Forest Service
United States Department of Agriculture

Oregon Department of Forestry
Forest Health

Pacific Northwest Region

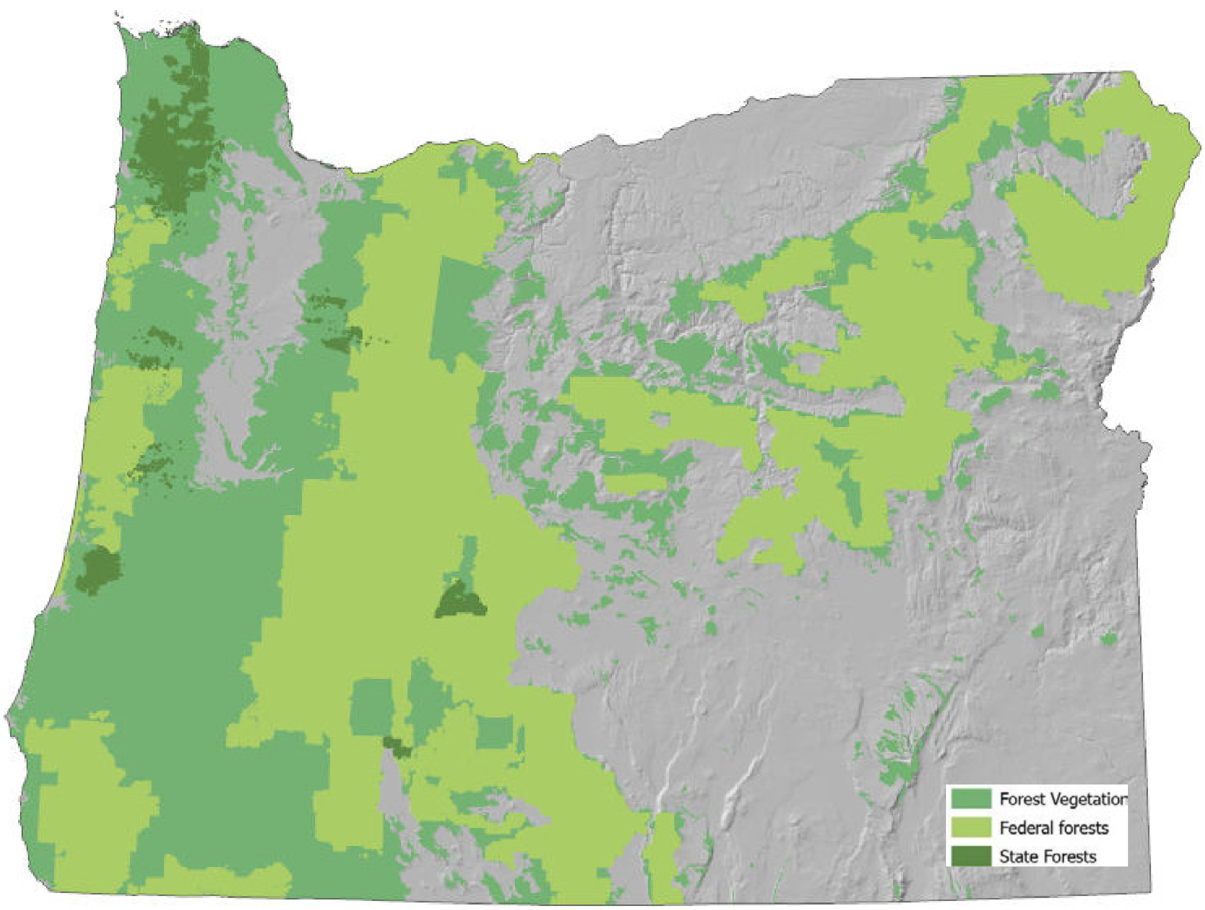
Forest Health Highlights in Oregon - 2024

FOREST HEALTH HIGHLIGHTS IN OREGON - 2024

Joint publication contributors:

Christine Buhl
Gabriela Ritokova
Wyatt Williams
Sean McKenzie

Karen Ripley
Sarah Navarro
Daniel DePinte
Tim Bryant
Phillip Chi



Above: Map of Oregon public (state and federal) and private forests.

Front cover: *Phytophthora austrocedri, a recently detected disease in Oregon nurseries, shown in Argentina (looking toward Rio Grande, Chubut Province) killing cypress (Everett Hansen, OSU).*

TABLE OF CONTENTS

FORESTRY TECHNICAL ASSISTANCE

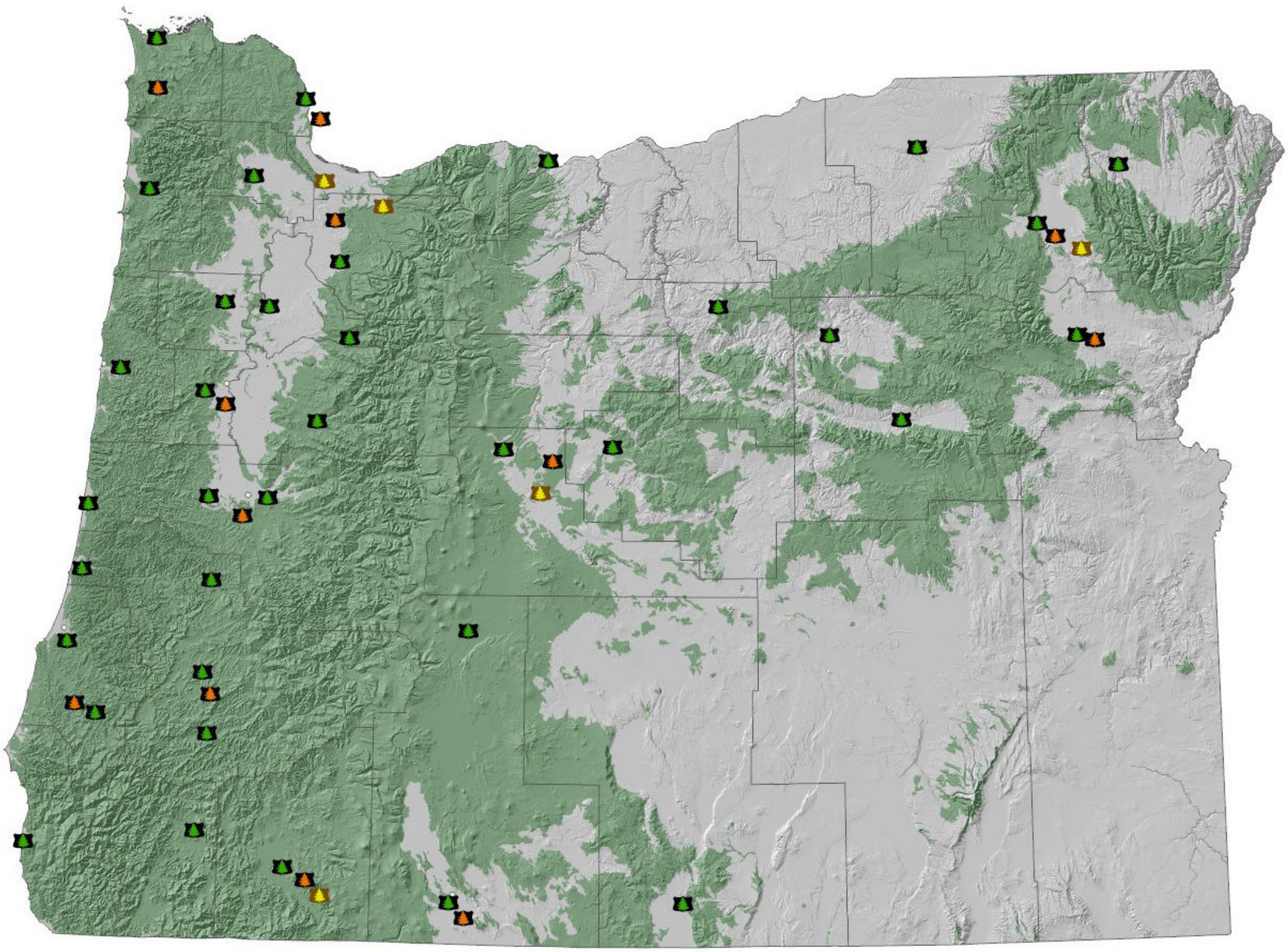


Figure 1. Map of office locations for ODF (green tree), USFS (yellow tree), and OSU Forestry Extension (orange tree).

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

REPORT SUMMARY

This report is a joint product from the Oregon Department of Forestry (ODF) - Forest Health and the U.S. Forest Service (USFS) – Forest Health programs. We also rely on reports from other ODF, USFS, and Oregon State University Forestry Extension staff from across the state (Fig. 1 and back cover) and collaborate with other natural resource agencies, universities, public and private forest landowners, and members of the public to gather information.

Each year we provide information on forest health trends and highlights as identified by aerial and ground monitoring efforts (see Monitoring section). A large part of estimating forest health is measuring damage from agents that cause injury or mortality. These agents include pest insects, diseases, and abiotic stressors such as drought, storms, and wildfire. Here, we review major damage-causing agents observed in the past year and provide guidance and resources for management. Some of these agents, such as disease-causing pathogens, are underrepresented in our reporting because they are hard to observe or verify on a large scale. For example, root diseases require ground-based assessment, such as excavating roots, for verification. This is labor-intensive and may be destructive to the tree. A large part of this report is devoted to climate change and specifically drought, which is often paired with high temperatures. These abiotic stressors are often the primary underlying causes for tree mortality across our landscape. Drought reduces tree growth and increases susceptibility to insect pests and some diseases, which healthy trees may otherwise resist or tolerate.

In 2024…

Oregon experienced a historic wildfire season, and many parts of the state are experiencing ongoing drought stress. The largest forest health issue affecting much of the state continues to be drought followed by infestation from opportunistic insects such as bark beetles. New research and tools are being developed to help forest landowners improve climate resilience in their stands by providing resources on appropriate seed sources, updated stand density guides, and landowner assistance funding.

The most important forest diseases in Oregon continue to be Swiss needle cast (SNC) and sudden oak death (SOD). We conducted an aerial survey and continue to see SNC impacting large sections of Douglas-fir along the coast. Collaborative disease monitoring efforts and ongoing trials to identify SNC-resistant Douglas-fir varieties are being conducted at several locations. New SOD infections continue to be identified in Curry County, and collaborative efforts of state and federal agencies continue to attempt to slow the spread of the disease.

Most of the forest insect and disease pests on our landscape are native species, and most are impacting our most susceptible trees. However several invasive species are threatening specific tree species, even when they are healthy. In 2024, multi-agency task forces continued to make progress in addressing invasive species such as Mediterranean oak borer, emerald ash borer, and sudden oak death, with emphasis on identifying pests' presence, slowing their spread, providing mitigation strategies, and increasing public outreach to aid in detection, diagnosis, and management. More recently detected exotic species include the Japanese cedar longhorned borer and *Phytophthora austrocedri*.

The following report provides highlights on forest health concerns in Oregon. Reports from previous years are available here: https://tinyurl.com/ForestHealthHighlights

OREGON FORESTS

At 30 million acres, almost half of Oregon is forestland. The number of acres of forest in Oregon has remained relatively consistent since 1953. These forests range from family-owned forests, large tracts of industrial timber land, to untouched wilderness. Oregon's forests consist of federal (60%), private (35%), state (3%), tribal (1%), and other public (1%) ownerships (Fig. 2).

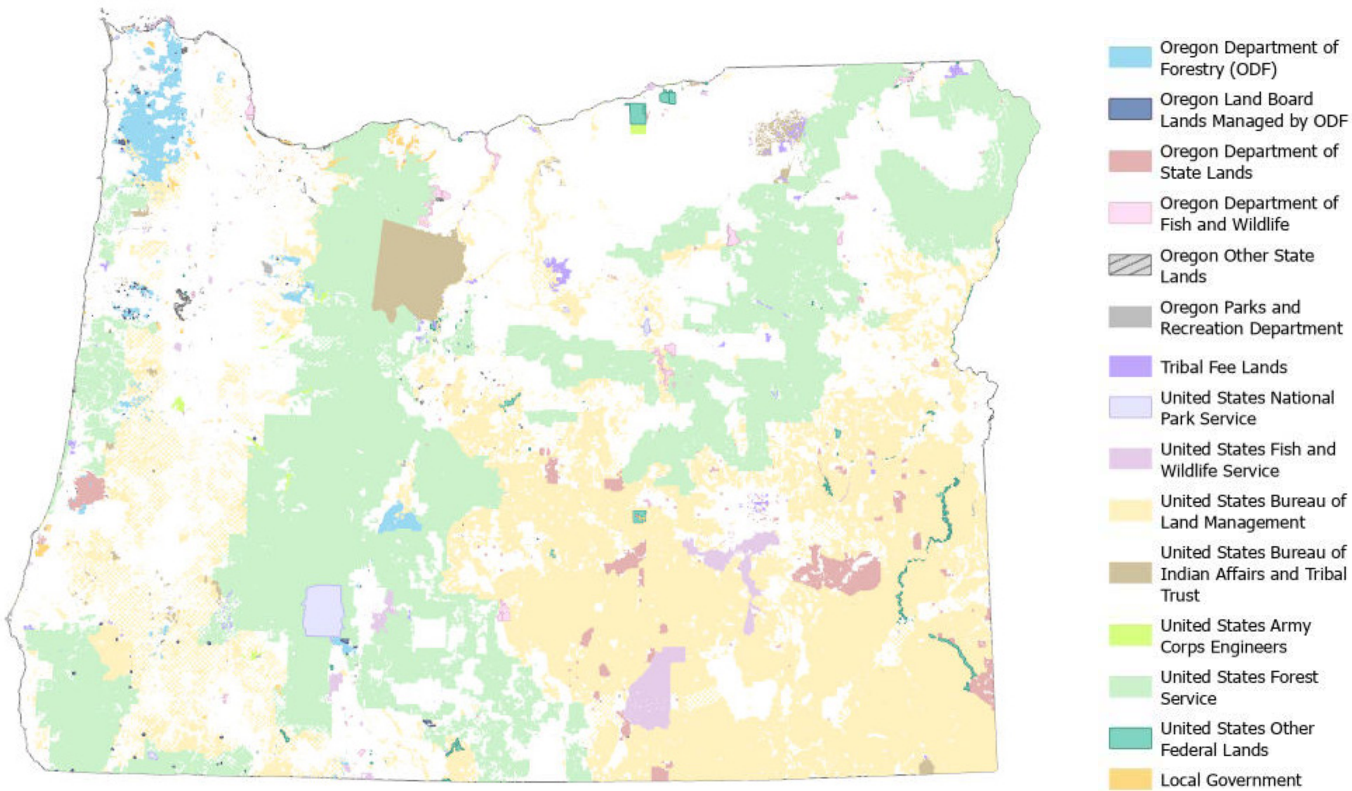


Figure 2. The majority of land ownership in Oregon is private (white) and public land managed by BLM (yellow) and USFS (green).

Oregon offers a diversity of forests such as mossy, rain-drenched coastal ecosystems dominated by Sitka spruce, Douglas- fir, red alder, western redcedar, and western hemlock, to oak-dominated savannas, and semi-arid mixed conifer forests of lodgepole, ponderosa and sugar pines, and incense cedar (Fig. 3). 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 sagebrush steppe. The most abundant conifers in Oregon include Douglas-fir, true fir species, western redcedar, western hemlock, lodgepole and ponderosa pines, and the most abundant hardwoods include bigleaf maple, red alder, Oregon white oak, Oregon ash, and black cottonwood.

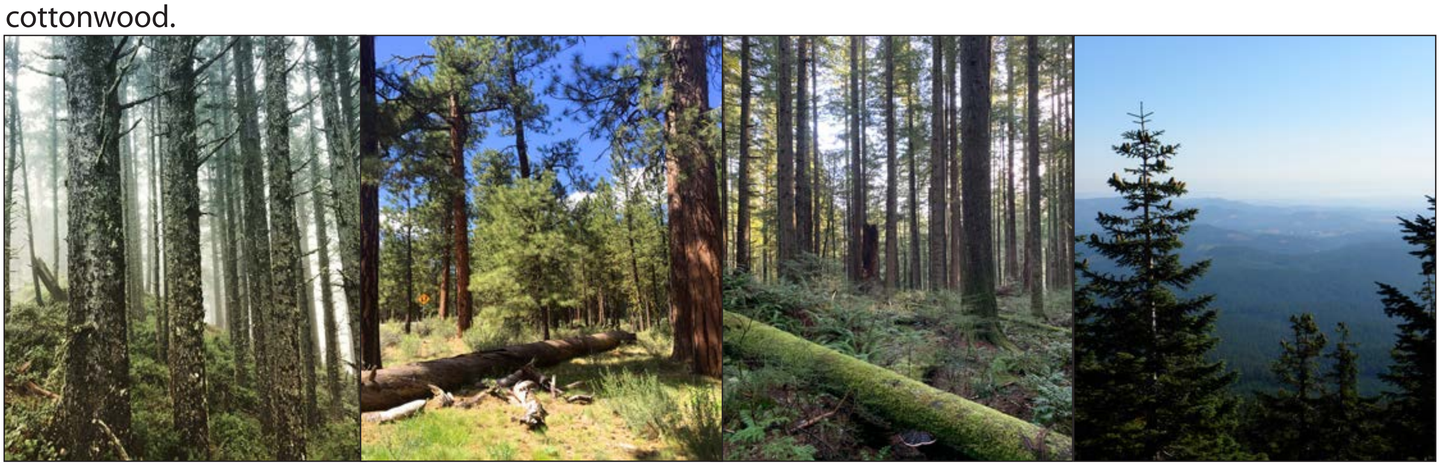


Figure 3. Diversity of Oregon forests (Christine Buhl, ODF).

MONITORING

Monitoring of forest health conditions is conducted using traps, ground observations, aerial surveys, and remote sensing. Ground monitoring via trapping and other forms of sampling is regularly used to determine presence, distribution, and/or intensity of various native and exotic insects and pathogens. Results from these efforts are summarized in the insect and disease sections of this report. Regular ground monitoring is conducted for Douglas-fir tussock moth, Mediterranean oak borer, emerald ash borer, sudden oak death, and hazard trees. Pathologists with ODF and the USFS regularly evaluate tree hazards and provide 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.

Figure 4. Insect funnel trap at Gilchrist Forest Products (Christine Buhl, ODF).

Gilchrist EDRR project

In 2024, an early detection rapid response (EDRR) monitoring project was conducted by the Oregon Department of Forestry, Oregon Department of Agriculture, U.S. Forest Service, and Gilchrist Forest Products (GFP). This effort was prompted by a USFS project that removed fire-damaged pine from California and shipped it to South Dakota. The goal was to reduce fuels in California and utilize viable timber through a facility with capacity in South Dakota. Logs traveled via rail from California to Gilchrist Forest Products in Oregon for pre-processing, then were transferred to South Dakota for milling. Interstate transport of goods, in addition to international imports, is a major pathway for moving exotic and potentially invasive species, and EDRR is a monitoring protocol commonly used to detect and prevent establishment of potentially costly pests. Through cooperation with GFP, sentinel monitoring traps (Fig. 4) were deployed in the summer of 2024 specifically to detect beetles of concern dispersing from logs entering Oregon from California. Over 27,000 specimens, consisting of at least 89 distinct species, were collected. No exotic invasive insect pests of concern were detected although some interesting state records of non-pests were identified (Fig. 5).

Figure 5. Heydenia sp. parasitoid wasp of bark beetles. This beneficial insect has only been recorded in the U.S. in California in 1968-69 (ODA).

MONITORING

Aerial detection survey

The Pacific Northwest forest health Aerial Detection Survey (ADS) is a cooperative effort among the Forest Health Protection program of the USDA Forest Service, the Forest Health Unit at the Oregon Department of Forestry (ODF), and the Forest Health Unit at the Washington Department Natural Resources (WA DNR). These surveys help ODF and its partners monitor forests for tree injury and mortality from insects, pathogens, and abiotic agents such as drought, windthrow, and fire. ODF and its partners conduct a general survey to map damage from all agents annually as well as several specialized surveys for damage from agents of special interest (Fig. 6). Specialized surveys are conducted for Swiss needle cast biennially and for sudden oak death three to four times per year. Specialized surveys for other agents such as oak looper and pandora moth are conducted on an as-needed basis.

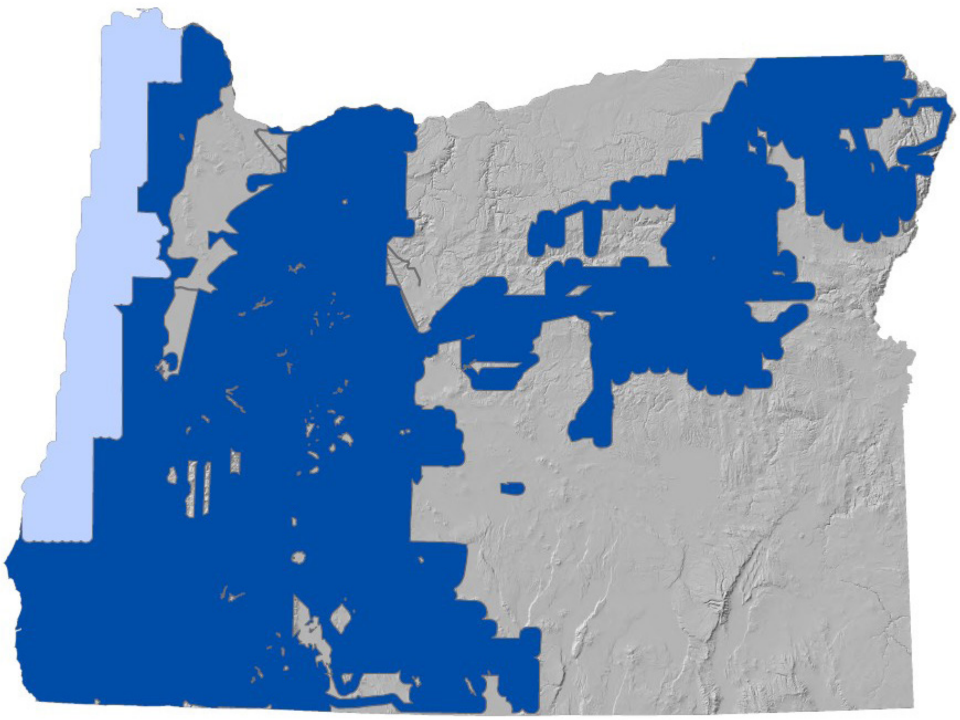


Figure 6. Area covered by the general survey (dark blue including light blue area) and the Swiss needle cast survey (just light blue area) in 2024.

For the general survey, trained observers fly over all forested lands in the Pacific Northwest in fixed-wing aircraft and record damage to trees from both abiotic and biotic agents (Figs. 7 and 8). Flights are staffed with one observer on each side of the aircraft. Survey flights typically maintain a flight altitude of approximately 1500 – 2500 feet above ground level, travel at approximately 90 to 140 miles and follow a systematic grid of transects spaced four miles apart. ADS staff use their knowledge of biogeography, host species, and visual cues to infer a proximate damage causal agent. Damage is recorded in real time using the specialized software platform Digital Mobile Sketching Mapping developed by the Forest Health Assessment and Applied Sciences Team at the USDA Forest Service. Crew members scan the forest up to two miles outboard from aircraft and record all damage observed. ADS staff draw either points or polygons to record the spatial location of the damage they observe and assign the observation a host and damage causal agent combination as well as an estimate of the extent of the damage. For points, the extent of the damage is expressed as the number of trees damaged. For polygons, the extent of damage is expressed as the percent of the area within the polygon containing damaged trees. At the end of the season, the data are reviewed for quality control. The spatial extent of each polygon is calculated to determine the acres with damage. Finally, the affected acres are calculated for both points and polygons using standardized formula, reflecting both the acres with damage and the extent of the damage.

Figure 7. View from the survey plane (Christine Buhl, ODF).

The Pacific Northwest ADS is the longest continuous survey of its kind in the United States, having been established in 1947 and flown every year thereafter, except 2020 due to the COVID-19 pandemic. ADS data provide a spatially extensive, point-in-time estimate of forest health issues on all forested lands in Oregon and Washington. However, there are important caveats to understand in the interpretation of these data. Due to the nature of the survey, ADS data are not necessarily comprehensive and spatial locations should be considered approximate. As noted above, damage causal agents are inferred from the combination of biogeography, host species, and visual cues. Some damage causal agents have similar visual signatures, overlapping biogeographies, and affect the same host species, leading to errors in the data. Finally, tree damage is frequently the result of a complex, interacting suite of abotic and biotic factors, including climate change, drought, soil conditions, pathogens, interspecific and intraspecifc competition, and others. Therefore, the assigned agent should be considered the presumed proximate cause of tree damage rather than either the sole or even the primary cause of tree damage.

In 2024, ODF and its partners surveyed approximately 28 million acres during the general survey. Additionally, ODF surveyed approximately 3.26 million acres as part of its Swiss needle cast survey. Finally, ODF and USFS jointly conducted two helicopter and one fixed-wing specialized survey for sudden oak death in 2024. Results from these surveys can be found in the 2024 Forest Health Summary, Forest insect and disease sections of this publication.

Figure 8. Aerial surveyor observing and recording tree damage (Christine Buhl, ODF).

2024 FOREST HEALTH SUMMARY

In 2024 Oregon forests experienced unprecedented tree damage due to wildfire and widespread damage from drought followed by opportunistic insect pests. Wildfire damaged a record 1.9 million-acre footprint (Wildfire summary p. 19), largely due to ongoing dry conditions and a buildup of fuels. Within those 1.9 million acres is a mosaic of damage that includes not only fire-damaged trees but also old snags, unaffected trees, and non-forest land such as grasslands, agriculture, and to a lesser degree, even urban areas.

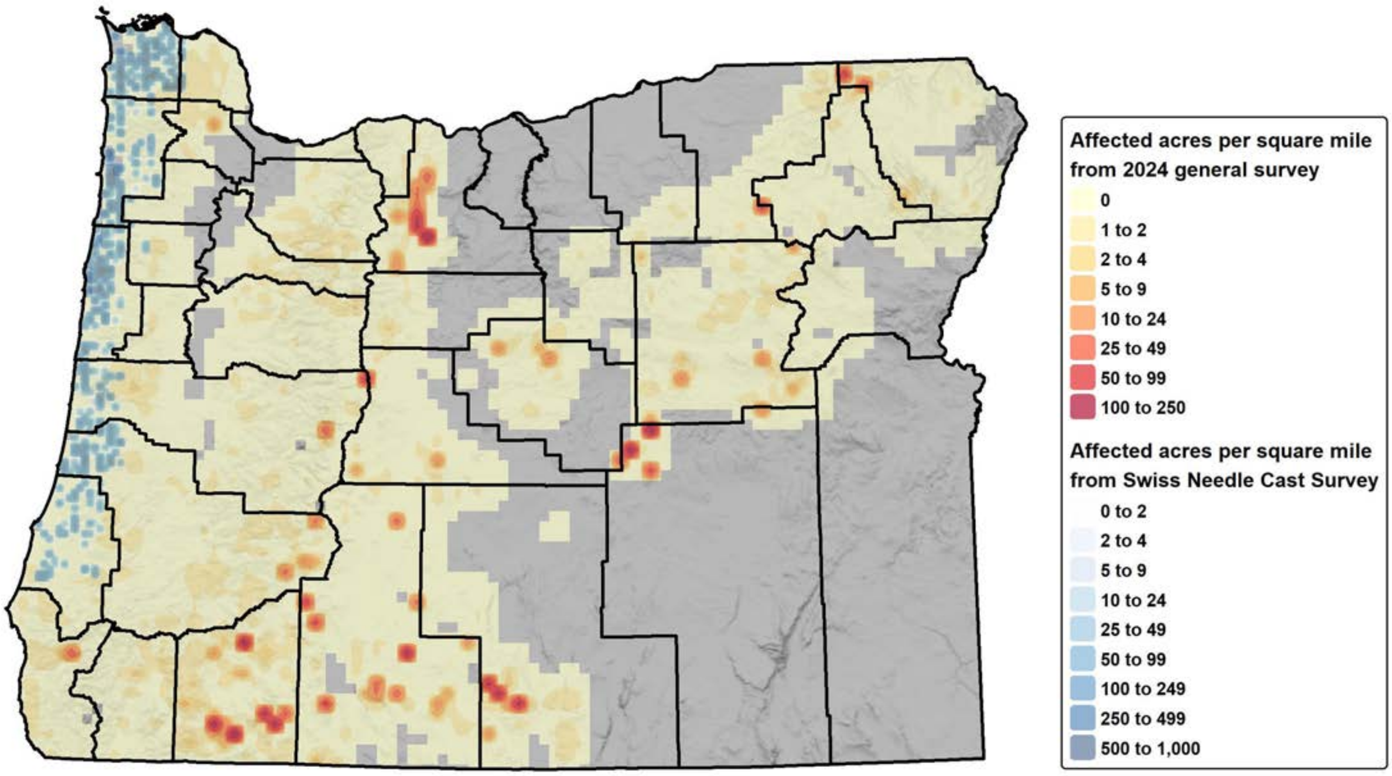


Figure 9. Heat map of damage from all agents (wildfire excluded) as mapped by 2024 general (yellow to red) and Swiss needle cast (blue) surveys (Sean McKenzie, ODF).

The largest amount of tree damage from abiotic (excluding wildfire) and biotic agents was recorded in areas hardest hit by drought such as the eastern foothills of the Cascades and some parts of northeastern Oregon (Fig. 9). 2.26 million acres with damage were recorded in treed areas from abiotic (excluding wildfire), insect, and disease agents. Within those 2.26 million acres is a mosaic of unaffected and current-year affected acres of forest. Due to improving mapping software we are now able to report numbers for only the current-year damaged trees, termed "affected acres" to denote acres of damage rather than acres with damage (Fig. 11). In 2024, 580,000 affected acres of damage from these agents was recorded. "Damage" consisted of 496,000 (463,000 from SNC) affected acres of tree injury, which trees may recover from, and 84,000 affected acres of tree mortality (Fig. 10). Injury is often underreported because missing foliage, breakage, and other signs of injury are less visible than discolored crowns of recently killed trees.

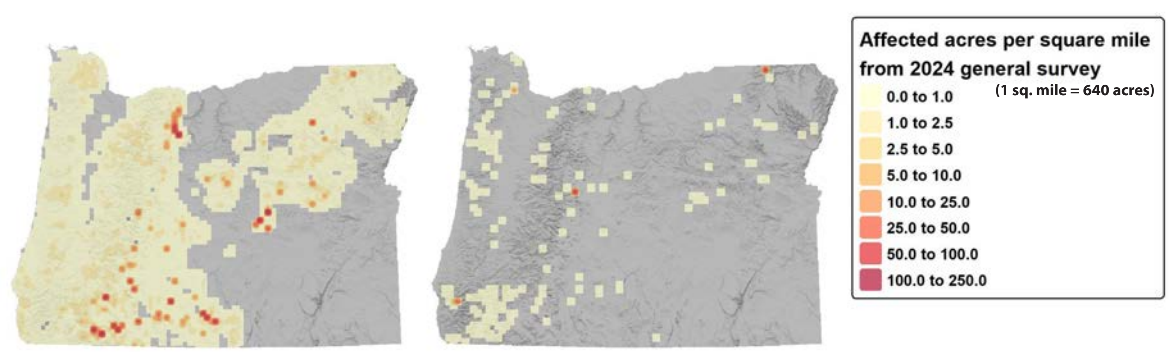


Figure 10. Heat map of mortality (left) and injury (right) from all agents (wildfire excluded) (Sean McKenzie, ODF).

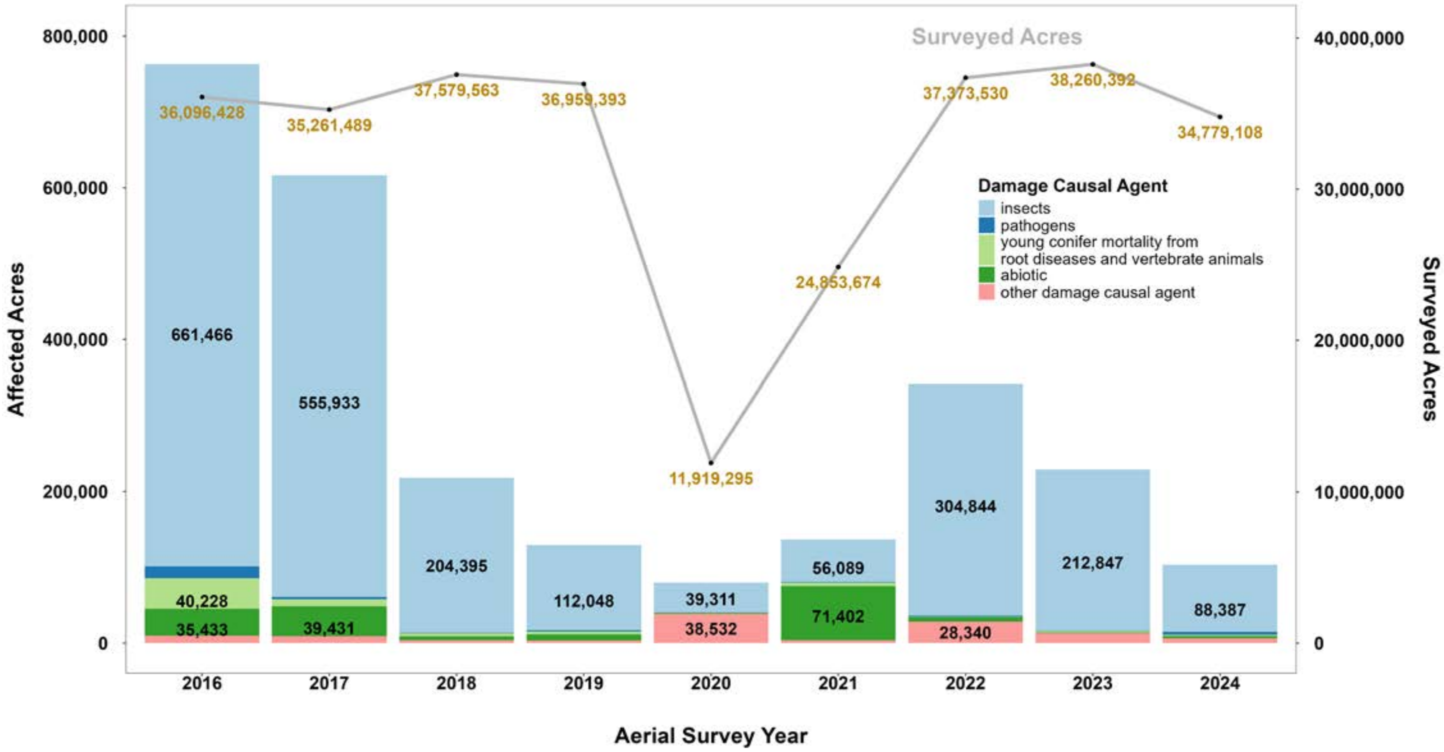


Figure 11. 10-year trend of affected acres of damage (injury and mortality) from insect, disease, and abiotic (wildfire excluded) data collected from annual aerial surveys (Sean McKenzie, ODF). Previous reports provided acres 'with' damage and here we show the more accurate affected acres which is acres 'of' damage.

Caveats to these data:
1) Insect damage often indicates underlying stress from a different primary causal agent such as drought.
2) Diseases are greatly underrepresented because they are hard to capture via aerial survey. Swiss needle cast is not shown here because it is not an annual survey.
3) Young conifer mortality is mostly due to root disease, and to a lesser extent vertebrate damage.
4) Data from 2020 are excluded because they were collected via a different method (Scan and Sketch 2020 Forest Health Highlights) that is not comparable across years.

Abiotic factors reported (Fig. 13) here include mostly environmental damage from wind, ice, snow or flooding but do not include wildfire. Drought is reported when it is the only direct cause of damage, such as in Christmas tree farms (Fig. 12), which often consist of densely packed, drought-intolerant species such as noble fir grown in the drier lower elevations of the Willamette Valley. Drought is directly responsible for most of what is reported here as insect-caused damage from native beetles and should be inferred as the ultimate cause of tree damage and the target of management strategies. Observable abiotic factors, excluding fire and underlying drought, affected 2,600 acres of trees and largely consisted of damage from winter storms.

Figure 12. Christmas tree farm in the Willamette Valley where true fir often struggle due to the warm and dry conditions (Christine Buhl, ODF).

Biotic factors reported (Fig. 13) here include damage from insects and diseases. 104,000 affected acres were the result of insect damage, and 79,000 of these acres consisted of mortality largely from insects such as beetles which are strongly associated with drought stress. Most pathogens are difficult to observe from aerial surveys and require ground surveys, therefore forest diseases are typically underreported. Swiss needle cast symptoms were identified across a total of 463,000 affected acres and a few other observable diseases affected another 7,000 acres.

Mortality in young conifer stands was identified on about 1,500 affected acres and is likely attributed to root diseases such as black stain root disease, and to a lesser extent vertebrate damage and poor planting practices. Tree damage from unknown agents that we were not able to verify with ground surveys affected 1000 acres of forest.

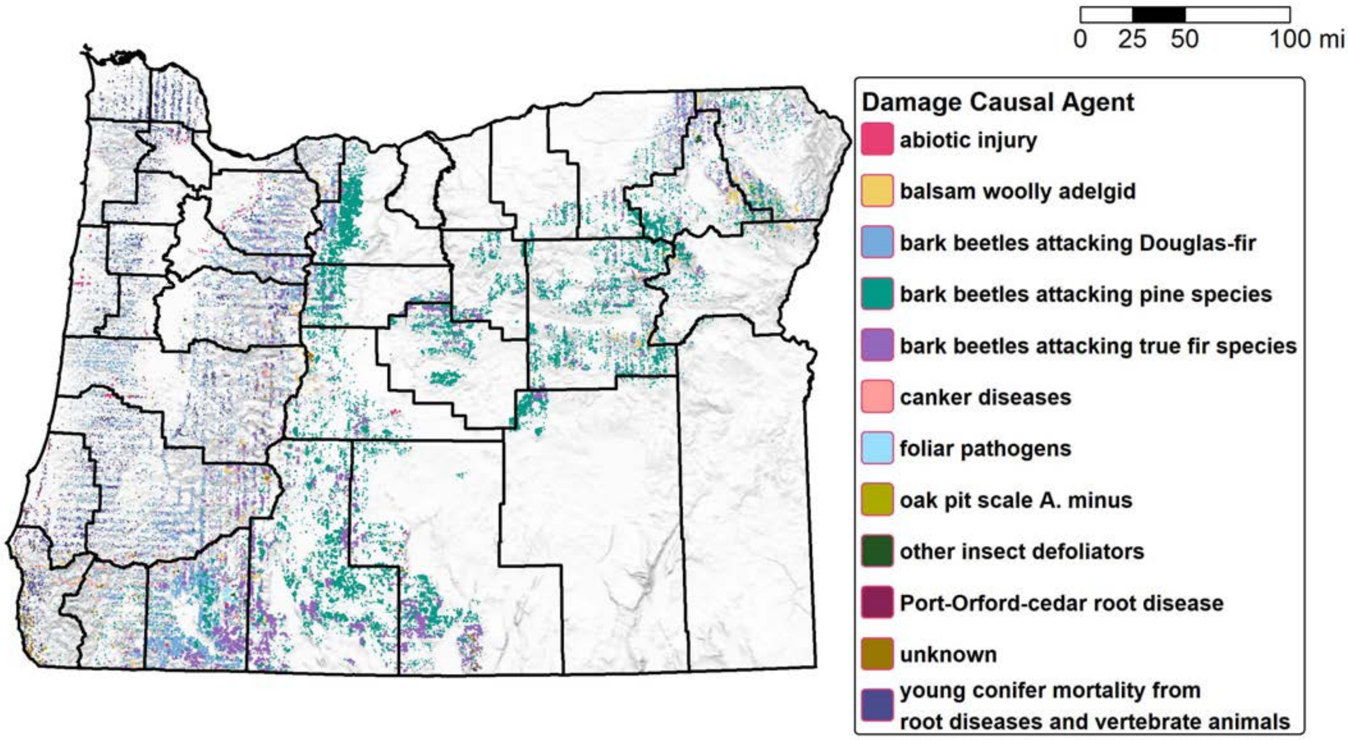


Figure 13. Map of damage by casual agent (Sean McKenzie, ODF).

The majority of damage occurred in pine species, specifically ponderosa pine, followed by true fir species, and Douglas-fir (Fig. 14). Ponderosa pine was mostly impacted by moisture stress from a combination of drought and site conditions, and opportunistic beetles such as western pine, mountain pine, and Ips beetles. Whitebark pine makes up a fraction of the pine species found in Oregon. However, this high-elevation species is listed as threatened and has suffered increasing losses over the years, which may result in eventual endangered status. True fir species were most impacted by drought and fir engraver, an opportunistic beetle, with the highest intensity occurring in low elevation and dry areas where drought-intolerant true fir have encroached due to wildfire suppression. Substantial numbers of true fir species were also impacted by balsam woolly adelgid, a stationary, long-established, invasive insect.

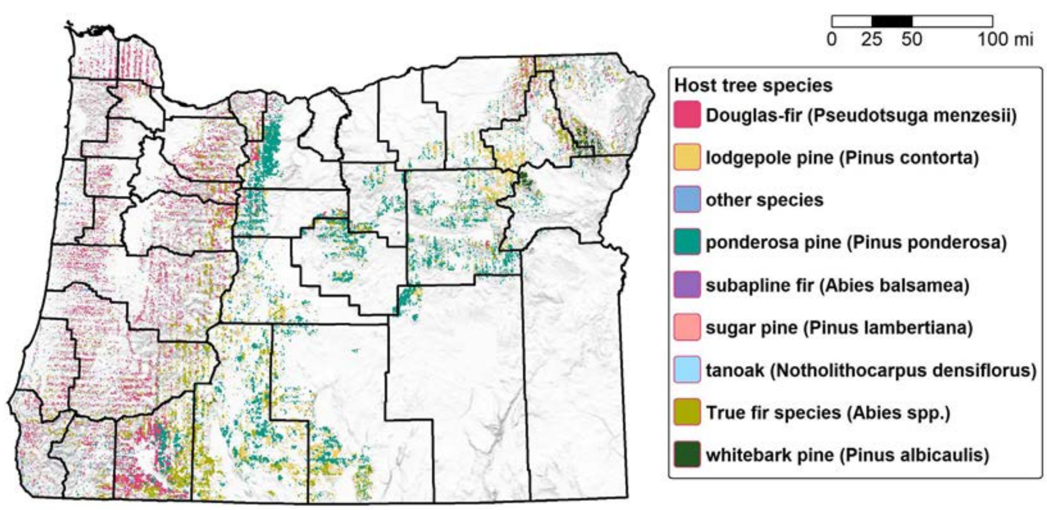


Figure 14. Map of damage by tree host (Sean McKenzie, ODF).

Due to the inaccessibility of its preferred habitat, and its chronic effects on true fir species, the impacts of balsam woolly adelgid are difficult to mitigate. Douglas-fir damage consisted of injury from Swiss needle cast along the coast, and mortality from drought plus opportunistic beetles such as Douglas-fir beetle and flatheaded fir borer in arid or poor quality sites.

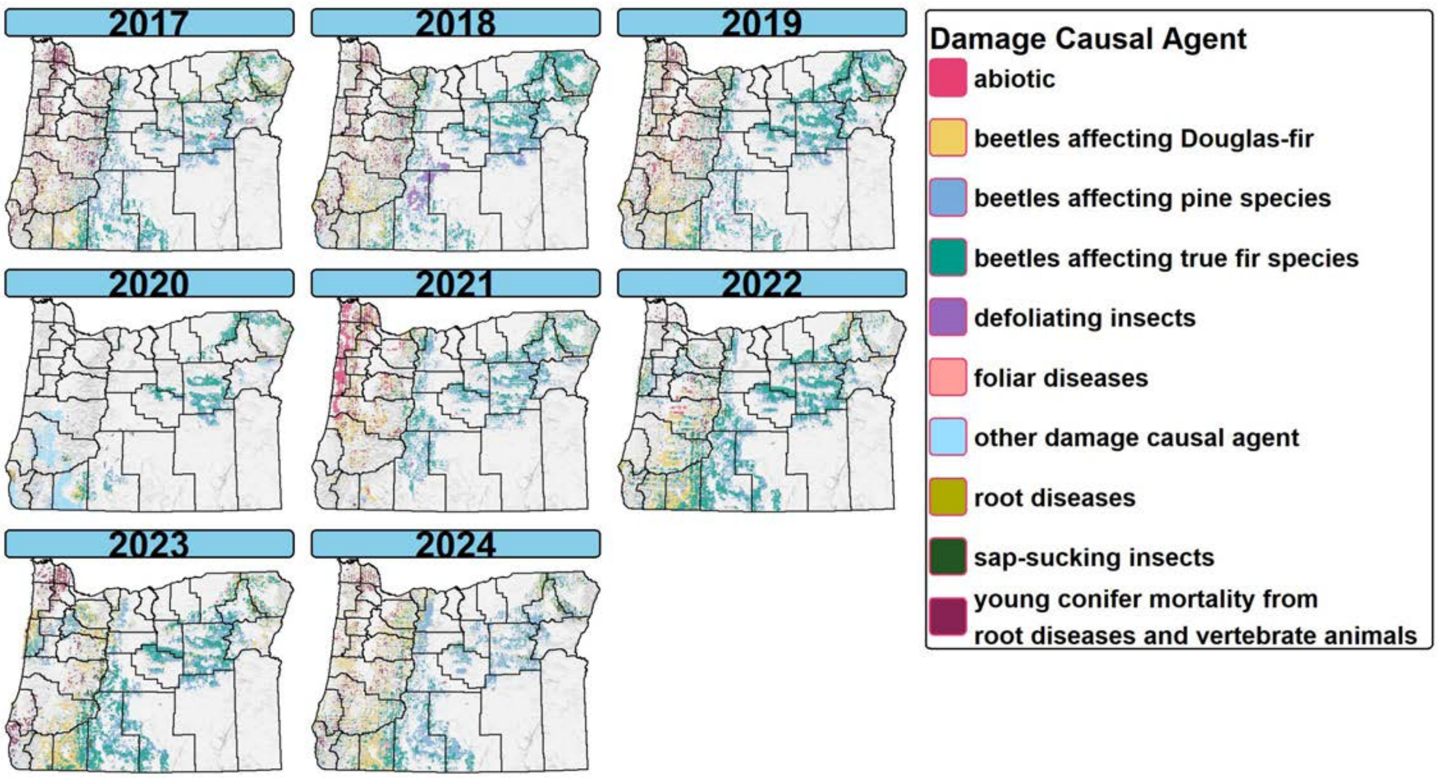


Figure 15. Trends in damage by causal agent (Sean McKenzie, ODF).

The dominant causal agents observed across the state are typically opportunistic beetles and, in 2024, pine species and Douglas-fir were most affected by a suite of these causal agents (Fig. 15). In recent years, damage in true fir species has increased dramatically and, although this decreased in 2024, true fir species was still the most affected tree group in proportion to its abundance on the landscape (Fig. 16).

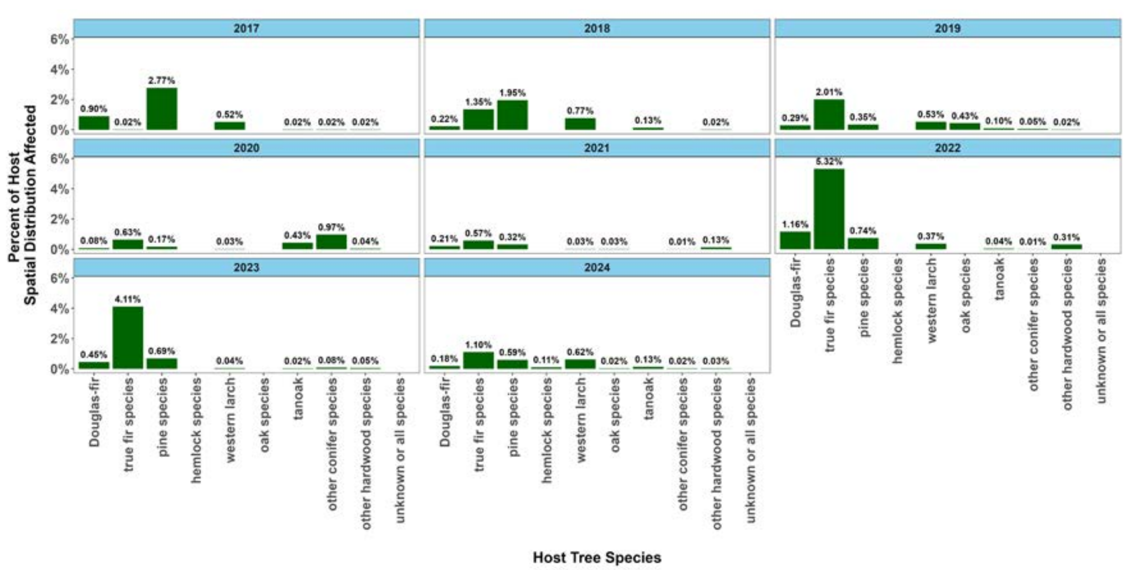


Figure 16. Trends in damage by tree host from ADS and 2021 USFS Forest Inventory Analysis (Sean McKenzie, ODF).

ABIOTIC: CLIMATE & WEATHER

Climate and weather are some of the most influential factors on tree health. They are often the underlying causes for susceptibility to secondary stressors such as opportunistic insects and some diseases. Natural fire cycles and endemic levels of native insects and diseases 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. Chronic conditions such as drought and acute events such as wind and ice events reduce tree resilience and defense against secondary pests. Drought, in particular, reduces moisture availability for trees to produce sufficient sap for mechanical and chemical defense against insect and some disease pests. Preventative silvicultural management strategies targeted to increase tree resilience and vigor may increase resistance and resilience to these abiotic and biotic stressors.

HEALTHY TREES = RESILIENT TREES

Understanding climate and weather

Climate is influenced by long-term or predictable variables across space and time. Climate varies across space in terms of regional factors such as latitude, elevation, topography, and proximity to bodies of water and mountains. Climate also varies across time due to large- to small-scale patterns: 1) glacial (cool) and interglacial (warm) periods across geologic time that differ by 5-15°F and alternate about every 10,000 years (Fig. 17), 2) periodic variability of ocean temperature masses that affect the jet stream such as our local Pacific Decadal Oscillation (PDO, Fig. 18), which alternates between warm and cool periods every 20-30 years, and the interannual El Niño and La Niña patterns that co-occur with PDO, and in the Pacific Northwest (PNW) result in warmer and drier or cooler and wetter conditions respectively, and typically last for a couple of years (Figs. 19 and 20), and 3) annual seasonality resulting from the tilt of earth's axis when rotating around the sun.

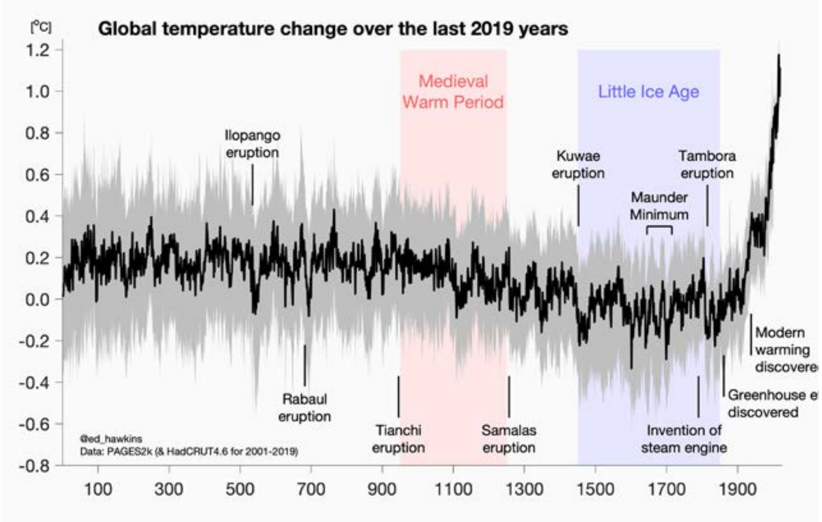


Figure 17. Warm and cool periods across geologic time (Ed Hawkins, National Center for Atmospheric Science).

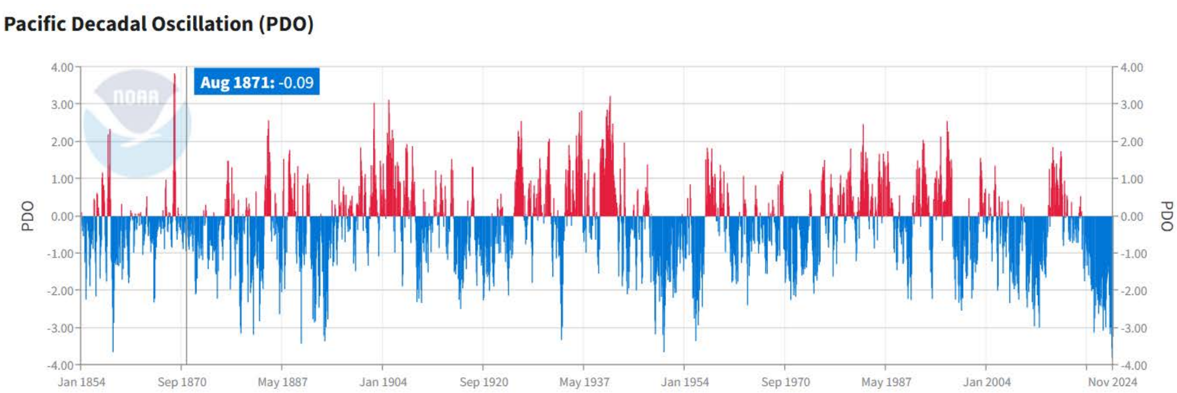


Figure 18. Pacific Decadal Oscillation trend of warm and cool periods across the modern era (NOAA).

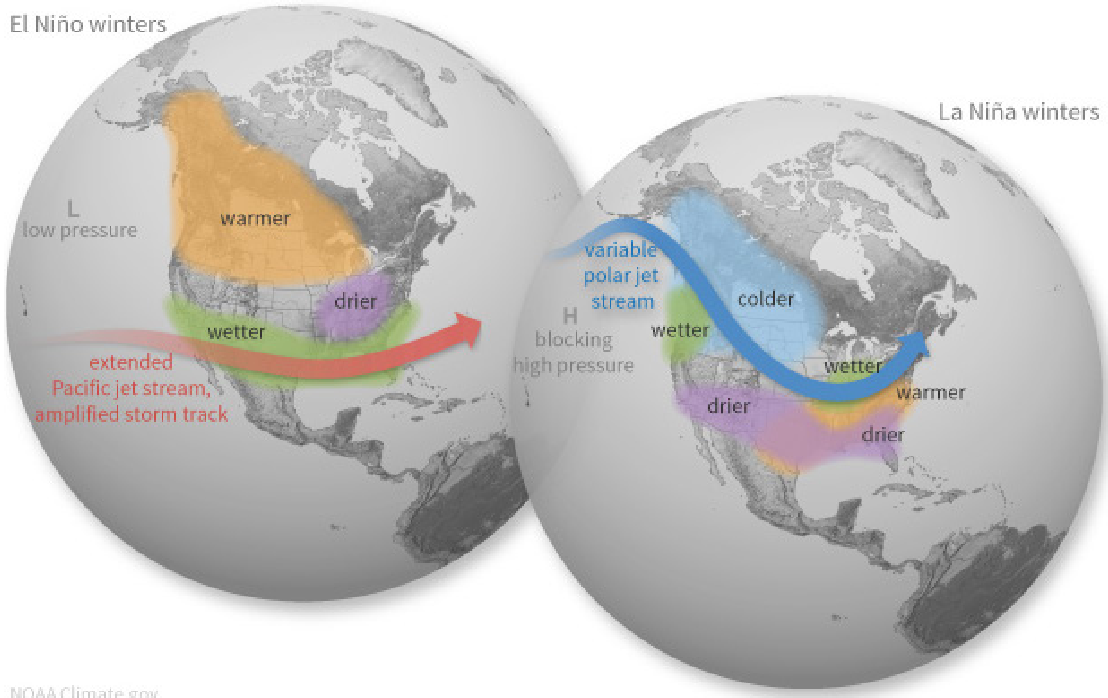


Figure 19. El Niño-Southern Oscillation (ENSO) map showing impacts on winter conditions from El Niño (left) or La Niña (right) patterns (NOAA).

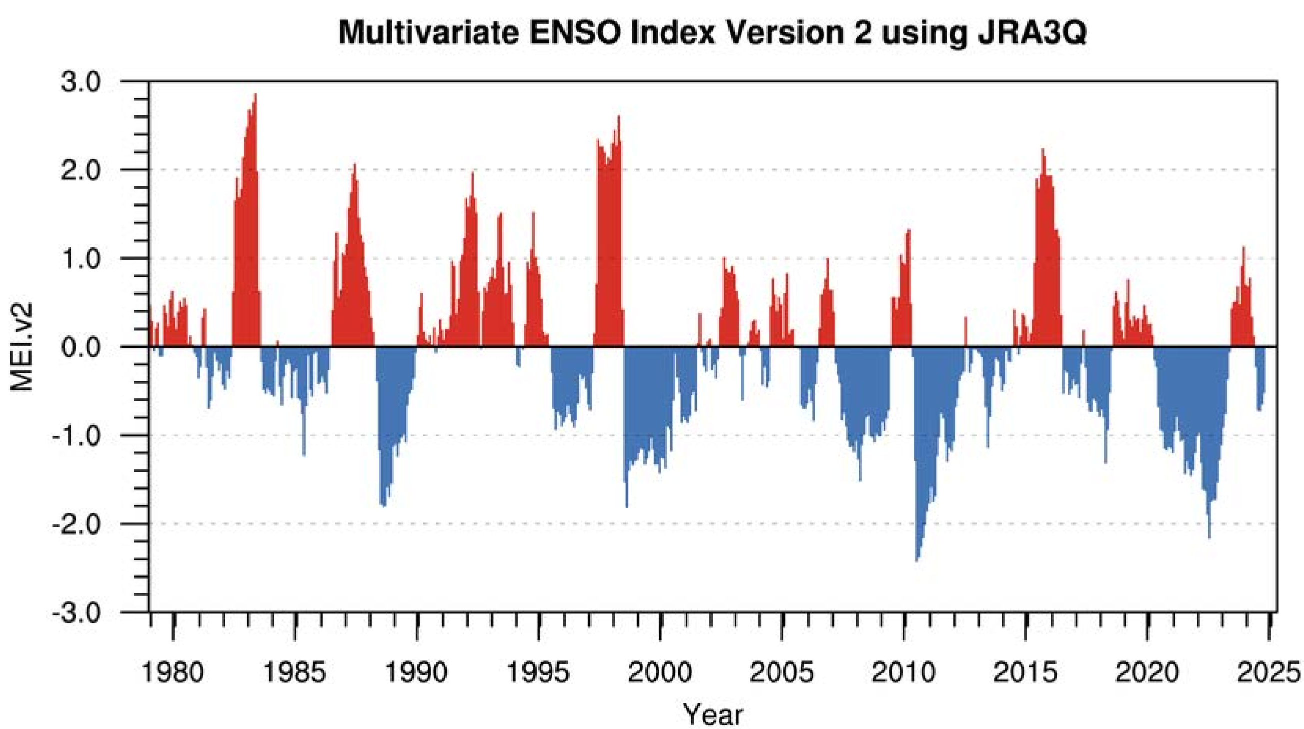
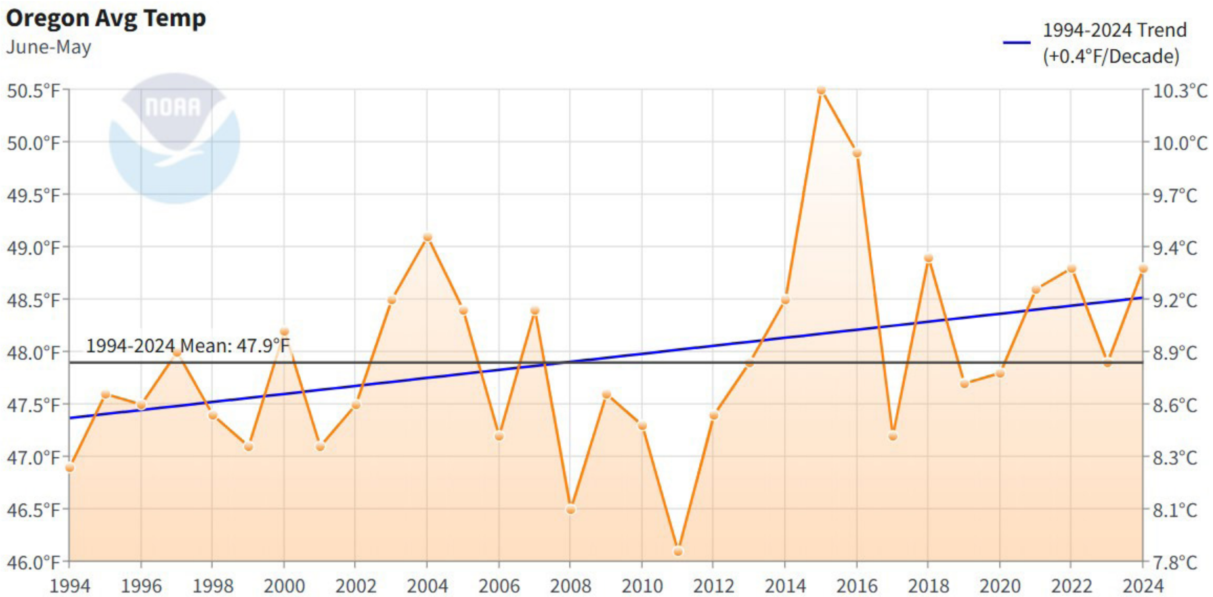


Figure 20. El Niño-Southern Oscillation trend of El Niño (warm phase) in red, alternating with La Niña (cool phase) in blue across the modern era (NOAA).

ABIOTIC: CLIMATE & WEATHER

Climate change, from human-caused emissions, is a modern anomaly that is less predictable but can be inferred from trends and predictive modeling. These trends show increasing average global temperature and decreasing average global precipitation ([Intergovernmental Panel on Climate Change Fifth Assessment Report](), Fig. 21). Precipitation averages at some scales can be misleading. For example at local scales or within narrow time periods, some regions may experience either no change or even increases in mean annual precipitation. The standard is to evaluate current climate against a 30-year average to avoid comparing current conditions against periodic or acute weather events. Additionally, precipitation as rain and snow is typically evaluated across the course of a 'water year', a 12-month period from October 1 to September 30 to evaluate precipitation as rain and snow throughout a year. Most climate models predict a range of outcomes with the same general trend in increasing temperature. Precipitation is harder to predict, but will likely vary dramatically from year-to-year (Fig. 22). For trees, the consistency of precipitation over time is equally important to the levels of precipitation received.



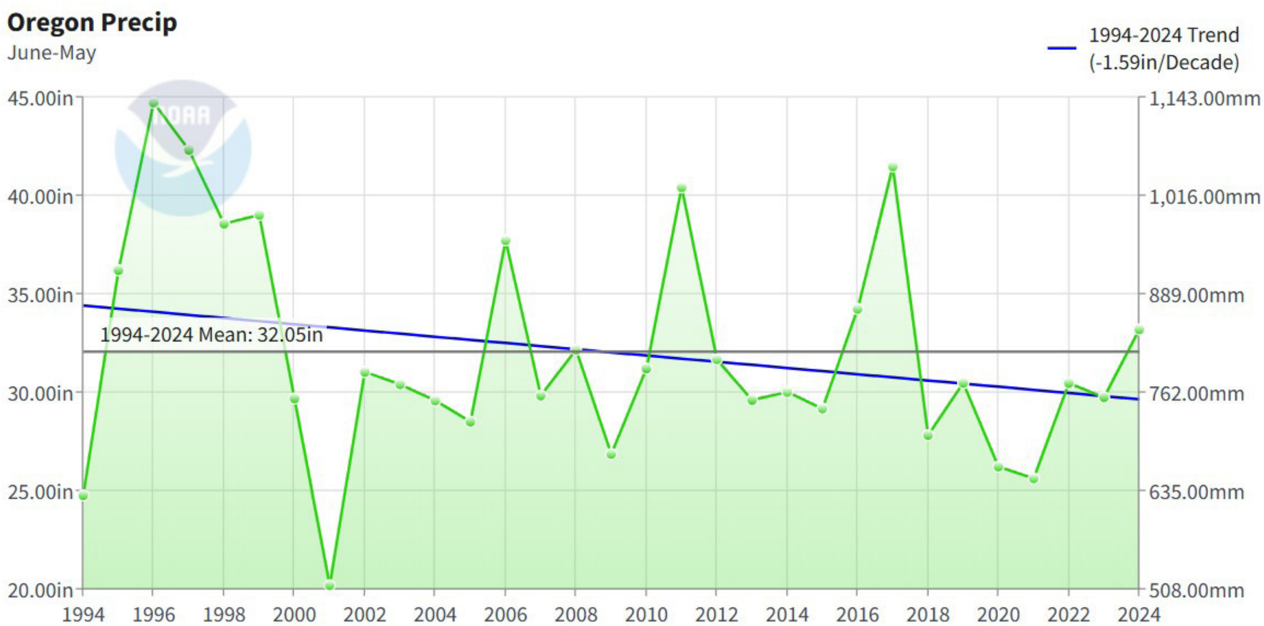


Figure 21. 30-year (1994-2024) annual average temperature (top) and total precipitation (bottom). Grey trend lines indicate the 30-year average and blue indicate the directional trend (NOAA).

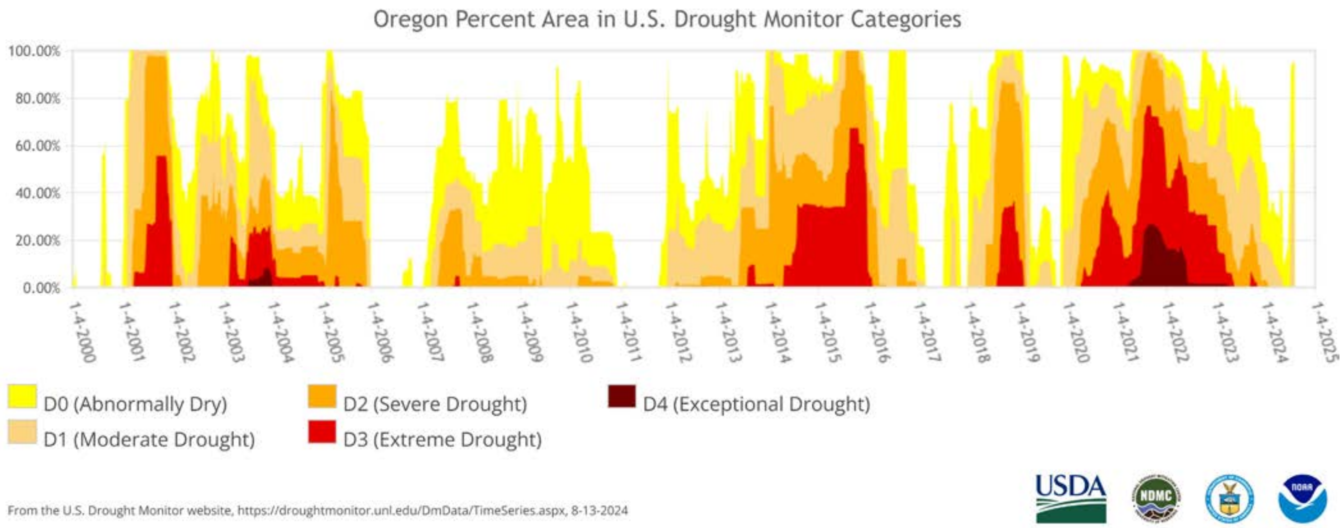


Figure 22. Drought trend since 2000 that shows the average proportion of Oregon that experienced each level of drought each year since 2000. In recent years larger proportions of the state (peak heights) have experienced longer periods (width of peaks) of more intense (increasing red color) (U.S. Drought Monitor).

Weather consists of short-term or less predictable events such as storm-related wind, ice, snow, floods or high heat events. In June 2021, the PNW experienced a record-breaking heat event termed a 'heat dome'. Many parts of Oregon experienced three sequential days between 110-120°F temperatures, which is 30°F higher than is typical for that time of year. Direct damage to trees from sun scorch was visible across the landscape. Although many trees rebounded with new foliage the next year, growth loss due to amplified evapotranspiration and reduced photosynthesis is likely, and long-term impacts of this unprecedented heat stress in trees are unknown. The heat dome was an example of a rare weather anomaly caused by persistent high-pressure systems that prevented warm air from rising and blocked cooling maritime winds (NW Climate Hub). Although this event would have occurred regardless of climate change, temperatures were about 3.6°F higher than they would have been in the absence of climate change and may occur more frequently (Philip et al. 2021).

Recent climate and weather conditions

In the past 30 years (1994-2024), mean temperatures in early summer started peaking above the average more often for this period starting in 2013 and trending toward increasing temperature relative to this 30-year average, at a rate of +0.4°F per decade (Fig. 21). The mean annual temperature for all of 2024 in Oregon (48.1°F) was 0.1°F higher than the current 30-year average (1994-2024) and 1.2°F higher than the previous 30-year average (1964-1994) (https://climatetoolbox.org accessed on 11/27/24). In 2024, the mean temperatures for each month were above the 30-year average with the greatest departure in April. By the end of summer and into fall average conditions were a bit warmer and drier than average. Higher than average temperatures occurred across the state but were most intense in southwest, central and northeast Oregon. Trees in these regions are often better acclimated to warmer, drier conditions, and they may tolerate short, mild droughts. However intense, prolonged, or frequent drought can damage or kill even the most drought-tolerant trees such as ponderosa pine.

In the past 30 years (1994-2024), annual means of statewide precipitation in early summer have remained mostly below normal for this period except for a few acute, high-yield events, and trended toward decreasing precipitation at a rate of 1.59 inches less moisture per decade (Fig. 21). The mean total precipitation for 2024 in Oregon (36.46 inches) was 4.39 inches higher than the current 30-year average (1994-2024) and 4.22 inches higher than the previous 30-year average (1964-1994) (https://climatetoolbox.org accessed on 11/27/24).

The increased precipitation in 2024 was indeed promising for encouraging recovery in drought-stressed trees; however, it takes more than a single year of increased moisture for trees to recover especially when this moisture follows multiple years of drought. The timing, consistency, and duration of precipitation through the water year are equally as important as the total volume of precipitation accumulated through the water year. Trees need moisture during their peak growing periods, and time to slowly absorb moisture. And acute high-precipitation events in between dry periods are not sufficient for uptake. Additionally, during latent periods of slow recovery following intense drought stress, tree defenses are lowered, making trees much more susceptible to insects and diseases for one to several years. In 2024, Oregon experienced higher than average precipitation along the coast and the mid to northern Cascades, but decreased precipitation in Central Oregon east of the Cascades and in the Blue Mountains of Northeastern Oregon. We had a warm fall of 2023 and extremely low snowpack relative to the 1991-2020 average. We experienced some drought recovery starting in January 2023 which brought us back up to normal levels from winter 2024 to summer 2024 (National Weather and Climate Center). As of December 2024, water storage was higher than normal in eastern Oregon and mixed elsewhere, although generally not too much below normal in most of those areas.

Climate and weather outlook

Every two years the Oregon Climate Change Research Institute produces a legislatively mandated climate assessment for Oregon. From the Sixth Oregon Climate Assessment (2023):

"Oregon's annual average temperature increased by about 2.2°F per century since 1895. If greenhouse gas emissions continue at current levels, annual temperature in Oregon is projected to increase by 5°F by the 2050s and 8.2°F by the 2080s, with the greatest seasonal increases in summer. Precipitation is projected to increase during winter and decrease during summer, and the number and intensity of heavy winter precipitation events is projected to increase. Furthermore, the proportion of precipitation falling as rain rather than snow is expected to increase."

Currently, the earth is in an interglacial/warm period which is predicted to last for another 8,000 years (Mörner 1972), and the PNW has been in a cooler Pacific Decadal Oscillation since 2020, which may last another couple of decades (NOAA). As of winter 2024 we have entered a mild, cooler and wetter La Niña (NOAA) predicted to last through January 2025 (NOAA Climate Prediction Center). It is too early to predict likely precipitation patterns for spring or summer 2025. Silvicultural planning should incorporate climate-adapted practices that promote stand resilience to higher temperatures and less consistent precipitation (Climate-adapted forestry guidance p. 18).

Resources:

- Oregon Water Resources Department monthly drought report email: https://tinyurl.com/drought-report-email
- Western Regional Climate Center: https://wrcc.dri.edu/
- National Integrated Drought Information System: https://www.drought.gov/
- Drought Impacts Toolkit: https://droughtimpacts.unl.edu/Home.aspx
- Multi-agency Climate Toolbox: https://climatetoolbox.org
- Climate Prediction Center 3-month outlook: https://www.cpc.ncep.noaa.gov/products/predictions/long_range/seasonal.php?lead=2
- El Niño and La Niña tracker: https://www.climate.gov/news-features/blogs/enso
- Sixth Oregon Climate Assessment: https://blogs.oregonstate.edu/occri/oregon-climate-assessments/

Impact of high temperatures and drought on trees:
Trees have a long 'memory' and are not just impacted by current year conditions. When tree tissues are damaged by events such as high temperatures and drought, they cannot simply be fixed or immediately revived by improved conditions; instead they need time and resources to rebuild. Drought causes root dieback, water-transporting vascular tissue collapse, and premature loss of photosynthesizing leaves - all of which decrease tree growth and defenses. Trees can respond to drought stress over a short period by closing breathing holes (stomata) in leaves to reduce natural water loss. When stomata close, photosynthesis is halted. After a period of paused photosynthesis, leaves and then other tissues start to die. Trees can rebuild these tissues if enough moisture is received over a sufficient period of time; however, each stress event weakens a tree. For most tree species in the PNW, there are no long-term drought-tolerance solutions, and prolonged or repeated droughts often result in mortality, sometimes years after the event(s). Mortality from drought stress has even been observed recently in western juniper, our most drought-tolerant tree that can survive in areas that receive <10 inches of water a year. A simple way to track tree growth and vigor is by taking core samples and observing the width of growth rings. Tree growth is affected by a variety of factors, but climate is often a primary driver. Changes in tree ring width from year-to-year frequently correspond to interannual changes in climate (Fig. 23). For example, timing and duration of compacted ring growth that follow a drought period can be an indicator of drought stress. If detected early, a trend in reduced growth in core samples may indicate trouble before external symptoms, such as crown thinning or topkill, are visible.

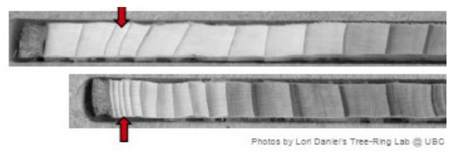


Figure 23. Compressed growth rings due to drought (Lori Daniels, UBC).

Impacts of drought on trees:
- https://www.youtube.com/watch?v=rzz5aThXIiE&feature=youtu.be
- https://sflonews.wordpress.com/2021/08/12/drought-and-tree-mortality-in-washingtons-conifers

Tree resilience to climate varies widely among species due to various strategies that reduce water loss or increase water use efficacy. Some of the first significant impacts of climate on our tree species have been identified in our least drought-tolerant species such as western redcedar (Fig. 24). We recorded multiple years of sudden crown thinning, topkill, and dieback throughout the range of western redcedar – even in the shaded, moist areas where it should be thriving. However, these sites were no longer providing enough moisture. Precipitation levels or consistent precipitation have fallen far below what these trees have been used to. Recent research has indicated that even damaged areas can show some recovery if moisture availability increases (https://tinyurl.com/WRCStorymap). In areas where western redcedar is struggling but can be retained, it is advised to increase moisture availability by reducing local competition. In drier areas, integration of more drought-tolerant species is suggested. As drought conditions intensified, we have observed injury and mortality in other less drought-tolerant species such as true fir species and later our moderately drought-tolerant species such as Douglas-fir, particularly acute in poor quality or extremely drought-stressed sites. Most recently, drought-caused dieback has been observed even in our most drought-tolerant species such as ponderosa pine (Fig. 14) and western juniper.


Figure 24. Thinning crowns in redcedar indicating decline (Christine Buhl, ODF).

There is also variation within tree species. For example, there is one species of Douglas fir but two varieties (*Pseudotsuga menziesii* var. *menziesii* and var. *glauca*). Furthermore, there are different seed zones in which Douglas-fir parent stock has adapted to over time and passes along these adapted characteristics in seeds. The impact of climate can be stronger at some sites due to site factors that influence microclimate. Site factors such as soil texture, soil depth, slope, aspect, hydrology, and physiography, can intensify or protect trees from climate stress. Trees develop adaptations to local conditions and their origin or "provenance" is categorized into seed zones that predict where a genotype is best suited. In some cases, drought-intolerant species have encroached into areas that are less suitable for their needs due to management decisions such as suppression of natural fire cycles. In other cases, trees are growing in their adapted provenance but the climate conditions around them have quickly changed and may be intensified by poor site conditions such as inadequate soil types, making sites more hospitable to trees from a different seed zone.

Climate change is a global, systemic issue that requires more money, legislative support, and innovation. Landowners can apply climate-adapted strategies to increase resilience to predicted future conditions. Changing climate may be contributing to range shift or shrinkage in our less drought-tolerant species, but we have strategies to establish and retain healthy forests. These strategies increase the resilience of trees, not just to drought, but also to wildfire and pests. Agency efforts are underway to provide landowners with more tools, guidance, and financial assistance to apply operationally effective strategies. Some of these tools and strategies are already available and incorporation on even a small-scale at any stage of forest management is advised.

- Account for increasing temperature and less consistent precipitation in selecting species and managing stand density
- Account for site factors that influence microclimate
- Reduce competition for moisture from overstocked stands and invasive weeds
- Retain species where they are doing well. Where they are struggling, attempt small-scale shifts toward more appropriate species or seed zones

Figure 25. Premature foliage loss and branch dieback due to drought (Christine Buhl, ODF).

Landowner assistance potential funding sources:

- ODF:
  https://www.Oregon.gov/odf/AboutODF/Pages/GrantsIncentives.aspx
  https://www.Oregon.gov/odf/working/Pages/federal-forest-restoration-program.aspx#:~:text=The%20Technical%20Assistance%20and%20Science%20Support%20(TASS)%20%E2%80%8Bprogram,increase%20the%20pace%2C%20scale%20and%20quality%20of%20restoration
  https://www.Oregon.gov/odf/forestbenefits/pages/urbanforests.aspx
- OSWA chapters: https://oswa.org/local-chapters
- NRCS: https://www.nrcs.usda.gov/conservation-basics/conservation-by-state/Oregon/whats-available-in-my-county
- SWCD: https://geo.maps.arcgis.com/apps/instant/lookup/index.html?appid=31b2f5ae9d494ecfbf7ff2608061a63f
- OWEB: https://www.Oregon.gov/oweb/grants/pages/grant-programs.aspx

Climate-adapted forestry guidance:

1. Track current and projected climate as a decision-making tool: https://tinyurl.com/drought-report-email
2. Plant the right tree in the right place.
   - Know your tree species requirements: https://plants.usda.gov/home
   - Plant within a species' range rather than along the edge. Be aware that ranges may be shifting due to climate change: https://usfs.maps.arcgis.com/apps/webappviewer/index.html?id=4ebf103ddeeb4766a72e58cb786d3ee2
   - Account for increasing temperature and inconsistent or lower precipitation potential at sites when considering species, genotype, and origin/provenance/seed zone. Consider planting genetically improved seed that has been bred for increased vigor and range tolerance: https://www.Oregon.gov/odf/documents/workingforests/seedling-catalog.pdf. Incorporate seed zones that are predicted to do well under future climate conditions: https://seedlotselectiontool
   - Account for site conditions that affect microclimate such as soil type, aspect, latitude, elevation, exposure (e.g., edge effect or open-grown trees are more exposed to stress or damage from sun, wind, ice, and snow). Soil type and moisture potential are of particular importance: https://www.arcgis.com/apps/View/index.html?webmap=38a93357a08b4f6d94d7e07a424fafd5 (Select location for description, scroll down to "droughty soil", a value of 1 indicates potential for drought)
3. Establish trees well: https://www.Oregon.gov/odf/Documents/workingforests/reforestationguide.pdf
4. Reduce competition from weeds and less vigorous trees, and reduce stand density (Fig. 26) to more climate-adapted levels: https://catalog.extension.oregonstate.edu/em9206/html
5. Be able to diagnose early symptoms of abiotic and biotic stressors. Prevention is the most effective strategy for most stressors; however, early detection of the onset of symptoms may be sufficient for mitigation. Drought symptoms progress slowly and usually include: thinning crowns that may start at the top or are visible throughout; topkill in the uppermost portion of the crown; or scorched foliage margins (Fig. 25). Look for a pattern of these symptoms across species with low-moderate drought tolerance.

Figure 26. Comparison of annual ring growth between trees from high-density (left) and lower-density (right) stands (Christine Buhl, ODF).

ABIOTIC: 2024 WILDFIRE

Wildfire

2024 was an unprecedented year for wildfire in Oregon. The season began with milder conditions with improved drought levels compared with those in recent years and above normal snowpack in many areas. However, higher temperatures in July caused most of the state to enter high and extreme fire danger and multiple dry lightning thunderstorms ignited many fires throughout the state. Fire burned through a mosaic of almost 2 million acres in Oregon (Figs. 29 and 30), which is the largest amount of fire damage in Oregon since the start of reliable documentation began in 1992. Previous records include 1.3 million acres in 2020 and 1.29 million acres in 2012. A combination of fuel accumulation, overstocked forests, and climate change-driven dry seasons contributed to this predictable fire activity. Increased precipitation in August (more so in western and eastern Oregon) aided wildfire mitigation efforts near the end of the season although higher temperatures and drier conditions returned and continued late into October.

The state experienced six megafires (fires over 100,000 acres) in 2024. The largest fires (Durkee (294k), Battle Mountain (183k, Figs. 27 and 28), Rail Ridge (176k), and Falls (151k)) occurred in eastern Oregon and the Durkee and Battle Creek Complex were largely concentrated in grasslands. The majority of the fire starts were human-caused although the overwhelming majority of forest damage occurred from lightning-caused fires. The cause of several hundred fires is yet undetermined.

Figure 27. Battle Mountain Fire (ODF).

Tools for wildfire prevention, mitigation, and recovery are improving. Technologies that aid early detection such as the FLIR, camera detection systems, and lighting strike detection have improved identification of wildfire starts and location for faster fire suppression. The 20-Year Landscape Resiliency Strategy is on track with identifying priority areas for treatments such as fuels reduction and post-fire restoration. In 2024, this program was involved in allocation of $14 million in state funds for wildfire mitigation projects.

Wildfire resources:

- ODF wildfire financial assistance: https://tinyurl.com/ODFcostshare
- ODF Help After Wildfire: https://www.Oregon.gov/odf/fire/Pages/afterafire.aspx
- Post-fire Tree Mortality predictive guide: https://tinyurl.com/ODFpostfire
- Oregon Wildfire Response & Recovery: https://wildfire.Oregon.gov
- Make your home Firewise: https://www.nfpa.org/education-and-research/wildfire/preparing-homes-for-wildfire

Figure 28. Battle Mountain Fire (ODF).

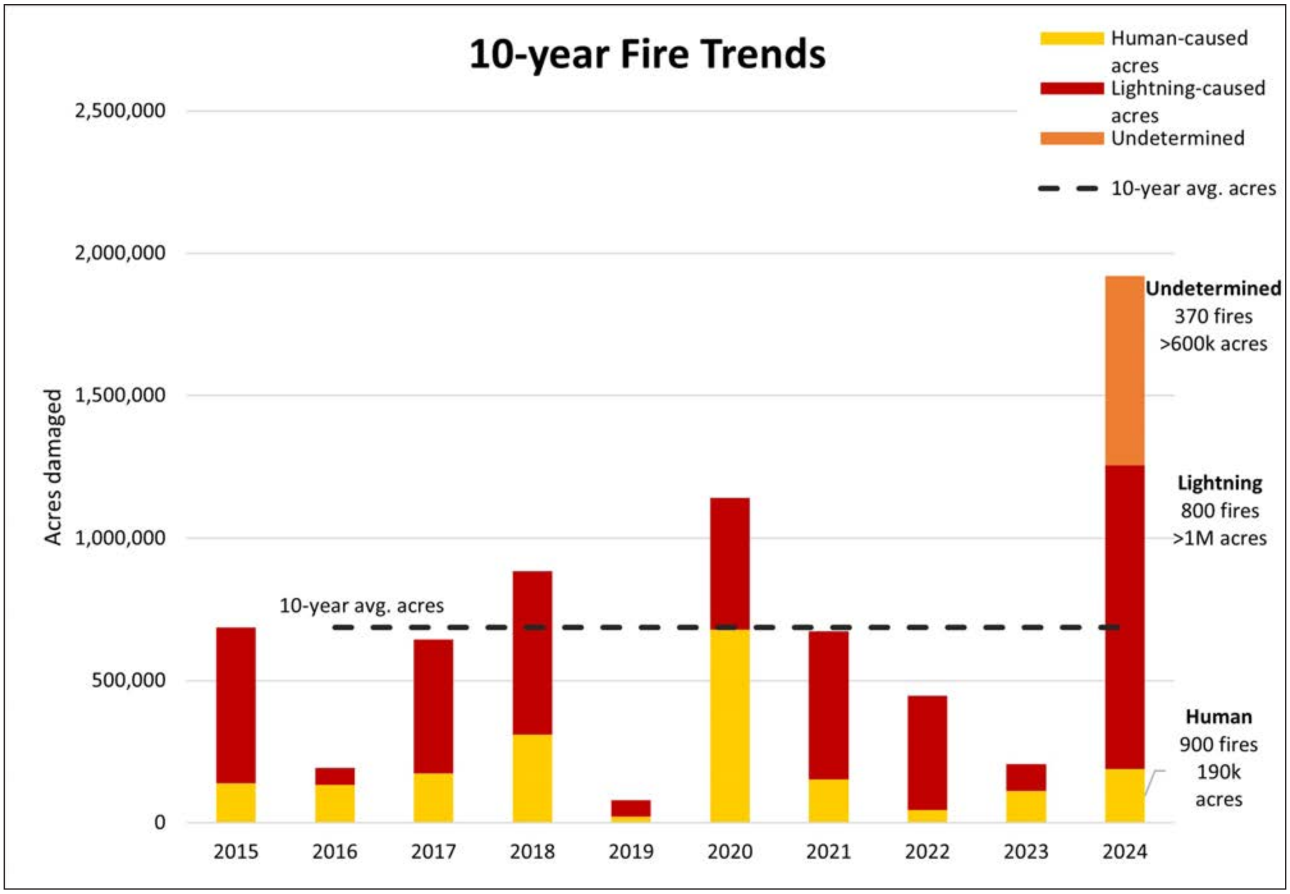


Figure 29. Oregon 10-year statewide wildfire trends across all ownerships and all protection districts (USFS, BLM, ODF, tribal, etc.). Wildfire data from the Northwest Interagency Coordination Center.

ABIOTIC: 2024 WILDFIRE

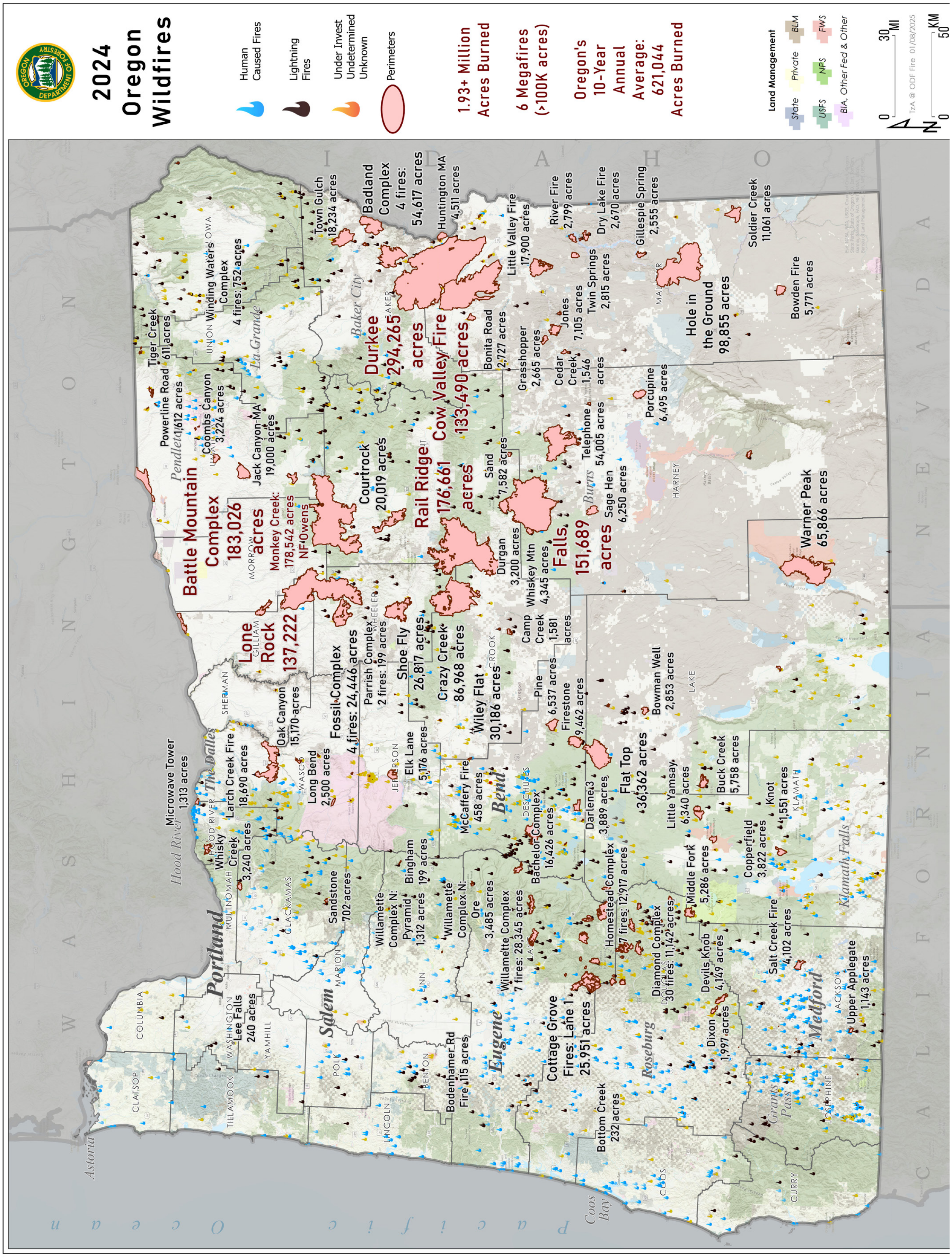


Figure 30. Map of statewide wildfires in 2024 (Teresa "TzA" Alcock, ODF).

WILDFIRE x INSECT PESTS

The majority of studies indicate that excess tree mortality from insect outbreaks doesn't necessarily result in increased fire risk. Beetle-killed trees that retain red, dry needles are highly flammable. However, once needles have dropped bare trees are less flammable than green trees. Tree species such as true fir retain their red needles longer, which may extend their risk of increased flammability. Trees such as pine that exude pitch tubes when attacked by bark beetles, may increase the vertical connectivity of fuel, presenting an increased risk of tree torching or crown fire behavior.

Trees that survive a fire, but are damaged, have weakened defenses and release chemicals that are attractive to insects. In Oregon, insects such as bark beetles and flatheaded fir borer can attack and kill these trees that are still alive if the phloem layer is not too damaged. These opportunistic insects reside just under the bark but do not tunnel into the wood. These tree-killing insects typically infest within the immediate few years following fire. Their populations can build in fire-damaged and otherwise stressed trees and spread into healthy trees, overwhelming their defenses, resulting in an outbreak. Many of these insects are native, widespread, and part of a healthy ecosystem when their numbers are at normal levels. *Most* of our native woodboring insects do not typically kill trees, but can infest severely damaged and dying trees (Fig. 31). As the name suggests, these woodboring insects tunnel into the sapwood of trees they infest, causing defects in merchantable timber. Woodboring insects include various roundheaded, flatheaded, and ambrosia beetles, and woodboring wasps: https://www.Oregon.gov/odf/Documents/forestbenefits/Woodboringbeetles.pdf

Post-fire forest health best management practices:

1. Focus restoration efforts on the least damaged or most resilient stands. Focus salvage and replant efforts on the more damaged stands.
2. Remove fire-damaged trees that are still alive and any other trees showing signs of stress, to reduce reservoirs for pest outbreaks that may spill over into healthy trees. Identify and remove trees with levels of crown scorch and/or bole char that may result in mortality or insect attack: (summary guide) https://tinyurl.com/ODFpostfire | (full guide) https://tinyurl.com/postfireguide
3. Remove and process merchantable salvage timber within the year, or as soon as possible, to reduce defect from woodboring insects and fungi.
4. Treat fire-damaged stands of >10" DBH Douglas-fir with MCH repellent the March after a wildfire, to prevent population buildup of Douglas-fir bark beetle in live, fire-damaged trees: https://www.Oregon.gov/odf/Documents/forestbenefits/mch-for-douglas-fir-beetle.pdf
5. Destroy slash from pine species (3-8" diameter) before April Ips beetle flights, or within 2 months of slash creation: https://www.Oregon.gov/odf/Documents/forestbenefits/Slashmanagement.pdf
6. Replant with seedlots appropriate for future climate predictions (Pg. 15).
7. Incorporate diversity in tree species, age, size, spacing, and stand patchiness wherever possible.
8. Consider implementing conservation strategies during post-fire restoration efforts, such as: adding pollinator plants to erosion control seed mixes; replanting riparian areas with the same pre-fire tree communities that support terrestrial and aquatic communities; and allowing growth of non-invasive understory plants as refugia for natural enemies in the understory, along roadsides, and around leave trees. During clearcuts, consider leaving clusters of leave trees that are skipped during herbicide treatments to create pockets of wildlife habitat.

Figure 31. Woodboring beetle larvae (top) cause defect and can even be heard chewing during or immediately after fire damage. Indicators of woodborer activity include: pale boring dust in bark crevices (middle) and feeding galleries and round or oval holes in wood (bottom) (Christine Buhl).

Often, biotic agents such as insects and diseases are blamed for tree damage or mortality but may be ruled out with closer inspection of signs and symptoms.

Figure 32. Holes with a messy perimeter (left) or arranged in a row (middle) are from woodpeckers and round or oval holes with a perfect perimeter as if created by a drill bit (right) are from beetles (Christine Buhl, ODF).

Figure 33. Large pitch masses (left) are often from mechanical injury and small masses (middle) or individual droplets or streams (right) are from beetles that are small enough to only elicit slight sap flow (Christine Buhl, ODF).

Figure 34. Slow decline in the form of crown thinning or topkill (left) or reduced and ragged crowns (right) is often a result of drought. Although some beetles can cause topkill, the rest of the crown usually turns red within 1-2 years of topkill, and these insects themselves are indicators of underlying drought stress (Christine Buhl, ODF).

In healthy forests, insect activity is normal and part of ecosystem functioning. Many insects are constantly working in the background providing ecosystem services such as decomposition of dead plants and animals for nutrient cycling, pest control via predation and parasitism, pollination, etc. At endemic, or low populations levels, most native and exotic (non-invasive) insects do not impact trees. When these insects cause visible damage, there is often an underlying cause such as abiotic stress that should be addressed. In some cases, population increases are cyclical and usually collapse on their own.

Figure 21. QR code linking to fact sheets on forest insects and diseases.

The most significant insect activity observed in 2024 resulted from:

- Western pine beetle in 23,000 acres of ponderosa pine east of the Cascades that are stressed by drought, some growing in poor quality soils
- Fir engraver in 20,000 acres of true fir species concentrated around the Cascades that is either stressed by drought or spreading to fringe lowland habitat due to years of fire suppression
- Mountain pine beetle in 16,000 acres of pine species, targeting dense stands of lodgepole or drought-stressed ponderosa east of the Cascades
- Flatheaded fir borer in 10,000 acres of Douglas-fir in southern Oregon and parts of the Willamette Valley that have suffered from years of drought stress, some growing in poor soils or sites
- Balsam woolly adelgid in 12,000 acres of true fir species occurring mostly at high elevations

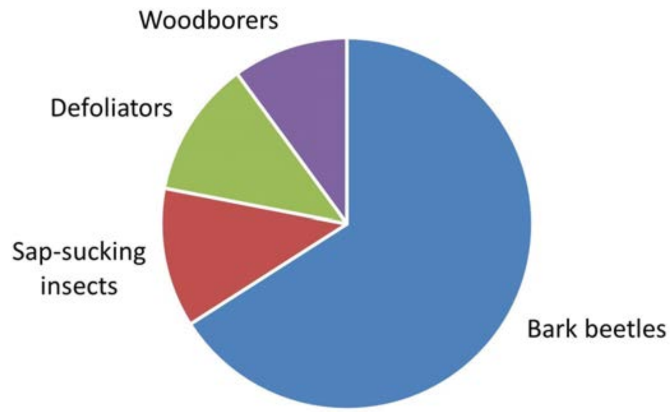


Figure 35. Proportion of damage by each forest insect pest functional group.

Western pine beetle (*Dendroctonus brevicomis,* Fig. 36), **fir engraver** (*Scolytus ventralis,* Fig. 37), and **mountain pine beetle** (*Dendroctonus ponderosae,* Fig. 37) are bark beetles that are native, widespread and can kill unhealthy trees. They can then increase in number and spread into healthy trees, overwhelming tree defenses. Drought is particularly stressful for tree defense against bark beetles because it reduces available moisture and thus pitch, which is an essential mechanical and chemical barrier. Bark beetles etch brood galleries under bark that girdle vascular tissues and, when trees are weakened, large numbers of bark beetles can cause enough damage to result in tree morality. Bark beetles use chemical cues to identify stressed trees and attract others to build large populations in stressed trees.

Figure 36. Western pine beetle diagnosis: pitch tubes (left), flecked off bark from woodpeckers (middle), meandering galleries on interior bark but not etched into sapwood (right) (Christine Buhl, ODF).

Figure 37. Fir engraver diagnosis: topkill and horizontal galleries etched into sapwood (left); Mountain pine beetle diagnosis (right): pitch tubes and J-curved galleries etched into sapwood (Christine Buhl, ODF).

Flatheaded fir borer (*Phaenops drummondi*, Fig. 38) is a woodboring beetle but despite the name, it does not tunnel into wood and instead behaves like a bark beetle by feeding under the bark and girdling vascular tissues. Unlike bark beetles, this insect does not use chemical communication to build populations and can only kill trees that are severely stressed.

Figure 38. Flatheaded fir borer diagnosis: flecked off bark from woodpeckers, pitch droplets, oval exit holes in bark but not wood, flatheaded grub in bark but not wood (Christine Buhl, ODF).

Balsam woolly adelgid (*Adelges piceae*, Fig. 40) is a long-established, exotic, invasive insect that has been contributing to widespread injury and mortality in true fir species for years. U.S. populations of this insect can only travel from tree to tree by crawling or blowing on the wind but they have become a chronic pest in contiguous stands of true fir species, which are more common at higher elevations (Fig. 39). Many true fir species thrive at cool, moist elevations because they are not generally drought-tolerant. The range of true fir species is shrinking due to climate change and further compounded by this insect. Balsam woolly adelgid slowly injures and disfigures true fir species over time and eventually, going unchecked, causes tree mortality.

Figure 39. Forests dominated by true fir that have experienced chronic dieback from balsam woolly adelgid and the effects of drought (Christine Buhl, ODF).

Figure 40. Balsam woolly adelgid diagnosis: white, woolly insects on needles or trunk, galls, deformed crowns, foliage loss which unveils dark moss and lichens (Christine Buhl, ODF).

Other impactful insect pests on our landscape include the recently detected exotic invasive emerald ash borer and Mediterranean oak borer. These insects are affecting smaller acreages; however, they are targeting ash and oak which are two ecologically important species. Ash is dominant in riparian areas, especially in the Willamette Valley and areas of the lower Umpqua and Rogue Rivers. It provides shade and bank stabilization. Oak is the primary overstory in savanna ecosystems and one of our most drought-tolerant trees. The loss of either of these species increases the risk of changes to ecological function and a shift away from native habitats. Japanese cedar longhorned beetle is another recently detected insect, and we do not yet know the impact this insect may have on our native "cedar" species. As with most exotic insects, it is important to report suspected infestations (https://oregoninvasiveshotline.org) and prevent moving firewood (https://www.dontmovefirewood.org/map/Oregon).

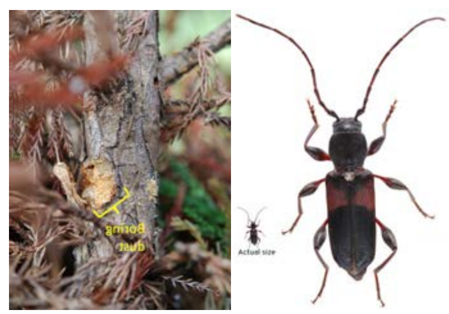


Figure 41. Japanese cedar longhorned beetle larval feeding results in pale boring dust (left, Sven-Erik Spichiger, WSDA). Adults create 3mm oval exit holes. Evidence of damage is likely to be seen more frequently than the beetle itself (right, ODA).

Japanese cedar longhorned beetle (*Callidiellum rufipenne*, Fig. 41) adults were first detected in Oregon in a residential wood chip drop in Portland in 2023, and traps in 2024 yielded additional populations. This insect is from east Asia and was first detected in the U.S. in North Carolina in 1997. Preferred hosts include juniper, Port-Orford cedar, western redcedar, and arborvitae. It is unknown what other native species it may infest; however, it is known to feed on true fir and pine species in its native range. This insect is a concern for western redcedar, which is already stressed by drought.

Figure 42. Dieback of oak crown (left) and boring dust (right) from Mediterranean oak borer (Christine Buhl, ODF).

Mediterranean oak borer (*Xyleborus monographus*) was first detected in Oregon in a trap in 2018 and since then has been observed killing oaks mainly in the northern Willamette Valley. It likely arrived via wood shipments from overseas such as wine barrels. This tiny ambrosia beetle introduces fungi that can kill oaks. This insect has also been detected in California and a multi-agency task force has been working on determining pathways of MOB introduction, distribution, and management strategies. Initial symptoms of infestation include dieback in oak of a whole branch or large sections of crown (Fig. 42). Pale boring dust may also be visible in cracks in the lower trunk.

Emerald ash borer (*Agrilus planipennis*) www.OregonEAB.com

New detections expand state quarantine
In 2024 several survey and monitoring projects for EAB took place across the state involving numerous agencies and landowners. The project coordination occurred through the Emerald Ash Borer Task Force, led by the Oregon Department of Agriculture (ODA). Three additional counties (Yamhill, Marion, and Clackamas) were added to the state quarantine after new detections of EAB were reported from those locations in 2024 (Fig. 43). In Yamhill County, the detection is believed to be from the expanding population first discovered in 2022 centered around Forest Grove in Washington County. The positive detections in Marion and Clackamas counties indicate a previously undiscovered population of EAB. The state quarantine prohibits the movement of unprocessed ash wood and all hardwood firewood out of the four-county area.

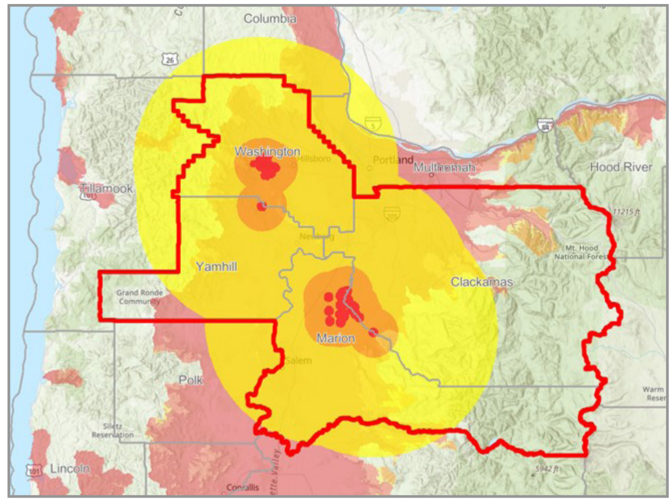


Figure 43. Emerald ash borer occurrences in Oregon (red dots). New detections were made in 2024 in Yamhill, Marion and Clackamas counties. The background shows the areas at risk for future spread of EAB in the state. See OregonEAB.com for interactive map.

Statewide EAB trap survey
In 2024, the USDA Animal and Plant Health Inspection Service (APHIS) provided purple prism traps, green funnel traps, and plant volatile lures to local governments and other cooperators who wished to survey for EAB in their jurisdictions. ODF Forest Health delivered trap supplies and provided methods and technical assistance to those local governments as well as organized incoming data and provided a real-time web map of trap locations. Trapping season started in May and concluded at the end of September. Of the 199 traps deployed, two were positive, both purple prism traps. One trap in Yamhill County had a single adult, while another trap in Marion County had five adults. These trap detection suggest high population density in the area; although no declining or infested trees were found nearby (Fig. 44).

Figure 44. Small stand of roadside ash trees in Marion County (left), purple prism trap with three adult EAB circled (middle), and adult EAB captured on purple trap (right) (Wyatt Williams, ODF).

Public reports of EAB
In 2024 there were nearly 90 reports of suspected EAB to the state's invasive species online hotline. After review, five were confirmed as EAB, all within the known extent of the Forest Grove EAB population. Many other reports were emailed directly to agency staff.

One of these reports from Clackamas County came from a professional arborist and was confirmed by ODF as EAB. Subsequent ground surveys in the area revealed hundreds of infested ash trees in riparian areas along Butte Creek (the border between Clackamas and Marion counties) as well as the Pudding River. Infested trees were found in the communities of Mt Angel, Woodburn, and Scotts Mills. This second discovery of EAB in Oregon is separate and distinct from the Forest Grove EAB population, and appears to be much further in progression (Fig. 43). It is likely that it has been present and growing for ten years or more.

Figure 43. Mortality of ash from EAB in riparian area in Clackamas County (left). Serpentine galleries of EAB in a heavily infested dying ash tree (right) (Wyatt Williams, ODF).

Slowing ash mortality

In 2024, ODF cooperated with ODA, the lead agency in the state's campaign to slow the spread of ash mortality (SLAM) due to EAB. In spring, more than 200 trees were chosen along the expanding front of the Forest Grove EAB population. These trees were girdled, attracting any EAB that were potentially in the area. The girdled trees were later harvested and systematically surveyed for EAB. Any infested trees were destroyed. The SLAM project is a tool to determine the year-to-year spread and density of EAB on the landscape, while also serving to reduce the local EAB population, slowing its spread. The known infestation area is currently at 25 square miles.

Outreach and training

Because EAB is expected to have a large financial impact on communities and homeowners, especially in the Willamette Valley, in the coming years, there was a big effort to conduct public outreach and education. In 2024, staff from ODF and partner agencies conducted outreach on the risk and management of EAB at more than 50 events, reaching more than 4,000 people (Fig. 44).

Figure 44. The creation of two new positions for EAB support has allowed ODF to educate thousands of urban forestry and small woodland clients on preparing for emerald ash borer (Wyatt Williams, ODF).

Phytophthora austrocedri: An Emerging Invasive Pathogen Threat to Juniper and Cypress

Phytophthora species significantly threaten tree health when introduced into new forest ecosystems, typically through infected plant nursery stock. The ability of *Phytophthora* species to spread through contaminated water and soil, along with their survival under harsh conditions, makes disease management very difficult once they become established. *Phytophthora austrocedri* (Figs. 45 and 46) is an aggressive soilborne plant pathogen of unknown origin that was identified on symptomatic common juniper plants at two Oregon nurseries in late 2023 and 2024. This is the first report of this plant pathogen in North America. USDA Animal Plant Health Inspection Service, Oregon Department of Agriculture, and the two nurseries cooperated to destroy infected plant material and monitor the areas. However, based on surveys and interviews of employees at both nurseries, it is likely that the pathogen has been present for many years before the recent detections.

Figure 45. Phytophthora austrocedri killing juniper in UK (Crown Copyright, Forest Research).

Phytophthora austrocedri kills several juniper and cypress species in the family Cupressaceae; however, its impact on most North American plant species is unknown or unconfirmed. With funding from the USDA Forest Service, researchers at Oregon State University are evaluating Pacific Northwest conifers' susceptibility. Understanding the susceptibility of our native species and partnering across agencies will give us the best chance to prevent the introduction of this disease into nurseries, ornamental plantings, managed landscapes, or natural forests. This pathogen attacks the roots and stem bases, causing discoloration and death of the tree crown through disruption of water transport. The pathogen is primarily spread over long distances via human transport of infected plant material or locally through water and soil movement.

In forests of southern Argentina, the disease *mal del ciprés* or cypress sickness began causing stand-level Chilean cypress mortality in the late 1940s. *Phytophthora austrocedri* was identified as the cause of the disease decades later in 2007. By 2010, it was found on dying common juniper in northern England, and has now been confirmed at over one hundred locations across England and Scotland. Impacted species in Europe include planted Port-Orford-cedar (a common ornamental plant) and yellow-cedar. Yellow cedar is an economically, culturally, and ecologically valuable native tree in Alaska and throughout its range, including the Cascade Range in Oregon and Washington. Based on the locations where the pathogen has been established and its affinity for sites with high soil moisture, it is likely to survive well in wet, mild climates of the Pacific Northwest where yellow-cedar and other susceptible hosts occur.

Figure 46. Phytophthora austrocedri causing stem lesion on juniper in UK (credit: Crown Copyright, Forest Research).

Preventing unintentional spread and eradicating infected plant material are critical steps to ensure this pathogen does not impact Pacific Northwest forests. Despite state nursery inspection programs and importation protocols, the movement of live plants is the most likely method of disease introduction, and care must be taken to prevent unintentional planting of infected seedlings. Oregon State University Extension Service has compiled best practices guidelines: [Preventing Phytophthora Infestations in Restoration Nurseries]. Building awareness of this new disease threat, promoting early detection, and preventing its introduction can help us safeguard forests.

Sudden Oak Death (SOD) is caused by the non-native pathogen *Phytophthora ramorum*. In Oregon, it readily kills tanoak (*Notholithocarpus densiflorus*), creating girdle-forming canker lesions on the main stem (Fig. 47) and threatening the species throughout its natural range. *P. ramorum* has a broad host range of over 100 plant species, including several species native to Oregon's forests. The pathogen thrives in Oregon's wet and cool coastal climate, spreading from infected plants to other trees, shrubs, and nearby vegetation during rainy and windy periods. The disease can spread up to 3-5 miles per year through windborne spore distribution. Humans also contribute to disease spread by moving infected material, whole plants, plant parts, or infested soil.

Figure 47. Phytophthora ramorum kills tanoak by causing cankers on the main stem (ODF).

In 2024, fifteen new *P. ramorum* infestations were detected outside of the 2015 SOD Quarantine area. These new detections triggered an immediate expansion of the SOD Emergency Quarantine boundary, now approximately 148 square miles. (Fig 48). Using a 300-600 ft treatment buffer, 2024 eradication treatment areas totaled approximately 319 acres of private land, 156 acres on State Park lands, and 51 acres of U.S. Forest Service lands.

To monitor the spread of sudden oak death disease and detect new infestations, the Oregon SOD program uses various survey methods conducted throughout the year. These methods include aerial detection surveys enhanced by high-resolution digital imagery and ground verification, as well as ground-based transects and stream monitoring.

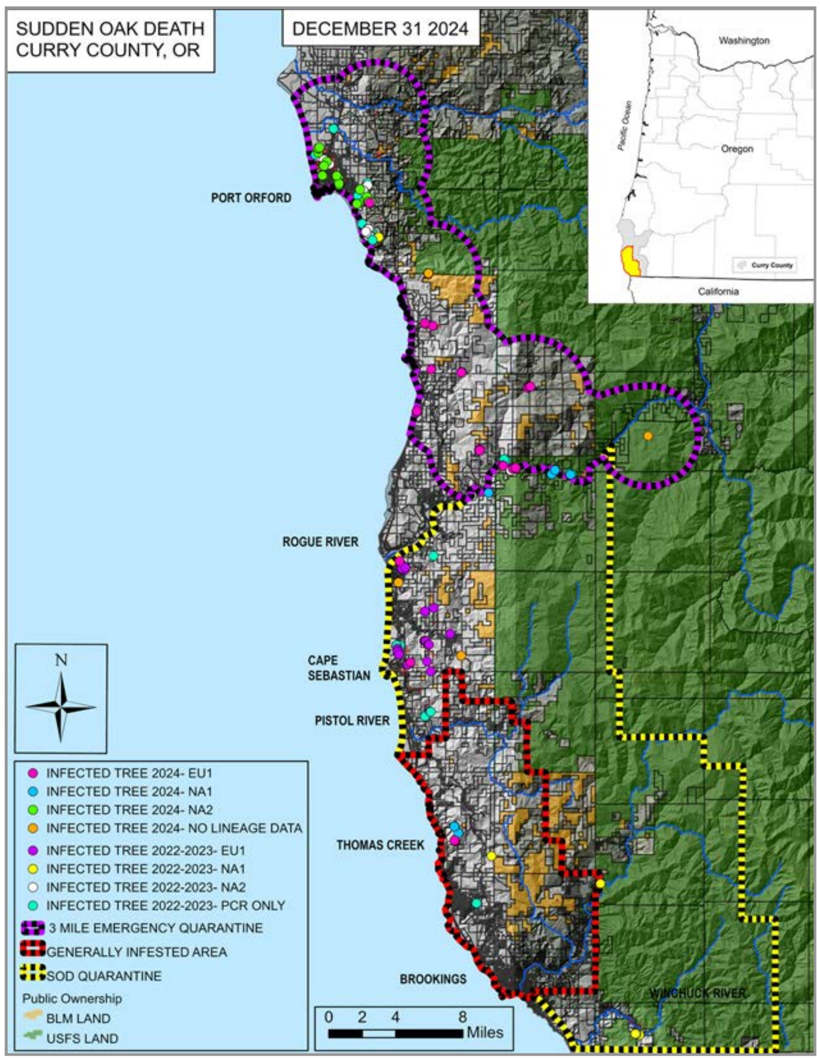


Figure 48. Location of sites infested with Phytophthora ramorum in southwest Oregon that were discovered in 2022-2024 (Sarah Navarro, USFS).

Oregon's *P. ramorum* stream baiting program, aimed at efficiently sampling entire watersheds for *P. ramorum*, began in late April and ended in December 2024, during which 64 stream drainages inside and outside the quarantine area were monitored. Thirteen streams contained plant material that tested positive for *P. ramorum*. Ground surveys are planned for the new drainages along the north bank of the Rogue River and a stream that flows into the Elk River east of Port Orford (Fig. 49).

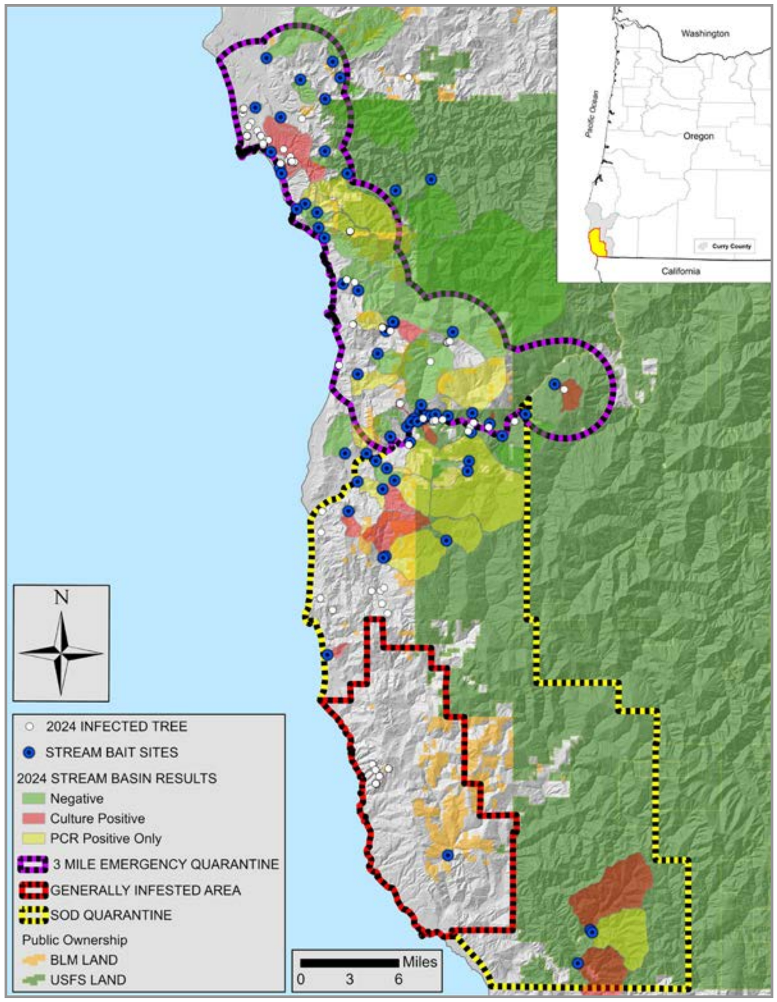


Figure. 49. 2024 Stream baiting drainages (64 total). Green or red drainages indicate negative or positive for Phytophthora ramorum respectively. Yellow indicates drainages positive for P. ramorum with molecular testing (Sarah Navarro, USFS).

In July 2024, the U.S. Forest Service and the Oregon Department of Forestry cooperative aerial detection survey team conducted a fixed-wing survey, followed by a helicopter survey, over forested lands in Curry County, to monitor the spread of disease and detect new infestations. These aerial surveys covered 787,500 acres of forested land. To complement the surveys, foresters from the Oregon SOD program began analyzing high-resolution imagery from 2024 outside the Generally Infested Area (GIA) to identify declining or dead tanoak trees. The imagery project area now spans approximately 539,000 acres (842 square miles), covering the region between the California border and Coos County. Ground surveys covered 860 acres, and 520 trees were sampled, of which 134 were positive for *P. ramorum*. SOD foresters conducted ground transect surveys covering 613 acres for the harvest of disease-free tanoak on private lands. Tanoak harvest is only allowed following the issuance of a special permit by the Oregon Department of Agriculture under OAR 603-052-1230, Oregon's *P. ramorum* quarantine rules.

Progress for Oregon's Slow-the-Spread Program in managing sudden oak death is updated monthly on the Oregon SOD Program Dashboard. Since the inception of the sudden oak death program, the Oregon Department of Agriculture (ODA) has expanded the quarantine boundary to address the spread of *P. ramorum* across the landscape. Although multiple new infestations have occurred outside the current official quarantine area, these regions are still covered under the existing ODA SOD regulations, which enforce quarantine in any area statewide where a SOD infestation is identified (OAR 603-052-1230(2)(d). Given the 23 new detections outside the 2015 SOD quarantine boundary since 2021, SOD program representatives have proposed expanding the quarantine and GIA. The new proposed quarantine area encompasses 901 square miles, or 45% of Curry County, reflecting a 15% increase since 2015. The proposed GIA area covers 178 square miles (Fig. 50).

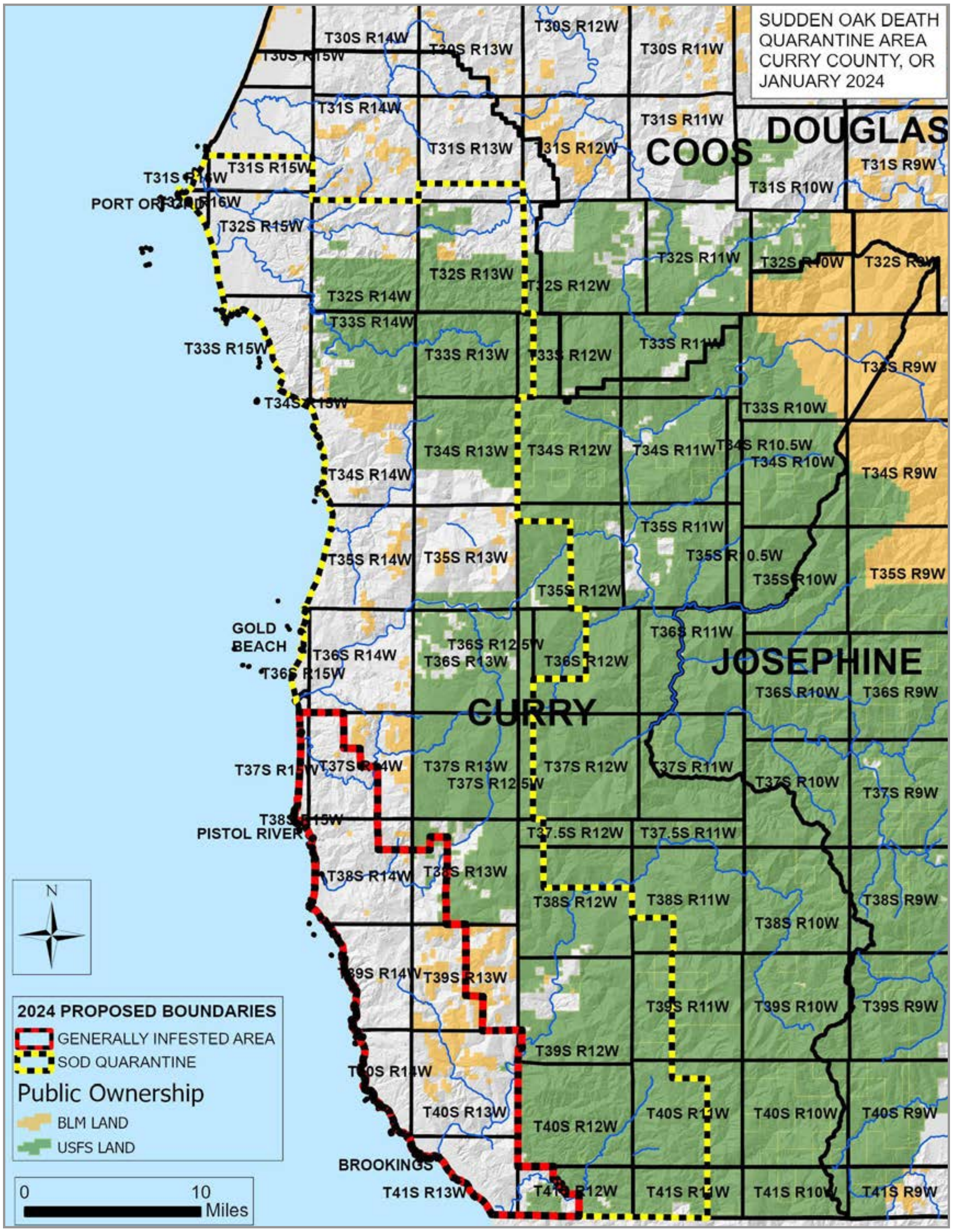


Figure 50. Proposed SOD Quarantine and Generally Infested Area boundaries (Sarah Navarro, USFS).

Resources:
http://tinyurl.com/SOD-Program
http://tinyurl.com/SOD-Guide
http://tinyurl.com/odf-foresthealth

Swiss needle cast (SNC), a native foliar disease of Douglas-fir, is caused by the fungus *Nothophaeocryptopus gaeumannii*. This disease has been prominent in Douglas-fir forests within 25 miles of the ocean since the 1990s. Early research into the emerging epidemic identified post-harvest species conversion to Douglas-fir within near-ocean stands, potential changes in influential climate variables, and planting off-site seed sources from areas with lower disease pressure and tolerance as factors increasing the prevalence and severity of SNC.

Figure 51. Heavily infected Douglas-fir shoot, with Nothophaeocryptopus gaeumannii fruiting bodies and yellowing foliage (Gabi Ritokova, ODF).

Fungal fruiting bodies on infected foliage block needle stomates and thus gas exchange; this early needle mortality can be thought of as a metaphoric strangulation (Fig. 51). Consequently, SNC-infected trees suffer from premature needle loss and reduced annual increment growth. Premature needle loss is most obvious in the tops of trees during the late spring prior to bud break, resulting in yellowing needles and sparse crowns (Fig. 52). Such trees provide a symptomatic color signature, visible from above, making the identification of infected stands possible using aerial survey. Aerial detection survey for SNC has been conducted since 1996, with symptomatic acreage (Fig. 53) generally increasing. In the 2024 Swiss needle cast aerial survey, approximately 900,000 acres were mapped in Oregon, representing approximately 500,000 acres of Douglas-fir affected by SNC.

Premature foliar loss has a significant effect on the growth and yield of infected Douglas-fir plantations. A 2008 analysis of SNC-related volume growth loss found that 10-30-year-old northern Oregon Coast Range Douglas-fir plantations were experiencing an average annual cubic volume growth loss of ~22%, with the most infected stands exhibiting volume growth losses as high as 50%. Subsequent analyses have shown that volume growth losses in the Oregon Coast Range exceed 190 million board feet per year. Analyses of more recent measurements have suggested that volume growth losses may have diminished somewhat but remain high enough that SNC continues to be an important consideration if financial returns for Douglas-fir production are an objective.

Figure 52. Heavily infected Douglas-fir stand, with yellowing Douglas-fir and dark green western hemlock and Sitka spruce (Gabi Ritokova, ODF).

Figure 53. Yellow foliage from SNC in Douglas-fir observed from aerial survey (ODF).

Collaborative research conducted over the last 25 years has explored numerous silvicultural means of counteracting the volume losses due to SNC, including thinning, multiple types of fertilization, and select genetics, but none of these tools has been found to provide a fix. Thinning from below can help maintain long crowns and diameter increment while focusing growth on those trees shown to best tolerate disease conditions. In a few cases, fertilization in SNC-infected stands has improved tree growth, but the low rate of response coupled with the high cost of fertilization makes this an impractical silvicultural intervention. While disease-tolerant genotypes have been identified, geneticists emphasize that this material is best used in areas showing only moderate levels of infection. Areas with high rates of infection are best planted to other, non-susceptible species.

Resources:
http://tinyurl.com/odf-foresthealth
https://sncc.forestry.oregonstate.edu

Calonectria californiensis

Leaf spotting and defoliation of Oregon myrtles (*Umbelluria californica*) (Fig. 54) have been observed in Coos and Curry counties, attributed to the newly named *Calonectria californiensis*. *C. californiensis* also affects other native trees and shrubs such as salal, mock orange, Oregon grape, native rhododendrons, and tanoak. Defoliation starts at the bottom of the tree and proceeds upward. Defoliation can be significant, sometimes affecting 80% of the tree (Fig. 55). The original symptoms were observed after a warm 2023-2024 winter followed by a wet spring. Areas with more severe defoliation were observed to be in drainage bottoms with diminished airflow, although some open grown Myrtles were also found to be severely defoliated.

Figure 54. Signs of blight in myrtle leaves (Gabi Ritokova, ODF).

Fortunately, many Oregon myrtles affected by the pathogen appear to have new foliage production. We are developing a data sheet with which interested landowners can help us monitor their myrtles' health and environmental settings. Unless an infected tree poses a particular hazard, we suggest that landowners take a wait-and-see approach to tree health recovery.

Figure 55. Myrtle crown dieback from Calonectria californiensis (Gabi Ritokova, ODF).

Citizen reports have played an important role in bringing these symptoms to the attention of local foresters, a valuable means of monitoring disease. To participate in the Oregon Myrtle monitoring project, report potential sightings on OSU's Myrtle Blight Monitoring form: https://oregonstate.app.box.com/s/y9afdolxw5b6a4n7dih5xe1kl9ei2htg.

Gilchrist State Forest Dwarf Mistletoe Survey

Gilchrist State Forest is a 65,000-acre State Forest managed by the Oregon Department of Forestry. Ponderosa pine and lodgepole pine dominate the forests, and sugar pine is abundant at higher elevations. One of the primary forest pests influencing the timber value and productivity of trees in the forest is dwarf mistletoe. Dwarf mistletoes are native parasitic flowering plants that infect conifers. Although a few plants in a tree crown have no real impact on the tree, a severely infected tree with abundant infections has reduced growth and stem deformation and may have tree-top and branch dieback. Dwarf mistletoe spreads by explosive discharge of the seed, which propels the seeds up to 35 feet. Mistletoe distribution is generally aggregated on the landscape, and severely infected trees will occur in distinct infection centers. Silvicultural techniques to reduce stand-level dwarf mistletoe ratings include minimizing the retention of heavily infected overstory leave-trees, cutting and thinning heavily infected understory trees, planting non-host trees around infection areas or around heavily infected leave-trees, prescribed fire, and creating gaps where heavily infected trees are aggregated.

On the Gilchrist State Forest, two dwarf mistletoes are present (Fig. 56): western dwarf mistletoe (*Arceuthobium campylopodum*) on ponderosa pine and lodgepole pine dwarf mistletoe (*A. americanum*). These two species are generally host-specific, although western dwarf mistletoe infecting lodgepole pine was observed several times.

Figure 56. Witches broom (left) caused by a stem infection of Arceuthobium campylopodum (left inset) on ponderosa pine and brooms (right) caused by a stem infection of Arceuthobium americanum (right inset) on lodgepole pine (Gabi Ritokova, ODF).

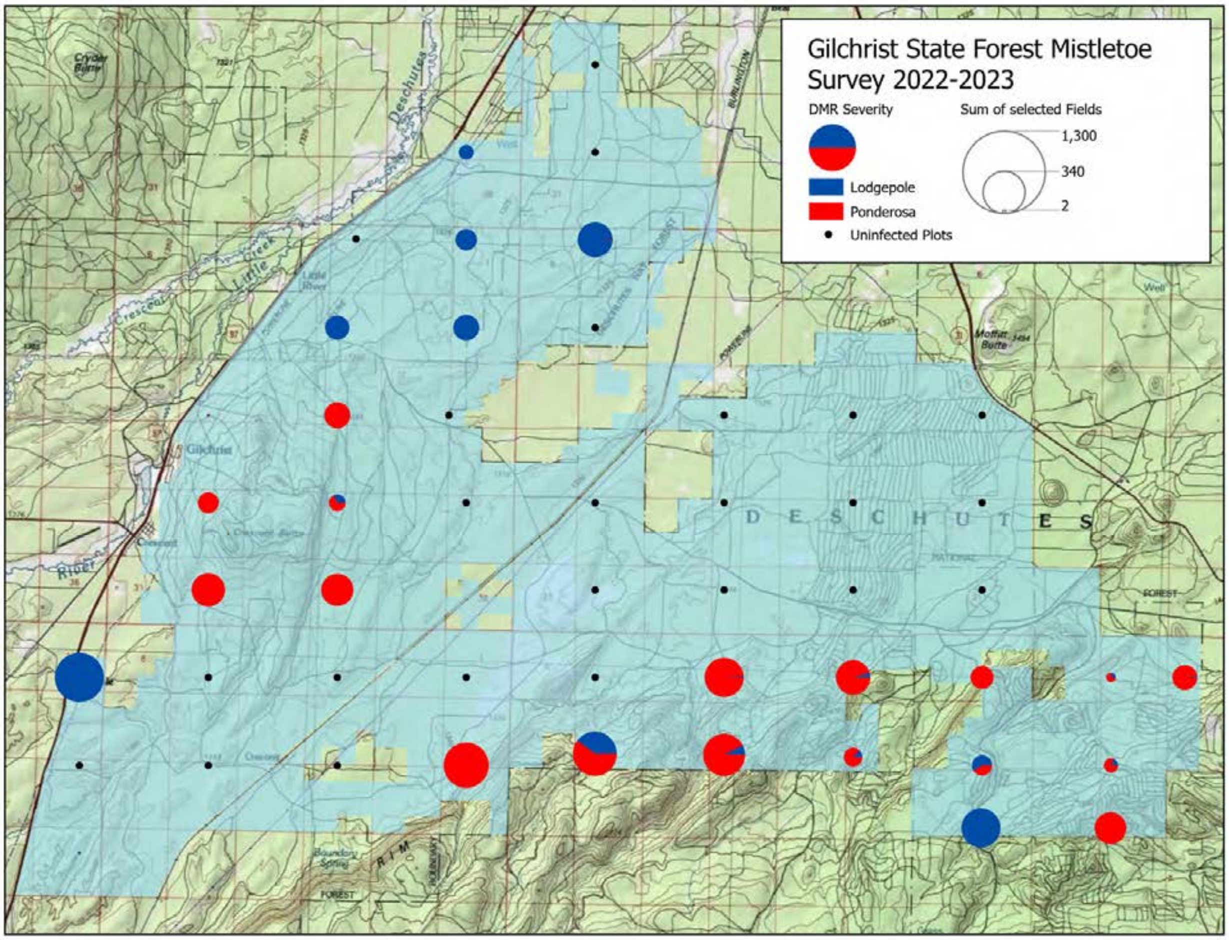


Fig. 57. Mistletoe survey map (James Monteil, ODF).

Fifty stands/locations were systematically selected for the installation of temporary transects. Within each stand, two 100 m transects were installed. On all trees within 5 meters of either side of the transect, the following were recorded for all trees greater than 5 cm DBH: species, DBH, and a dwarf mistletoe severity rating for each crown third. The severity rating values were 0 (no infection), 1 (moderate infection), or 2 (severe infection). The total severity rating for a tree was the sum of each crown third and thus varied from 0 to 6. Given the transect length and width, the sampled area in the GSF was 0.2 ha per stand, or a total of 24.711 acres, approximately 0.035% of the total forest area. Of the 50 stands sampled, 24 had no evidence of dwarf mistletoe infection. Infection within each stand tended to be either in lodgepole or ponderosa, with only 4 stands having similar amounts in both species. Among all trees surveyed, 20.9% of ponderosa pine, 17.7% of lodgepole pine, and 0% of sugar pine were infected (Fig. 57). The average dwarf mistletoe rating for infected ponderosa pine was 3.53 and 2.24 for lodgepole pine, whereas the average rating for all trees was 0.73 for ponderosa pine and 0.40 for lodgepole pine, indicating a manageable level of infection. Distribution of the mistletoes across the forest indicates a generally clustered effect, with significant areas being free of dwarf mistletoe.

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	• Heterobasidion root disease • Cytospora canker • 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 mistletoes

	TANOAK	WHITE OAK	MAPLE
INSECTS	• **Spongy moth complex** 	• **Spongy moth complex** • **Mediterranean oak borer** • Oak looper* • Gall-making wasps & flies* • Leaf miners* 	• **Asian longhorned beetle** • **Spongy moth complex** • 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 • Sooty bark 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*	 • **Japanese cedar longhorned beetle** • Cedar bark beetles* • Amethyst borer* • Western cedar borer*	 • **Larch casebearer**
• Heterobasidion 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 complex** • Western tent caterpillar* • Alder flea beetle* 	• **Emerald ash borer** • **Spongy moth complex** 	• **Spongy moth complex** • **Satin moth*** • Webworm* 	• **Spongy moth complex** • Webworm* 
• 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 Resources | Forest Health
2600 State Street, Salem, OR 97310
https://tinyurl.com/odf-foresthealth

Christine Buhl	Entomologist	(503) 798-7739	christine.j.buhl@odf.oregon.gov
Gabriela Ritokova	Pathologist	(503) 798-2404	gabriela.ritokova@odf.oregon.gov
Wyatt Williams	Invasive Species Specialist	(503) 798-5436	wyatt.williams@odf.oregon.gov
Sean McKenzie	Aerial Survey Specialist	(503) 945-7353	sean.c.mckenzie@odf.oregon.gov

USDA Forest Service – Forest Health Protection and Forest Health Monitoring Programs
1220 SW Third Avenue, Portland, OR 97204
https://www.fs.usda.gov/main/r6/forest-grasslandhealth/insects-diseases

Karen Ripley	Entomologist	(503) 808-2674	karen.ripley@usda.gov
Robbie Flowers	Entomologist	(503) 808-2915	robbie.flowers@usda.gov
Ya-Wen Ott	Entomologist	(541) 523-1264	ya-wen.ott@usda.gov
Betsy Goodrich	Pathologist	(503) 808-2997	anne.goodrich@usda.gov
Sarah Navarro	SOD Pathologist	(503) 808-2257	sarah.navarro@usda.gov
Daniel DePinte	Aerial Survey Manager	(541) 840-2311	daniel.depinte@usda.gov
Justin Hof	Aerial Observer	(503) 668-1646	justin.hof@usda.gov
Tim Bryant	Aerial Observer	(971) 930-7173	timothy.bryant@usda.gov
Phillip Chi	GIS Analyst	(541) 383-4030	phillip.chi@usda.gov

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

Melissa Fischer	Entomologist	(971) 442-0870	melissa.fischer@usda.gov
Kristen Chadwick	Pathologist	(503) 668-1474	kristen.chadwick@usda.gov
Holly Kearns	Pathologist	(503) 668-1475	holly.kearns@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	(503) 808-2915	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

USDA Forest Service – Blue Mountains Service Center
1550 Dewey Avenue, Baker City, OR 97814

Eric Ott	Entomologist	(541) 523-1277	eric.ott@usda.gov
Vacant	Pathologist		