


2023 Forest Health Highlights in Washington

A summary of insect, disease, and other disturbance conditions affecting Washington's forests

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Cover photos (clockwise from top left): Foliar blight on Pacific madrone caused by *Mycosphaerella* spp. and other fungi in Puyallup: Rachel Brooks / DNR; lodgepole pines killed by mountain pine beetle with fall coloring in western larch in Okanogan County (Mount Bonaparte), 2023: Isaac Davis / DNR; Red killed branch caused by white pine blister rust infection: Rachel Brooks / DNR ; Douglas-fir tussock moth larva: Glenn Kohler / DNR.

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Washington State Department
of Natural Resources (DNR)
Forest Resilience Division
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WASHINGTON STATE DEPT OF
NATURAL RESOURCES
HILARY S. FRANZ
COMMISSIONER OF PUBLIC LANDS

Summary

This is the 77th year of interagency coordination between the USDA Forest Service (USFS) and Washington State Department of Natural Resources (DNR) on an annual insect and disease aerial detection survey (ADS). Since 1947, the two agencies and Oregon Department of Forestry have flown across millions of acres in Washington each year to observe recently killed and currently damaged forest trees.

In 2023, surveyors covered approximately 22 million forested acres across Washington. This acreage represents the majority of the forested land in Washington, excluding large urban areas and restricted airspace. No survey flights were conducted in 2020 in order to reduce COVID-19 exposure and spread among flight crews and their contacts. In place of aerial surveys in 2020, the data used for statewide insect and disease surveys were acquired through a combination of ground sampling and remote sensing.

- **In 2023, the statewide insect and disease survey recorded some level of tree mortality, tree defoliation, or foliar diseases on approximately 517,000 acres.** The area with damage from mortality agents was approximately 457,000 acres, including 348,000 acres attributed to bark beetles and 88,000 acres attributed to young conifer mortality (primarily bear damage or root disease). Approximately 16,000 acres with damage were attributed to defoliators, and approximately 44,000 acres were attributed to tree diseases or other causes of damage. Previous annual totals for all damage agents were:

2022: 672,000 acres with damage out of approximately 22 million acres surveyed

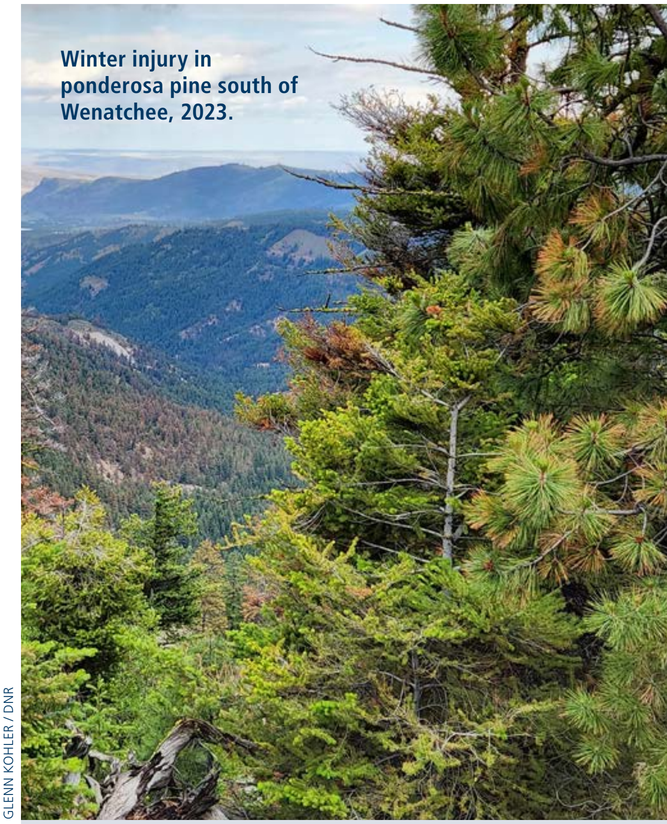
2021: 555,000 acres with damage out of approximately 19 million acres surveyed

2020: 322,000 acres with damage out of approximately 10.5 million acres surveyed

2019: 658,000 acres with damage out of approximately 22 million acres surveyed

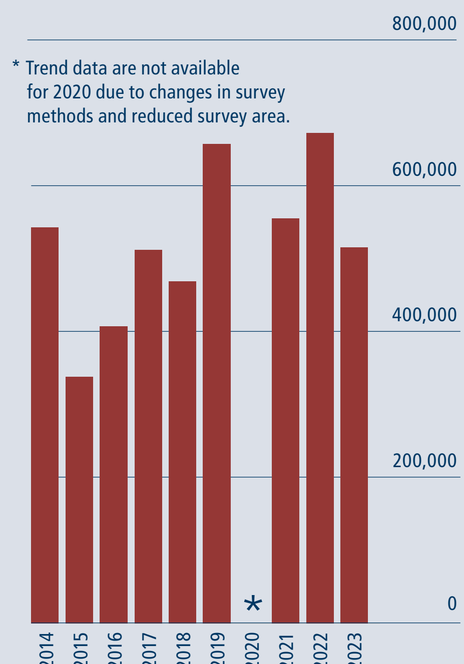
2018: 469,000 acres with damage out of approximately 22 million acres surveyed

- **All forested areas of Washington experienced below-normal spring precipitation amounts, and some level of drought conditions by the fall.** Drought conditions and warm, dry spring weather tend to increase tree stress and insect success, increasing the number of acres with



Winter injury in ponderosa pine south of Wenatchee, 2023.

GLENN KOHLER / DNR



TOTAL ACRES WITH INSECT AND DISEASE DAMAGE 2014-2023

Recorded during annual aerial detection surveys damage in both the current and subsequent year. Wet spring weather tends to increase acres affected by foliage diseases and bear damage in both the current and subsequent year. Precipitation in Washington was below normal in spring 2023 and near normal in both summer and fall. Monthly average temperatures were slightly above normal in spring and early summer 2023 and near normal in late summer and fall. According to the U.S. Drought Monitor, all of Washington experienced some level of drought condition by fall of 2023. All of western Washington ranged from moderate to extreme drought condition by late September, while all forested areas of eastern Washington were in abnormally dry to severe drought conditions.

- **The area with mortality caused by pine bark beetles in 2023 was approximately 124,000 acres.** Mountain pine beetle damage increased from 76,800 acres in 2022 to approximately 90,200 acres in 2023. The majority of annual pine bark beetle mortality is lodgepole pine killed by mountain pine beetle, which totaled 80,900 acres in 2023. Surveyors mapped the highest concentrations of mountain pine beetle mortality in lodgepole at high elevation areas of Yakima, Kittitas, Chelan, Okanogan, Ferry, and Pend Oreille counties.

- **Mortality of ponderosa pine due to western pine beetle decreased to approximately 32,800 acres in 2023 but is still above the 10-year average.** Recent drought conditions have driven a steady increase since 2012, reaching a peak of approximately 44,300 acres in 2022, the highest level recorded since 2006. Concentrations of mortality were widespread throughout lower elevation forests in eastern Washington.

- **Pine mortality attributed to California fivespined Ips was recorded for the first time in western Washington** in ponderosa pine at Joint Base Lewis McChord, and in new hosts – shore pine and Austrian pine – in urban areas of Renton, Seattle, Mercer Island, and Bothell.

- **The area with Douglas-fir beetle damage decreased to approximately 73,500 acres in 2023 but is still above the 10-year average of 50,100 acres.** Mortality due to Douglas-fir beetle has been increasing in recent years and reached a recent peak of 105,000 acres in 2022, the highest level recorded since 2001.

- **The amount of Douglas-fir mortality caused by Douglas-fir engraver (and other secondary bark beetles) in 2023 was approximately 25,600 acres, the highest level recorded in Washington aerial surveys since 1969.** Another recent peak of 20,300 acres with Douglas-fir engraver damage occurred in 2019, with both years well above the 10-year average of 8,100 acres. Increased activity is likely due to cumulative drought stress.

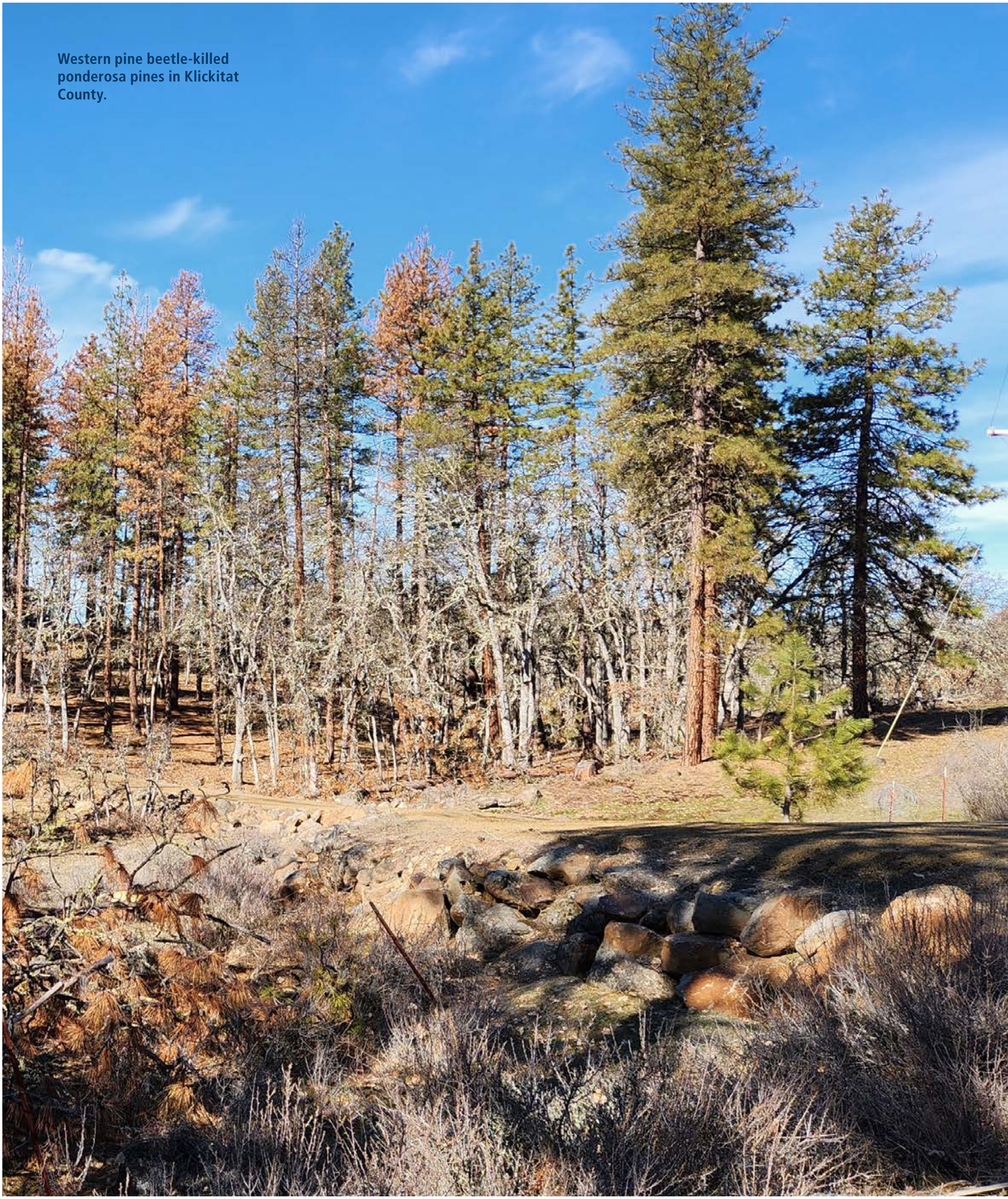
DROUGHT CONDITIONS AND WARM, DRY SPRING WEATHER TEND TO INCREASE TREE STRESS AND INSECT SUCCESS, INCREASING THE NUMBER OF ACRES WITH DAMAGE IN BOTH THE CURRENT AND SUBSEQUENT YEAR.

- **Following a drop to 52,500 acres in 2021, the upward trend of fir engraver caused mortality, primarily in grand fir, has resumed with an increase in 2023 to approximately 99,000 acres, up from 65,700 acres in 2022.** Fir engraver had been steadily increasing since 2015 and reached a 10-year high of 166,300 acres in 2019.

- **Chronic infestations of the non-native balsam woolly adelgid decreased to approximately 14,400 acres in 2023, but still accounted for much of the defoliation damage in Washington.** Damage was primarily in subalpine fir at high elevations in the Olympic Mountains and scattered high elevation areas of eastern Washington. No **Douglas-fir tussock moth** defoliation has been recorded in eastern Washington since the 2018-2019 outbreaks in Kittitas, Chelan, and Okanogan counties collapsed. No new **western spruce budworm** defoliation has been observed from the air since 2019. Small but intense outbreaks of **western tent caterpillar** were reported in western Skagit County and Clallam County.

- **No notable changes regarding *Phytophthora ramorum*, the causal agent of sudden oak death, were observed in 2023.** *P. ramorum* may be found in streams associated with commercial plant nursery trade activity, but there has yet to be any indication that the pathogen is leaving the waterways and impacting bordering vegetation. No stream-baiting sampling location tested positive for *Phytophthora ramorum* in 2023.

GLENN KOHLER / DNR


Western pine beetle-killed ponderosa pines in Klickitat County.

Abiotic Disturbances Influencing Forest Health

Abiotic disturbances — disturbances caused by non-living factors — are a natural and integral part of forest ecosystems. They are responsible for major impacts, both positive and negative, on our forests. They influence forest structure, composition, and function, and can be important for maintaining biological diversity and facilitating regeneration. Abiotic disturbances such as wildfire, drought, landslides, flooding, and extreme weather events can cause tree mortality. Surviving trees may be damaged or weakened by these events. This can indirectly influence forest health conditions by making them more susceptible to attack by insects and pathogens. Abiotic disturbances that cause mortality and damage over large areas, such as wildfire, windstorms, and drought, may provide enough breeding material to increase local bark beetle populations to the level of an outbreak. Such outbreaks can then cause mortality in adjacent healthy trees. Drought and other disturbances that compromise tree defenses can lead to increased levels of mortality from forest pathogens. Unseasonal extremes in precipitation may lead to increased levels of foliar pathogens that cause diseases such as needle casts and needle blights.

The following section is a summary of recent weather, drought, and wildfire events that may influence forest health conditions in Washington.

Weather

Severe weather events that injure or kill trees often make them more susceptible to attack by insects and pathogens. Examples include heat stress, winter damage (defoliation, cracks or breakage from cold temperatures, snow, or ice), flooding, windthrow, landslides, and hail. Unusually wet spring or fall weather, such as what occurred April-June 2022 (Fig.1), can increase the incidence of foliar diseases. Outbreaks of certain bark beetle species, such as Douglas-fir beetle or Ips pine engravers, follow weather or fire events that kill or injure numerous trees. Conifer trees killed by bark beetles typically do not appear red until a year after they died. Therefore, increases in mortality from bark beetles related to events such as drought or storms may not appear in aerial survey or remote sensing data until two years after the event. In years like 2023, when early summer precipitation is below average and temperatures are above normal (Fig.2), the symptoms of drought stress are amplified and trees are less likely to recover from injury, which could lead to measurable tree mortality in drought-prone forests in 2024.

Vigor and resilience to adverse weather can be increased by ensuring that trees have room to grow and are appropriate species for the habitat and microsite. For example, forests in eastern Washington are generally overstocked with fir trees and under-populated with more drought-tolerant pine and larch species. Such conditions favor defoliators like western spruce budworm, perpetuate root disease, and encourage bark beetle activity. In western Washington, Swiss needle cast disease affects Douglas-fir trees growing on coastal sites that may be better suited to western hemlock and Sitka spruce.

Figure 1.

WASHINGTON STATE PRECIPITATION

Average monthly precipitation (blue line) and 30-year average (green line) for Washington.

SOURCE: WESTERN REGIONAL CLIMATE CENTER (HTTPS://WRCC.DRI.EDU/)

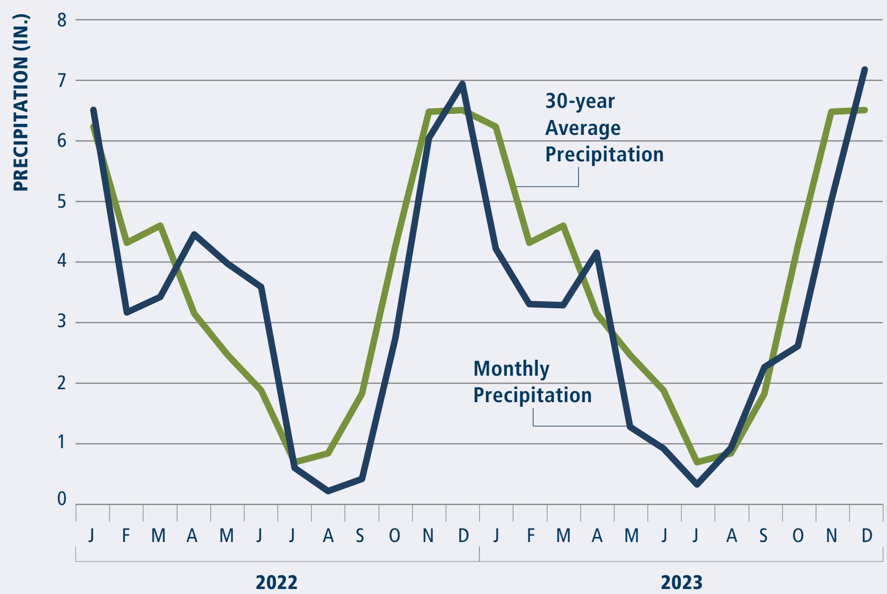
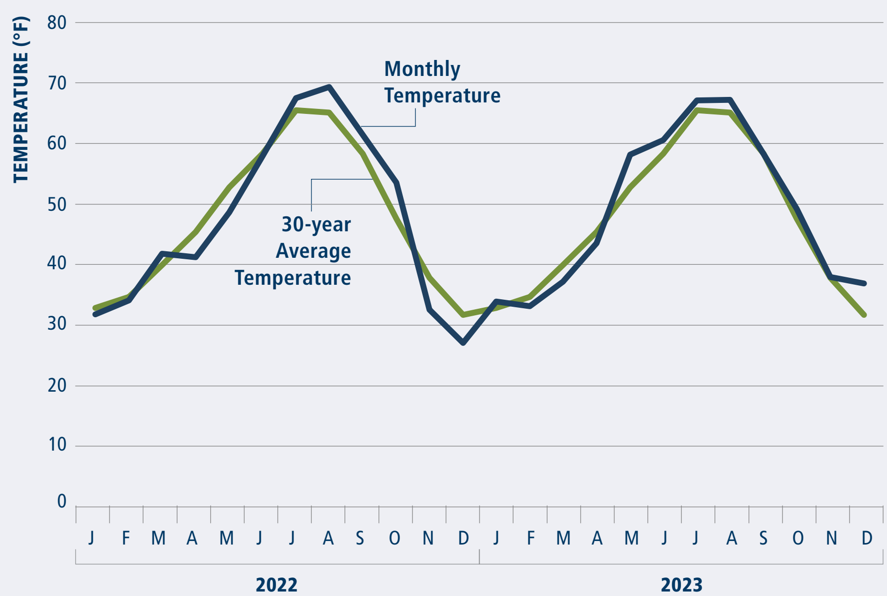


Figure 2.

WASHINGTON STATE MEAN TEMPERATURES

Average monthly temperatures (blue line) and 30-year average (green line) for Washington.

SOURCE: WESTERN REGIONAL CLIMATE CENTER (HTTPS://WRCC.DRI.EDU/).



RACHEL BROOKS / DNR

RACHEL BROOKS / DNR

Above: A western white pine tree impacted by winter desiccation damage photographed in August 2023. This pine's exposed top was killed while the lower branches protected by the snow survived.

Top: Winter desiccation damage to a white pine planting in northeast Washington (photo taken May 2023). Note the lowest branches on all the pine trees have no visible damage, as they were covered by snow during the desiccation event.

Weather-Related Damage

WINTER DESICCATION

Winter desiccation damage occurs when tree foliage increases transpiration levels during the dormant winter season when soils remain frozen. The increase in transpiration may be caused by wind, sun, or warm weather. This means that the water lost in the foliage during transpiration cannot be replaced, resulting in desiccation of tissues. Symptoms include browning or reddening of leaves and branches, typically on the southwest or windward side of the tree. In areas that receive snow, lower branches may be protected and show no damage (see top). Killed foliage will be shed over time and the impacted trees may completely recover, lose lateral branches, or have entire tops killed (see photos this page). Top kill may result in trees with multiple stems or other tree-form issues. Winter desiccation damage was observed in a handful of places in northeast Washington during the spring of 2023. Field observations are key to diagnosing winter desiccation damage, as laboratory analysis can only confirm the absence of disease or pest damage. Other damaging agents such as insects, drought, or canker fungi may also cause top kill, but these other agents won't be uniformly distributed across a landscape or be consistent in which side or part of the trees is most impacted.

WINTER INJURY OR "RED BELT"

DNR received reports in 2023 of severely damaged conifers – mostly ponderosa pine from the Mission Ridge area south of Wenatchee and areas of Chelan and Douglas counties near Entiat. Most of the foliage was orange-brown and could have been mistaken for bark beetle mortality when viewed from a distance (see right, top). On closer inspection, only the older needles were damaged, and trees were still alive with mostly healthy buds and newly expanding spring foliage (see right, middle). The damage was attributed to a winter event such as an abrupt temperature change, needle desiccation as described above, or a temperature inversion that results in "red belt" injury. However, the damage pattern on the landscape did not appear to follow an elevational band. Grand fir, subalpine fir, and Douglas-fir were also affected, but damage was much less noticeable than in pines.

Surveyors mapped approximately 6,900 acres with this winter injury in 2023, however, this is likely an underestimate due to aerial survey flights mostly occurring after trees greened up with new foliage and old discolored needles were in the process of dropping. Affected mapped areas include the Status Pass area and south of Ahtanum Ridge on the Yakama Indian Reservation, Mission Ridge and Colockum Pass areas south of Wenatchee, Badger Mountain, areas around Leavenworth and Entiat, mountains around southern Lake Chelan, and west of Omak Lake on the Confederated Tribes of the Colville Reservation.

LATE SPRING FROST

Damage determined to be caused by a late spring frost was seen in numerous locations during the spring of 2023. This damage occurs when warm spring temperatures that cause plants to come out of dormancy are followed by a cold period. Damage is usually observed as discoloration and/or wilting of newly emerging foliage (see right, bottom). Damage on the landscape is often located in lower elevations, where colder air is more likely to settle. Field observations are key to diagnosing late spring frost damage, as laboratory analysis can only confirm the absence of disease or pest damage. Damage caused by misapplication of herbicides may look similar.

RACHEL BROOKS / DNR

Bottom: Damage to a Douglas-fir seedling caused by a late spring frost in Mason County (spring 2023).

Middle: New foliage expansion and recovery in grand fir following winter desiccation damage.

Top: Foliar damage from winter desiccation at Mission Ridge south of Wenatchee in June 2023.

Drought

Except for April, precipitation in Washington was well below average for the first half of 2023. Late summer saw average rainfall conditions, only to drop back below normal later that fall. These recordings are inconsistent with 2022 precipitation measures of below average rainfall at the beginning of the year, above average rainfall from April through July, then back to below average readings through the fall. (Fig.1, p.8). Both 2022 and 2023 fail to align with the 30-year average of monthly precipitation measurements. Monthly average temperatures in 2023 were above average May-August but otherwise remained consistent with the 30-year average (Fig.2, p.8). A record-setting extreme heat event in 2021 resulted in widespread conifer needle desiccation damage in parts of western Washington. Lasting effects, in terms of mature tree mortality, of this needle desiccation event were not observed in aerial survey data in 2022 or 2023. Below average rainfall throughout much of the 2023 growing season coupled with above average summer temperatures could increase the potential for drought stress on susceptible trees.

Conditions in eastern Washington, the Cascades, and much of western Washington were abnormally dry from January through May. Dry conditions expanded statewide in June to include areas of moderate drought. Beginning in mid-July and continuing through late August, drought levels reached severe drought in Whatcom, Skagit, Snohomish, and King counties as well as the Tri-Cities area. This trend continued upwards from September through November, leading to a period of extreme drought in Whatcom, Skagit, Snohomish, and King counties while the rest of the state sustained conditions ranging from abnormally dry to severe drought (Fig.4). Most of Washington dropped again to abnormally dry-to-severe drought late November and stayed there for the remainder of 2023. Almost all of Washington experienced some level of drought in 2023. The areas that experienced no drought in 2023 are largely non-forested regions of the Columbia River Basin (Fig.3). Drought conditions will likely increase tree susceptibility to insect and disease attacks, making them less likely to recover from injury.

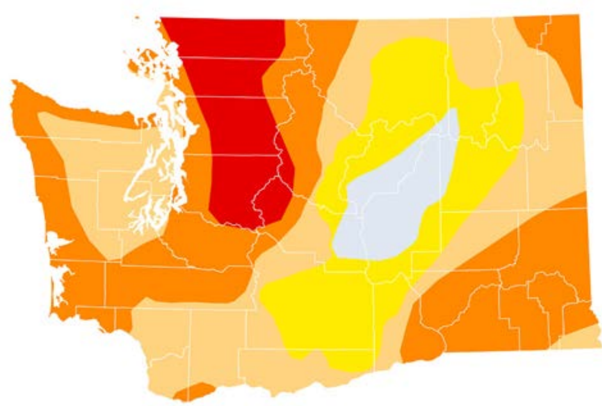


Figure 3.

DROUGHT CONDITIONS IN WASHINGTON ON SEPT. 26, 2023

SOURCE: US DROUGHT MONITOR (HTTPS://DROUGHTMONITOR.UNL.EDU/)

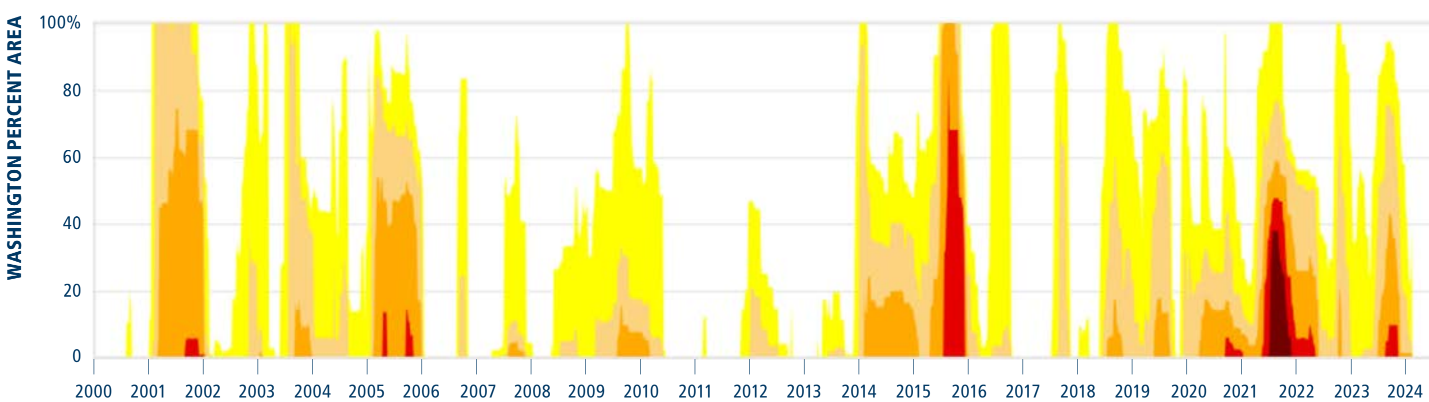
- No Intensity
- Abnormally Dry
- Moderate Drought
- Severe Drought
- Extreme Drought
- Exceptional Drought

Figure 4.

PROPORTION OF WASHINGTON STATE AREA AFFECTED BY DROUGHT FROM 2000 – 2023

SOURCE: US DROUGHT MONITOR (HTTPS://DROUGHTMONITOR.UNL.EDU/)

- D0 (Abnormally Dry)
- D1 (Moderate Drought)
- D2 (Severe Drought)
- D3 (Extreme Drought)
- D4 (Exceptional Drought)



Wildfire

According to data compiled by the Northwest Coordination Center (NWCC) and Washington State Department of Natural Resources (DNR), wildfires burned 151,317 acres in all of Washington during the 2023 season, down 22,345 acres from the 2022 total. According to a geospatial analysis of statewide fire perimeters intersected with the National Land Cover Database, large fires burned the following fuel types in 2023: 19% forest, 9% shrub-steppe, 9% grassland, and 63% other (i.e. agricultural lands, urban areas, wetlands).

In 2023 there were a total of 1,088 fires on DNR protected lands, up from 831 fires in 2022. The annual count of fire occurrences on DNR protected lands is higher than the average of 968 fire occurrences per year over the period 2014 to 2023. Data show that 10% of these fires were lightning caused, 60% were human caused, and the remaining 30% were undetermined (Fig.5). For human-caused fire ignitions, debris burning is the leading cause of fires on DNR-protected land. Of the 1,707 total fire responses statewide in 2023 (including both DNR and other agency protected lands), 41 were considered "large fires" (greater than 100 acres of forestland or 300 acres of brush/grass) (Fig.6), and 17 of those large fires included DNR involvement.

According to DNR fire occurrence data, much of DNR's wildfire activity occurred earlier in the year, during the months of May, June, and July, although fires occurred in every month of the fire year. The most impactful fires were the Oregon and Gray Fires in August. The Oregon and Gray fires destroyed or damaged approximately 775 structures.

The first large DNR fire of the year was the Sutherland Fire just outside of Port Angeles, which started June 17 and burned 108 acres of forestland. The largest DNR fire for the year was Newell Road, which started on July 21 in Klickitat County and burned 60,551 acres. Fortunately, the lack of significant east wind events and resulting fires during September and October did not occur, so DNR was able to meet its performance goal of keeping 95% of fires at less than 10 acres.

FUELS, FIRE DANGER, AND WEATHER

Fuel conditions were problematic from the start of the 2023 fire year. Snowpack at the beginning of May was mostly normal across the state, with snow water equivalents (SWE) in all the basins in Washington between 94% and 148% of normal. Snowpack had dwindled across the northern half of the state by the end of May, with SWE tracking from 26% to 45% of normal levels. The southern tier fared better, with SWE between 91% and 109% of normal. The discrepancy was due to warmer weather in May that included average temperatures 2-9 degrees above normal along with significant precipitation deficits.

The warm, dry weather also initiated an early start to the green-up process (the springtime period where plants break dormancy and produce new growth). Fire danger rating areas (FDRAs) reached green-up conditions by the first week of May. When climate conditions are normal, an early green-

Helitack crew at Iron Creek Fire in Gifford Pinchot National Forest in Lewis County.

IN 2023 THERE WERE A TOTAL OF 1,088 FIRES ON DNR PROTECTED LANDS, UP FROM 831 FIRES IN 2022. THE ANNUAL COUNT OF FIRE OCCURRENCES ON DNR PROTECTED LANDS IS HIGHER THAN THE AVERAGE OF 968 FIRE OCCURRENCES PER YEAR OVER THE PERIOD 2014 TO 2023.

Figure 6.

2023 LARGE FIRES OF CONCERN

Locations of large wildfires and other fires that occurred in Washington in 2023. Large fire names in text box.

DATA SOURCES: NATIONAL INCIDENT FEATURE SERVICE 2021 (NIFC), WADNR FIRE STATISTICS 2022 (FIReS)

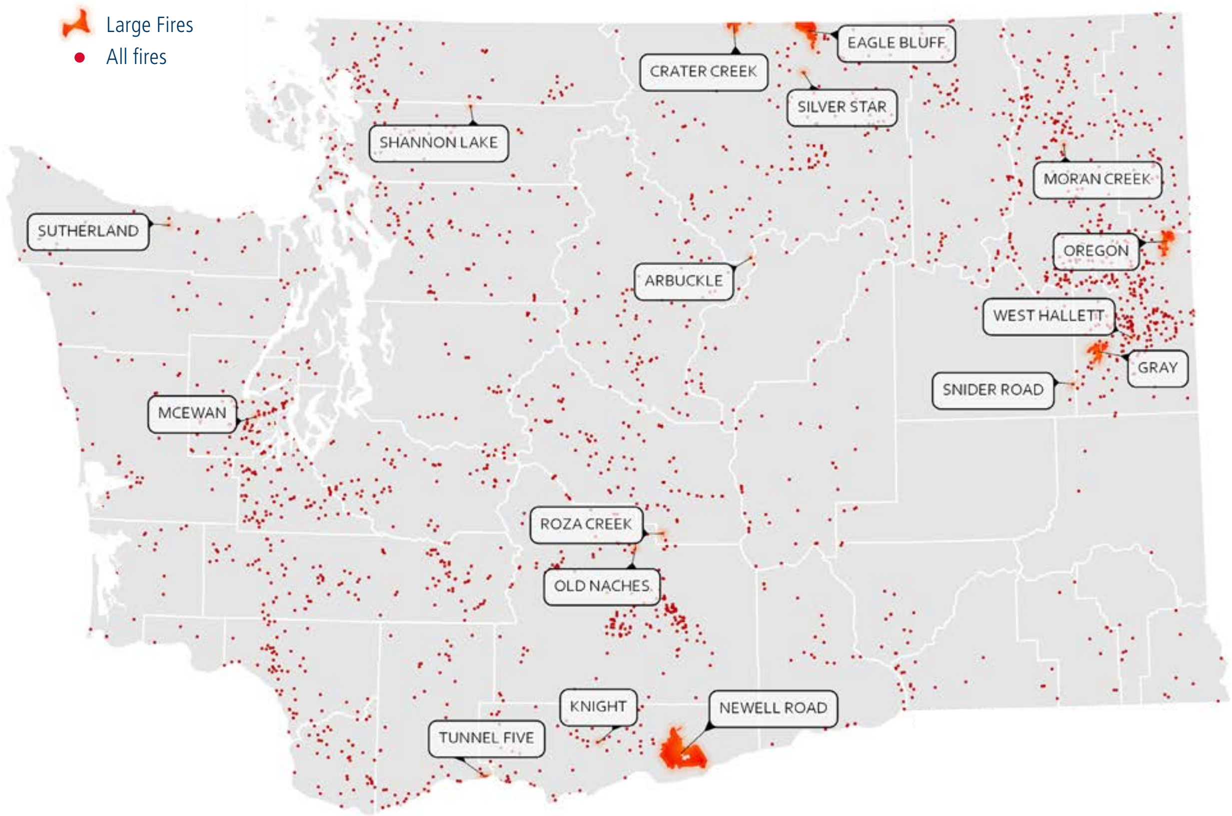
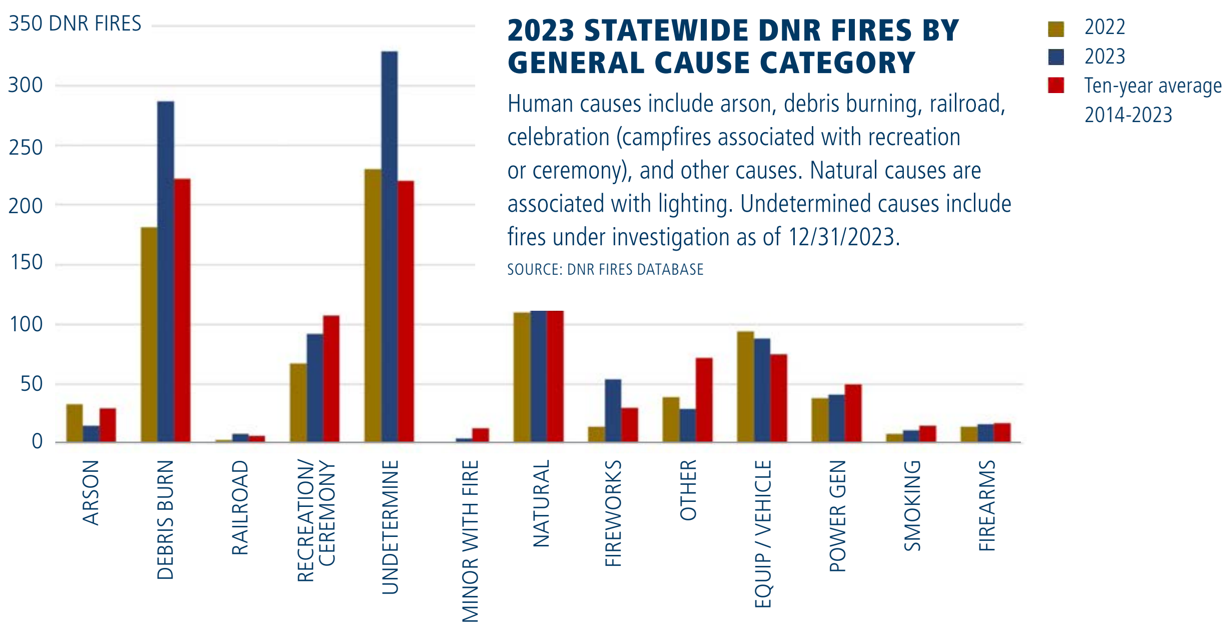


Figure 5.

2023 STATEWIDE DNR FIRES BY GENERAL CAUSE CATEGORY

Human causes include arson, debris burning, railroad, celebration (campfires associated with recreation or ceremony), and other causes. Natural causes are associated with lighting. Undetermined causes include fires under investigation as of 12/31/2023.

SOURCE: DNR FIRES DATABASE



up tends to lead to early fuel drying and thus an early start to the fire season. Compounding on the low snowpack and early green-up, the lack of precipitation caused the dead and down woody fuels to dry out sooner than typical.

Fire danger conditions trended a month ahead of schedule by the first week of June. Areas including the Methow, Blue Mountains, and entire west side of the state pushed new daily maximum energy release components (ERC) by that time (Fig.7). Lush, live vegetation kept fire activity mostly in check during that period. A long-lasting rain event that took place over 48 hours during the first week of June covered most of the state and sent fire danger plummeting. The precipitation had long-lasting dampening effects in most areas of the state, but not in the Columbia Basin. By the end of July, the largest fire, Newell Road burned over 60,000 acres.

A cold front that arrived at the end of the first week of August took a significant, temporary bite out of the fire danger in Washington. Indices in western Washington ran well above normal through most of July despite onshore flow mitigating the immediate fire threat. Eastern Washington areas benefited from the cold front, but by mid-August, fire danger began to crest. Fires deep within wilderness areas along the Cascade Crest began to intensify. New daily ERC records were set each day in the Central Cascades FDRA from August 15-22 as fires there found ample growing space. The Oregon Road and Gray fires in Spokane County started on August 18 (see Fig.7).

The 2023 fire year highlighted the growing volatility of eastern Washington's shrub and grasslands in the face of an otherwise average fire season in Washington's forestland. Critical fire weather events were predominantly characterized by strong westerly winds ahead of frontal systems, which are of most concern for the Columbia Gorge, the Columbia Basin, and the east slopes of the Cascades. Lightning events were typically accompanied by rainfall that limited initial fire growth.

There was no shortage of critical fire weather events during the 2023 fire season. Despite well-above average temperatures coupled with below normal precipitation statewide, the above-average atmospheric moisture in eastern Washington during May and June, plus the well-timed rainfall events in August and September, greatly reduced the overall potential of most critical weather events.

ISAAC DAVIS / DNR

The Kid Fire, as seen from aerial survey aircraft northwestern Okanogan County in 2023.

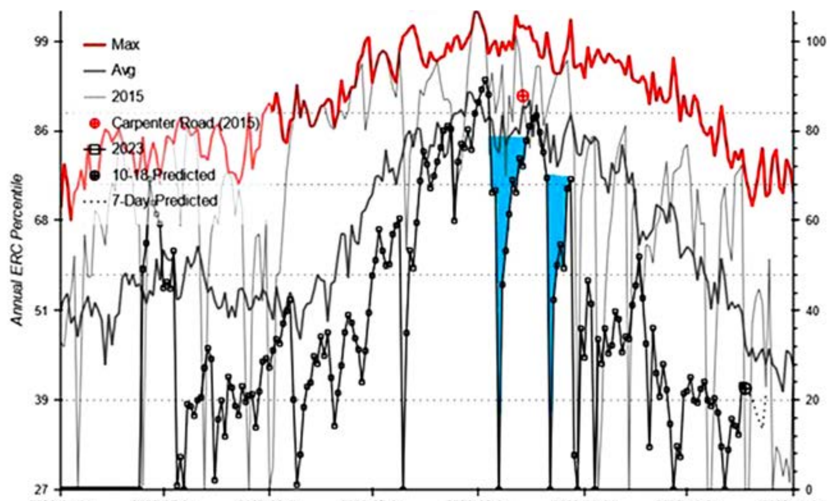


Figure 7.

ENERGY RELEASE COMPONENT (ERC) FOR THE FOOTHILLS FDRA NORTH OF SPOKANE

This chart highlights the two rain events in early and mid-August 2023. The peak between the two rain events was August 18 and 19 when the Oregon Road and Gray fires started.

WASHINGTON'S FOREST ACTION PLAN UPDATE

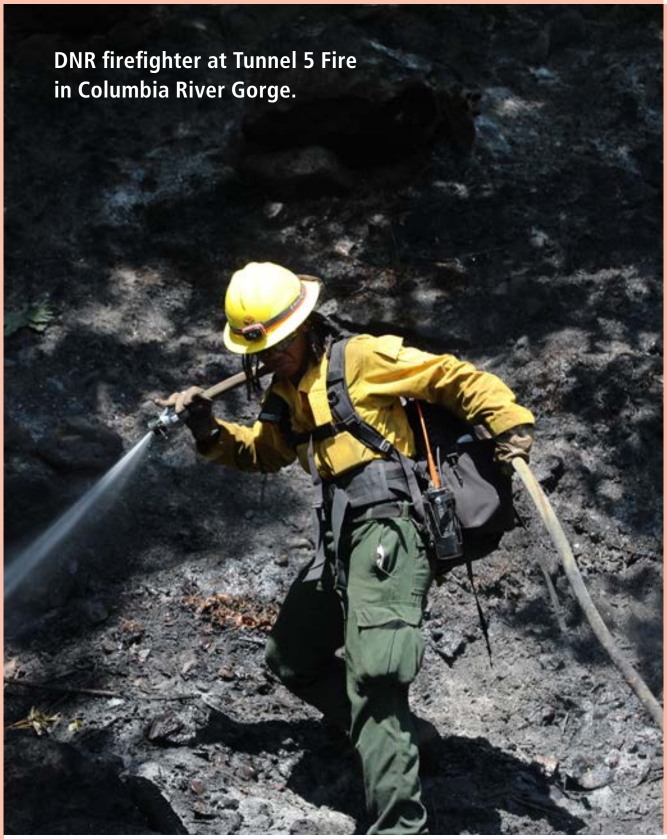
Wahington's Washington's Forest Action Plan was revised and adopted in October of 2020. The Forest Action Plan is a comprehensive review of forests across all lands statewide — public and private, rural and urban — and offers proactive solutions to conserve, protect, and enhance the trees and forests that people and wildlife depend on. Partners contributed and collaborated toward the development of an ambitious statewide plan by identifying 23 goals and 159 priorities across eight themes to restore forest resilience and advance ecological, community, and socio-economic objectives. The plan also makes firm commitments to monitoring collective progress made by individual organizations and through partnerships, in addition to sharing successes and lessons learned along the way.

Washington partners were able to leverage both federal and state legislative support and funding in 2023 to invest in critical forest health initiatives, fuel reduction programs, and community-based wildfire preparedness programs. Highlights from the year are summarized in our annual report, available at dnr.wa.gov/ForestActionPlan. As Washington navigates the complexities of a changing climate, this report provides hope and reminder of the dedication, innovation, and determination of Washingtonians.

In February 2024, DNR also released a new, standalone monitoring report that assesses our progress towards achieving the forest condition goals described in the 20-Year Forest Health Strategic Plan for Eastern Washington. DNR scientists developed two complementary datasets to track causes of forest structure change using both satellite-based change detection from 2015-2022 and a user-reported treatment database from 2017-2022. This new report compiles results from regional, planning area, and stand-level monitoring analyses to address two overarching questions:

1. **How are forest health conditions changing over time?**
2. **What are the outcomes of forest health treatments?**

The monitoring report will be released during odd-numbered years as a complement to the biennial report to the legislature on progress towards implementation of the 20-Year Forest Health Strategic Plan. As of October 2023, DNR and partners reported completing forest health treatments on more than 600,000 acres across central and eastern Washington since the plan's adoption, impacting 350,714 footprint acres (some acres received multiple treatments). Updates on treatment progress for eastern Washington are released in June and November each year, available along with annual reports via DNR's Forest Resilience Digital Library (dnr.wa.gov/DigitalLibrary).


DNR firefighter at Tunnel 5 Fire in Columbia River Gorge.

DNR AND PARTNERS REPORTED COMPLETING FOREST HEALTH TREATMENTS ON MORE THAN 600,000 ACRES ACROSS CENTRAL AND EASTERN WASHINGTON SINCE THE PLAN'S ADOPTION, IMPACTING 350,714 FOOTPRINT ACRES.

Figure 8.

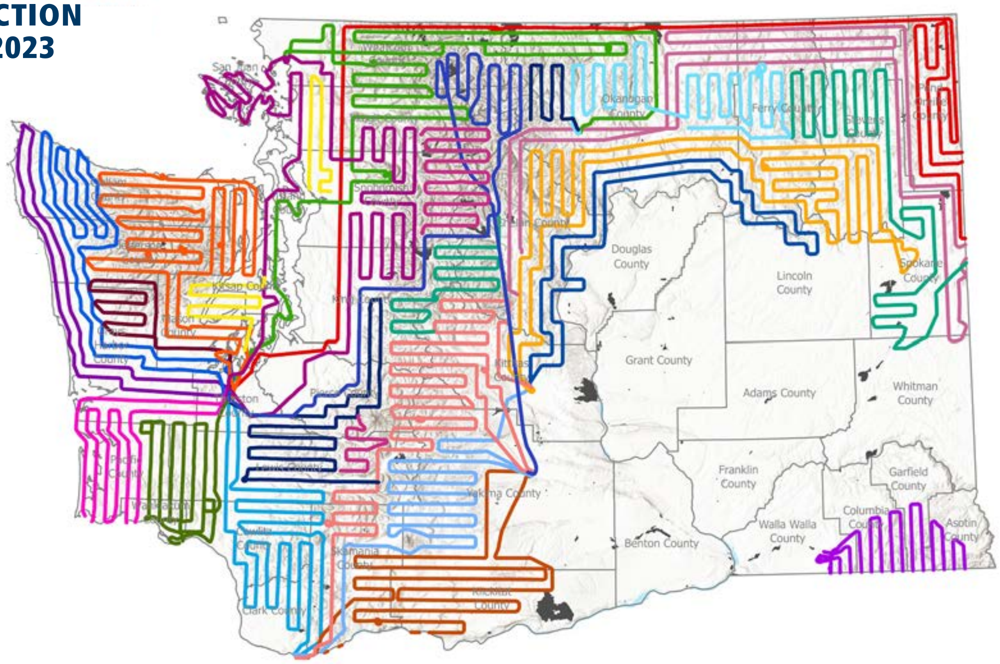
WASHINGTON AERIAL DETECTION SURVEY FLIGHT LINES FOR 2023

Urbanized land and areas without forests are not flown in ADS.

SOURCE: DNR, USFS

FLIGHT DATES

7/6/23	8/21/23
7/17/23	8/23/23
7/19/23	8/24/23
8/8/23	9/1/23
8/9/23	9/11/23
8/10/23	9/12/23
8/11/23	9/13/23
8/14/23	9/14/23
8/15/23	9/15/23
8/16/23	9/22/23
8/17/23	10/5/23
8/18/23	2022-23 Fires



Kodiak aircraft operated by the Washington DNR that was used for portions of 2023 aerial detection surveys in Washington. Its high-wing design allows observers a clear view of forests below. Inset: US Forest Service aerial observer recording damage along the edge of the Olympic Mountains during the 2023 ADS season.

GLENN KOHLER / DNR ; INSET: RACHEL BROOKS / DNR

Aerial Detection Survey

The insect and disease aerial detection survey (ADS) is a specialized monitoring strategy used to assess forest health conditions across all forested lands in the state of Washington. The survey has been conducted annually since 1947 by the USDA Forest Service (USFS), DNR, and the Oregon Department of Forestry under a shared responsibility to document tree mortality and damage and report findings to federal, state, tribal, and private cooperators. The data collected has a range of practical applications such as tracking insect outbreaks and disease spread, communicating wildfire risk to local communities, and informing responsible forest management practices. The 2023 ADS season marked the second consecutive year post-pandemic when all 22 million acres of Washington's forestland were surveyed. The program was grounded in 2020 for the first time in its 75-year history. In 2021, only 87% of the ADS was completed due to lack of aircraft availability and staff vacancies. Thanks to dedicated aerial survey crew equipped with newly acquired technologies and state resources, 2023's achievements signify a promising future for the multi-agency collaborative program.

In spring 2023, DNR's full time aerial observer, Isaac Davis, completed the USFS's intensive certification process to become a fixed-wing flight manager, which authorizes ADS specialists to plan, coordinate, and conduct survey operations without the direct supervision of USFS personnel. This immediately alleviated many recent challenges associated with observer availability and qualified experience. The Washington ADS program adopted the use of ForeFlight, the leading flight planning application used by pilots and professionals in the aviation industry. This tool helped streamline flight logistics, enhanced pilot-surveyor communications, and brought a greater level of situational awareness to the survey crew with respect to real-time traffic in congested airspace, emergency services, and aircraft-specific resources along planned flight routes. The DNR Aviation Program purchased two Kodiak 100's in 2023, modern aircraft well-equipped to meet the demands of ADS objectives. The Washington ADS program worked extensively with DNR Aviation to establish a cooperative agreement to assist ADS missions when aircraft are not engaged in higher priority fire operations. DNR Aviation is a tremendous resource to have on-hand and will provide the ADS program with much-needed flexibility going forward. Despite these recent acquisitions and overall program success, the 2023 survey season endured notable setbacks that threatened its completion.

The greatest challenge to the success of the Washington ADS program in 2023 was the severely limited availability of aircraft resources. The primary aircraft used for aerial survey throughout Washington during the past decade failed an annual inspection in late 2022. Corrosion discovered in the wings of the Washington Department of Fish & Wildlife (WDFW) Partenavia P.68 contracted by DNR rendered the aircraft unusable for the entirety of the aerial survey season (June through October). Agreements with DNR Aviation were not established until mid-September, so the Washington ADS program relied almost exclusively on federal resources to conduct the annual mission. Missing almost the entire month of July, surveying was delayed until the second week of August, when federal aircraft and pilots stationed in Oregon could be reassigned to assist ADS in Washington. Reallocation of such scarce resources prioritized for federal wildfire operations and the Oregon ADS program was a challenging effort and put significant strain on all programs involved. Between the WDFW aircraft returning to assignment in 2024 and the acquisition of DNR Aviation resources, limited aircraft availability is less likely to interfere with future ADS operations in Washington.

Adverse weather conditions and wildfire activity are the expected hinderances of ADS missions. These events frequently coincide with the time when damage signatures from insect and disease agents are most apparent in forests from an aerial perspective. Wildfire smoke or low hanging clouds compromise safety and obstruct views of the forest canopy, preventing the collection of precise, usable data. Thankfully, given the challenges mentioned above, these factors were not as impactful as they have potential to be any given year (Fig.6, p.13). Occasional deviations from flight routes due to smoke occurred in 2023, but surveying resumed in impacted areas after wildfires subsided or successful mitigation efforts were completed. Late-season coastal weather fronts flowing inland in western Washington interrupted a handful of planned survey routes, however, contingency plans were in place and the flexibility of ADS personnel allowed the affected areas to be surveyed later in the season. For a detailed description of the methods the Washington ADS program uses to conduct survey missions, see the "Aerial Detection Survey Methodology" section on page 59.

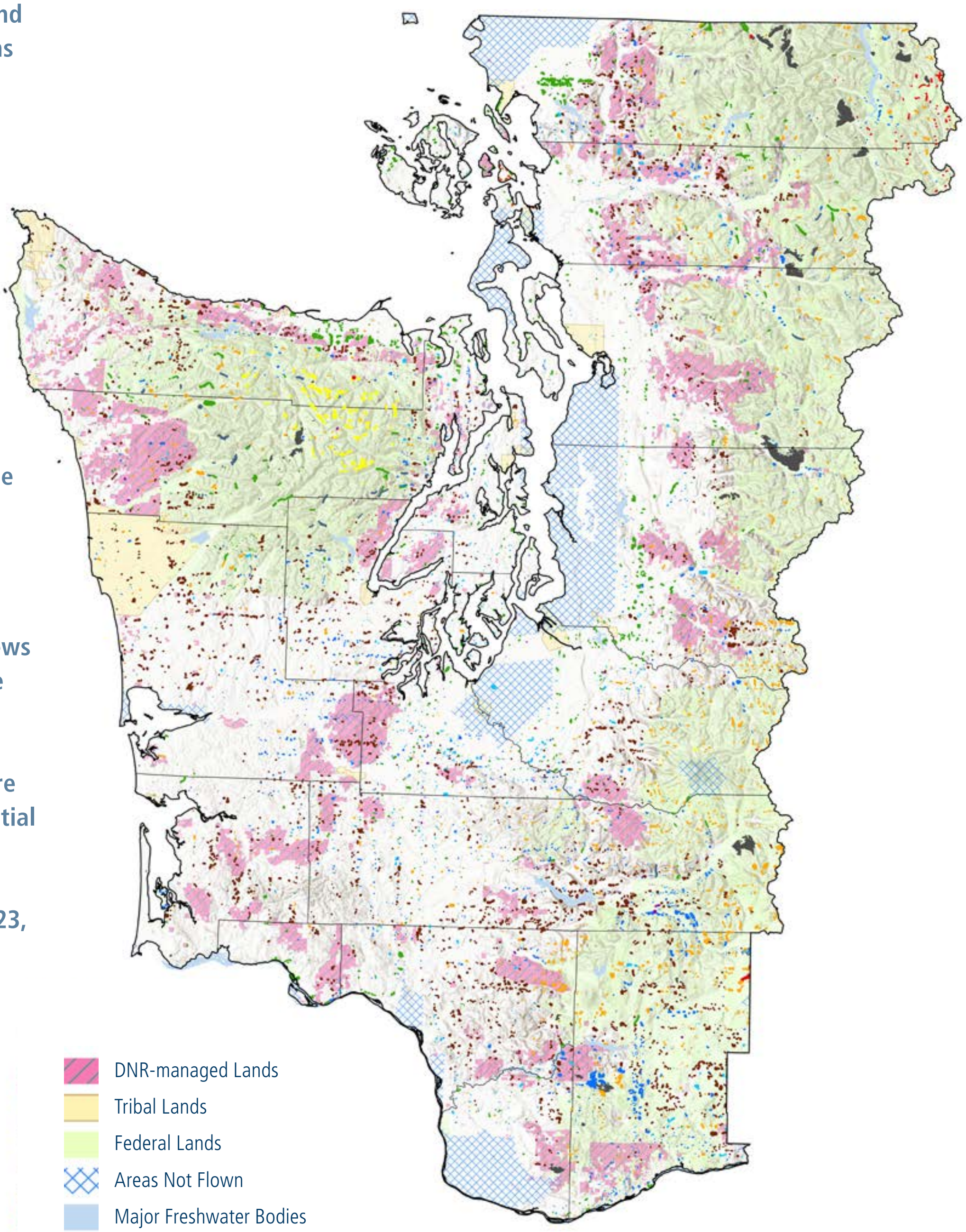


Figure 9.

FOREST DISTURBANCE ACTIVITY IN WESTERN WASHINGTON BASED ON 2023 AERIAL DETECTION SURVEY DATA

SOURCE: DNR, USFS

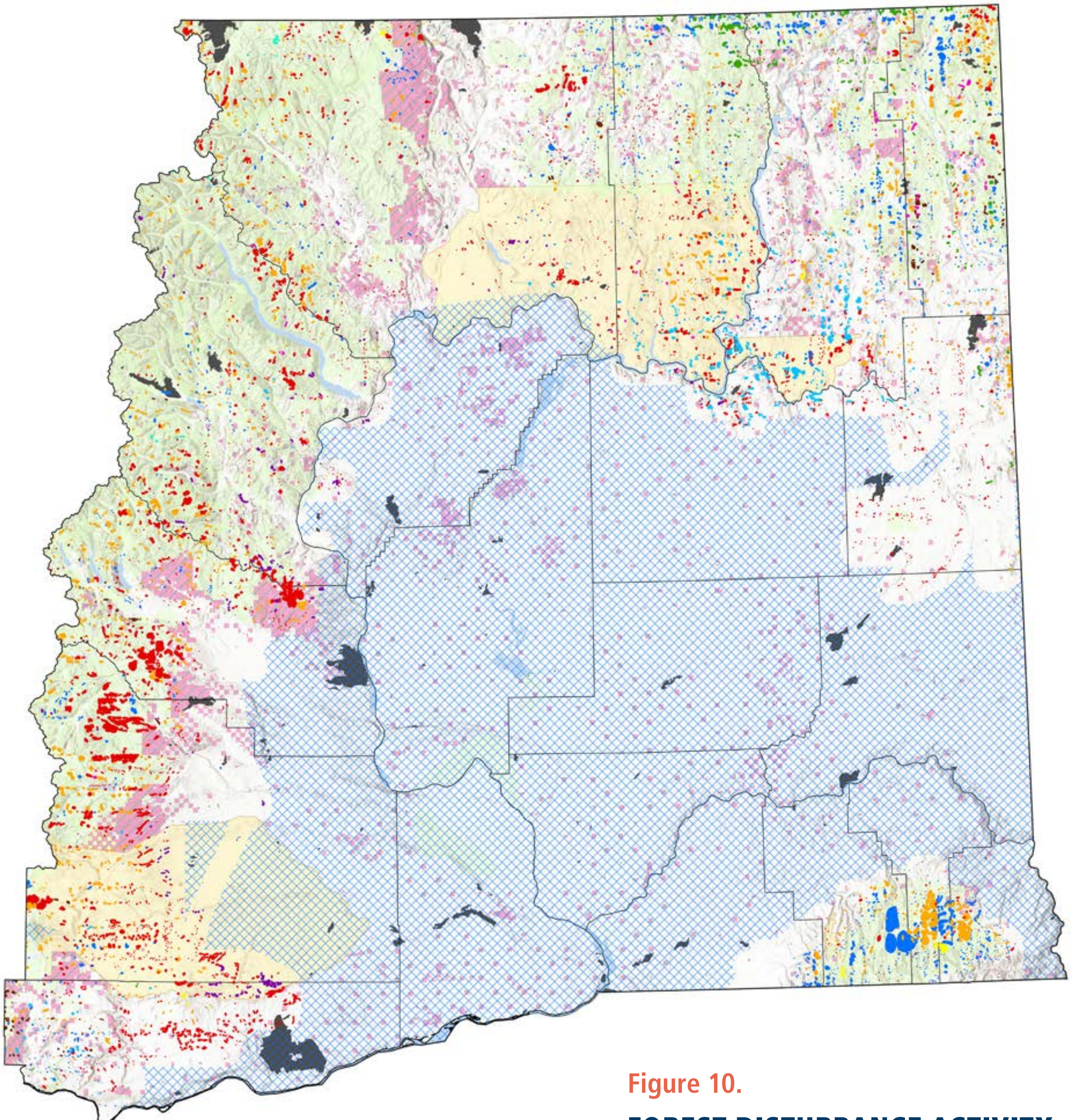


Figure 10.

FOREST DISTURBANCE ACTIVITY IN EASTERN WASHINGTON BASED ON 2023 AERIAL DETECTION SURVEY DATA

SOURCE: DNR, USFS

DNR-managed Lands
Tribal Lands
Federal Lands
Areas Not Flown
Major Freshwater Bodies
2022-23 Fires
Douglas-fir Beetle
Douglas-fir Engraver
Fir Bark Beetles
Pine Bark Beetles
Spruce Beetle
Balsam Woolly Adelgid
Young Conifer Mortality
Cedar Dieback
Hemlock Mortality
Larch Defoliation
Other Damage Agents

N
0 20 40 miles

RACHEL BROOKS / DNR

Foliar blight on Pacific madrone caused by *Mycosphaerella* spp. and other fungi in Puyallup.

Biotic Disturbances Influencing Forest Health

Biotic disturbances — disturbances caused by living agents — such as insects, fungi, animals, and parasitic dwarf mistletoe plants can influence forest health directly by causing mortality or chronic declines in tree health. Damage from these agents can also have an indirect influence on forest health by weakening trees and predisposing them to attacks from more damaging or lethal pests.

Unlike abiotic disturbances such as drought and wildfire, forest insects and pathogens typically attack a specific host tree species or narrow range of hosts, so damage may be limited in mixed-species forests. At normal population levels, native insects and pathogens provide important ecological roles in nutrient cycling of dead plant material and removal of weak, suppressed, and unthrifty trees, leaving healthier trees with more access to water, light, and nutrients. At high levels, outbreak populations can cause significant changes in stand structure and composition over time. Non-native or invasive forest insects and diseases, such as spongy moth and sudden oak death, are major threats to Washington's forests as native trees lack effective defense mechanisms.

The following section is a summary of recent forest insect and disease damage trends and conditions collected through a combination of aerial surveys, remote sensing, pheromone trapping, stream baiting, field observations, and ground monitoring plots.

INSECTS | BARK BEETLES

GLENN KOHLER / DNR

Pine Bark Beetles

(Dendroctonus ponderosae Hopkins,
Dendroctonus brevicomis LeConte & *Ips* spp.)

NATIVE

The area with mortality caused by pine bark beetles in 2023 was approximately 124,000 acres, above the ten-year average of 112,700 acres and similar to the 2022 level (Fig.11). Trend data for 2020 is not included in this calculation due to changes in survey methods and reduced survey area. Relative to 2022, acres with mortality caused by pine bark beetle increased for mountain pine beetle but decreased for western pine beetle and Ips pine engravers (Table 1).

Mountain pine beetle (*Dendroctonus ponderosae*) damage increased from 76,800 acres in 2022 to approximately 90,200 acres in 2023. The majority of pine bark beetle mortality recorded each year is in lodgepole pine killed by mountain pine beetle (MPB), which killed lodgepole pine on 80,900 acres in 2023 (top facing page). Recent areas with MPB-killed lodgepole pines totaled 66,800 acres in 2022 and 51,300 acres in 2021.

In 2023, the highest concentrations of MPB mortality in lodgepole were mapped: north of Mt. Adams in Yakima County; around the William O. Douglas Wilderness area; in the Manastash Ridge area of southwest Kittitas County; along the Kittitas-Chelan county border including the Colockum Pass area between Wenatchee and Ellensburg; around the Lake Chelan-Sawtooth Wilderness area and the Pasayten Wilderness area; around Mount Bonaparte in northwest Okanogan County; in central Ferry County and in northern Pend Oreille County.

SOME MORTALITY IN WHITEBARK PINE AND WESTERN WHITE PINE IS DUE TO NON-NATIVE WHITE PINE BLISTER RUST DISEASE.

MPB-caused mortality in ponderosa pine was mapped on 6,800 acres in 2023, below the 10-year average of about 17,300 acres. Observers recorded approximately 7,100 acres with MPB-caused mortality of whitebark pine in 2023, the highest level since 2010 (16,200 acres). Areas with high concentrations of whitebark pine mortality included areas on the north side of Mt. Adams, the upper Ahtanum in Yakima County, around the Manastash Ridge area of southwest Kittitas County, around the Alpine Lakes Wilderness west of Leavenworth, along the Chelan-Okanogan County border, and in western Okanogan County north of Mazama. Observers mapped approximately 300 acres with western white pine mortality in 2023. Some mortality in whitebark pine and western white pine may be due to non-native white pine blister rust disease directly killing trees or predisposing infected trees to attack by MPB.

Mortality of ponderosa pine due to western pine beetle (*Dendroctonus brevicomis*) has increased steadily since 2012. It reached a peak of approximately 44,300 acres in 2022, decreased to approximately 32,800 acres in 2023, but is still above the 10-year average of 20,700 acres (Fig. 12). 2022 was the highest level of WPB damage recorded since 2006. Western pine beetle (WPB) damage has been widely reported throughout eastern Washington, resulting in increased requests for information from landowners and land managers. Recent drought conditions are likely an important driver of these increases. Concentrations of WPB-caused mortality were widespread throughout lower elevation forested areas of Klickitat County and the Yakama Indian Reservation, central Kittitas County, eastern Okanogan County, the Confederated Tribes of the Colville Reservation, and throughout Stevens and Spokane counties.

Pine mortality attributed to Ips pine engravers (*Ips* species) was mapped on approximately 900 acres in 2023, a decrease from the 2,500 acres mapped in 2022 and below the 10-year average of 1,800 acres. Ponderosa pine was the most common species affected. Some of the same areas are also experiencing WPB outbreaks, which have a very similar aerial survey damage signature in young ponderosa pines.

MARYAM MAJIDIAN / DNR

Mountain pine beetle mortality in lodgepole pine in Kittitas County.

Mountain pine beetle pitch tubes in lodgepole pine bark.

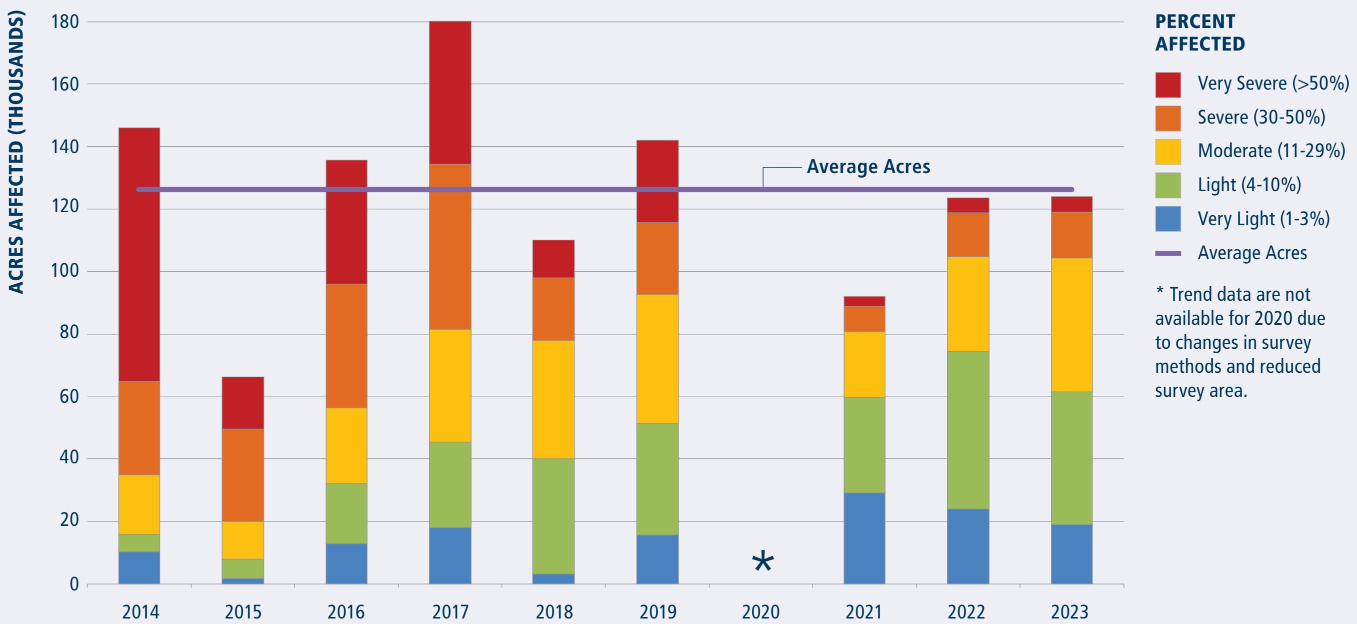
Table 1.

PINE BARK BEETLE DAMAGE IN WASHINGTON OBSERVED IN AERIAL DETECTION SURVEY, IN ACRES

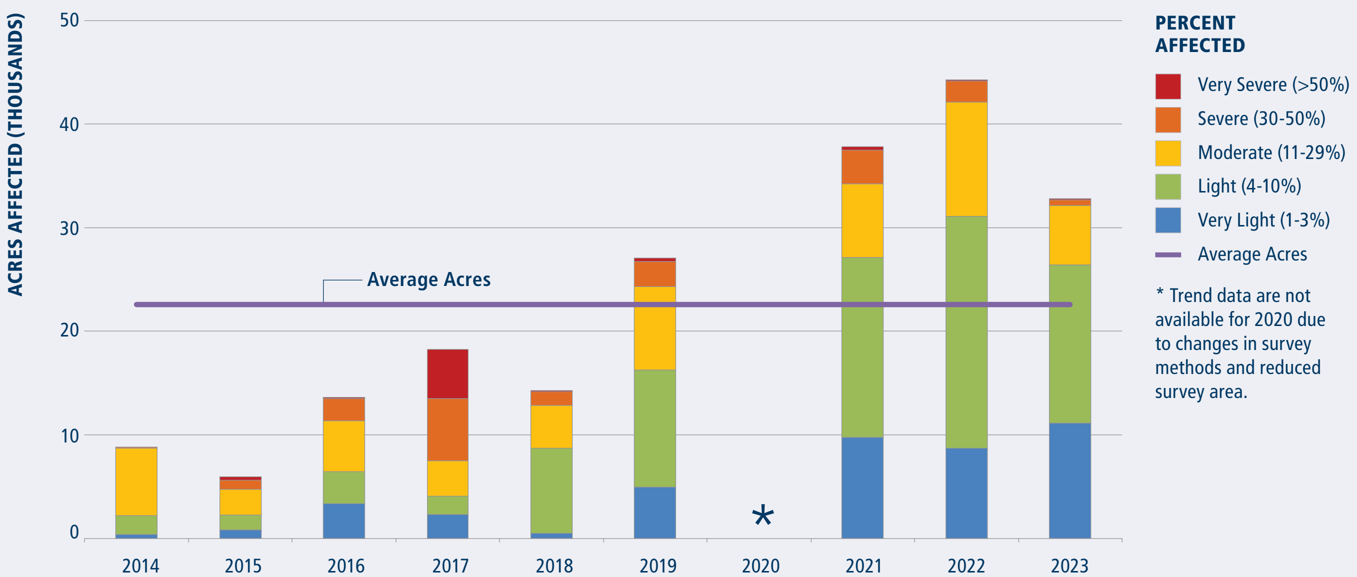
BEETLE SPECIES	HOST(S)	2022 ACRES WITH MORTALITY	2023 ACRES WITH MORTALITY
Mountain Pine Beetle	Lodgepole Pine	66,750	76,100
Mountain Pine Beetle	Ponderosa Pine	4,800	6,800
Mountain Pine Beetle	Whitebark Pine	5,100	7,100
Mountain Pine Beetle	Western White Pine	160	300
Western Pine Beetle	Ponderosa Pine	44,300	32,800
Pine Engravers (*Ips* species)	All Pines	2,500	900
Totals		123,610*	124,000*

*Multiple host species can be recorded in a single area, therefore the sum of acres for all hosts is greater than the total footprint affected.

PINE BARK BEETLES 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 11.



WESTERN PINE BEETLE 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 12.



INSECTS | BARK BEETLES

IMAGE LIBRARY / BUGWOOD.ORG PEST AND DISEASES

California Fivespined Ips

(*Ips paraconfusus* Lanier)

NATIVE

California fivespined Ips (CFI), a pine engraver beetle native to Oregon and California, was first detected in Washington State in 2010. It has either expanded its range or re-occupied a historic range. Localized outbreaks of CFI continue to cause unusually high levels of ponderosa pine mortality in areas along the Columbia River Gorge in Skamania, Klickitat, and Benton counties.

Bark beetles that killed ponderosa pines in July 2022 at Joint Base Lewis-McChord (JBLM) were identified as CFI by a USFS entomologist. This was the first known occurrence of CFI killing pines in western Washington. In early 2023, shore pine (*Pinus contorta*) and Austrian pine (*Pinus nigra*) mortality at four locations in the greater Seattle area were also verified by DNR to be caused by CFI (see right). These are new host records for Washington and likely increase potential for CFI mortality spreading to new areas. To date, CFI has been detected in 13 Washington counties, extending the previously reported range in 1987 by approximately 150 miles to the north and 200 miles to the east.

GLENN KOHLER / DNR

Ornamental pine killed by CFI in Seattle, 2023.

MONITORING

In 2023, a site with CFI-killed shore pine in Bothell (King County) became the farthest north record of CFI in Washington. Other sites with new mortality in western Washington include ponderosa pine at JBLM, shore pines and Austrian pines in Renton and Seattle, and Austrian pines in Mercer Island. Six new trap sites in northwest Washington (Pierce, King, Snohomish, Skagit, and Island counties) were set up in 2023 to target stands with shore pine and ornamental pine hosts, as well as to determine if CFI is found north of King County. CFI was not detected further north of Bothell (Fig.13).

From 2010-2018 and 2022-2023, pheromone-baited funnel traps have been used at 61 sites in 28 counties to monitor CFI occurrence and distribution in Washington. Not all sites were trapped each year. Separate traps were also baited for *Ips pini*, the more common native pine engraver in Washington, at each site. DNR, USFS, Washington State University Extension, and the Washington State Department of Agriculture have cooperated to conduct these surveys.

In 2011 and 2012, only three CFI adults were collected in traps at JBLM, outnumbered by over 200 *Ips pini*. At that time, JBLM was the farthest north CFI had been collected in Washington, with no related mortality reported. In 2018, a trap site near Shelton (Mason County) became the new northernmost record of CFI, with very low numbers like JBLM (five CFI and over 5,000 *Ips pini*). Prior to 2023, CFI populations at western Washington detection sites north of Vancouver also tended to be low, but CFI collections at Renton and Bothell sites are now in the hundreds.

IMPACTS AND RANGE EXPANSION

CFI can infest numerous species of pines and has been a serious pest of young ponderosa pine in Oregon's Willamette Valley since it was first reported there in 1999. CFI can rapidly increase its population in small diameter (but greater than 3 inches) dead pine slash created by storms, fires, logging, or thinning.

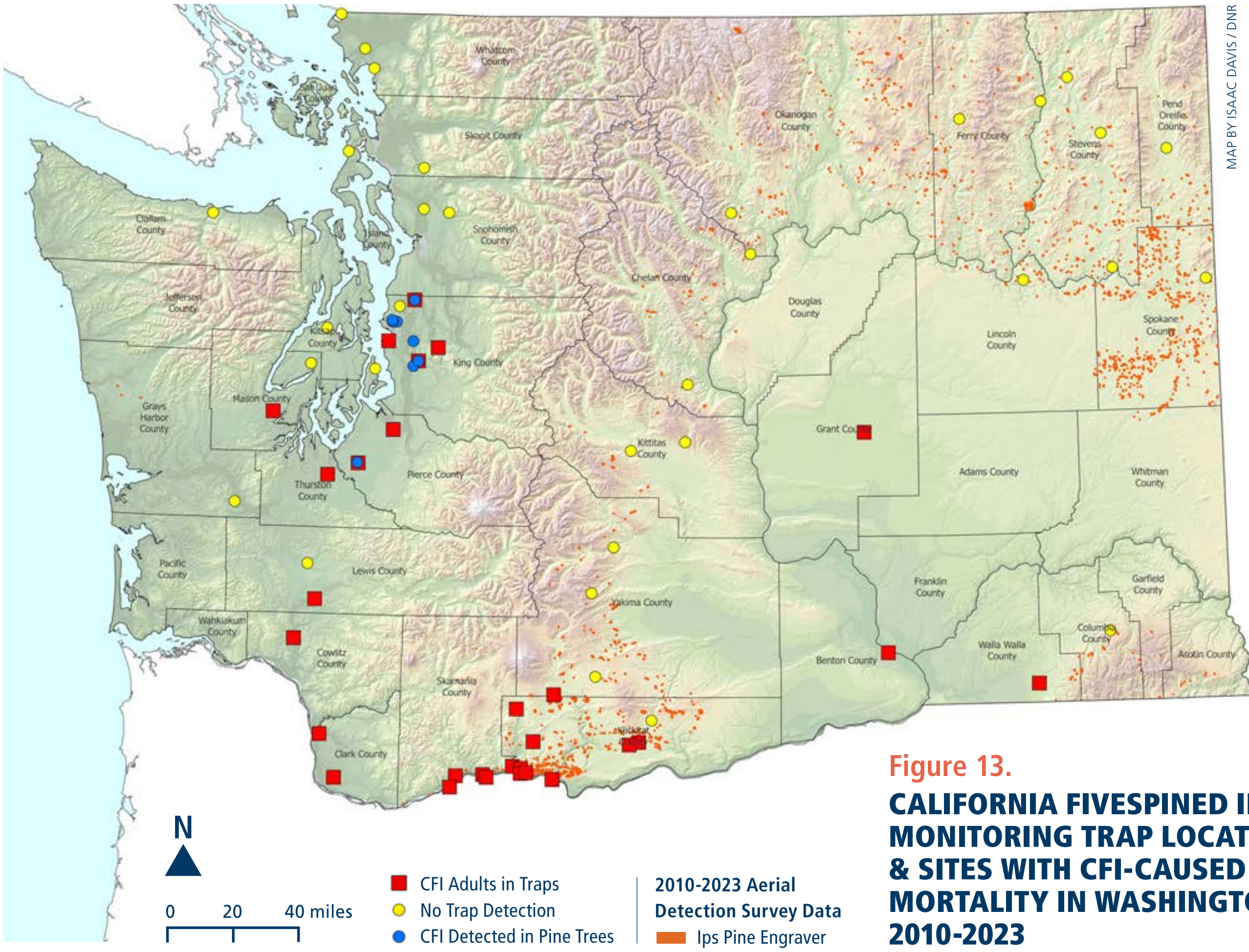


Figure 13.

CALIFORNIA FIVESPINED IPS MONITORING TRAP LOCATIONS & SITES WITH CFI-CAUSED PINE MORTALITY IN WASHINGTON, 2010-2023

Offspring produced the same year can then successfully attack live trees nearby. The risk of outbreak is much higher during drought conditions when live trees are stressed. Ips outbreaks typically subside within a year unless fresh breeding material becomes available for a second year. That said, CFI outbreaks in Washington may be lasting longer due to drought stress and more susceptible hosts that haven't been previously exposed to CFI attack.

CFI outbreaks in the eastern Columbia River Gorge affecting Hood River and Wasco counties in Oregon and Skamania and Klickitat counties in Washington have led to numerous killed and top-killed ponderosa pines most years since 2010. Approximately 2,900 acres with CFI-killed ponderosa pine were recorded in Oregon and Washington during the 2016 ADS, which is the most recent peak of activity. Outbreaks have been driven by consecutive years of fires, storm damage, and drought conditions. Attacks by western pine beetle (*Dendroctonus brevicomis*), red turpentine beetle (*Dendroctonus valens*), and infections of bluestain fungi may also contribute to mortality of some larger ponderosa pine.

It is unclear why CFI has transitioned in the greater Puget Sound region from low trap catch numbers in 2011-2018 to killing pines at several locations in 2022 and 2023. Increased tree stress due to recent droughts and extreme temperatures, such as the 2021 "heat dome" event, are likely contributors. Why CFI seems to be more successful at killing stressed pines than the more abundant *Ips pini* is unknown, but increasing populations and new host species such as shore pine and Austrian pine could be playing a role. Trap survey data indicate that populations of CFI and *Ips pini* do not appear to overlap in high numbers at the same locations. The two species are rarely found in the same tree, which suggests competition may also be a factor.

It is difficult to know with just trap data alone whether CFI is actively moving north and east into new areas, or whether it is just being collected more frequently because of increased monitoring efforts. Contents of five regional insect collections indicate that CFI was not likely collected in Washington prior to 2010. While not every trap site is monitored every year, there have been numerous trap sites in northern counties that have not detected CFI, clearly showing the northern edge of its current range. These data can be used as a baseline for continued trapping to the north. The new development of CFI killing pines at several sites in the Puget Sound area suggests that CFI was not well established or killing trees there in the past, otherwise it would have been more likely to have been reported and collected.

INSECTS | BARK BEETLES

GLENN KOHLER / DNR

Douglas-fir Beetle

(*Dendroctonus pseudotsugae* Hopkins)

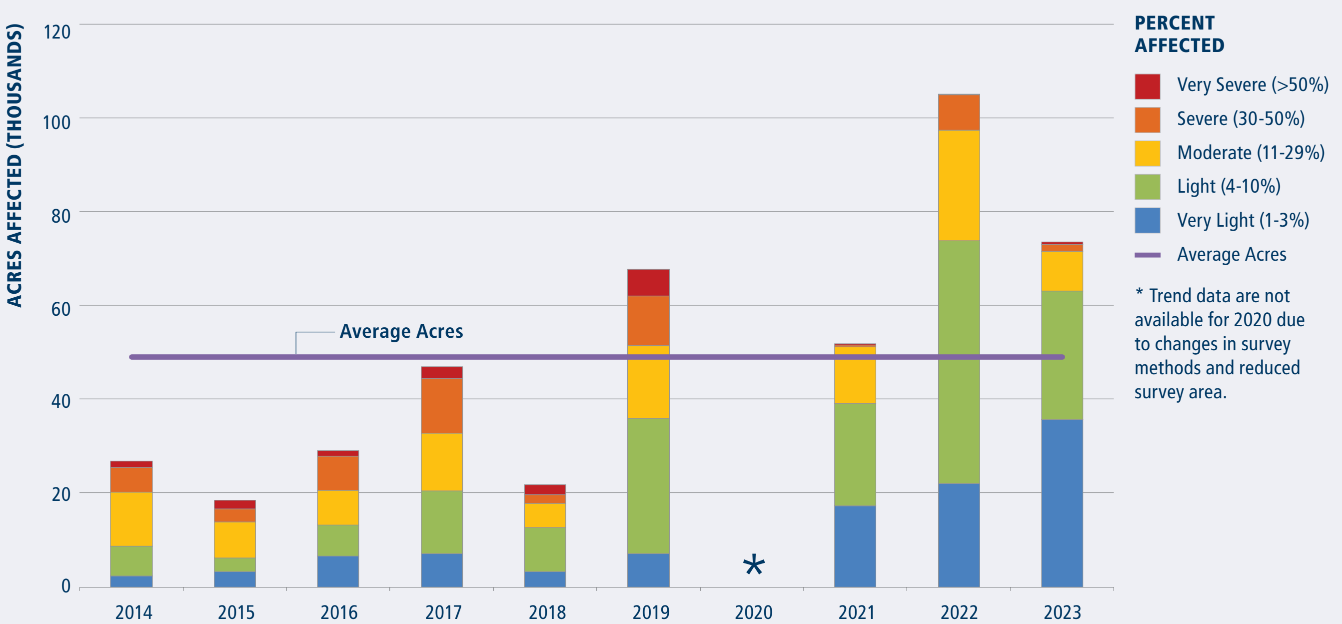
NATIVE

Mortality due to Douglas-fir beetle (DFB) has been increasing in recent years, reaching a peak of 105,000 acres in 2022, the highest level recorded since 2001. The area with DFB damage decreased to approximately 73,500 acres in 2023 but is still above the 10-year average of 50,100 acres (Fig.14). Scattered areas of DFB-caused mortality were detected throughout western Washington, with higher concentrations in Skamania, Lewis, Thurston, Pierce, King, Skagit, Whatcom, Grays Harbor, and Mason counties. In eastern Washington, the highest concentrations were in western Klickitat, Yakima, and Kittitas counties; northern Okanogan, Ferry, Stevens, Pend Oreille, and Spokane counties; and in the Blue Mountains in southeast Washington. Some of the eastern Washington mortality was likely associated with recent wildfire damage.

Douglas-fir beetle boring dust.

DOUGLAS-FIR BEETLE 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON

Figure 14.



INSECTS | BARK BEETLES

Secondary Bark Beetles in Douglas-fir

(*Scolytus monticolae* (Swaine), *Scolytus unispinosus* LeConte, and *Pseudohylesinus nebulosus* (LeConte))

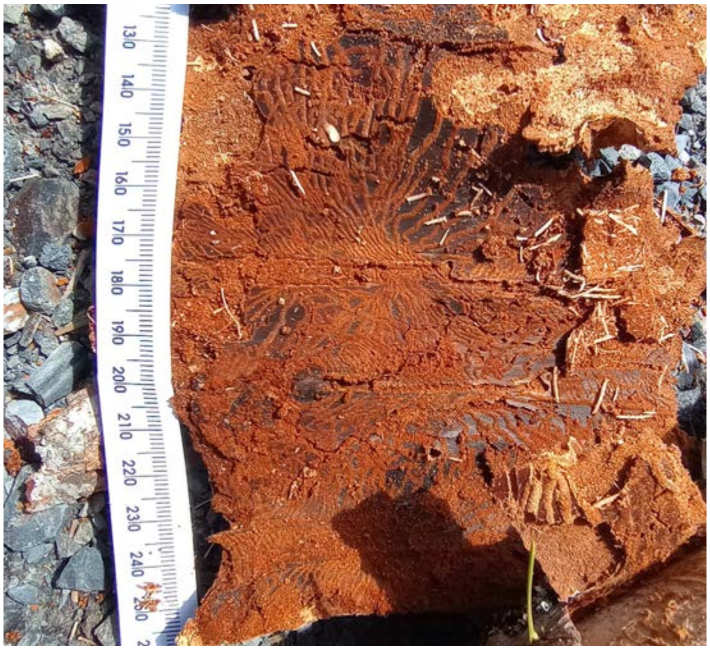
NATIVE

The aerial survey damage signature of dead tops and branch flagging in Douglas-fir is attributed to Douglas-fir engraver (*Scolytus unispinosus*). However, this type of damage is also caused by at least two other secondary bark beetle species: Douglas-fir pole beetle (*Pseudohylesinus nebulosus*) and *Scolytus monticolae*. This group of bark beetles is "secondary" because they are not typically the primary killers of healthy trees but tend to attack trees stressed by other factors like drought when given the opportunity. All three species can infest the same tree and are difficult to distinguish based on their egg and larval galleries alone.

The amount of Douglas-fir engraver damage mapped in 2023 was approximately 25,600 acres, the highest level recorded in Washington aerial surveys since 1969. Another recent peak of 20,300 acres with Douglas-fir engraver damage occurred in 2019, both well above the 10-year average of 8,100 acres. Increased activity is likely due to recent cumulative drought stress. The highest concentrations of damage in western Washington were in the Cascade foothills areas. In eastern Washington, the highest concentrations of damage were in western Klickitat County and in southern Ferry and Stevens counties.

Attacks by these species usually occur in small diameter Douglas-fir trees, or the tops and branches of larger trees, resulting in a patchy pattern of dieback in mature Douglas-fir tree crowns. Secondary bark beetle species do not typically cause mortality, particularly in mature trees. Stressors such as drought and root disease may predispose Douglas-fir to attack by these species. Attacks during drought are more likely to be successful and cause mortality.

TERRI BAUCK



GLENN KOHLER / DNR

Above: Secondary bark beetle larval galleries in Douglas-fir.

Right: Douglas-fir damage from secondary bark beetles in northeast Washington.

INSECTS | BARK BEETLES

DAVID MCCOMB / USDA FOREST SERVICE, BUGWOOD.ORG

Spruce Beetle

(*Dendroctonus rufipennis* Kirby)

NATIVE

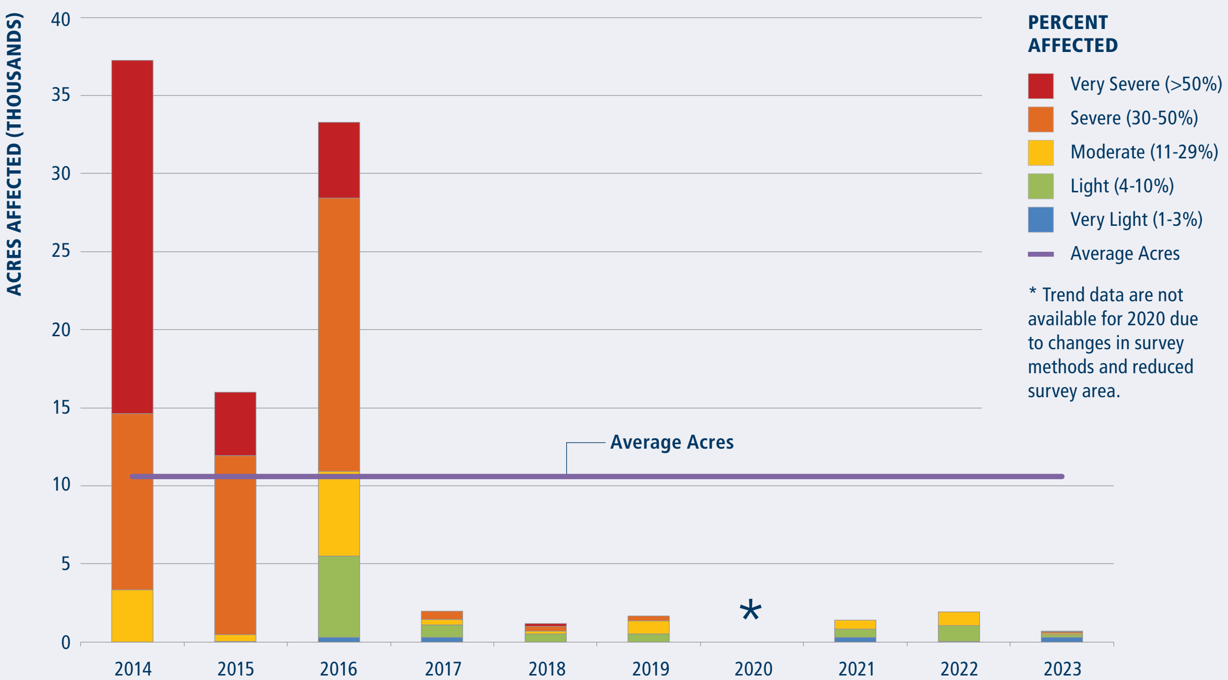
The area affected by spruce beetle in Engelmann spruce in 2023 was approximately 650 acres, a decrease from the 1,900 acres mapped in 2022, and well below the 10-year average of 11,600 acres (Fig.15).

The affected areas are near the Cascade crest in Okanogan and Chelan counties. Areas of western Okanogan County around the Pasayten Wilderness experienced a large spruce beetle outbreak until 2017, with a peak of over 60,000 acres with mortality in 2012. Low levels of spruce beetle activity have persisted in this area since 2018.

Spruce beetle galleries.

DARREN BLACKFORD / USDA FOREST SERVICE, BUGWOOD.ORG

SPRUCE BEETLE 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 15.



INSECTS | BARK BEETLES

DONALD OWEN, CALIFORNIA DEPARTMENT OF FORESTRY AND FIRE PROTECTION, BUGWOOD.ORG

Fir Engraver

(*Scolytus ventralis* LeConte)

NATIVE

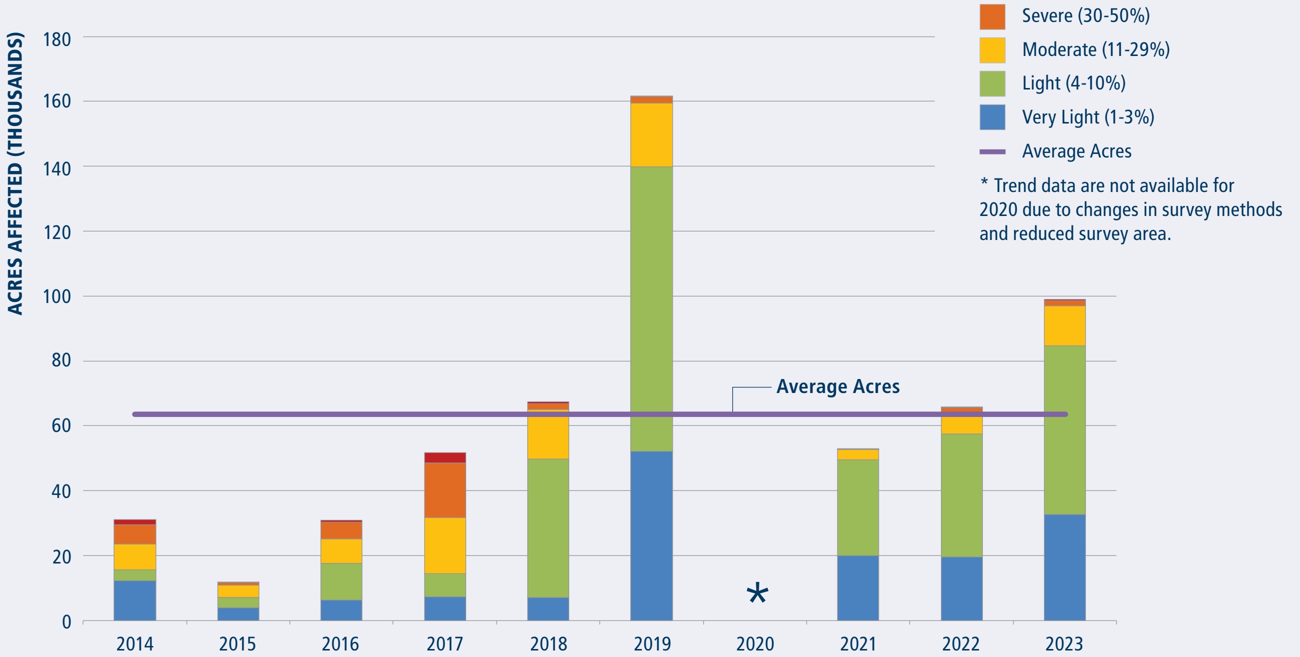
The fir engraver beetle can attack all species of true fir (*Abies*) in Washington, but its primary hosts in Washington are grand fir and noble fir. Fir engraver-caused mortality, primarily in grand fir, has been steadily increasing since 2015 and reached a 10-year high of 166,300 acres in 2019, more than twice the area recorded in 2018 (Fig.16). Following a drop to 52,500 acres in 2021, the upward trend has resumed with an increase in 2023 to approximately 99,000 acres, up from 65,700 acres in 2022, remaining above the 10-year average of 63,800 acres.

In eastern Washington, the most concentrated areas of mortality were throughout the Cascade Mountain areas of Klickitat, Yakima, Kittitas, Chelan, and western Okanogan counties; in the Kettle River Range and Selkirk Mountains in Ferry, Stevens, and Pend Oreille counties; in northern Spokane County; and the Blue Mountains in southwest Washington. West of the Cascades, concentrated areas of damage were recorded in Skamania, Cowlitz, Lewis, Pierce, King, Snohomish, Skagit, and Whatcom counties.

GLENN KOHLER / DNR

Fir engraver beetle galleries.

FIR ENGRAVER 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 16.



INSECTS | BARK BEETLES

STEVEN VALLEY / OREGON DEPARTMENT OF AGRICULTURE, BUGWOOD.ORG

Silver Fir Beetle

(*Pseudohylesinus sericeus* (Mannerheim))

NATIVE

The silver fir beetle and a related species the fir root bark beetle (*Pseudohylesinus granulatus*) can kill true firs (*Abies*) and other conifer hosts in Washington such as western hemlock and Douglas-fir. The most oft-damaged host is Pacific silver fir. Mortality is scattered during a typical year and attacks are focused on trees weakened by disease or attacks by other fir bark beetles. Outbreaks are rare; however, increases in population can occur following windthrow events that generate abundant breeding material.

Observers mapped approximately 500 acres in Washington with mortality caused by silver fir beetle (SFB) in 2023, a decrease from the 1,100 acres mapped in 2022. The highest level of SFB recorded by aerial survey in recent decades was 6,400 acres in 2004. Very low amounts of mortality were recorded from 2005 until 2015 when levels began increasing to a recent peak of 1,700 acres in 2019. Small areas with silver fir beetle mortality were mapped in 2023 in the Snoqualmie Pass area of eastern King County and western Kittitas County.

THE TREND IN SUBALPINE FIR MORTALITY APPEARS TO BE DECREASING FROM A RECENT PEAK OF 49,900 ACRES WITH DAMAGE IN 2021, THE HIGHEST LEVEL SINCE 2007.

INSECTS | BARK BEETLES

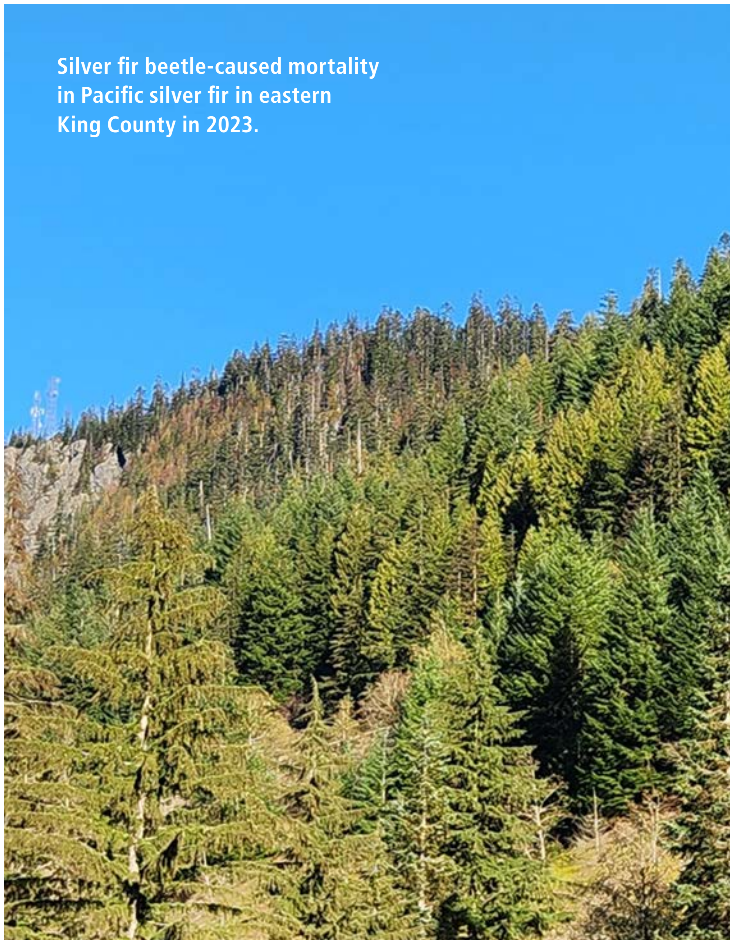
USDA FOREST SERVICE - REGION 2 ROCKY MOUNTAIN REGION, USDA FOREST SERVICE, BUGWOOD.ORG

Western Balsam Bark Beetle

(*Dryocoetes confusus* Swaine)

NATIVE

Western balsam bark beetle (WBBB), often in conjunction with balsam woolly adelgid, is an important driver of subalpine fir mortality in high-elevation Washington forests. Observers mapped approximately 24,900 acres with WBBB-caused mortality in 2023, a decrease from 39,400 acres in 2022. The trend in subalpine fir mortality appears to be decreasing from a recent peak of 49,900 acres with damage in 2021, the highest level since 2007. The most concentrated areas with damage were along the Cascade crest in western Okanogan County, eastern Whatcom and Skagit counties, north Chelan County, western Klickitat County, and northwest Yakima County. Areas affected in northeast Washington were throughout high elevations in the Colville National Forest in Ferry, Stevens, and Pend Oreille counties.



GLENN KOHLER / DNR

Silver fir beetle-caused mortality in Pacific silver fir in eastern King County in 2023.

INSECTS | AMBROSIA BEETLES

UDO SCHMIDT

Mediterranean Oak Borer

(*Xyleborus monographus* Fabricius)

NON-NATIVE

Recent Mediterranean oak borer (MOB) infestations of Oregon white oak (*Quercus garryana*) in northwest Oregon increase the potential of this serious, non-native, forest insect pest moving into Washington state. Native to Europe, North Africa, and western Asia, these tiny, one-eighth inch ambrosia beetles can tunnel into wood of several western oak species, including Washington's only native oak: Oregon white oak.

The beetles do not eat wood but use it to grow fungi they feed to their young. Unfortunately, two of these fungi, *Raffaelea montetyi* and *Fusarium solani*, can cause wilting diseases that cause branch and crown dieback. Reinfestation over several years can cause a top-down pattern of crown dieback and may eventually result in whole tree mortality.

MOB was likely introduced into central California around 2010 and was reported to be killing valley oaks in Napa and Sonoma counties by 2019. California populations of MOB have spread to nearby Lake and Sacramento counties, and have also been recorded in blue oak, California black oak, and Oregon white oak. MOB was first detected in traps in Multnomah County, Oregon in 2018 and has since been collected in traps from three other northwest Oregon counties (Clackamas, Marion, and Washington). The first Oregon record of MOB infestation resulting in mortality of Oregon white oak occurred in 2022 in Multnomah County. Since then, approximately 30 MOB-infested Oregon white oaks were found in Clackamas County.

Multiple agencies are collaborating to monitor MOB activity in Oregon, determine potential management strategies, and slow its spread. More information about the situation in Oregon can be found in the Oregon Department of Forestry MOB factsheet: https://tinyurl.com/MOB-oregon

MOB has not been detected in Washington state. The Washington Department of Agriculture is using traps to monitor MOB and other invasive insects in Washington. The public is encouraged to report suspected MOB sightings or related damage to oak trees (see "what to look for" below) in Washington State at https://invasivespecies.wa.gov/report-a-sighting/invasive-insects/.

Diligence by the public to avoid moving firewood and other potentially infested oak materials is more important than ever.

MOB's spread over wider areas in California and Oregon raises the concern that it will be difficult to eradicate or contain once established in new areas. The potential impact to Oregon white oak forests in the Pacific Northwest is not well understood. In its native range, oaks attacked by MOB are more likely to be unhealthy or stressed. In California and Oregon, MOB appears more capable of attacking generally healthy oaks.

Mediterranean oak borer galleries and staining in sapwood.

CHRISTINE BUHL / OREGON DEPARTMENT OF FORESTRY

WHAT TO LOOK FOR:

The most easily spotted symptom of possible MOB infestation is partial crown dieback that proceeds down to lower branches and the main stem over several years (see next page, top right). Similar crown dieback symptoms can have other causes, such as drought stress or attack by other insects such as oak pit scale and carpenterworm. More direct signs of MOB activity include piles of powdery white or tan frass on bark, perfectly round 1/16th inch wide entrance/exit holes through bark, and branching, black-stained pinhole tunnels in wood that usually don't enter heartwood (see next page). Other ambrosia beetle species in oak will have similar signs, so adult beetle specimens are needed for positive identification. Female adults are about one-eighth inch long, dark brown, and cylinder shaped. Males are smaller and rarely seen.

Above: Mediterranean oak borer adult and entrance or exit hole.

Top: Crown dieback symptoms in Oregon white oak due to Mediterranean oak borer infestation and wilting disease.

Left: Powdery frass accumulation typical of ambrosia beetle infestation.

PHOTOS ON THIS PAGE: CHRISTINE BUHL / OREGON DEPARTMENT OF FORESTRY

INSECTS | DEFOLIATORS

GLENN KOHLER /DNR

Douglas-fir Tussock Moth

(*Orgyia pseudotsugata* McDunnough)

NATIVE

GLENN KOHLER /DNR

Douglas-fir tussock moth larvae defoliating grand fir in Kittitas County, 2018.

No Douglas-fir tussock moth (DFTM) defoliation was recorded in Washington in 2023. The most recent outbreaks in Kittitas, Chelan, and Okanogan counties defoliated 1,900 acres in 2018 and 5,600 acres in 2019.

Established over 40 years ago, the interagency network of "Early Warning System" pheromone traps at approximately 240 locations in eastern Washington continues to be monitored annually (Fig.18). The Early Warning System is a pheromone-based trapping system used to detect outbreaks of Douglas-fir tussock moth in the western United States. Each year, forest health specialists set out sticky traps baited with a synthetic version of the pheromone produced by female moths to attract male moths. These traps are retrieved after the male flight period, and the number of male DFTM moths is recorded. Increases in trap catch numbers may indicate outbreak events in the following years (Fig.17).

Overall, trap catches across eastern Washington decreased in 2023 compared to 2022. At a few sites in Okanogan County east of Oroville, catches remained elevated but were lower than 2022 and at fewer locations. DFTM defoliation has not been recorded in this area since 2019. DFTM defoliation in this area is possible in 2024, but not likely, given virus load and absence of defoliation in 2023. One trap site near Trout Lake in Klickitat County has increased in 2022 and 2023. This area does not have a recent history of tussock moth defoliation. High trap-catch numbers do not always correlate with the exact location of future defoliation, and high numbers can be associated with declining outbreak events. Outbreaks of DFTM in the Pacific Northwest are cyclical and occur approximately every seven to ten years from the first year with defoliation during the previous outbreak (Fig.17). For more information on the Early Warning System, go to: https://www.fs.usda.gov/detail/r6/forest-grasslandhealth/?cid=fsbdev2_027373.

INSECTS | DEFOLIATORS

DOUGLAS-FIR TUSSOCK MOTH TRAP CATCHES AND DEFOLIATION IN WASHINGTON 1987-2023 Figure 17.

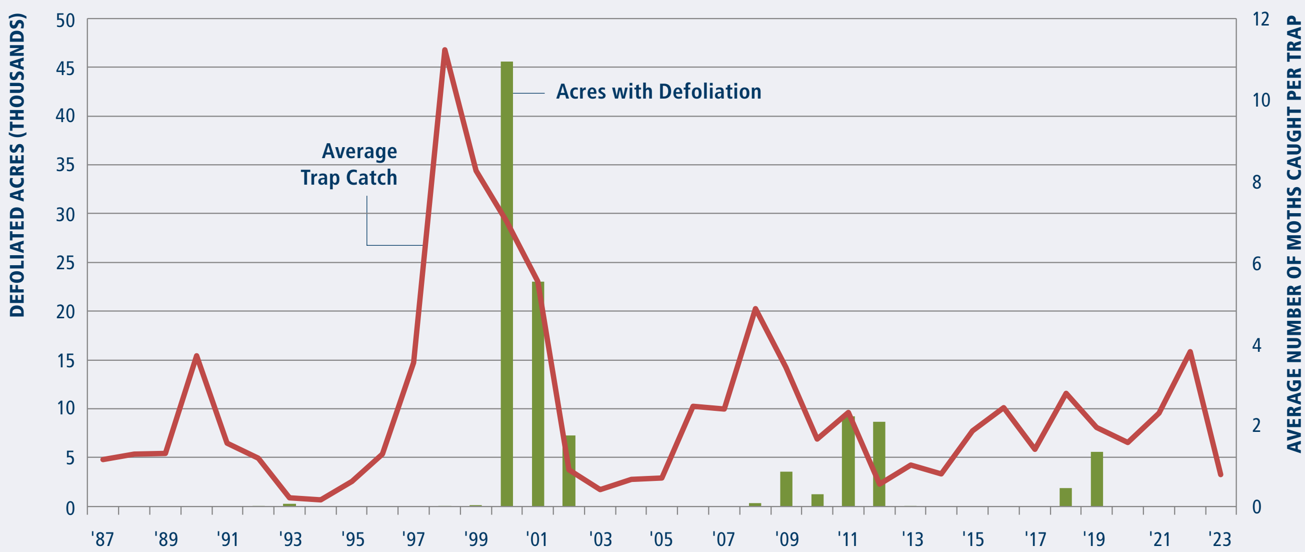


Figure 18.

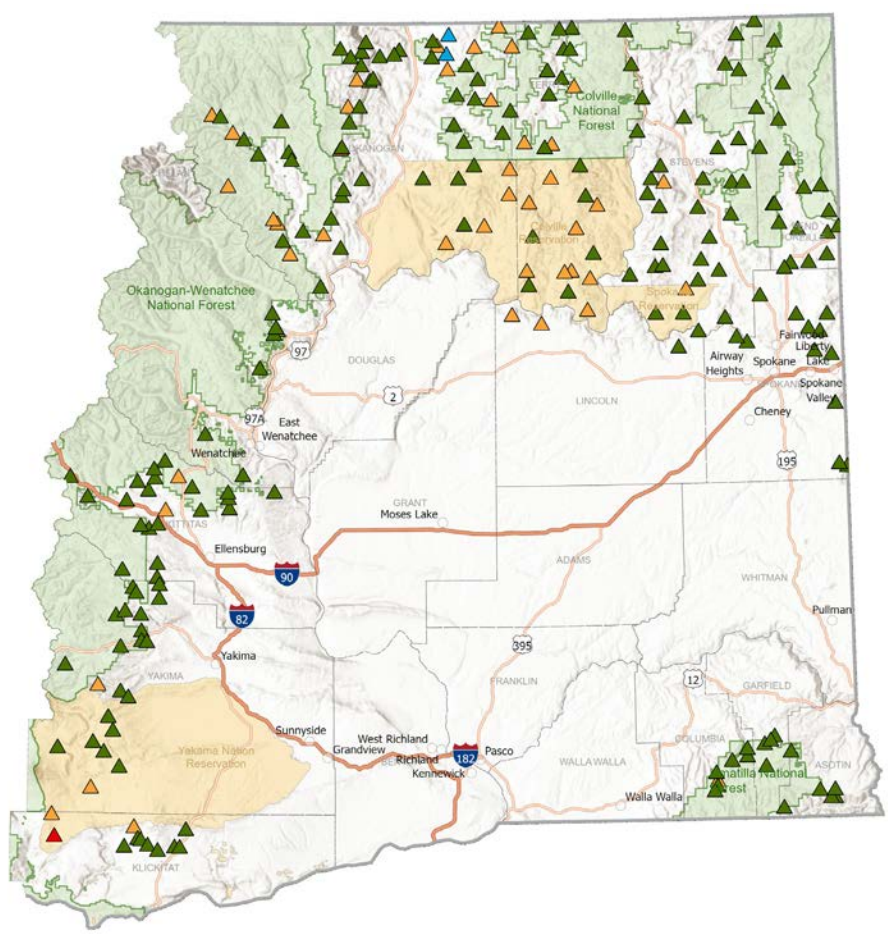
DOUGLAS-FIR TUSSOCK MOTH PHEROMONE TRAP CATCH RESULTS IN EASTERN WASHINGTON 2023

SOURCE: USFS

- <1 Moths
- 1 to 10
- 11 to 25
- 26 to 40
- More Than 40

N

40 miles



INSECTS | DEFOLIATORS

GLENN KOHLER /DNR

Western Spruce Budworm

(*Choristoneura occidentalis* Freeman)

NATIVE

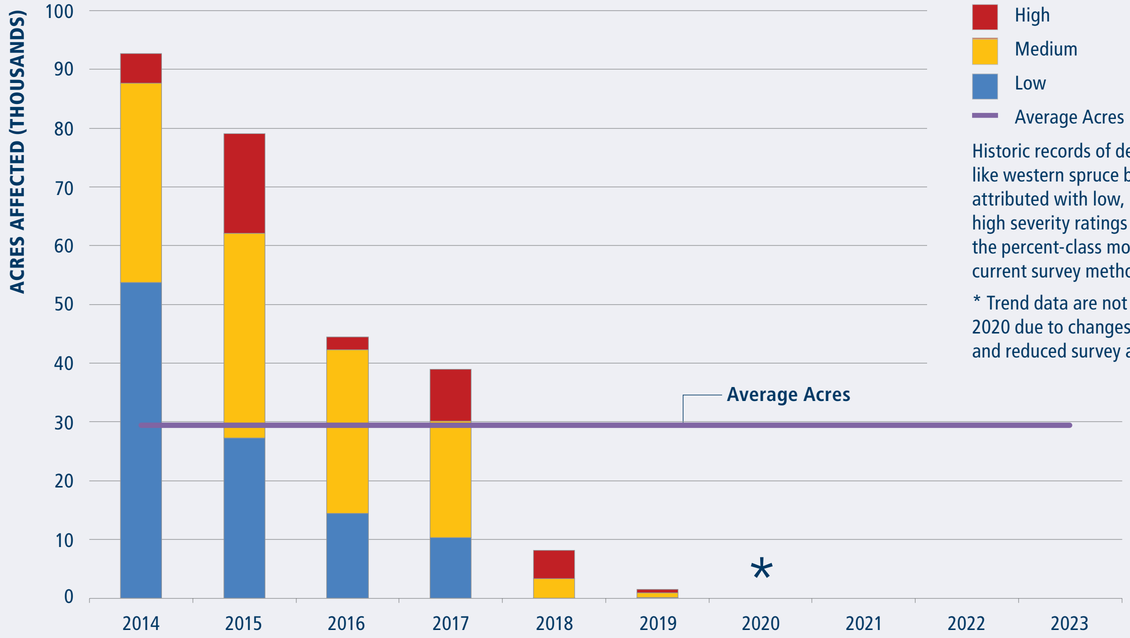
The total acres with western spruce budworm (WSB) defoliation in Washington has steadily declined from peak levels over 500,000 acres in 2011 and 2012 down to no detectable damage mapped from the air in 2021-2023 (Fig.19). The last major outbreak in the central Washington Cascades that lasted over a decade had declined by 2017. A shorter-lived and smaller outbreak in northeast Washington appears to have also declined with a large reduction of defoliated acres in 2019.

WSB pheromone traps were placed at 107 locations in northeast Washington in 2023 (Fig.20). Only a few trap sites in northern Okanogan County indicated the potential for defoliation in 2024. Trap catches elsewhere remain low. The purpose of WSB trapping is to predict the next year's defoliation severity in an area that is currently experiencing an outbreak. After three years with no detectable defoliation, the WSB trap network in northeast Washington will be discontinued in 2024.

WILLIAM M. CIESLA, FOREST HEALTH MANAGEMENT INT. / BUGWOOD.ORG

Western spruce budworm adult with grand fir foliar damage.

WESTERN SPRUCE BUDWORM 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 19.



SEVERITY RATING

- High
- Medium
- Low
- Average Acres

Historic records of defoliation agents like western spruce budworm are attributed with low, medium, and high severity ratings and differ from the percent-class mortality ratings of current survey methodology.

* Trend data are not available for 2020 due to changes in survey methods and reduced survey area.

INSECTS | DEFOLIATORS

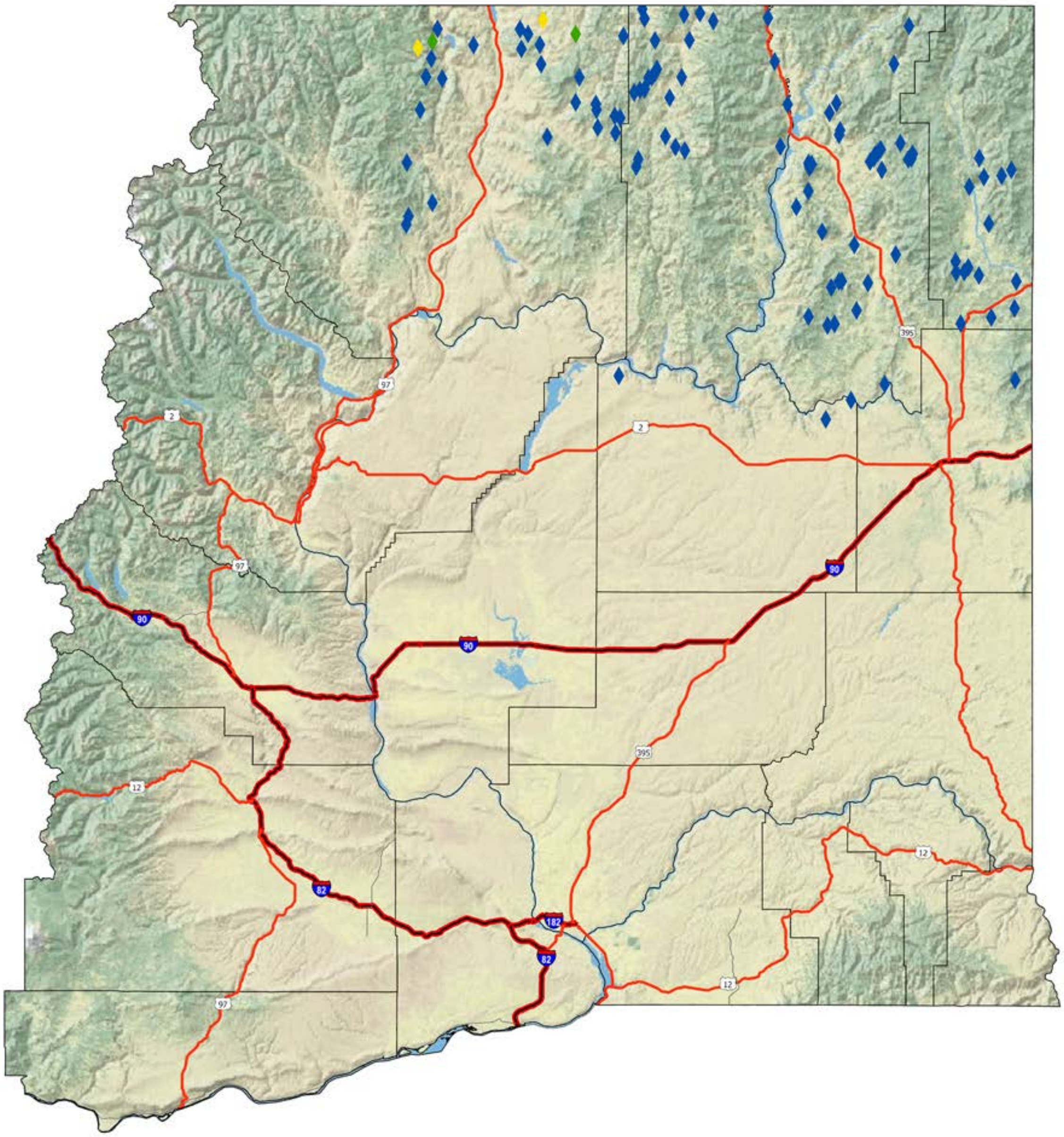


Figure 20.

WESTERN SPRUCE BUDWORM PHEROMONE TRAP RESULTS IN EASTERN WASHINGTON 2023

Western spruce budworm pheromone trap catch results for 2023 and expected 2024 defoliation.

SOURCE: DNR

(0-4)	Defoliation undetectable by cursory observation
(5-19)	Patchy defoliation with some trees
(20-34)	Most trees lightly defoliated
(35-44)	Stand moderately defoliated
(45-55)	Heavy defoliation of upper crowns
(>55)	Heavy defoliation of entire crown

0 20 40 miles

N

INSECTS | DEFOLIATORS

FRANCO FOLINI

Western Tent Caterpillar

(*Malacosoma californicum* (Packard))

NATIVE

JAKE WHITTENBERG / KING 5 NEWS

Isolated outbreaks of western tent caterpillar (WTC) developed in areas of northwest Washington in 2023. Large aggregations of wandering caterpillars and heavy defoliation on Guemes Island in Skagit County were reported by the public and featured on Seattle TV news. There were also reports from the Anacortes (Skagit County) and Port Angeles (Clallam County) areas. Aerial surveys recorded WTC defoliation of hardwoods on approximately 330 acres on Guemes and Fidalgo Islands. This may be an underestimate since survey flights in these areas were conducted later than the peak of defoliation. The last major WTC outbreak in western Washington occurred from 2012 to 2014. WTC outbreaks are cyclical and rarely last more than a few years.

THE LAST MAJOR WTC OUTBREAK IN WESTERN WASHINGTON OCCURRED FROM 2012 TO 2014. WTC OUTBREAKS ARE CYCLICAL AND RARELY LAST MORE THAN A FEW YEARS.

Above: Western tent caterpillar larvae and defoliation in 2023.

Next page: Wandering western tent caterpillar larvae on Guemes Island in 2023.

JAKE WHITTENBERG / KING 5 NEWS

INSECTS | DEFOLIATORS

JON YUSCHOCK / BUGWOOD.ORG

Spongy Moth

(*Lymantria dispar* Linnaeus)

NON-NATIVE

The Washington State Department of Agriculture deployed nearly 21,000 detection traps statewide to survey for the presence of all species and subspecies of spongy moth and the flighted spongy moth complex in 2023. Trap detections increased considerably this year with 103 spongy moths, *Lymantria dispar dispar*, collected in western Washington.

Survey data have identified two areas showing signs that a spongy moth population is in the early stages of establishing. Of the moths trapped, 81 were in Thurston County, with 77 trapped near Steamboat Island Road and Highway 101. Survey of this area in October 2023 resulted in one viable egg mass, confirming a reproducing population at this site. An additional site of concern is located in Skagit County near the town of Concrete where 2 moths were trapped in 2022 and an additional 13 moths in 2023.

In response to the threat posed by the invasive characteristics of the spongy moth, the Washington State Department of Agriculture, the USDA Animal and Plant Health Inspection Service, and the U.S. Forest Service continue to work cooperatively and, as in similar situations in the past, are proposing spongy moth eradication measures on 1,383 acres in Thurston County and 920 acres in Skagit County. The proposed eradication measures are expected to consist of at least three aerial spray treatments with the biological insecticide *Bacillus thuringiensis* var. *kurstaki* in a formulation approved for organic agriculture. The first treatment date is driven by biological monitoring and modeling, and can be expected to take place between late April and late May 2024. The first treatment will be followed by two to four subsequent treatments at roughly 7-10 day intervals thereafter, weather permitting. Additionally, high density trapping is proposed around the eradication treatment areas for three years following treatments to evaluate the success of the treatments. More information on the proposed eradication project can be found here.

Other counties with spongy moth detections include King (3), Pierce (3), San Juan (1), and Snohomish (2). All detection sites will continue to be monitored in 2024 for further spongy moth activity.

More information about spongy moth in Washington State can be found at www.agr.wa.gov/moths.

SUSAN ELLIS / BUGWOOD.ORG

Adult male spongy moth.

SURVEY DATA HAVE IDENTIFIED TWO AREAS SHOWING SIGNS THAT A SPONGY MOTH POPULATION IS IN THE EARLY STAGES OF ESTABLISHING.

INSECTS | BRANCH AND TERMINAL INSECTS

GILLES SAN MARTIN

Balsam Woolly Adelgid

(*Adelges piceae* Ratzeburg)

NON-NATIVE

Balsam woolly adelgid (BWA) is a non-native sucking insect that continues to be widespread in Washington and has caused mortality to subalpine fir, Pacific silver fir, and grand fir. The most significant BWA damage is in subalpine fir stands at high elevation. Observers mapped approximately 14,400 acres with damage in 2023, less than half the 30,000 acres mapped in 2022 and the 10-year average of 32,600 acres (Fig.21). The majority of BWA damage occurs on federal land.

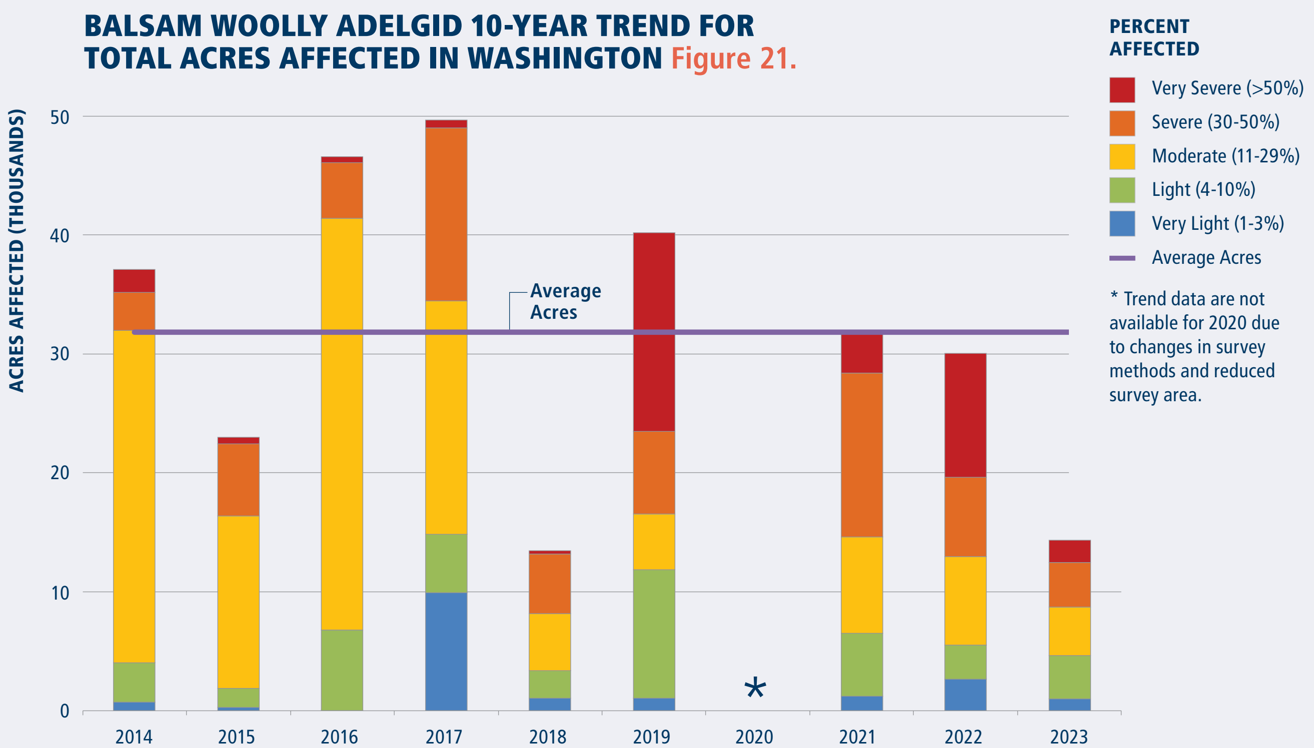
BWA damage, primarily to subalpine fir and Pacific silver fir, was recorded at high elevations in the eastern Olympic Mountains and in scattered high elevation areas east of the Cascades. Levels of damage in eastern Washington were more isolated and generally smaller than in recent years, like what was observed in 2018. BWA infestations are often chronic, and cumulative effects may result in mortality. BWA damage levels included approximately 4,500 acres with some host mortality in 2023.

Western balsam bark beetle (page 33) is another important mortality agent in subalpine fir stands that may attack trees weakened by BWA infestation. Approximately 24,900 acres in these same high elevation areas were mapped with some western balsam bark beetle caused mortality in subalpine fir. BWA infestation can be a predisposing factor to western balsam bark beetle attack.

GLENN KOHLER /DNR

Balsam woolly adelgid cotton-like ovisacs containing insects on subalpine fir bark.

BALSAM WOOLLY ADELGID 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 21.



INSECTS | WOOD BORERS

USDA FOREST SERVICE

Flatheaded Fir Borer

(*Phaenops drummondi* Kirby)

NATIVE

There are many different native wood borer species in the families Cerambycidae (longhorned wood borers), Buprestidae (metallic wood borers), and Siricidae (woodwasps) that will attack already dead or dying trees afflicted with other mortality agents. Some species can be more aggressive, especially during droughts or on drier sites. The flatheaded fir borer (FFB) is known to kill Douglas-fir on dry sites in southwest Oregon. Recently there have been reports of FFB killing green trees in Idaho, southern British Columbia, and northeast Washington.

Symptoms associated with FFB attack in live Douglas-fir include woodpecker holes and removal of outer bark, discoloration and loss of older foliage, clear "pitch pearls" in bark crevices, one-eighth inch, oval-shaped exit holes, and fine tunneling tracks in live inner bark (see this page). This combination of symptoms and absence of bark beetle activity may indicate FFB is killing Douglas-fir, with drought being the most likely inciting factor. Adult beetles are needed for positive identification but are rarely found in trees. FFB cannot be identified from gallery patterns and larvae alone.

Several declining Douglas-fir with these symptoms at two sites in Kittitas and Stevens counties were used to determine if aerial observers could map this type of damage (see next page). Unfortunately, the damage signature was difficult to see from the air, possibly because FFB-attacked trees decline slowly and often retain some green foliage. Unless the damage becomes more severe and widespread, it may be challenging to capture in an aerial survey. FFB damage can also occur in Douglas-fir stands affected by secondary bark beetle attacks, which have a more distinct aerial signature of top-kill and branch flagging (see p.28).

Under hotter and more intense droughts, FFB may become a wider emerging issue for some lower elevation Douglas-fir stands. FFB-caused mortality tends to be worse on stand edges, south or west-facing slopes, and ridges. These sites all receive more heat, often retain less moisture, and can desiccate needles.

GLENN KOHLER /DNR

Above: Woodpecker removal of outer bark and flatheaded fir borer adult exit holes (circled). Top: Flatheaded fir borer larval tracks in inner bark.

ISAAC SDAVIS / DNR

Crown symptoms and woodpecker removal of outer bark associated with flatheaded fir borer attacks.

UNDER HOTTER AND MORE INTENSE DROUGHTS, FLATHEADED FIR BORER MAY BECOME A WIDER EMERGING ISSUE FOR SOME LOWER ELEVATION DOUGLAS-FIR STANDS.

INSECTS | WOOD BORERS

BENJAMIN SMITH

Emerald Ash Borer

(*Agrilus planipennis* Fairmaire)

NON-NATIVE

The first West Coast detection of emerald ash borer (EAB) occurred in 2022 in the northwest Oregon city of Forest Grove (Washington County). EAB has since been found in forested areas close to Forest Grove. To help slow the spread of EAB, a quarantine in Oregon's Washington County is in place to reduce potential movement of infested wood and nursery stock to unaffected areas. More information about the situation in Oregon can be found at the Oregon Department of Agriculture website: https://www.oregon.gov/oda/programs/IPPM/SurveyTreatment/Pages/EmeraldAshBorer.aspx

EAB introduction and spread in Oregon increases the potential of this serious, non-native, forest insect pest moving into Washington. The small, metallic green, wood-boring beetle attacks and kills true ash trees (*Fraxinus* species), the primary host trees for EAB. The larvae burrow under tree bark, eat the phloem, and etch tunnels into the sapwood. Once damaged, these vascular tissues can't transport water and nutrients, causing the leaves and tree to die.

EAB has killed over 100 million ash trees in eastern North America since its original introduction to Michigan in 2002. Since then, it has spread to 36 states and moved gradually westward. An EAB infestation could devastate the ash component of Washington's urban forests, as well as sensitive riparian areas where the native Oregon ash (*Fraxinus latifolia*) is a keystone species. Infestations of ornamental ash in urban forests will result in very costly removal and replacement activities.

Efforts thus far to eradicate EAB by state and federal agencies in infested areas across the United States and Canada have been unsuccessful.

Diligence by the public to avoid moving firewood and other potentially infested ash materials is more important than ever.

The most common symptoms of infestation in true ash trees are crown and branch dieback (see next page) and unusual leaf sprouting from trunks. More direct signs of EAB activity include distinctive serpentine galleries under the bark of dead trees and one-eighth inch wide,

MICHIGAN DEPARTMENT OF AGRICULTURE, BUGWOOD.ORG

LEAH BAUER / USDA FOREST SERVICE NORTHERN RESEARCH STATION, BUGWOOD.ORG

Above: Serpentine emerald ash borer larval galleries under ash bark.

Left: Adult emerald ash borer.

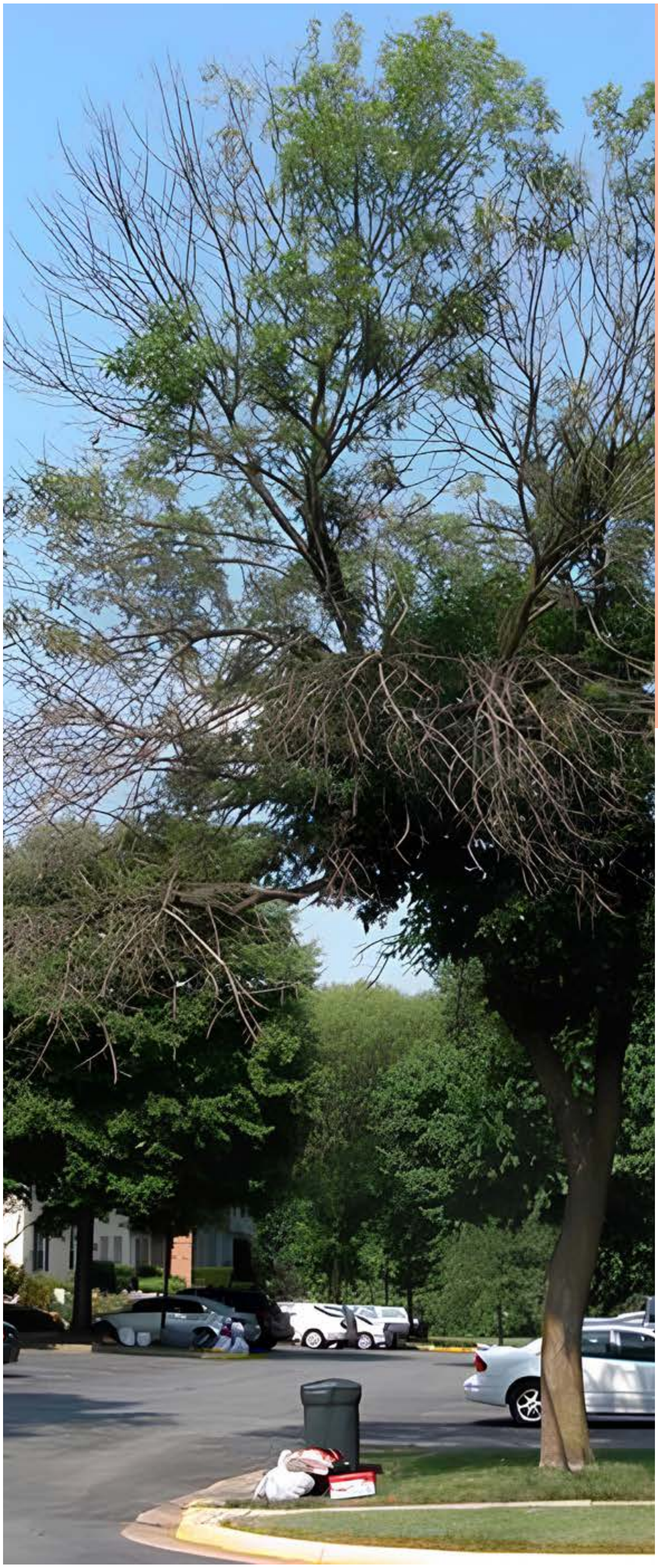
D-shaped exit holes through the bark (see p. 46). Adults are about one-third to one-half inch in size, with a slim, pointed body shape and a dull, metallic green color (see inset, p.46). Adult beetles are needed for positive identification but are rarely seen in areas with new introductions and outside of their May to July flight period. Traps used for EAB monitoring are only partially effective at detecting new infestations.

The public is encouraged to report suspected EAB sightings or damage to ash trees. In Washington state, report a sighting at https://invasivespecies.wa.gov/report-a-sighting/.

EAB HAS KILLED OVER 100 MILLION ASH TREES IN EASTERN NORTH AMERICA SINCE ITS ORIGINAL INTRODUCTION TO MICHIGAN IN 2002. SINCE THEN, IT HAS SPREAD TO 36 STATES AND MOVED GRADUALLY WESTWARD.

In forested areas, there are several native species of metallic green wood borer adults in the same family as EAB (Buprestidae). These are commonly referred to as "jewel beetles" and look very similar to EAB. In addition, there are several unrelated insect species with metallic green coloration. A guide to potential look-alikes and other EAB information can be found at the Washington Invasive Species Council (WISC) website: https://invasivespecies.wa.gov/priorityspecies/emerald-ash-borer/.

EAB is a serious and destructive threat to urban and community forests where ash has been planted. Washington communities can prepare by identifying and inventorying ash in cities, learning how to recognize and report potential EAB infestations, increasing species diversity, avoiding ash in tree planting projects, and by destroying or preventing movement of dead ash wood material. In partnership with WISC and other collaborators, the DNR Urban and Community Forestry Program developed the Urban Forest Pest Readiness Playbook to help communities prepare for invasive pest outbreaks. You can read more about the ongoing project here and learn about actions that your town and community can take to prepare for a pest outbreak: https://invasivespecies.wa.gov/projects/pest-ready/.



ERIC R. DAY / VIRGINIA POLYTECHNIC INSTITUTE AND STATE UNIVERSITY, BUGWOOD.ORG

Right: Early stages of ash crown dieback symptoms from emerald ash borer infestation.

DISEASES | ROOT ROTS

Variety of Fungi

NATIVE

A handful of root rot diseases impact forests throughout Washington. These include Armillaria root rot (*Armillaria solidipes*, also known as North American *A. ostoyae*); Heterobasidion root rot (*Heterobasidion irregulare* or *H. occidentale*, formerly *H. annosum* P-type and S-type, respectively); and laminated root rot (*Coniferiporia sulphurascens*, formerly *Phellinus sulphurascens*) to name a few.

Root rot diseases that occur on Washington forest trees are caused by native fungi and are a well-established part of forest systems. Root rot diseases are persistent. They affect tree growth and cause tree mortality, but also may help diversify forest structure and tree species composition. Root rot diseases are very challenging to manage and are typically considered "diseases of the site." Correct identification of the specific fungus is important for determining management response.

Root rots are difficult to monitor during the aerial detection survey (ADS), as their signature is not clearly seen from above and, if mapped at all, are often classified under an associated disturbance category (for example, see 'young conifer damage,' p.57, and 'Douglas-fir beetle,' p.27). Despite our inability to map these pathogens from the air, root rot diseases are a common management concern in Washington forests and represent a large portion of site visits and questions DNR's forest pathologists respond to.

ISAAC DAVIS / DNR

Right: A gap in the forest canopy of a ponderosa pine stand caused by Armillaria root disease.

DISEASES | CANKERS

USFS

White Pine Blister Rust

(Cronartium ribicola)

NON-NATIVE

The non-native fungal pathogen *Cronartium ribicola*, the cause of white pine blister rust (WPBR), was accidently introduced into North America more than 100 years ago. All nine species of white pine (five-needle pines) native to the United States are highly susceptible to the disease, with mortality rates surpassing 90% on high-hazard sites. Today, this pathogen is found throughout Washington, where it has caused widespread mortality of both native western white pine (*Pinus monticola*) and whitebark pine (*Pinus albicaulis*).

Western white pine is an important economic and ecologic tree species in the Pacific Northwest. It was once a major timber tree and dominated many forest stands before being devastated by WPBR. Whitebark pine is considered a keystone species in high alpine ecosystems but is now listed as threatened under the Endangered Species Act due to mortality caused by WPBR, in addition to increasing pressures from mountain pine beetle, wildfire, and weather extremes.

Natural variation has fortunately provided some individual western white pine and whitebark pine lineages with varying degrees of resistance to WPBR. To take advantage of this, breeding programs for these species have been active for decades.

DNR, in collaboration with USFS, local tribes, and British Columbia, maintains 16 long-term research field sites focused on understanding the natural genetic variation found within western white pine. These include six sites in western Washington planted 2006-2007, six sites in eastern Washington planted 2014-2015, and four high-elevation whitebark pine sites planted 2015-2017 (Fig.22). At these sites, numerous lineages of seedlings will be monitored for decades to help determine which lineages should be used in future restoration and reforestation efforts.

Between 2021 and 2023, DNR and the USFS Dorena Genetic Crew revisited all the previously established sites to update survival data, field maps, and take growth measurements. Sites varied dramatically in size and survival depending on planting age, site conditions, rust pressure, and other stressors. Future monitoring and analysis of findings are planned.

RACHEL BROOKS / DNR

A diamond-shaped white pine blister rust canker on a western white pine.

RACHEL BROOKS / DNR

RACHEL BROOKS / DNR

Above: A whitebark pine planted on Goodenough Peak in the Loomis State Forest following the Newby Lake Fire.

Top Left: A western white pine research site in western Washington. The red branch on the middle tree is a classic symptom of WPBR infection.

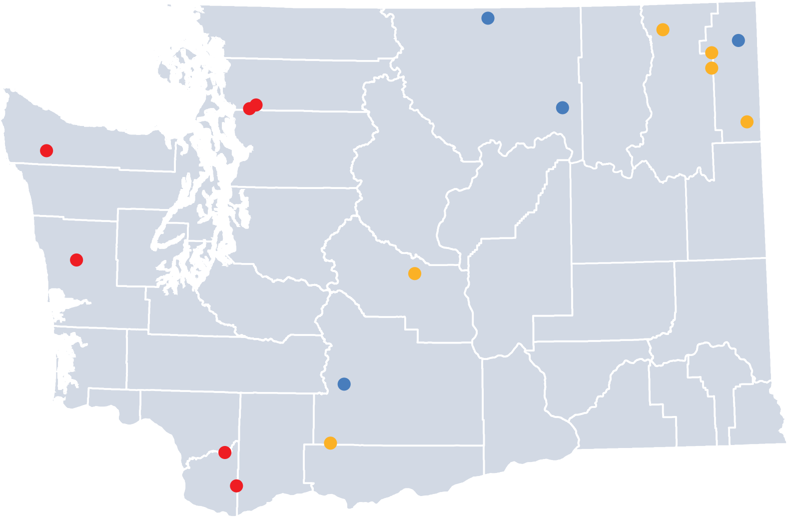


Figure 22.

LOCATION OF WASHINGTON LONG-TERM WESTERN WHITE PINE AND WHITEBARK PINE FIELD RESEARCH SITES BY PROJECT TYPE

RESEARCH SITE TYPES

- Whitebark pine: High Elevation
- Western white pine: Eastern WA
- Western white pine: Western WA

DISEASES | CANKERS

JOSEPH OBRIEN / USDA FOREST SERVICE, BUGWOOD.ORG

Sudden Oak Death

(*Phytophthora ramorum* Werres et al.)

NON-NATIVE

Phytophthora ramorum **(Pr) is the causal agent of Sudden Oak Death, ramorum leaf blight, and ramorum dieback. Invasive in North America, Pr has caused extensive mortality of tanoaks and several oak species in southwestern Oregon and California. Luckily, Oregon white oak (*Quercus garryana*), the oak native to Washington, is not considered susceptible. Unfortunately, other native Washington plants and trees are susceptible, including western larch (*Larix occidentalis*). This pathogen can move through landscapes via wind and wind-driven rain and can be moved long distances by humans on nursery plant materials. Due to the presence of susceptible hosts, suitable climatic conditions, and plant nurseries with Pr-infected stock, Washington's forests remain at risk for Pr spread and Pr-caused disease. However, to date, damage like that caused by Pr in forests of Oregon and California has not been observed in Washington.**

With funding provided by the USFS National *Phytophthora ramorum* Early Detection Survey of Forests, two western Washington waterways and ten eastern Washington waterways were bait sampled for Pr using fresh rhododendron leaves in 2023. Selected western Washington sites were either downstream of previously known positive Pr locations identified by WSDA (one site in King County) or in an area with no known Pr presence in which rhododendron leaves for sampling were collected (Mason County). Selected eastern sites were in watersheds that contained large numbers of western larch (three sites in Chelan County, one site in Kittitas County, three sites in Pend Oreille County, two sites in Okanogan County, and one site in Stevens County). Sites were sampled six times from March through June.

No sampling location either in western or eastern Washington waterways tested positive for Pr in 2023. Overall, most sampled waterways in Washington are free from Pr, apart from the Sammamish River which has regularly tested positive for Pr since 2007, though did not test positive in 2023 (Table 2; Fig.23). There has been no indication to date that the pathogen is leaving waterways, as all vegetation samples collected in the woodlands bordering these positive waterways have been negative for Pr.

Advanced techniques were used in collaboration with WSDA and WSU to identify other *Phytophthora* species collected from streams during the Early Warning Detection Survey. Several *Phytophthora* species were identified, as well as other Oomycete genera. While the absence of *P. ramorum* in these surveys is welcome news, more research is needed to understand the roles and effects of other pathogenic species in these waterways. The results of this work demonstrate the value of these surveys not only as a method of early detection, but also as a method to advance baseline understanding about the diversity of *Phytophthora* species in our watersheds.

RACHEL BROOKS / DNR

Bait traps containing rhododendron leaves floating in a water way.

NO SAMPLING LOCATION EITHER IN WESTERN OR EASTERN WASHINGTON WATERWAYS TESTED POSITIVE FOR PHYTOPHTHORA RAMORUM IN 2023.

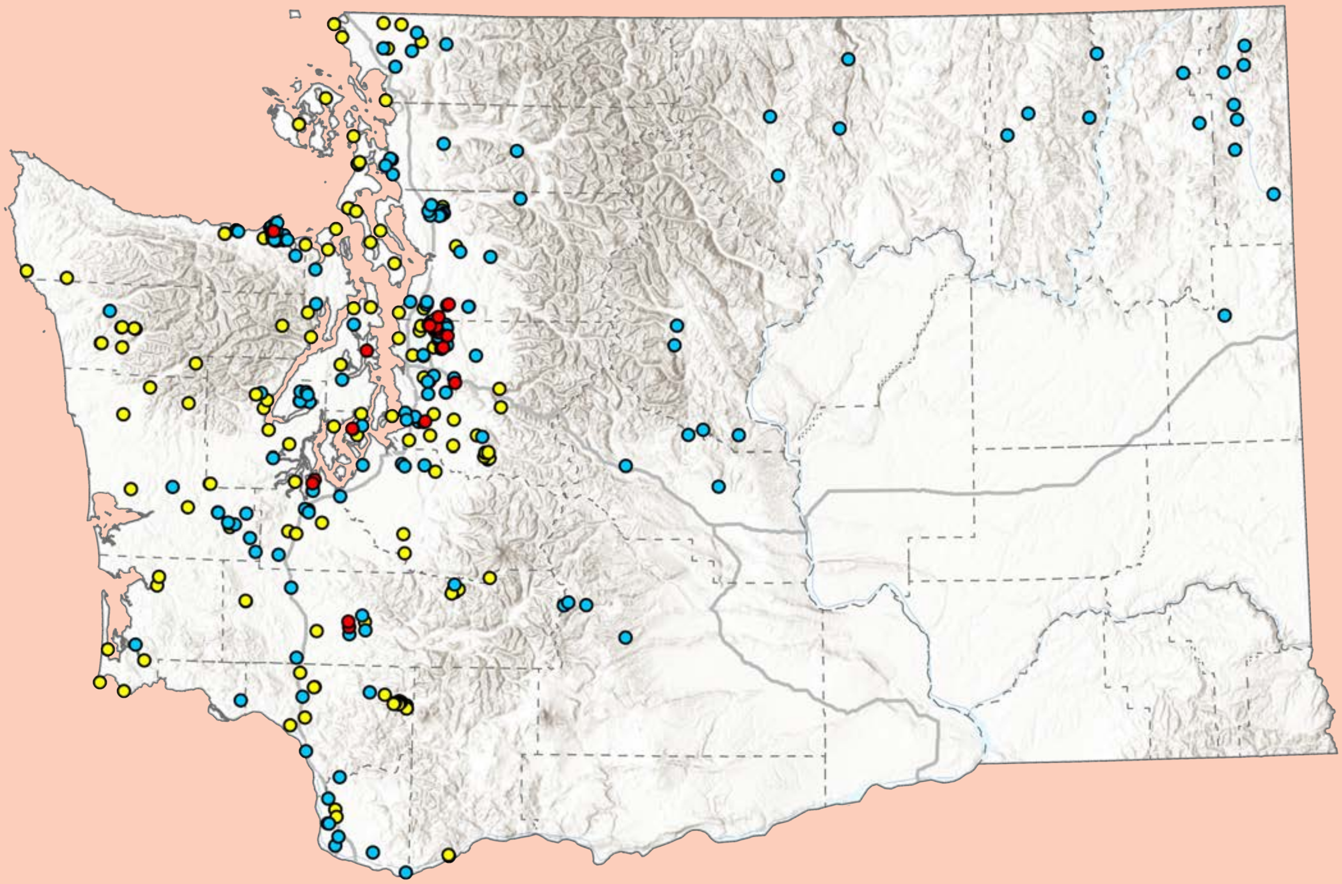
DISEASES | CANKERS

Table 2. Monitoring history of waterways that have tested positive for *Phytophthora ramorum* (Pr).

Years with positive detections are indicated with a red square and a plus sign. Years with no detection are indicated with a blue square and a minus sign. White squares indicate years the waterway was not surveyed. Only positive waterways are included in this table.

COUNTY	WATERWAY	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Clallam	Dungeness River & Canals									+	+	–	–							
King	Bear Creek							+	–											
King	Cottage Lake Creek								+	–										
King	Issaquah Creek										–	–	–	+						
King	Little Bear Creek							+	–								+			
King	Mill Creek																	+		
King	Sammamish River			+	+	+	+	+	+	+	+	+	+	+	+	+				–
King	Woodin Creek						+	+	+											
Kitsap	Issel Creek										+	+								
Lewis	Mill Creek							+	+			–	–							
Pierce	Unnamed stream, Rosedale		+	–	+															
Snohomish	Evans Creek																+			
Thurston	Woodard Creek								–	+	–	+								
TOTAL POSITIVE WATERWAYS		0	1	1	2	1	2	5	4	3	3	3	1	2	1	1	2	1	0	0

+ Year with positive detection   – Year with no detection   ☐ Year not surveyed



THERE HAS BEEN NO INDICATION TO DATE THAT THE PATHOGEN IS LEAVING WATERWAYS, AS ALL VEGETATION SAMPLES COLLECTED IN THE WOODLANDS BORDERING THESE POSITIVE WATERWAYS HAVE BEEN NEGATIVE FOR PR.

Figure 23.

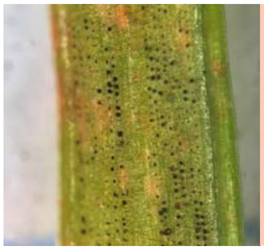
DNR *PHYTOPHTHORA RAMORUM* SAMPLING LOCATIONS 2002-2023

SOURCE: WA STATE PARKS GIS, ESRI, TOMTOM, GARMIN, FAO, NOAA, USGS, BUREAU OF LAND MANAGEMENT, EPA, NPS, USFWS, USGS

- **Positive** Aquatic Baiting Location
- **Negative** Aquatic Baiting Location
- **Negative** Wildland Survey Location

DISEASES | FOLIAR DISEASES

RACHEL BROOKS / DNR



Swiss Needle Cast

(*Nothophaeocryptopus gaeumanni*)

NATIVE

Nothophaeocryptopus gaeumannii, the fungus that causes Swiss needle cast (SNC), is found wherever Douglas-fir (*Pseudotsuga menziessii*) — its only host — is found. This native foliar disease rarely causes tree mortality but can cause needle discoloration and premature foliage loss that may result in reduced tree growth. This pathogen became a priority in the coastal forests of Washington and Oregon in the late 1980s and early 1990s and has more recently become a concern in British Columbia. These areas have likely seen impact due to the fungi-favorable topographic and climatic conditions (such as mild winters and wet springs), historical plantings using off-site seed sources, and increases in Douglas-fir numbers due to forest management practices. Ground and aerial surveys monitoring this disease and its symptoms are currently conducted every other year (see the 2022 Forest Health Highlights report for the most recent survey results).

The Washington State Legislature provided funding in the 2023-2025 biennium to monitor infection and damage trends in Washington's coastal forests. Both aerial survey flights and a ground survey are planned for spring 2024 in collaboration with the USDA Forest Service, the Washington State Department of Fish and Wildlife, and the University of Washington.

As always, site-specific ground surveys should be conducted in stands of concern before specific SNC mitigation and management decisions are made. For a more detailed management discussion, refer to the "Silvicultural decision guide for Swiss needle cast in coastal Oregon and Washington" available online at: extension.oregonstate.edu/pub/em-9352.

RACHEL BROOKS / DNR

The underside of a Swiss needle cast-infected Douglas-fir needle. The black spheres are fungal repoductive structures (pseudothecia) clogging the needle's stomates and blocking gas exchange.

DISEASES | FOLIAR DISEASES

NEEDLE CAST AND NEEDLE BLIGHT: USDA; LARCH CASEBEARER: CONNECTICUT AGRICULTURAL EXPERIMENT STATION

Larch Needle Cast

(*Rhabdocline laricis*)

NATIVE

Larch Needle Blight

(*Hypodermella laricis*)

NATIVE

Larch Casebearer

(*Coleophora laricella*)

NON-NATIVE

RACHEL BROOKS / DNR

A variety of fungi and insects impact larch foliage. Observers mapped larch defoliation on approximately 3,200 acres in 2023, a large decrease from the 27,500 acres mapped in 2022. Of these acres affected, defoliation due to larch needle cast (*Rabdocline laricis*) was mapped on approximately 2,500 acres, where foliage discoloration in the lower crown was observed (see top, right). Discolored whole crowns of western larch, indicative of both larch needle blight (*Hypodermella laricis*; see bottom, right) and larch casebearer (*Coleophora laricella*) were observed on approximately 700 acres. These three agents can be found on the same tree, though they are mapped separately based on the dominant signature as seen from the air. This decrease in acres affected was likely driven by dry spring weather conditions which disfavored fungi and insect development. Long-term impacts on forest stands from foliar damage, even at years with higher acreage mapped, are minimal.

RACHEL BROOKS / DNR

Top right: Larch needle cast discoloration in lower crown. Right: Dead larch needles killed by larch needle blight on a single spur.

Western Redcedar Dieback

Approximately 47,000 acres with western redcedar (WRC) dieback and mortality were observed in 2023 throughout Washington, a significant decrease from the 105,000 acres observed in 2022. Since aerial mapping of WRC dieback began in 2017, the affected area had increased every year until 2023, when it reverted close to the 46,000 acres mapped in 2021. Symptoms of dieback include thinning crowns, discoloration (yellowing or browning) of the needles, heavy cone crops, branch dieback and flagging, topkill, and mortality (see right). The highest concentrations of damage in western Washington were in the Olympic National Forest, Olympic National Park, the north coast of the Olympic Peninsula in Callam and Jefferson counties, the San Juan Islands, and the foothills and mountain valley areas in Whatcom, Skagit, Snohomish, and King counties. In northeast Washington, northern Ferry and Stevens counties, Pend Oreille County, and western Spokane County were most affected.

Ground observations of WRC damage agents include cedar bark beetles (*Phloeosinus* species), wood-boring beetles, and root diseases, but these are typically secondary damage agents taking advantage of trees stressed by other inciting factors. Recent research on WRC decline in the Pacific Northwest found that affected cedars experienced reduced growth for several years prior to dying or thinning. This indicates cumulative stress brought on by warmer and drier conditions in late spring and early summer, resulting in a longer-than-normal dry season. Changing climatic conditions account for the wide range of damage observed throughout the region. Not all forests with WRC have experienced the same impacts and many healthy WRC remain, but future drought and higher temperature events may lead to more dieback. More information on this research can be found here: https://labs.wsu.edu/meddenslab/projects/western-redcedar-mortality/

ROBERT ANDRUS / WASHINGTON STATE UNIVERSITY

Top-kill and thinning crown symptoms in western redcedar in western Washington.

More information on WRC dieback cooperative monitoring work is available in this online story map: https://storymaps.arcgis.com/stories/1405dab5f59246aa83849ec43f72b15a

REFERENCE

Andrus, R.A., L.R. Peach, A.R. Cinquini, B. Mills, J.T. Yusi, C. Buhl, M. Fischer, B.A. Goodrich, J.M. Hulbert, A. Holz, A.J.H. Meddens, K.B. Moffett, A. Ramirez, and H.D. Adams. 2023. Canary in the Forest? – Tree mortality and canopy dieback of western redcedar linked to drier and warmer summers. Journal of Biogeograpghy, 00, 1-17.

Young Conifer Mortality

Aerial surveys record scattered, pole-sized, newly dead trees of all conifer species as "young confiner mortality." Based on ground checks, bear girdling and root disease are the primary causes of this distinct damage pattern. Drought, secondary bark beetles, or other cambium-feeding animals such as porcupines and mountain beavers may also play a role. This damage signature is commonly identified in young timber stands in western Washington but is present throughout all forest types.

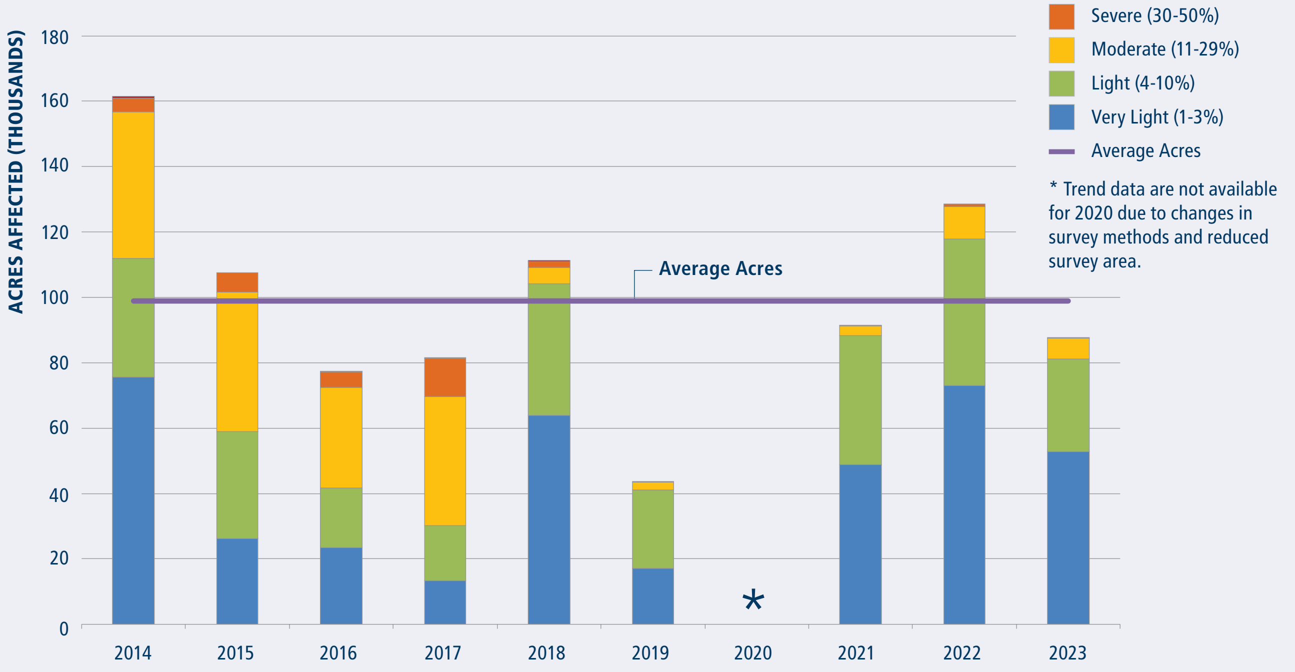
When bears emerge from hibernation in spring, they strip bark from trees and feed on the sugary wood beneath (see right). Trees are either girdled entirely or become weakened and vulnerable to secondary damage agents. While this behavior is quite common, our ability to detect and record the resulting mortality varies. In normal conditions, it can take more than a year for the tree to die, its needles to turn red, and the damage to become recognizable from the air. Alternatively, in drought conditions, trees may become visible the same year they are injured. In years with wet and cool spring conditions, the berries that bears feed on mature later, so bears are more likely to exploit more trees as an alternative source of food. Above-average spring precipitation may also delay the reddening of bear damaged trees, which may result in less observed damage that year. Other factors that may influence fluctuation in bear damage are local bear populations and the age of trees.

Root diseases (see root disease section, p.48) manifest themselves in a similar pattern in young conifer stands, causing scattered dead trees. Ground inspection of trees can easily determine if the bark has been stripped by bear or if additional investigation into root rot or other stressors should be conducted.

Approximately 87,700 acres with young conifer mortality were observed in 2023, a 32% decrease from 2022 and below the ten-year average of 99,600 acres (Fig.24). Over the last decade, the total area observed with this type of damage signature has ranged from a high of 183,000 acres in 2013 to a low of 46,300 acres in 2019, with 2023 results falling near average.

RACHEL BROOKS / DNR

Right: Typical bear girdling damage on a Douglas-fir.



YOUNG CONIFER MORTALITY 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 24.

Young conifer mortality damage signature.

ALAN MAINWARING / DNR

Aerial Detection Survey Methodology

Disclaimer: *To accurately identify and record damage observations on a statewide scale from an aircraft is a challenging task that takes years to master. Mistakes occur. Occasionally, the wrong damage agent is identified or the marking on the map is geographically off-target. The aircrafts used in aerial survey travel at high altitude and great speed. Subtle signs of damage can be overlooked, particularly in areas of diverse, congested damage. The goal of the program is to correctly identify and accurately map forest damage within ¼ mile of its precise location at least 70% of the time.*

Since 1947, the USDA Forest Service (USFS) Pacific Northwest Region in cooperation with the DNR and Oregon Department of Forestry has monitored recent tree mortality and forest damage throughout the state of Washington using a special method of survey. The insect and disease aerial detection survey (ADS) is performed from a fixed-wing aircraft travelling at speeds of 90-150 mph between 500 and 3,500 feet above the forest canopy in a 4-mile grid pattern **(see Figure 8, p.16, Washington Aerial Detection Survey Flight Lines)**. Two aerial surveyors, one on each side of the aircraft, work in synchrony scanning the landscape below looking for recently killed and defoliated trees. Damage directly underneath and up to two miles beyond the wing of the plane is quickly surveyed. When damage is observed, tablet computers and specialized software designed by the USFS called digital mobile sketch mapping (DMSM) are used to document tree damage. Points indicate small clusters of trees and polygons indicate large groupings. Areas of damage are cross-referenced with satellite and topographic imagery within DMSM and circled (or pointed) using an electronic stylus. Extensive training, skilled pattern recognition, and experience allow aerial observers to designate each point and polygon with both a causal agent and a metric for damage intensity (see "Methods for recording damage activity" below for greater detail). Tree size and species, location, the presence of thin or faded foliage, and nuanced patterns of mortality or decline reveal the most likely cause of visible forest damage. Collectively, these classifications are referred to as "damage signatures." Both aerial surveyors maintain constant communication throughout each survey flight discussing observations and relevant damage signatures to ensure the data recorded are consistent and accurate across all landscapes.

ADS professionals undergo rigorous training to identify a range of tree species and damage signatures quickly and confidently with respect to varying forest composition across Washington's diverse environments. The DMSM software used in aerial survey allows users to display satellite imagery, sectional aeronautical charts, spatial and topographic information, and previous years' damage on their tablets. These tools help guide surveyors in their decision making and promote geographical accuracy when recording damage points and polygons. ADS protocol mandates that at least one of the two observers has at minimum three years of sketch-mapping experience in the region being surveyed, further supporting the integrity of the data collected and published. For users of published data, it would be incorrect to assume all trees within a given damage polygon are dead or declining when interpreting the information presented in this report. Tree mortality and decline are defined by a range of damage intensity modifiers and recently killed or damaged trees typically make up just a fraction of the forestland mapped within a polygon.

The appearance of trees within areas affected by wildfire any given year closely mimics the damage caused by forest pests the subsequent year and the damage is virtually indistinguishable when surveyed from the air. Therefore, it is standard practice to ignore fire damaged areas when mapping until two years after the occurrence of wildfire. Only then will current damage signatures be attributed to forest pests and diseases and represented within agent-specific damage totals. To assist surveyors in this effort, fire perimeters from one and two years prior to the active survey are loaded onto DMSM tablets for reference in flight.

Table 3. Percent of treed area affected classes used for ADS damage polygons.

PERCENT-CLASS CODE	NAME (VALUE RANGE)
1	Very Light (1-3%)
2	Light (4-10%)
3	Moderate (11-29%)
4	Severe (30-50%)
5	Very Severe (>50%)

Table 4. Range classes of individual affected tree counts used for ADS damage points.

POINT-CLASS CODE	NUMBER OF TREES AFFECTED (VALUE RANGE)
1	1
2	2 – 5
3	6 – 15
4	16 – 30
5	>30

ZACK ADAMS / USFS

Unmanned aircraft system used for aerial survey ground checks and other forest health monitoring missions.

METHODS FOR RECORDING DAMAGE INTENSITY

Damage polygons are assigned a "percent-class" value representing one of five incremental ranges of percent of treed area affected **(Table 3, p.59)**. Observers assign a percent-class value by estimating the canopy area with current year's damage and visually dividing this by the canopy area of all trees present within the polygon. This includes currently damaged, live, and old dead trees as well as non-host trees. For areas of forest affected by defoliating agents, polygons are also assigned values for the intensity of within-crown defoliation (L-Light, M-Moderate, H-Heavy). When observers record a point of damage in areas less than 2 acres, they assign a range estimate of the number of trees affected by a given agent **(Table 4, p.59)**.

Adoption of the percent-class/point-range method presents challenges for trend analysis and cumulative mortality assessments when compared to the trees per acre (TPA) method used prior to 2018. Summary statistics of approximate number of trees killed, such as totals and averages by agent, cannot be derived directly from percent-class data. In the USFS Pacific Northwest Region (Washington and Oregon), percent-class polygons are converted to a calculated TPA value using a "histogram matching" method. This method separates several recent years of historical TPA data into 5 categories similar in range to the percent-class categories, then calculates a derived TPA value for each percent-class polygon based on the midpoint of each TPA category and the relative polygon size. Point-range categories are converted to TPA values based on the upper range of each point-class code. All 2023 ADS mortality polygons in DNR's downloadable GIS datasets use calculated TPA values as intensity modifiers. USFS Pacific Northwest Region quadrangle reporting maps available in PDF format use percent treed area affected classes and tree ranges as label modifiers. See "Data and Services" on the next page for more information on accessing these distinct datasets.

THE APPEARANCE OF TREES WITHIN AREAS AFFECTED BY WILDFIRE ANY GIVEN YEAR CLOSELY MIMICS THE DAMAGE CAUSED BY FOREST PESTS THE SUBSEQUENT YEAR AND THE DAMAGE IS VIRTUALLY INDISTINGUISHABLE WHEN SURVEYED FROM THE AIR.

Data and Services

Tree damage and forest health conditions are systematically documented across all 22 million acres of Washington's forestland through annual aircraft surveys. Aerial detection surveys are accomplished through the cooperation of the Washington DNR and the USFS and are an economical alternative to traditional survey methods, considering the amount and quality of data collected. The maps and data produced by aerial survey professionals are made available to the public and serve as valuable tools for evaluating forest disturbance events and informing responsible forest management practices. Aerial survey products also provide a wealth of historical data for monitoring environmental trends throughout Washington's dynamic forest landscapes.

PDF MAPS AVAILABLE FOR DOWNLOAD

Traditional insect and disease survey quadrangle maps from 2003 to 2023 are available for download as PDF files at: **www.fs.usda.gov/goto/r6/fhp/ads/maps.**

Select the year of interest under **"Aerial Detection Survey Quad Maps"** to open an interactive map of all available quads from Washington and Oregon. Identify the 2-digit code of the map you want to view (e.g., 4E for MT. RAINIER), and click the corresponding quad link in the table displayed below the map. Click "Download" on the top right of the webpage that follows to download the PDF. Damage polygons are colored according to damage type and labelled with specific damage agent codes. Each code is followed by a modifier indicating the range class of trees affected in each polygon (Tables 3 & 4, p.59) or intensity of damage (L-light, M-moderate, H-heavy). Relevant damage codes are defined in the legend located in the lower lefthand side of each quad map. PDF maps are georeferenced so the user's location will be visible on a compatible mobile device when uploaded to a PDF map viewing application (e.g., Avenza).

INTERACTIVE MAP TOOLS

2015 to 2023 annual aerial survey data are available on Washington DNR's interactive, web-based mapping site: "Forest Resilience Data and Mapping System" at: **https://experience.arcgis.com/experience/4f3323f1a82b418d9dbf16faf32dd9f2/**. Navigate to the left whand side of the webpage to the "Map Layers" dialog box, click the expand button next to the "Monitoring" tab, and then click the eye icon (visibility) next to "Forest Health Aerial Survey" to make the layer visible. Click the expand button on the "Forest Health Aerial Survey" tab to view all selectable aerial survey data layers, 2015 through 2023."

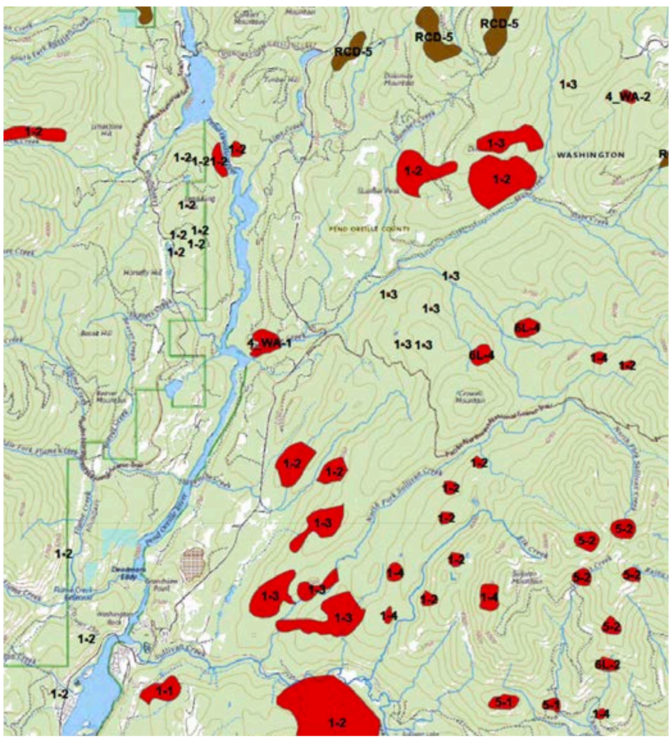
The USFS provides interactive online services for viewing aerial survey data and learning how it defines forest health trends in the Pacific Northwest at: **www.fs.usda.gov/goto/r6/fhp/ads**.

• **2023 Forest Health Summary for the Pacific Northwest Region.** The first primary link under the heading "What's New" in the main body of the website opens a story map rich with information, photos, and videos of forest pests and the damage they cause in addition to a compendium of current forest health conditions and ADS methodology.

• **2022 PNW Swiss Needle Cast Survey.** The second primary link under the heading "What's New" opens a second interactive story map detailing SNC on coastal Douglas-fir trees in the PNW and the monitoring efforts used to capture its breadth and severity. Like the previous story map, this webpage shares information, findings, photos, and videos of the distinct foliar disease. Aerial survey for SNC is conducted every other year and will occur in Spring of 2024.

• **Pacific Northwest Region Forest Health Dashboard 2023.** For a breakdown of aerial survey data by a specific region or tree species, click the "Learn More" link under "Forest Health Dashboard." This tool provides the user with an interactive graphic of forest pests and diseases and the acres of damage attributed to them in 2023. To expand a category within the dashboard, hover over the desired cell and click the small, circular icon that appears in the upper righthand corner.

• **2024 Aerial Survey Data Viewer.** To view current-year aerial survey data in a web-based map, click the "Learn More" link under "Data Viewer." This tool allows the user to visualize recent aerial survey data and create customized maps with a collection of background layers. Damage points and polygons are color-coded as *Mortality, Defoliation*, or *Other Damage*. Note: aerial survey is conducted between the months of July and October; data will be in draft form and incomplete until the following year.



Screenshot of an aerial detection survey quad map.

The Forest Health Assessment & Applied Sciences Team (FHAAST aerial), a cooperative division of USFS, provides a supplementary interactive map service for 2023 survey data of all 50 states at: **https://usfs.maps.arcgis.com/apps/mapviewer/index.html?webmap=6c8f8b7ae79e422188683b0b93aac833**.

• **2023 Aerial Survey Data Viewer.** To view 2023 aerial survey data online, navigate to the link above in a web browser and zoom to Washington. Damage points and polygons are color-coded as Mortality, Defoliation, or Other Damage.

For questions on how to use these interactive map products, please contact Isaac Davis listed in the "Forest Health Contacts" section on page 63.

GIS DATA AVAILABLE FOR DOWNLOAD

Washington DNR maintains downloadable GIS datasets, including aerial survey data for Washington State from 1980 to 2023. The feature layer download is titled "Forest Health Aerial Survey 1980-2022" and can be accessed by visiting **http://data-wadnr.opendata.arcgis.com/** and clicking the brown "Forest Health" icon beneath the search bar at the top of the page. The USFS maintains a site for combined Oregon and Washington ADS data from 1947 through 2023 (including data from the ground-based 2020 insect and disease survey). Visit **www.fs.usda.gov/goto/r6/fhp/ads** and click "Learn More" under "Data Download."

FOREST HEALTH WEBSITES

The latest information on exotic pests, insect and disease outbreaks, and forest damage trends in Washington are published annually in the Washington Forest Health Highlights report. Additional annual reports, Washington DNR research and programs, and other forest health information are available at **http://www.dnr.wa.gov/ForestHealth**. Click the "Insects and Disease Monitoring" link under the "Assistance and Information" heading for more detail on current forest health monitoring efforts and reporting.

Historic Forest Health Highlights reports for Alaska, California, Oregon, Washington, and Hawaii and several Pacific Islands are available at: **https://www.fs.usda.gov/detail/r6/forest-grasslandhealth/insects-diseases/**.

The USFS Pacific Northwest Region Forest Health Protection (FHP) program has a shared mission to monitor and promote the health of forests in Washington and Oregon. It provides technical and financial assistance to federal resource managers regarding pest insects, tree diseases, and harmful vegetation in forest ecosystems. Assistance to state and private resource managers is provided through state forestry agencies (Washington DNR, Oregon Department of Forestry).

Learn more about USFS FHP programs and resources at: **https://www.fs.usda.gov/main/r6/forest-grasslandhealth**.

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If you have questions about forest insect and disease activity in Washington, please contact any of the DNR or USFS staff listed here.

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