timber, tree mortality from bark beetles is not a concern although defect from woodboring beetles can be costly. Woodborers range widely in size. Signs and symptoms of woodborers include white (not brown) frass and holes and tunnels in the wood (Fig. 25). Most of our native woodboring beetles are not tree killers and infest in large number only when trees are dead or dying, as part of the natural decomposition process. Removing logs and getting them processed quickly can reduce the amount of woodborer infestation and activity, thereby reducing extent of defect.

Figure 25. Woodborer exit hole (Christine Buhl, ODF).

Non-established exotic pest: Emerald ash borer

There is a significant risk of emerald ash borer (EAB; *Agrilus planipennis*) invading Oregon's riparian forests. EAB (Fig. 26) has not yet been detected in Oregon or in other western states. Oregon ash (*Fraxinus latifolia*), a native and susceptible ash, grows widely across the western part of the state in riparian habitats often occupied by rare, threatened, or endangered 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. Because of its ability to grow in saturated soils where other woody plants simply cannot, 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 26. EAB larvae (top) and galleries (bottom) in ash trees in Maryland (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. In 2020 and 2021, due to complications surrounding COVID-19, no statewide surveys were conducted.

In 2018, ODF Forest Health received funding from the USFS to collect and store seeds of Oregon ash before the arrival of EAB to the state. The seeds will be stored in freezers for genetic conservation (USDA Seed Lab, Fort Collins) and grown for 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 2020-2021 fire seasons 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 2022.

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

Defoliators

Within the area of the state aerially surveyed in 2021 we observed defoliator-caused damage and some mortality on about (Fig. 27):

- 14k acres of true fir, attributed mostly to balsam woolly adelgid
- 13k acres of Douglas-fir and true fir, attributed to Douglas-fir tussock moth
- 3k acres of pine, attributed to sawflies

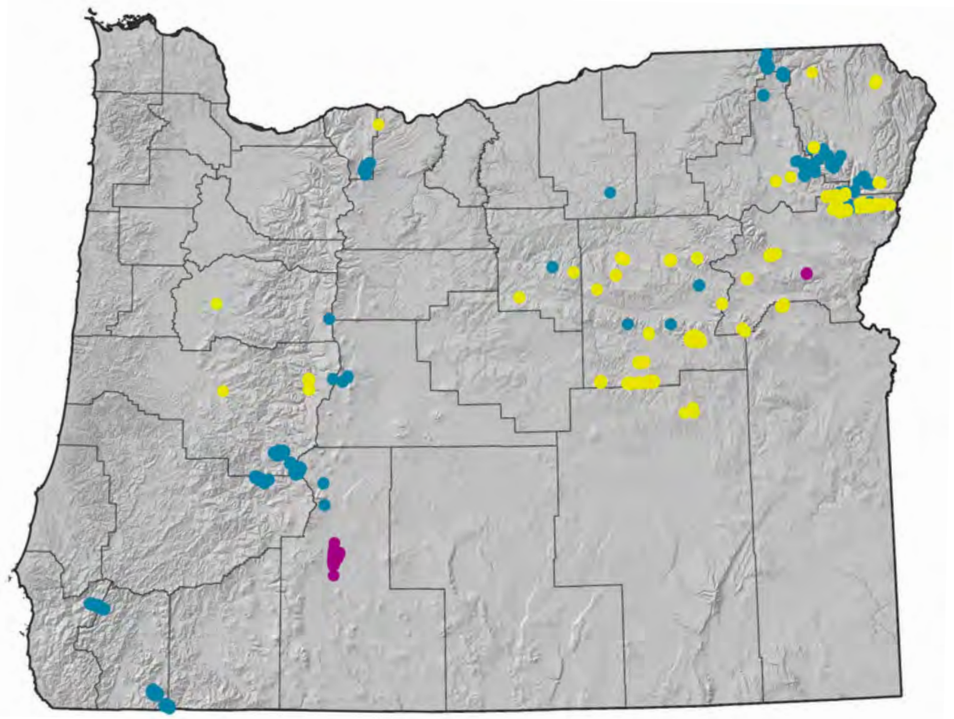


Figure 27. Defoliator damage/mortality in true fir from balsam woolly adelgid (blue), Douglas-fir and true fir from Douglas-fir tussock moth (yellow), and pine from sawflies (purple).

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 killed by fir engraver beetles. In addition to root disease, drought, and fir engraver beetle complexes, true fir are also suffering from high levels of damage and mortality from balsam woolly adelgid (*Adelges piceae*). This insect is a non-native but long-established pest particularly in higher elevation trees where control and/or sanitation are difficult.

Since around 2018, true fir and Douglas-fir in eastern Oregon have been defoliated by scattered outbreak populations of Douglas-fir tussock moth (*Orgyia pseudotsugata*) caterpillars. These outbreaks have generally collapsed which is typical after 2-3 years.

Pine defoliation from sawfly larvae was observed in south central Oregon. Outbreaks from sawflies in Oregon tend to be short-lived and not widespread. Ground observations of pandora moth (*Coloradia pandora*) populations in central Oregon indicate declining populations and possibly the end of an outbreak that started around 2013; these outbreaks tend to collapse after 8 years. Pandora moth caterpillars feed only during "even" years so forest damage was not visible during 2021.

Non-established exotic pest: Spongy moth (formerly gypsy moth)

Spongy moth (formerly called 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 would likely increase aerial pesticide use and timber harvest costs through increased regulation to prevent the further spread of this forest pest. European spongy moth (ESM; *Lymantria dispar dispar*) is established in the eastern U.S. and is regularly detected in Oregon; Asian spongy moth (ASM; *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 spongy moth have been successfully eradicated in Oregon since monitoring began in the 1970s. Today, there are no established populations of spongy moth in Oregon due to our effective early detection and rapid response system.

FOREST INSECTS

Since the 1970s, ODA has been the agency responsible for surveying the state for spongy moth and deploys approximately 15,000 detection traps annually. In the last several years, state funding for this large trapping program has been generated from the Oregon Lottery.

In 2021, ODA requested in-kind assistance from ODF at a forested site near Rainier, where spongy moth was detected in 2020. ODF reached out to local forest landowners and over 150 traps were placed across roughly 60 properties. Traps were in place June to September to catch and monitor spongy moth adult populations. No spongy moths were captured in any of the traps. Capturing no moths in 2022 will indicate that the small population from 2020 declined to extinction. No eradication projects occurred at this site or others in Oregon in 2021. *More information:* https://www.oregon.gov/odf/Documents/forestbenefits/fact-sheet-spongy-moth.pdf

Non-established exotic pest: Asian giant hornet
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 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. 28). Features that distinguish Asian giant hornet are its large head and its huge size (1.25 - 2 inches long). There is concern around this insect establishing due to its aggression toward honey bees. Additionally, this insect creates large underground nests. Due to its potent venom and large nest populations, it can become a human health hazard.

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 information:
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

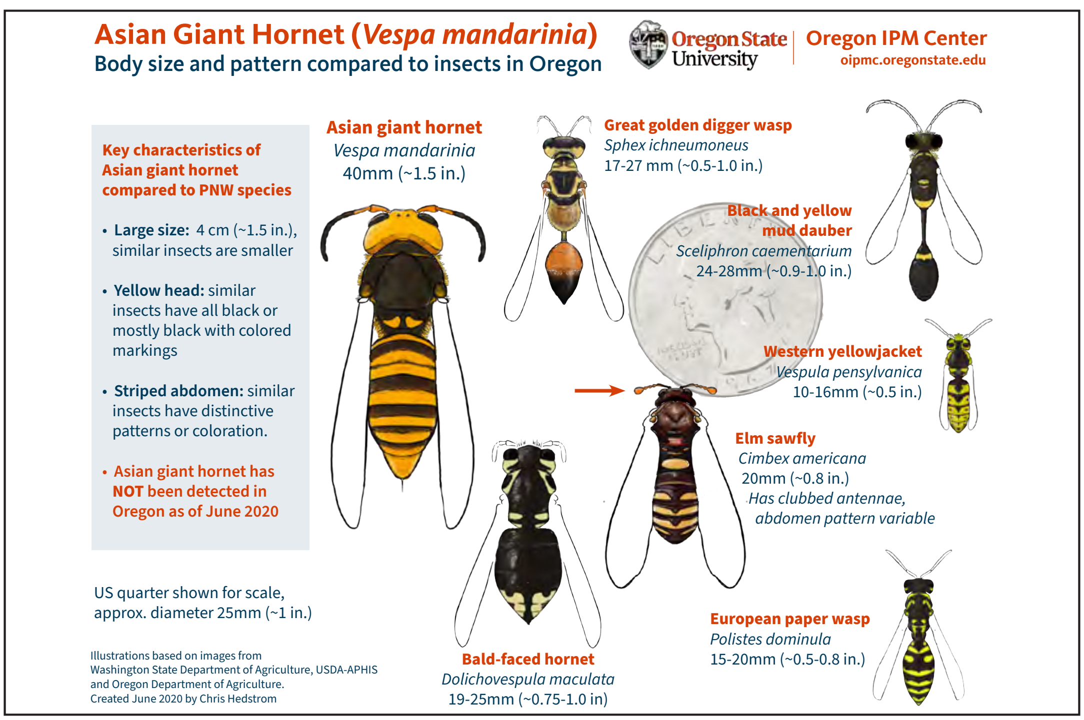


Figure 28. Asian giant hornet and similar looking insects (Oregon State University publication EM 9297).

FOREST DISEASES

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. *P. ramorum* spreads during rainy periods when spores produced on infected leaves or twigs are released into the air and washed downward or transported in air currents. The disease can also 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 their main stems (Fig. 29).

Figure 29. Bleeding on the exterior of tanoak bark (left) and cankers (dead lesions) underneath the bark (right) are symptoms of SOD infection (Sarah Navarro, USFS).

The disease was first discovered in coastal southwest Oregon forests in July 2001. Since then, an interagency team has continued 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 (Fig. 32) 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 the quarantine area. Oregon regulations require infested sites on state and private lands outside the GIA to undergo eradication treatment.

In 2021, the Oregon SOD Program found two new infestations of *P. ramorum* outside the state SOD quarantine area (Fig. 30). The first, detected in March, was on the Rogue River Siskiyou National Forest along the north bank of the Rogue River, six miles north of any previously known infestation. Infected trees were identified by interpretation of high-resolution aerial imagery as a part of the annual USFS and ODF Aerial Detection Survey. Cutting and piling of all tanoaks within the 600-foot treatment buffer was completed mid-May and burning is ongoing as weather conditions permit.

The second infestation, just outside Port Orford, 21 miles northwest of the Rogue River and 13 miles south of Coos Co., was detected on April 27, 2021, along Highway 101 by an Oregon State University (OSU) researcher. All samples collected have tested positive for the NA2 variant of *P. ramorum*. Previously found only in nurseries, this is the first time the NA2 variant has been found in wildlands. Since April, this infestation has been the program's top priority with ODF, USFS, and OSU surveying over 400 acres of ground transects and collecting over 200 samples, resulting in 154 positive detections. The samples were identified as SOD at two independent laboratories (OSU and USDA ARS), and specifically as the NA2 variant by the USDA lab.

Figure 30. Researcher sampling a canker on a recently cut NA2 positive tree (Sarah Navarro, USFS).

Given the number of infected trees and a new variant, Oregon SOD pathologists believe this to be a unique introduction to Oregon forests that has been intensifying in the area for at least four years. A tentative 600-foot treatment buffer has been placed around the confirmed positive trees totaling 581 acres. ODF has begun treatment on 208 acres within the proposed treatment area and will continue treatments as weather and fire risk conditions allow.

Other SOD survey and detection efforts continued in and adjacent to the SOD quarantine area throughout 2021, including monitoring 58 stream bait sites, aerial imagery interpretation of 379,000 acres, and 662 acres of ground transect surveys for the harvesting of disease-free tanoak. ODA put two separate 3-mile emergency quarantines into place until the extent of the new infestations could be determined. Oregon's SOD Program will consult with stakeholders regarding the expansion of quarantine boundaries in early 2022. The Oregon State Legislature appropriated $1.7 million to ODF to carry out an integrated pest management program to combat SOD with $50,000 set aside to fund the OR SOD Task Force. The goal of Oregon's SOD program since 2010 has been to slow the spread of the disease, recognizing that eradication in the generally infested area of Curry Co. is not feasible. To date, eradication treatments (Fig. 31) have been completed on more than 7,900 acres at an estimated cost of over $34 million.

Figure 31. Contract crews starting work in a treatment area. Treatments include cutting and burning infected and potentially exposed host material (Sarah Navarro, USFS).

More information:
SOD GIS data dashboard: https://tinyurl.com/2p8vdp3x
Forest operations guide within SOD quarantine areas: https://tinyurl.com/9zvmdbht

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

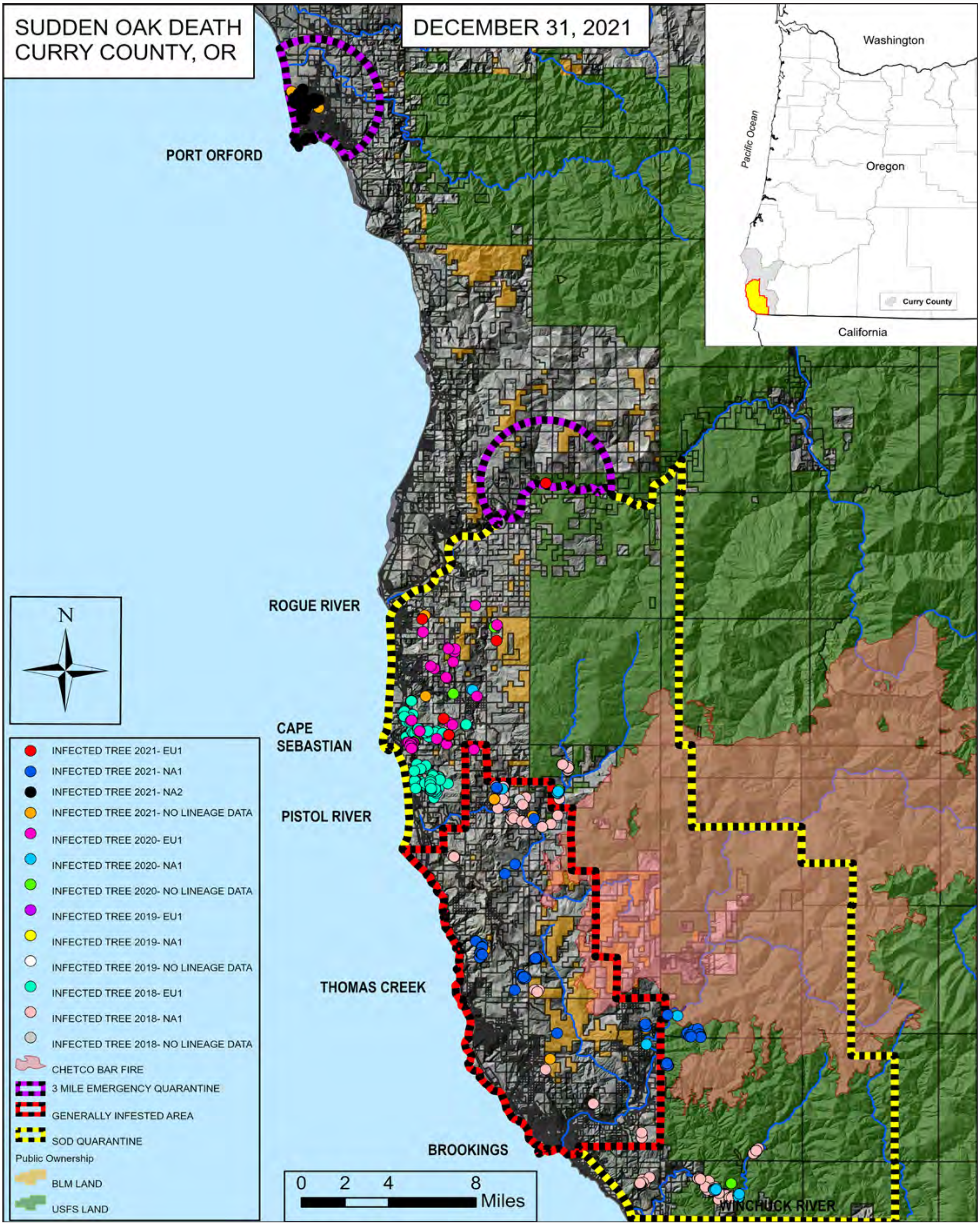


Figure 32. Map of SOD infection area (red) and quarantine area (yellow). EU1 and NA1 are two different lineages of P. ramorum. In Europe, the EU1 lineage kills or damages conifer tree species and is considered more aggressive than the NA1 lineage.

FOREST DISEASES

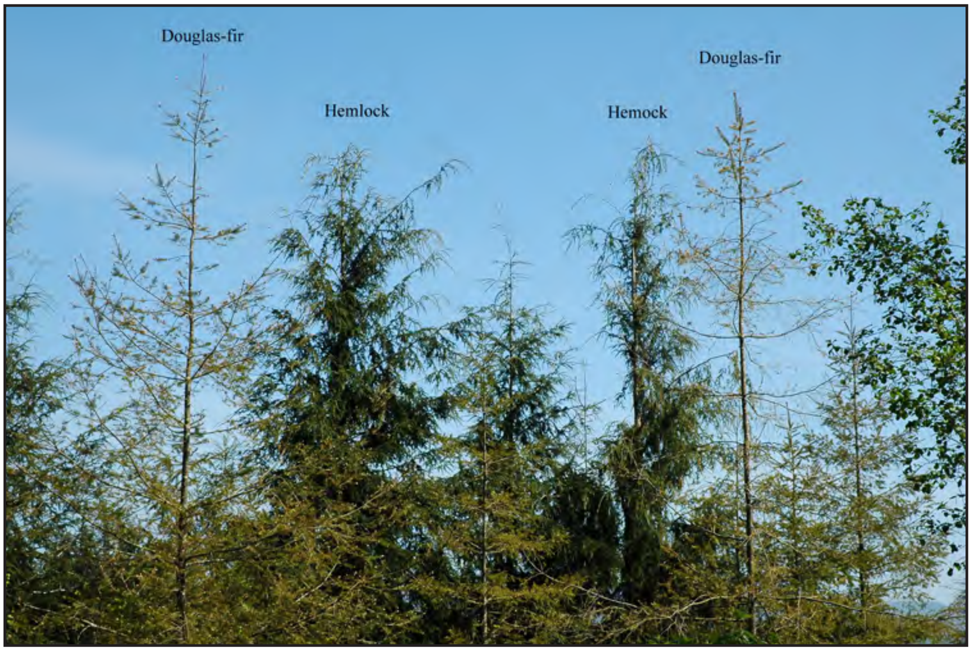


Figure 33. SNC causes foliage loss and sparse yellow crowns in Douglas-fir in Oregon's Coast Range. Low foliage retention can reduce tree volume growth by more than 50%. Western hemlock is unaffected (Alan Kanaskie, ODF).

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. SNC was first noted in coastal Douglas-fir in the 1980's, emerged as an epidemic in the 1990's, and has continued to persist. The host-pathogen interaction is interesting because both the fungus and the host tree are native to the Pacific Northwest (PNW).

Trees affected by SNC exhibit chlorotic foliage in the late spring and drop ("cast") needles prematurely, resulting in sparse crowns (Fig. 33). 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 two years. SNC rarely kills trees but reduces diameter and height growth due to foliage loss.

Previous analyses (Maguire et al. 2011 ten-year study from 1998-2008) have shown that cubic volume growth in the most heavily infected stands is less than half of the volume growth in uninfected stands. 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 affects the properties of milled lumber such as by increasing the percentage of knots (pers. comm. Stimson Lumber), slows the development of stand structure and wildlife habitat, and limits stand management options.

Over three years, 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 ten years. The first five-year period of plot re-measurement has been completed. It has provided information about disease severity, growth loss, and geographic distribution on 102 surviving plots throughout the Coast Range. Analysis of these new data showed that cubic volume growth in the most heavily infected stands is about two-thirds of that expected in uninfected stands. The diminished growth losses (relative to the 1998-2008 period) are thought to be due to post-harvest replacement of Douglas-fir with western hemlock in coastal zones subject to the greatest disease pressure and demonstrating the poorest growth performance.

A special SNC aerial survey (Fig. 35) is conducted by ODF and USFS every other year (the survey was annual until 2018). It was canceled in 2020 and 2021 due to COVID-19 restrictions and reduced staff, but is planned to resume in spring 2022: https://tinyurl.com/35dv2p33

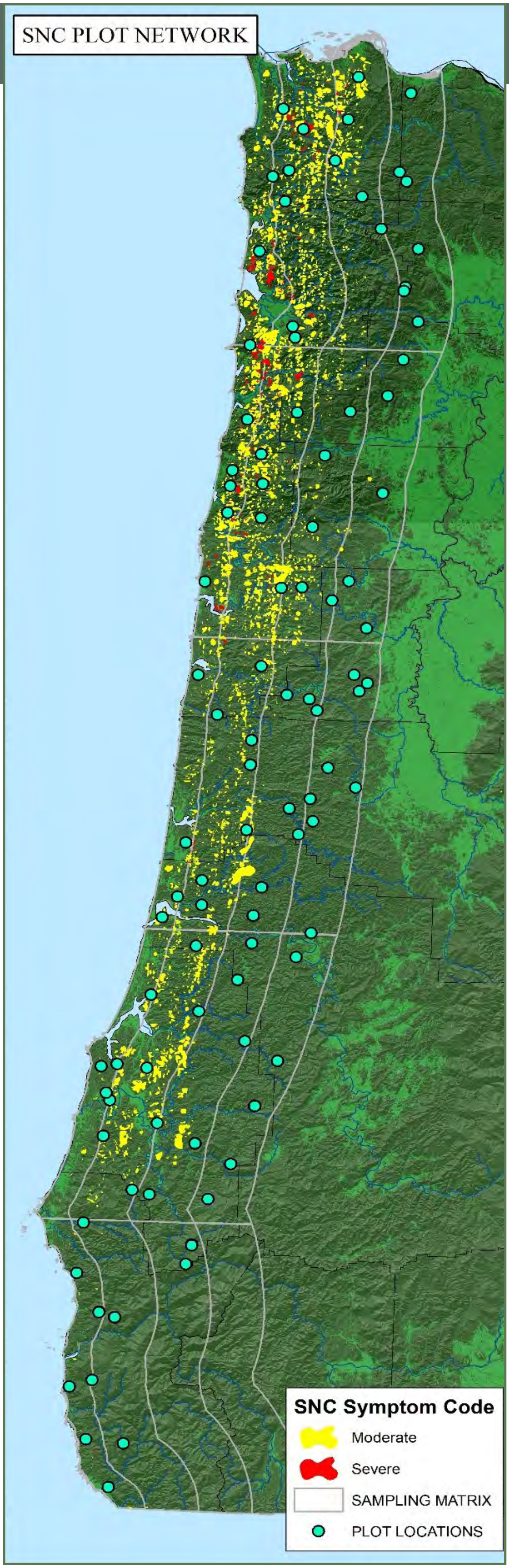


Figure 34. (left) Map of SNC plot locations and SNC damage observed in Douglas-fir during the 2018 SNC aerial survey. The next aerial survey will take place in late spring of 2022.

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

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 (Fig. 37) in northwest and southern Oregon. In 2020, ODF Forest Health and ODF State Forests assisted Oregon State University (OSU) researchers and Oregon Department of Agriculture (ODA) in locating sites on the Nehalem River for release of a new biological control agent, the knotweed psyllid (*Aphalara itadori*). The knotweed psyllid (Fig. 36) is an insect from Japan that feeds solely on knotweed. This insect was tested for several years in a quarantine facility at OSU, and in 2020 was deemed safe for open field releases by the USDA. Included in the field sites selected by OSU researchers was a site on the Tillamook State Forest and another on nearby private land. At both 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 36. Knotweed psyllid (inset; CABI) and damage to knotweed leaf (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 37. 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 an estimated $80 million dollars annually to Oregon's forestland owners and farmers. ODA 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 ODA Noxious weed program.

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

FOREST HEALTH CONTACTS

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2600 State Street, Salem, OR 97310
https://tinyurl.com/odf-foresthealth

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Wyatt Williams	Invasive Species Spec.	(503) 798-5436	wyatt.williams@odf.oregon.gov
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1220 SW Third Avenue, Portland, OR 97204
https://www.fs.usda.gov/main/r6/forest-grasslandhealth/insects-diseases

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

Vacant	Entomologist		
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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	• **Spongy moth** 	• **Spongy moth** • Oak looper* • Gall-making wasps & flies* • Leaf miners* 	• **Asian longhorned beetle** • **Spongy 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
• **Spongy moth** • Western tent caterpillar* • Alder flea beetle* 	• **Emerald ash borer** • **Spongy moth** 	• **Spongy moth** • **Satin moth*** • Webworm* 	• **Spongy 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