# Forest Health Highlights in Washington / 2021

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

WASHINGTON DEPARTMENT OF NATURAL RESOURCES

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

**4 SUMMARY**

**7 ABIOTIC DISTURBANCES INFLUENCING FOREST HEALTH**
8 Weather
9 Drought
10 Weather-Related Tree Damage and Needle Desiccation
14 Wildfire

**16 WASHINGTON'S FOREST ACTION PLAN UPDATE**

**18 AERIAL DETECTION SURVEY**

**23 BIOTIC DISTURBANCES INFLUENCING FOREST HEALTH**
**24 INSECTS**
**24 Bark Beetles**
24 Pine Bark Beetles
28 Douglas-fir Beetle
29 Secondary Bark Beetles in Douglas-fir
31 Spruce Beetle
32 Fir Engraver
33 Silver Fir Beetle
33 Western Balsam Bark Beetle
**34 Defoliators**
34 Douglas-fir Tussock Moth
36 Western Spruce Budworm
38 Larch Defoliation
39 Leafminers in Hardwoods
40 Spongy Moth (formerly known as Gypsy Moth)
**41 Branch and Terminal Insects**
41 Balsam Woolly Adelgid
**43 Apex Predators**
43 Asian Giant Hornet
**44 DISEASES**
**44 Cankers**
44 White Pine Blister Rust
46 Sooty Bark Disease of Maple
47 Sudden Oak Death
**50 Foliar Diseases**
50 Swiss Needle Cast
**53 WESTERN REDCEDAR DIEBACK MONITORING**
**55 ANIMALS**
55 Bear Damage / Root Disease

**56 AERIAL DETECTION SURVEY METHODOLOGY**

**57 DATA AND SERVICES**
Electronic PDF Maps Available for Download
Interactive Map Tools
GIS Data Available for Download
Forest Health Websites

**58 FOREST HEALTH CONTACTS**

**JOINT PUBLICATION CONTRIBUTORS**

**Washington State Department of Natural Resources (DNR)**
Rachel Brooks
Isaac Davis
Melissa Fischer
Glenn Kohler
Sarah Krock
Angie Lane
Daniel Omdal
Luis Prado
Will Rubin
Jen Watkins

**U.S. Department of Agriculture, Forest Service (USFS)**
Justin Hof
Betsy Goodrich
Karen Ripley

**Washington State Department of Agriculture (WSDA)**
Tiffany Pahs
Karla Salp

**Cover photos (clockwise from top left):** A recently planted Douglas-fir impacted by heat scorch: Rachel Brooks / DNR; Laminated root rot-caused mortality and chlorosis in Mason County: Eric Grando / DNR; grand fir killed by fir engraver: Glenn Kohler / DNR; western spruce budworm larva: Melissa Fischer / DNR.

# Forest Health Highlights in Washington / 2021

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

Washington State Department
of Natural Resources (DNR)
Forest Resilience Division
March 2022

WASHINGTON STATE DEPT OF NATURAL RESOURCES
HILARY S. FRANZ
COMMISSIONER OF PUBLIC LANDS

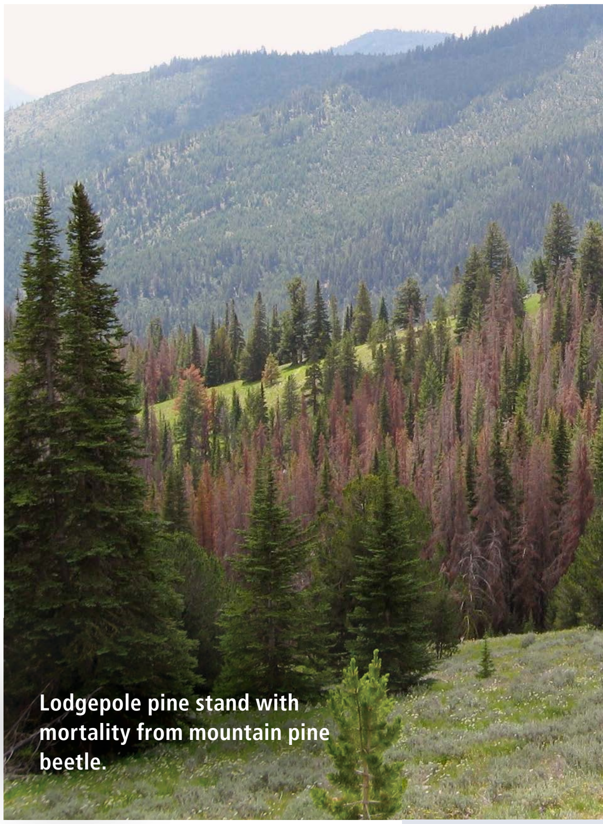
# Summary

**The annual insect and disease aerial detection survey (ADS) to detect recently killed and acutely damaged forest trees in Washington is conducted by the USDA Forest Service (USFS) in cooperation with the Washington Department of Natural Resources (DNR) and has been ongoing since 1947. In 2021, approximately 19 million forested acres across Washington were surveyed. About 3 million forested acres — 13 percent of the 22 million forested acres in the state – were not included due to fire activity, as well as limitations on aircraft availability and observer availability. No survey flights were conducted in 2020 in order to lower risk of 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 2021, the statewide insect and disease survey recorded some level of tree mortality, tree defoliation, or foliar diseases on approximately 555,000 acres** of the 19 million acres surveyed. The area with damage from mortality agents was approximately 433,000 acres, including 257,000 acres attributed to bark beetles and 91,000 acres attributed to bear damage or root disease. Approximately 33,000 acres with damage were attributed to defoliators and approximately 89,000 acres were assigned tree damage due to other causes, including 84,000 acres with needle desiccation damage from record-breaking temperatures in late June. Previous annual totals for all damage agents were:

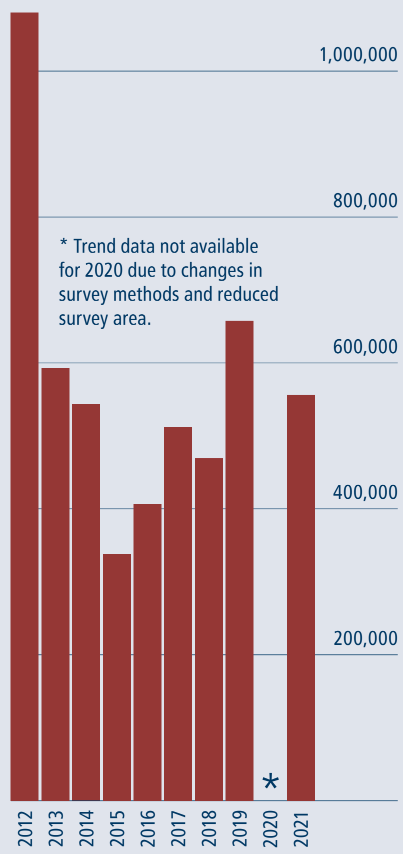
**2020:** 322,000 acres with damage out of 10.5 million acres surveyed
**2019:** 658,000 acres
**2018:** 469,000 acres
**2017:** 512,000 acres
**2016:** 407,000 acres

- **Drought conditions and warm, dry spring weather tend to increase tree stress and insect success,** increasing acres with 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 well below normal in spring and early summer 2021, but monthly average temperatures were well above normal during the summer months. A record-breaking extreme heat event occurred in late June, resulting in widespread tree needle desiccation damage in parts of western Washington. According to the US Drought Monitor, all of Washington experienced some level of drought condition in summer 2021. All of eastern Washington was under moderate to extreme drought conditions by late June. Through August and into September, forested areas of northeast Washington progressed to exceptional drought conditions. The area of eastern Washington that experienced exceptional drought was the largest recorded in the last 20 years.



CONNIE MEHMEL / USFS

Lodgepole pine stand with mortality from mountain pine beetle.




**TOTAL ACRES WITH INSECT AND DISEASE DAMAGE 2012-2021**

**The area with mortality caused by pine bark beetles in 2021 was approximately 92,500 acres, the lowest level recorded since 2015.** Mountain pine beetle damage decreased from 86,500 acres in 2019 to 53,100 acres in 2021. Part of this decrease may be due to reduced survey area around the Schneider Springs fire that includes a portion of recent mountain pine beetle outbreaks in northwest Yakima County. The majority of annual pine bark beetle mortality is in lodgepole pine killed by mountain pine beetle, totaling 51,300 acres in 2021. The highest concentrations of MPB mortality in lodgepole were mapped in northwest Yakima County, high elevation areas of Kittitas and Chelan counties, western Okanogan County, and in northern Pend Oreille and Stevens counties.

**Mortality of ponderosa pine due to western pine beetle has increased steadily since 2012 and reached a peak of 37,800 acres in 2021,** the highest level since 2006. The 2021 total is likely an underestimate due to reduced survey area in eastern Washington around several 2021 wildfires. Recent drought conditions are likely an important driver of these increases. The highest concentrations of western pine beetle mortality occurred throughout 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 was mapped on 1,500 acres in 2021, equal to the ten-year average.

**Mortality due to Douglas-fir beetle decreased to 51,700 acres in 2021,** departing from a recent pattern of growth in recent years that reached a 10-year high of 69,100 acres in 2019. **Fir engraver** mortality, primarily in grand fir, also decreased in 2021 to 52,500 acres, after a similar trend that also reached a 10-year high of 166,300 acres in 2019. The 2021 totals for Douglas-fir beetle and fir engraver are likely underestimated due to reduced survey area in eastern Washington around several 2021 wildfires.

**Chronic infestations of the non-native balsam woolly adelgid** affected 31,900 acres in 2021, accounting for the majority of defoliation damage in Washington. Damage was primarily in subalpine fir at high elevations in the Olympic, Cascade, and Selkirk mountain ranges. Outbreaks of **Douglas-fir tussock moth** in Kittitas, Chelan, and Okanogan counties have collapsed with no new defoliation reported in 2021. No new **western spruce budworm** defoliation was observed from the air in northeast Washington, where the most recent outbreak is declining.

**An extreme heatwave that occurred during the last weekend of June 2021** resulted in desiccation damage, primarily to new needles and buds of conifers on the south and west facing sides of tree crowns. Approximately 84,000 acres with this type of damage was recorded by aerial survey, primarily in western Washington. The highest concentrations were on the west side of the Olympic Peninsula, in the Cascade foothills areas of Snohomish, King, and Lewis counties, western Pacific County, Wahkiakum County, and southern Clark and Skamania counties. The extent of damage was likely underestimated by aerial survey because crown discoloration was difficult to see by observers looking to the west and south. Many different tree species were impacted, with damage most visible on conifers including Douglas-fir, western hemlock, western redcedar, and Pacific silver fir.

**The possibly non-native sooty bark disease of maple, caused by the fungus *Cryptostroma corticale*,** continues to be detected around the Seattle area, with additional samples found as far north as Bellingham, as far south as Olympia, and as far east as Rattlesnake Lake (King County). These samples have confirmed the presence of *C. corticale* on eight maple species, horse chestnut, Pacific dogwood, and cherry plum. The full distribution of this pathogen is not known, so a survey covering western Washington is planned for summer 2022.

***Phytophthora ramorum*,** the causal agent of sudden oak death, continues to 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.

GLENN KOHLER / DNR

Western redcedar foliage damaged by heat scorch event in June 2021.

# Abiotic Disturbances Influencing Forest Health

Abiotic disturbances — disturbances caused by non-living factors — are a natural and integral part of forest ecosystems and can have major impacts, both positive and negative. 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. Trees that survive these events may be damaged or weakened, which can 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 outbreak levels, which can then cause mortality in healthy trees. Drought and other disturbances that compromise tree defenses can lead to increased levels of mortality from root disease and other forest pathogens. Unseasonal extremes in precipitation during spring or fall 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 windthrow, winter damage (defoliation, cracks or breakage from cold, snow or ice), heat stress, flooding, landslides and hail. Unusually wet spring or fall weather, such as occurred in fall 2021 (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, such as a windthrow event that occurred in the Mt. Adams area in 2021. In years when spring and summer precipitation are below average and temperatures are above normal (Fig. 2), as was the case in 2021, the number of bark beetle-killed trees may increase the following year. Conifer trees killed by bark beetles typically do not appear red until the year after they die. 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 following the event.

Vigor and resilience to adverse weather can be increased by ensuring that trees have room to grow and are appropriate species for the site. For example, forests in eastern Washington are generally overstocked with too much fir and not enough drought tolerant pine and larch. These conditions favor defoliators such as the western spruce budworm and perpetuate root disease and bark beetle activity. In western Washington, Swiss needle cast disease affects Douglas-fir growing on coastal sites that may be more suited to western hemlock and Sitka spruce.

Figure 1.

**WASHINGTON STATE PRECIPITATION (IN.)**

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

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

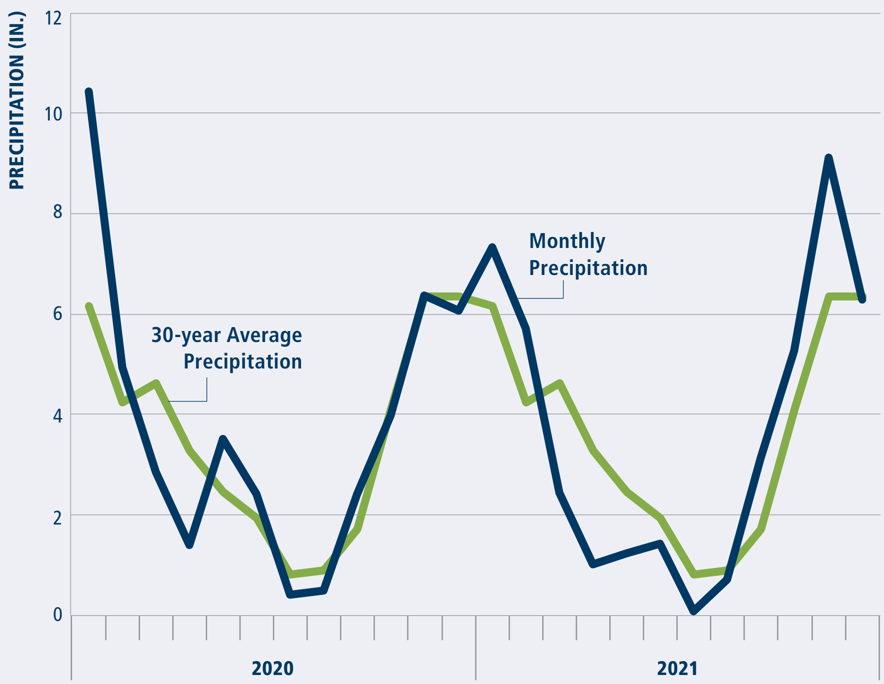
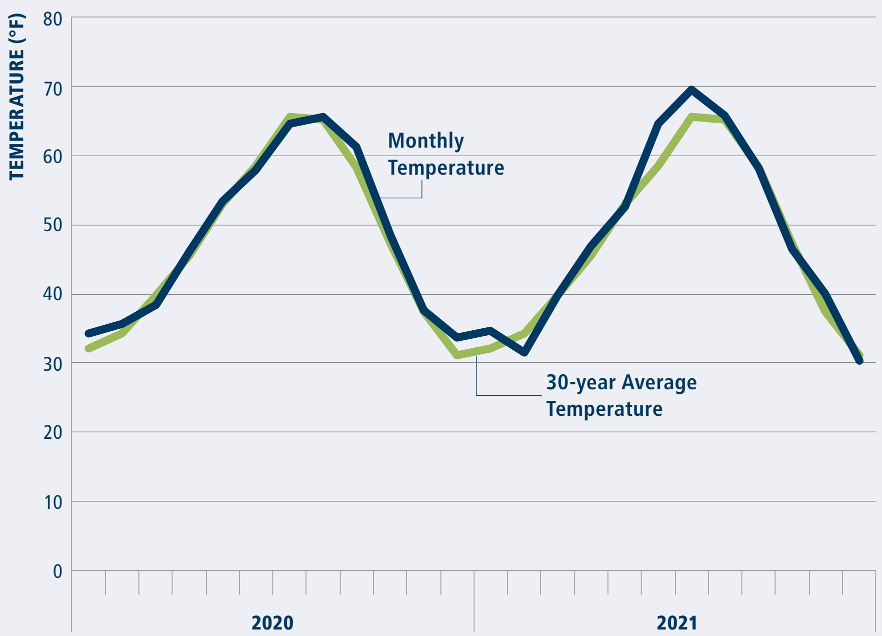



Figure 2.

**WASHINGTON STATE MEAN TEMPERATURES (°F)**

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

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



# Drought

Precipitation in Washington was well below normal in spring and early summer 2021, followed by above normal rainfall during late summer and fall. Average temperatures during the summer months were well above normal. A record extreme heat event occurred in late June, resulting in widespread tree needle desiccation damage in parts of western Washington. See page 10 "Weather Related Tree Damage" section. Below-normal rainfall during the growing season may increase the potential for drought stress on trees; however, near normal temperatures can mitigate drought effects. From April through June 2021, drought conditions throughout western Washington lowlands were moderately dry with areas of moderate and severe drought in southwest Washington. Drought conditions ranging from moderate to extreme covered all of eastern Washington by the end of June. Through August and early September, forested areas of northeast Washington developed into exceptional drought condition (Fig. 3). All of Washington experienced some level of drought condition in summer 2021. The area of eastern Washington that experienced exceptional drought was the largest recorded during the last 20 years (Fig. 4). The last comparable drought event was in 2015. These conditions will likely increase tree susceptibility to insect and disease attacks and make them less likely to recover from injuries.

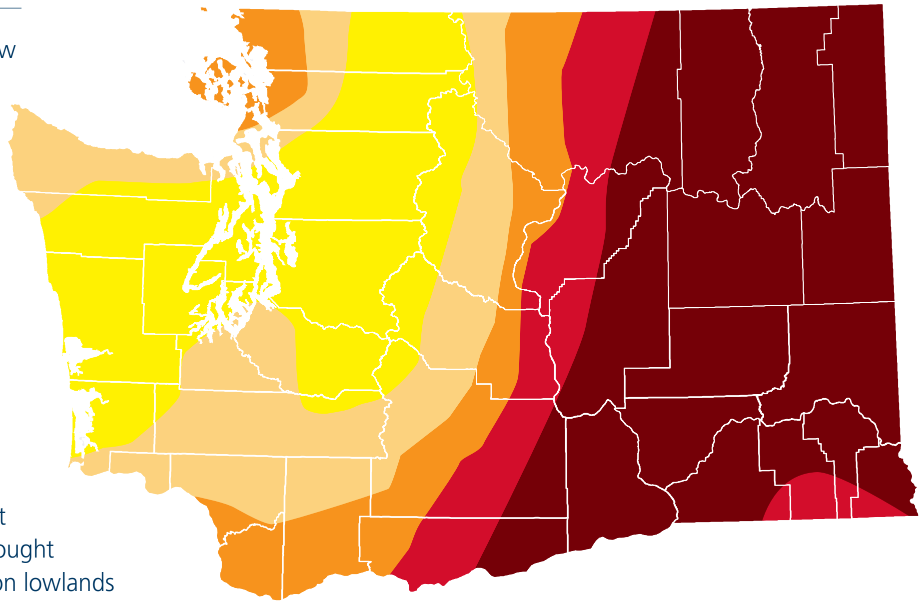



Figure 3.

**DROUGHT CONDITIONS IN WASHINGTON ON AUGUST 31, 2021**

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

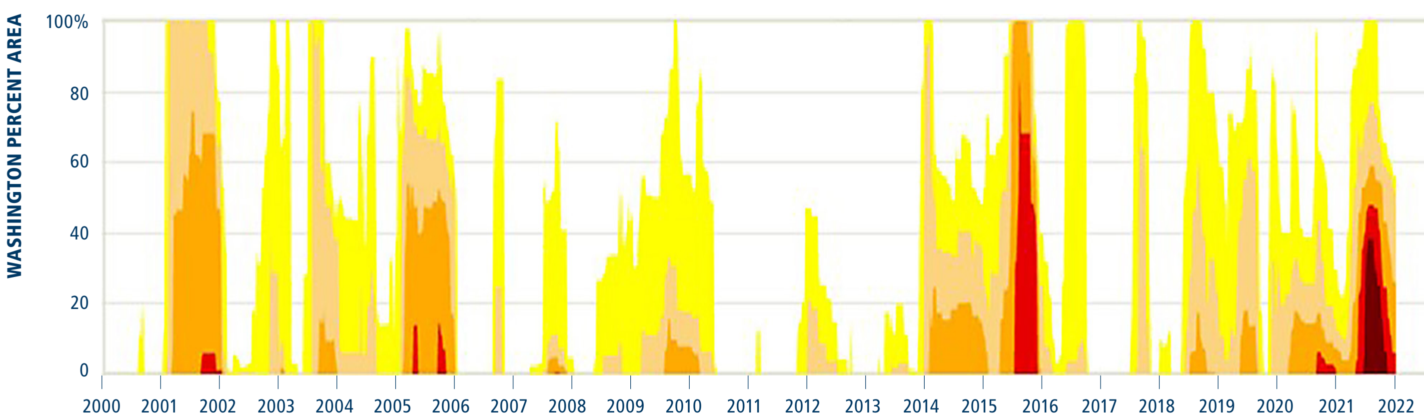



Figure 4.

**PROPORTION OF WASHINGTON STATE AREA AFFECTED BY DROUGHT FROM 2000 – 2021**

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

# Weather Related Tree Damage

## NEEDLE DESICCATION

Two needle desiccation events were noted in Washington State during 2021; one likely in late winter and early spring, and one in late June.

The first desiccation symptoms were first observed in central to northern Washington starting in April on the west side of several cascade passes, especially around Rockport and Sedro-Woolley. Needle desiccation in late winter and early spring, due at least in part to easterly winds, is often referred to as “parch blight” and is not an unusual occurrence in the foothills and western slopes of the Cascade Mountains. Similar desiccation events on multiple conifer species have occurred in Washington, most recently in 2015 and 2016.

This type of injury occurs when prolonged cold, dry, east-to-west winds increase needle desiccation by increasing both needle respiration and transpiration at a time when trees are unable to effectively absorb water from cold or frozen soils. This drying out of needles results in browning or reddening of the foliage on the windward side of the crown. There is often a lag time between the wind event and the damage becoming visible on the tree. In this case, with the damage on the eastern side of tree crowns, the symptoms were clearly visible when looking west but often imperceptible when looking east. This damage was widespread over large areas with no signs of related fungi or insect activity. Exposed crowns above the canopy, at the edge of stands, or along roads appeared to be the most affected.

This damage can impact numerous evergreen tree species, but was most visible during this past year on Douglas-fir in the western Cascades (Fig. 5), although symptoms were observed on several other conifer species in urban settings. Since winter desiccation occurs prior to bud break and typically does not impact buds, impacted trees should recover quickly in most cases, with symptoms becoming no longer evident after new needles expand. This normal flush of new foliage obscures damaged needles, making this type of damage undetectable in summer aerial surveys.

The second needle desiccation event was noted after the extreme heatwave that occurred during the last weekend of June 2021. This weather event, commonly referred to as the “Heat Dome”, caused temperatures to peak at or above record levels for much of the state, with ongoing research connecting the event to human-caused climate change.

BETSY A. GOODRICH / USFS

**AN EXTREME HEATWAVE IN LATE JUNE 2021, KNOWN AS A "HEAT DOME," CAUSED DAMAGE TO NEW FOLIAGE AND BUDS OF SEVERAL CONIFER SPECIES ACROSS AT LEAST 84,000 ACRES IN WESTERN WASHINGTON.**

**Figure 5 (above):**
Winter desiccation (parch blight) impacted Douglas-fir in Rockport (Skagit County) with reddening needles on the east side of the tree as seen in May, 2021.

**Figure 6.**
A mature Douglas-fir impacted by heat scorch near Glenoma (Lewis County) photographed in July, 2021.

RACHEL BROOKS / DNR

With temperatures of darker-colored foliage in direct sunlight reaching even higher temperatures than that of the air, needle desiccation on foliage exposed to the afternoon sun appeared widespread in parts of western Washington starting in early July. Approximately 84,000 acres with this type of damage was recorded by aerial survey, primarily in western Washington (Fig. 10). The highest concentrations were on the west side of the Olympic Peninsula, in the Cascade foothills areas of Snohomish, King, and Lewis counties, western Pacific County, Wahkiakum County, and southern Clark and Skamania counties. Heat scorch (also known as sun scorch) was especially notable on the southwest and western sides of tree canopies, on south and west facing slopes, on younger trees (Fig. 7), on trees with more sky exposure, and on trees closer to the coast. The extent of damage was likely underestimated by aerial survey because crown discoloration was difficult to see by observers looking to the west and south. Many different tree species were impacted, with damage most visible on conifers including Douglas-fir (Fig. 6), western hemlock (Fig. 8), western redcedar (Fig. 9), and Pacific silver fir. Needles appeared brown or red, and in places branch tips and buds were also killed. The long-term impact of needle desiccation is not well studied, and it is assumed that larger well-established and otherwise healthy trees will be able to recover from this desiccation event.

While both damaging events were associated with environmental extremes, winter desiccation and heat/sun scorch can be distinguished by noting the timing of symptom appearance (spring vs. after a summer heat wave) and the side of the tree canopy impacted (eastern facing vs. south-western facing). If damage occurred during the winter (winter desiccation), the needles that emerged in spring after the desiccation event should not be damaged, while the current year's new foliage may be damaged by a summer heat/sun scorch event.

RACHEL BROOKS / DNR

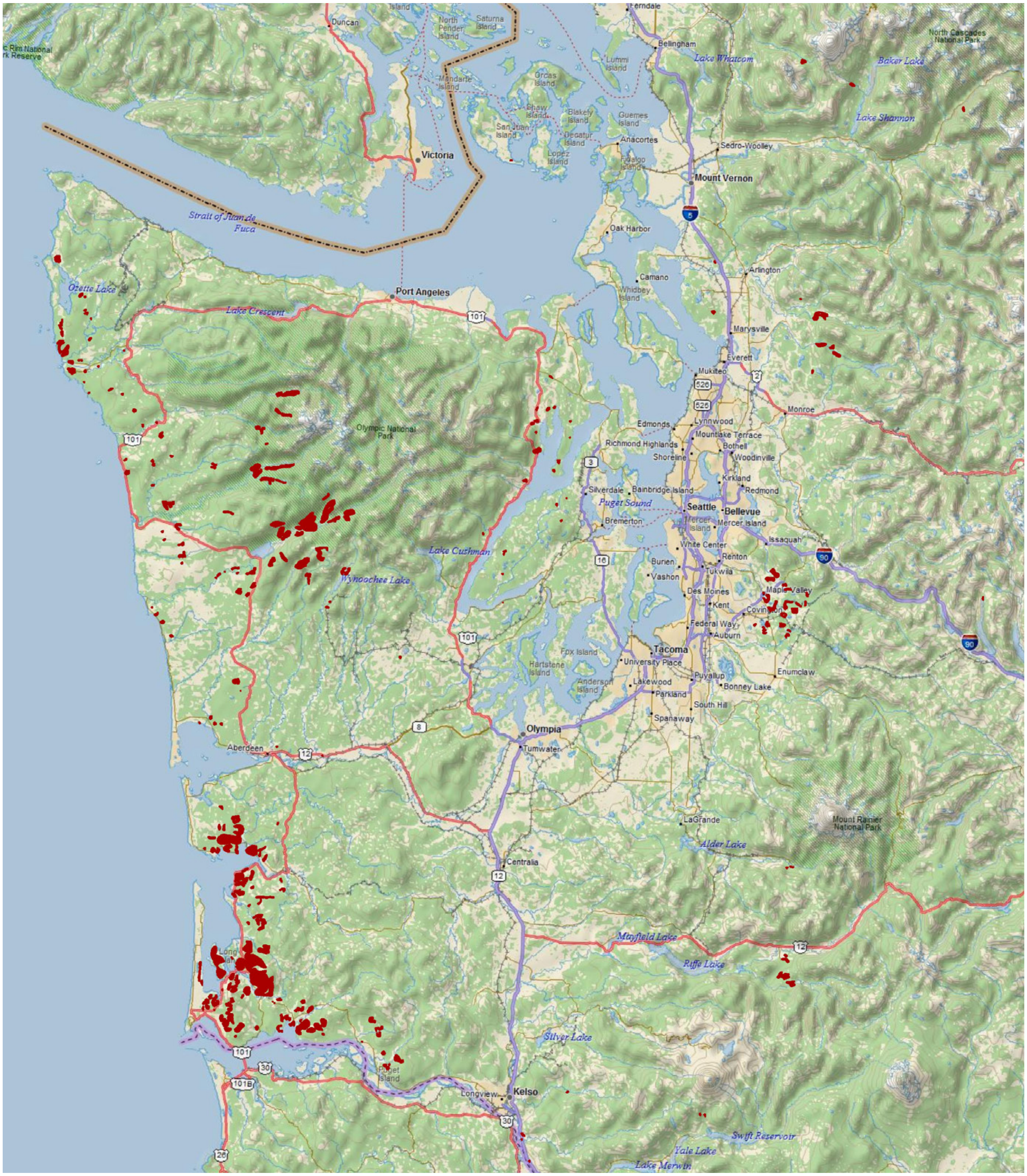
RACHEL BROOKS / DNR

RACHEL BROOKS / DNR

**Figure 7 (top):** A recently planted Douglas-fir impacted by heat/sun scorch near Humptulips (Grays Harbor County) photographed in July, 2021.

**Figure 8 (middle):** A mature western hemlock impacted by heat scorch in Olympia (Thurston County) photographed in July, 2021.

**Figure 9 (bottom):** Western redcedar along US-101 near Humptulips (Grays Harbor County) impacted by heat scorch photographed in July, 2021.



Desiccation damage to conifers

0 20 miles N

**Figure 10.**

## HEAT RELATED DESICCATION DAMAGE IN WESTERN WASHINGTON RECORDED IN 2021 AERIAL DETECTION SURVEY.

SOURCE: DNR, USFS

# Wildfire

According to data compiled by the Northwest Coordination Center (NWCC) and DNR, wildfires burned 674,249 acres in all of Washington during the 2021 season, down from the 842,358 acres burned in 2020. According to a GIS analysis of statewide fire polygons, estimates for large fire fuel types burned were: 54 percent forest, 26 percent shrub-steppe, 17 percent grassland, and 4 percent other (i.e. agricultural lands, urban areas, wetlands).

In 2021 there were a total of 1,271 fires on DNR protected lands, up from 1,001 fires in 2020. The annual count of fire occurrences on DNR protected lands was higher than the average of 953 fire occurrences per year over the period 2011 to 2020 – data shows that 7 percent of these fires were lightning caused while the remainder were human caused. Of the 1,872 total fire occurrences statewide in 2021 (including both DNR and other agency protected lands), 44 were considered "large fires" per NWCC definition for size (greater than 100 acres of forestland or 300 acres of brush/grass) (Fig. 11).

According to DNR fire occurrence data, the bulk of DNR's wildfire activity occurred in April, July and August, though fires occurred in every month of the year (Fig. 12). High fire counts in April were primarily driven by escaped debris burn fires. Of the 226 total fires in April, 133 or 59 percent of them were caused by debris burning. Overall, DNR fires were 60 percent human-caused, 7 percent lightning-caused, and 32 percent undetermined at the time of this writing.

Of note for the 2021 fire year was the drought that Washington experienced. Even though snowpack was above normal measurement at most automated snow telemetry (SNOTEL) monitoring sites, having recorded no measurable precipitation during the spring and summer months set Washington up for expanded and escalated drought conditions. Human-caused fires in April during a dry spring and active lightning storms over dry fuels in July contributed to an active fire year. The largest fire in Washington during 2021 was Schneider Springs at 107,118 acres. This fire started on Aug. 4 and was contained on Nov. 3, 2021. The fire was located in Yakima County, caused by lightning, and burned in short grass, timber, and brush. Evacuations were in place during the incident, but no homes were lost or destroyed.

JAY PHIPPS / DNR

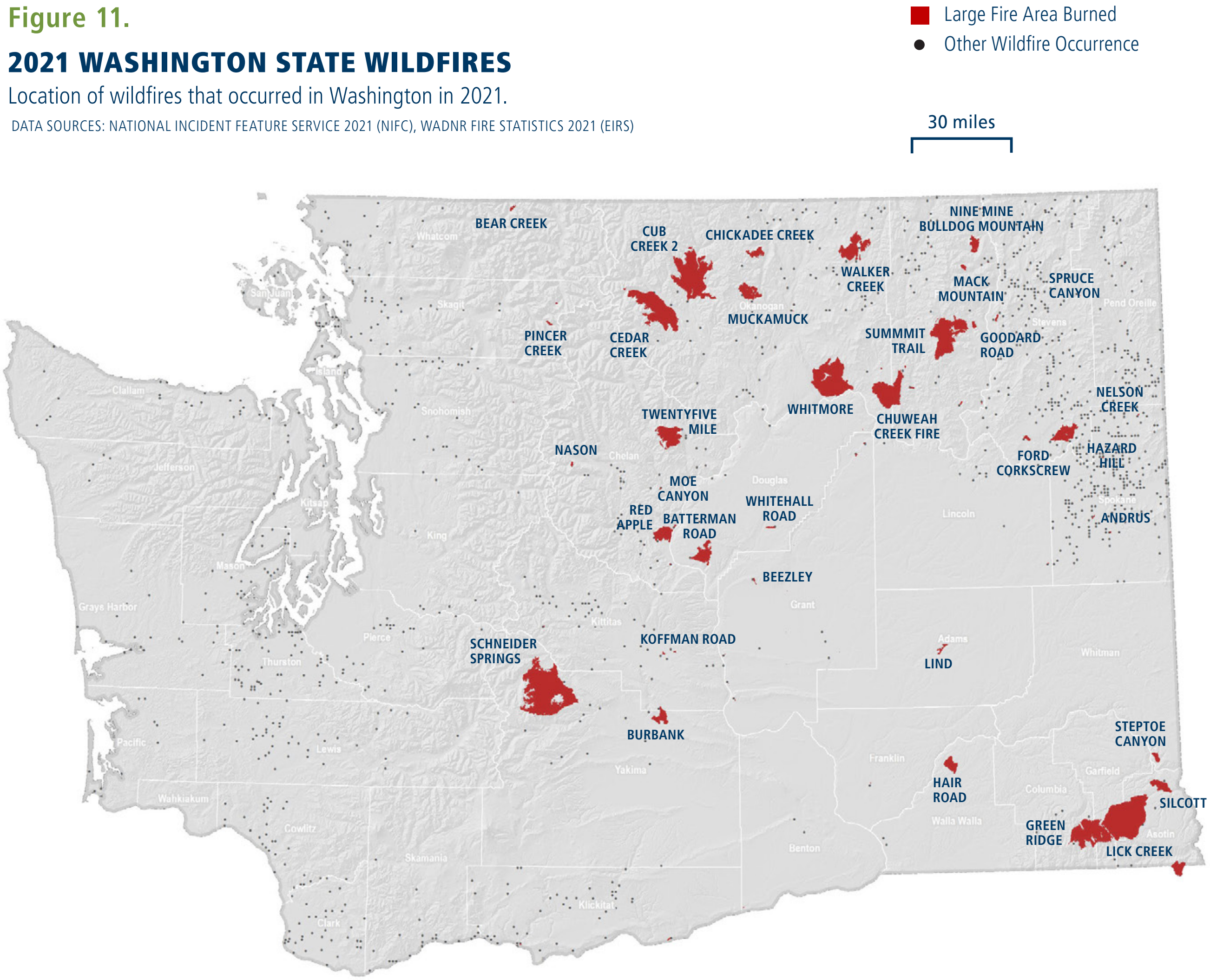
**2021 SNOWPACK WAS ABOVE NORMAL AT MOST MONITORING SITES; HOWEVER, BELOW NORMAL PRECIPITATION DURING SPRING AND SUMMER SET WASHINGTON UP FOR DROUGHT CONDITIONS THAT EXPANDED AND ESCALATED.**

**Figure 11.**

## 2021 WASHINGTON STATE WILDFIRES

Location of wildfires that occurred in Washington in 2021.

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



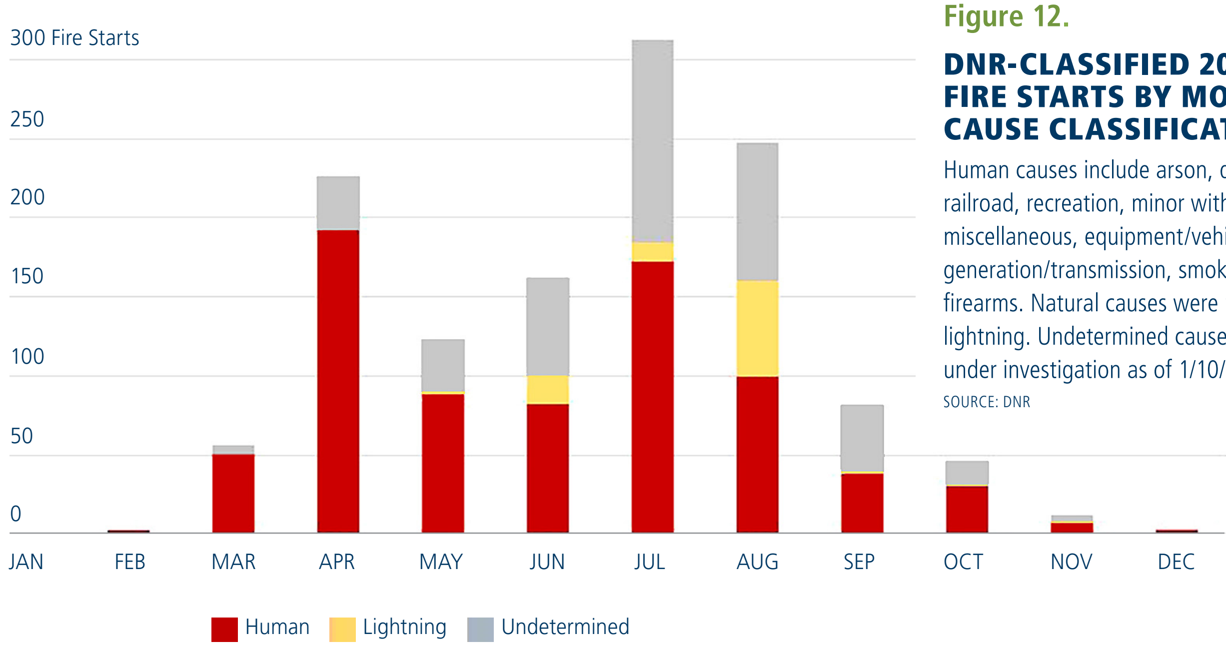




**Figure 12.**

## DNR-CLASSIFIED 2021 FIRE STARTS BY MONTH AND CAUSE CLASSIFICATION

Human causes include arson, debris burning, railroad, recreation, minor with fire, fireworks, miscellaneous, equipment/vehicle, power generation/transmission, smoking, and firearms. Natural causes were primarily lightning. Undetermined causes include fires under investigation as of 1/10/2022.

SOURCE: DNR

# WASHINGTON'S FOREST ACTION PLAN UPDATE

The 2020 Washington State Forest Action Plan was approved by the USFS and formally adopted by the DNR on October 26, 2020. Washington's Forest Action Plan is a comprehensive review of forests across all lands — public, private, rural, and urban — and offers proactive solutions to conserve, protect, and enhance the trees and forests that people and wildlife depend on.

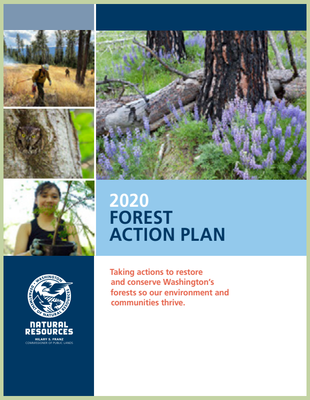
To meet the scale of challenges and opportunities facing Washington's forests, the plan established 23 goals and 159 priority actions to guide implementation through June 30, 2025. The plan also commits to monitoring progress made towards those goals in partnership with the USFS, Washington Department of Fish and Wildlife (WDFW), and other Shared Stewardship partners, while also communicating the story of our collective implementation effort and lessons learned over time.

The first year of implementation was influenced by significant events of local and global importance. The 2020 Forest Action Plan was finalized and published during the first year of Washington's response to the COVID-19 pandemic. The historic 2020 Labor Day wildfires that besieged the Pacific Northwest impacted our forests and communities. Record-breaking weather patterns extending into 2021 resulted in Washington declaring both wildfire and drought emergencies. The same year also saw passage of historic legislation that provides a significant increase in available resources to address wildfire risk and the forest health crisis facing Washington State, specifically stating that "it is the intent of the legislature to take immediate action to increase the pace and scale of forest management across different land ownerships and fully fund the 20-Year Forest Health Strategic Plan and activities developed to facilitate implementation of the Washington State Forest Action Plan."

Implementation of the action plan was and continues to be influenced and challenged by these events. Tremendous progress has been made to help Washington's forests thrive. Incredible stories of individual and community resilience, innovation and scientific inquiry, and collaboration among sometimes unlikely partners are highlighted throughout this report.

In January 2021, DNR released a Forest Action Plan annual report highlighting implementation during the first year following plan adoption, providing an overview of agency and partner priorities related to ongoing actions, and featuring updates that will inform and drive our collaborative efforts to achieve our goals moving forward. The successes and opportunities detailed in this report also highlight the commitment of our elected officials, community leaders, tribal leaders, and numerous agencies, nonprofits, and industry partners who remain deeply invested in addressing the threats facing forest ecosystems.

**Read the 2020-2021 Forest Action Plan annual report at https://www.dnr.wa.gov/ForestActionPlan**




**MORE THAN 20 MILLION ACRES OF WASHINGTON IS FORESTED, AFFECTING CLEAN AIR AND WATER AND OUR QUALITY OF LIFE. TO HELP FORESTS THRIVE, THE FOREST ACTION PLAN PROVIDES A COMPREHENSIVE REVIEW OF FORESTS ACROSS ALL LAND OWNERSHIPS AND OFFERS SOLUTIONS TO CONSERVE, PROTECT AND ENHANCE THE TREES AND FORESTS THAT PEOPLE AND WILDLIFE DEPEND ON.**

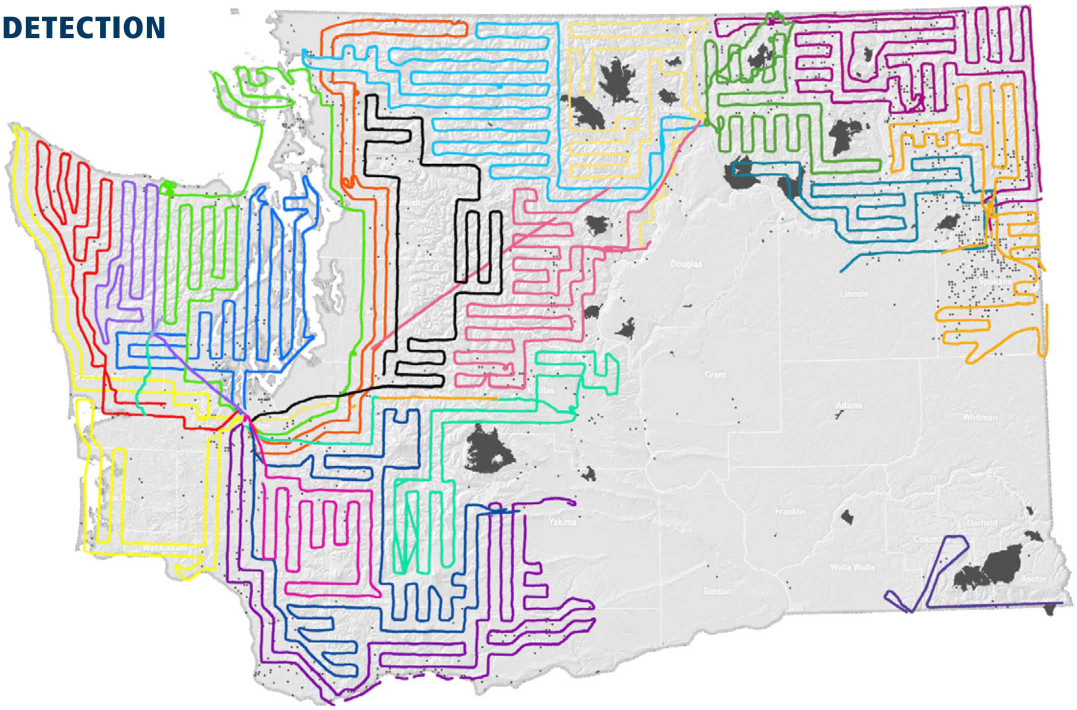
In spring 2021, DNR funded and helped to organize a Prescribed Fire Training Exchange in northeast Washington supporting 25 trainees to assist on prescribed fire treatments on 246 acres.

RRIC KEIHN

Figure 13.

## WASHINGTON AERIAL DETECTION SURVEY FLIGHT LINES FOR 2021

SOURCE: DNR, USFS



**FLIGHT DATES**

- 7/26/21
- 7/27/21
- 7/28/21
- 7/29/21
- 7/30/21
- 8/02/21
- 8/04/21
- 8/17/21
- 8/18/21
- 8/23/21
- 8/24/21
- 8/25/21
- 9/01/21
- 9/20/21
- 9/21/21
- 9/22/21
- 9/23/21
- 9/24/21
- 9/25/21
- 10/07/21

2021 Fires

GLENN KOHLER / DNR


Aircraft owned by the Washington Department of Fish and Wildlife that was used for 2021 aerial detection surveys in Washington. Its high-wing design allows observers a clear view of forests below.

# Aerial Detection Survey

The annual insect and disease aerial detection survey (ADS) to detect recently killed and currently damaged forest trees in Washington is conducted by the USDA Forest Service (USFS) in cooperation with DNR. In 2021, approximately 13 percent of the 22 million forested acres in Washington were not surveyed due to fire activity, lack of aircraft availability, and challenges with observer availability. Forested areas of Washington not surveyed in 2021 due to lack of availability included eastern Pacific County and adjacent areas of Grays Harbor and Lewis counties, areas of the Cascade foothills in Snohomish and King counties, and small areas of Cowlitz and Skamania counties (Fig. 13). Areas not surveyed due to 2021 wildfire activity included parts of northwest Yakima County (Schneider Springs fire), east-central Chelan County (Twentyfive Mile fire), western Okanogan County (Cedar Creek and Cub Creek 2 fires), the Confederated Tribes of the Colville Reservation (Summit Trail fire), southern Stevens County (Ford Corkscrew fire), and most of the Blue Mountains (Lick Creek and Green Ridge fires) (Fig. 11 & Fig. 15). Some other areas not surveyed were either non-forested, recently burned, or were in restricted airspace. The survey was completed in early October when late-season conditions made damage signatures difficult to see. Wildfire smoke was not a significant issue. For a detailed description of ADS methods, see "Aerial Detection Survey Methodology" section on page 56.

No survey flights were conducted in 2020 for the first time since 1947 in order to lower risk of COVID-19 exposure and spread among flight crews and their contacts. This included both statewide aerial insect and disease survey flights and focused springtime aerial surveys for Swiss needle cast along Washington's coastal forests. In place of aerial surveys in 2020, the data used for statewide insect and disease surveys were acquired through a combination of ground sampling in the field and a "Scan and Sketch" remote sensing method where observers manually delineated damage areas on high-resolution satellite or aerial orthophoto imagery. For more information on the 2020 survey methods, see Forest Health Highlights in Washington 2020.

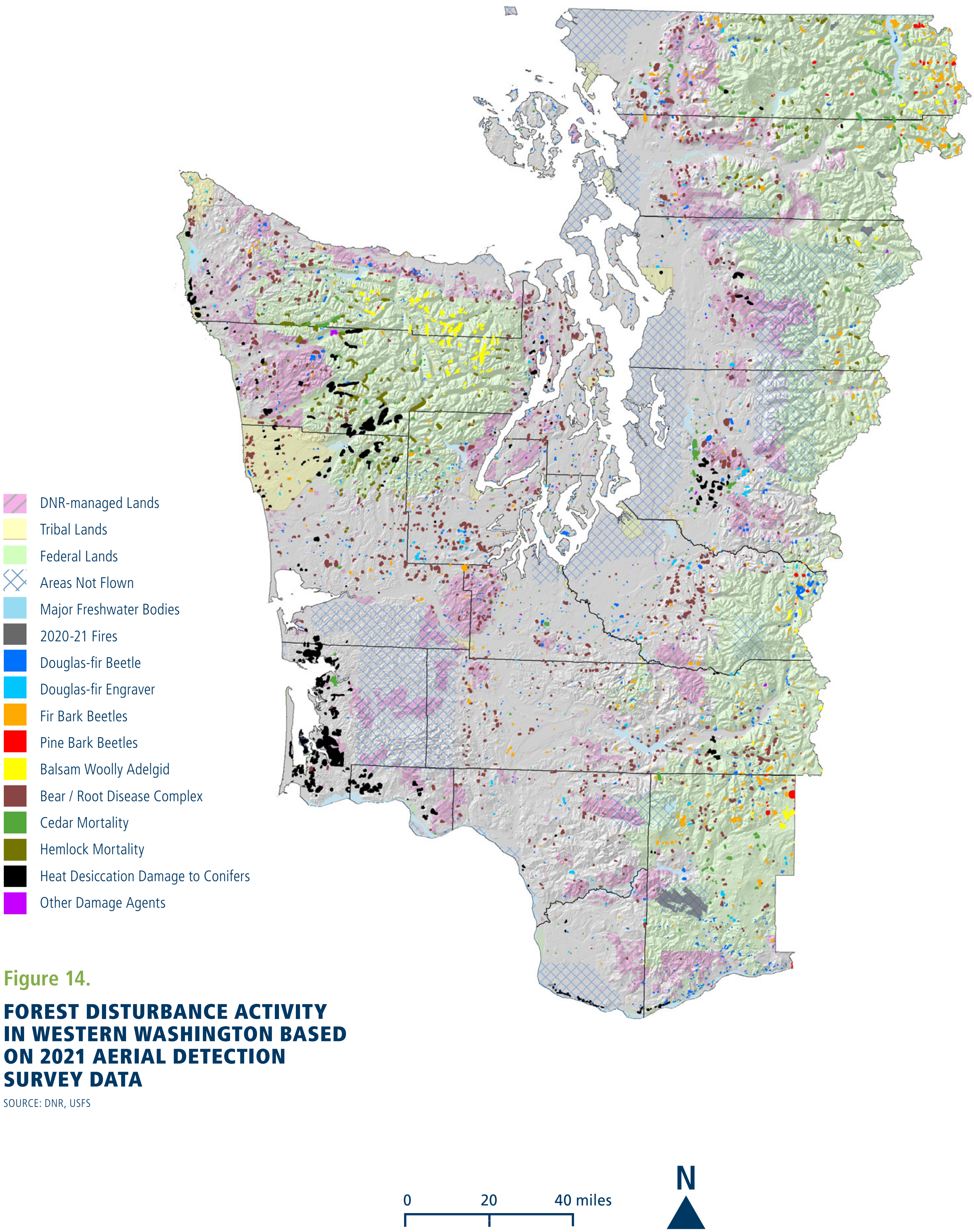



**Figure 14.**

**FOREST DISTURBANCE ACTIVITY IN WESTERN WASHINGTON BASED ON 2021 AERIAL DETECTION SURVEY DATA**

SOURCE: DNR, USFS

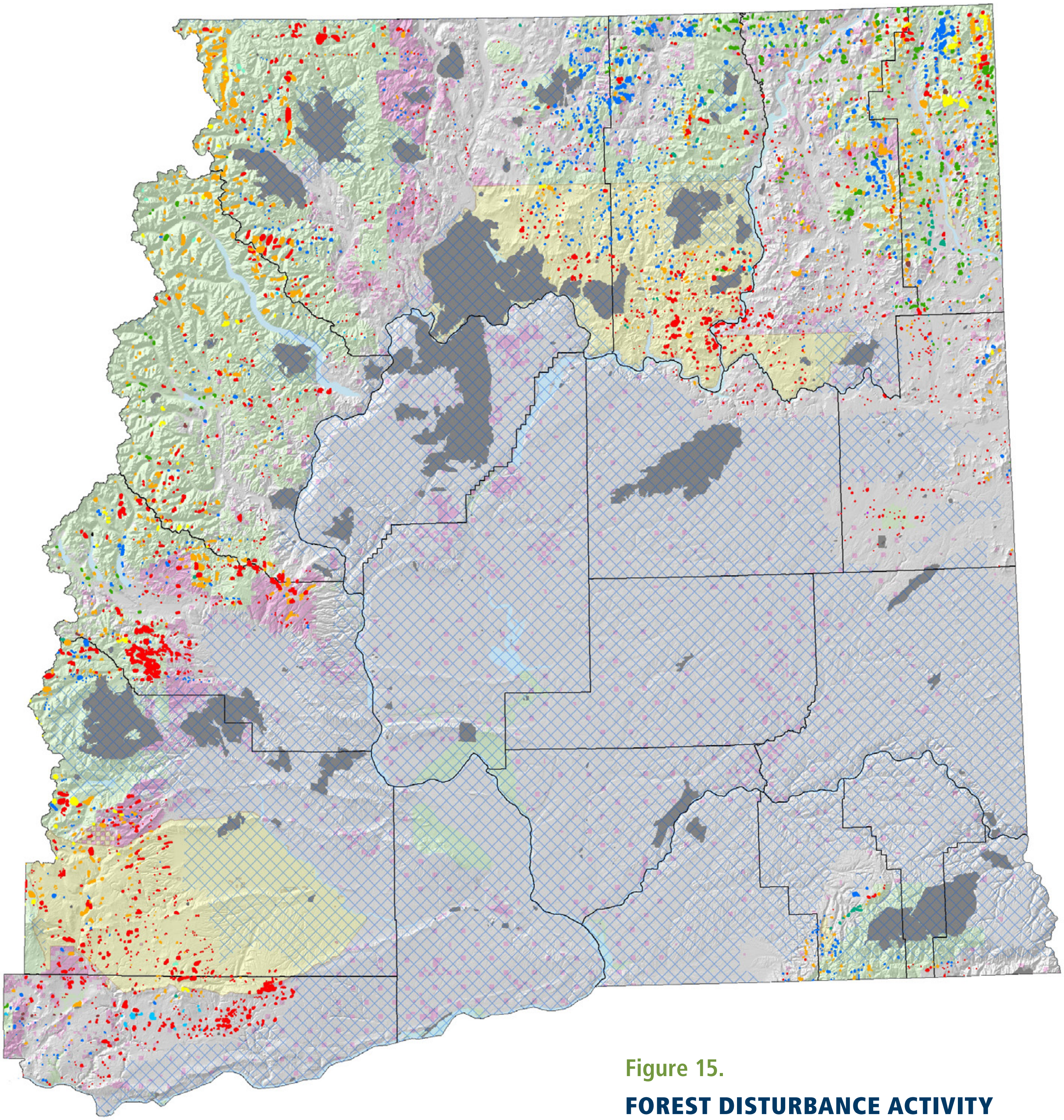



**Figure 15.**

## FOREST DISTURBANCE ACTIVITY IN EASTERN WASHINGTON BASED ON 2021 AERIAL DETECTION SURVEY DATA.

SOURCE: DNR, USFS

GLENN KOHLER / DNR

Forest insect and disease identification and management training for professional foresters at a site with grand fir mortality caused by fir engraver.

# 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 attack by other pests that may be more damaging or lethal. 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 low levels, native insects and pathogens provide important ecological roles in nutrient cycling of dead plant material and removal of weak, suppressed, and unthrifty trees, thus leaving healthier trees with better 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 (formerly known as gypsy moth) and sudden oak death, are major threats to Washington's forests, because native trees do not have 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.)

The area with mortality caused by pine bark beetles in 2021 was approximately 92,500 acres, the lowest level recorded since 2015 and well below the 10-year average of 129,000 acres (Fig. 16). Trend data for 2020 are not included in this calculation due to changes in survey methods and reduced survey area. Mountain pine beetle *Dendroctonus ponderosae* (MPB) damage decreased from 86,500 acres in 2019 to 53,100 acres in 2021. Part of this decrease may be due to reduced survey area around the Schneider Springs fire that includes a portion of recent MPB outbreaks in northwest Yakima County.

**MORTALITY OF PONDEROSA PINE DUE TO WESTERN PINE BEETLE HAS INCREASED STEADILY SINCE 2012 AND REACHED A PEAK OF 37,800 ACRES IN 2021, MORE THAN TWICE THE AFFECTED AREAS OBSERVED IN 2017 AND 2018 AND THE LARGEST NUMBER OF ACRES RECORDED SINCE 2006.**

The majority of annual pine bark beetle mortality is in lodgepole pine killed by MPB, totaling 51,300 acres in 2021 (Table 1). Recent MPB-killed lodgepole totaled 59,300 acres in 2018 and 76,500 acres in 2019. The highest concentrations of MPB mortality in lodgepole mapped in 2021 were north of Mt. Adams in Yakima County around the Goat Rocks Wilderness area, in Kittitas County around the Norse Peak Wilderness and upper Manastash Creek areas, along the border between Kittitas County and Chelan County, in western Okanogan County west of Twisp and north of Mazama, and in Pend Oreille and Stevens counties in the Metaline Falls and Northport areas. MPB-caused mortality in ponderosa pine has averaged about 20,000 acres annually over the last decade, but declined in recent years to a low of approximately 750 acres in 2021. Part of this reduction may be due to an increased emphasis by observers in attributing recent bark beetle outbreaks in ponderosa pine to western pine beetle *Dendroctonus brevicomis* (WPB). Observers recorded 1,100 acres of whitebark pine with MPB-caused mortality in 2021, the largest amount since 1,200 acres were recorded in 2013. Areas with higher concentrations of whitebark pine mortality were in the upper Ahtanum in Yakima County, around the Alpine Lakes Wilderness west of Leavenworth, and in western Okanogan County north of Mazama. Only trace amounts of western white pine mortality were mapped in 2021. 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 WPB has increased steadily since 2012 and reached a peak of 37,800 acres in 2021, more than twice the affected areas observed in 2017 and 2018 and the largest number of acres recorded since 2006 (Fig. 17). The 2021 total is likely an underestimate due to reduced survey area in eastern Washington around several 2021 wildfires (see Aerial Detection Survey section on page 18). Damage from WPB has been widely reported throughout eastern Washington, and there has been a significant increase in requests for information from landowners and land managers. Recent drought conditions are likely an important driver of these increases. The highest concentrations of WPB-caused mortality were throughout 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 1,500 acres in 2021, equal to the ten-year average. Ponderosa pine was the most common species affected. Ground sampling and landowner reports of pine engraver-caused mortality in northeast Washington suggest an increase in activity that may not be captured in aerial survey data. Pine engraver mortality was much higher – 3,900 acres – in 2019. Some of the same areas are also experiencing WPB outbreaks, which has a very similar aerial survey damage signature in young ponderosa pines. The highest concentrations of mortality were in Spokane, southern Stevens, and eastern Okanogan counties. Activity also continued in Klickitat and Yakima counties.

GLENN KOHLER / DNR

Lodgepole pines killed by mountain pine beetle in Kittitas County.

## Table 1.

## ACRES OBSERVED IN AERIAL SURVEY WITH PINE BARK BEETLE DAMAGE IN WASHINGTON

| BEETLE SPECIES | HOST(S) | 2019 ACRES WITH MORTALITY* | 2021 ACRES WITH MORTALITY |
|---|---|---|---|
| Mountain Pine Beetle | Lodgepole Pine | 76,500 | 51,300 |
| Mountain Pine Beetle | Ponderosa Pine | 14,000 | 750 |
| Mountain Pine Beetle | Whitebark Pine | 900 | 1,100 |
| Mountain Pine Beetle | Western White Pine | 300 | 10 |
| Western Pine Beetle | Ponderosa Pine | 29,400 | 37,800 |
| Pine Engravers (*Ips* species) | All Pines | 3,900 | 1,500 |
| Totals | | 119,400 (footprint)** | 92,460 |

* Trend data are not available for 2020 due to changes in survey methods and reduced survey area.
**Multiple host species can be recorded in a single area, therefore the sum of acres for all hosts may be greater than the total footprint affected.

STEVE DECOOK / DNR

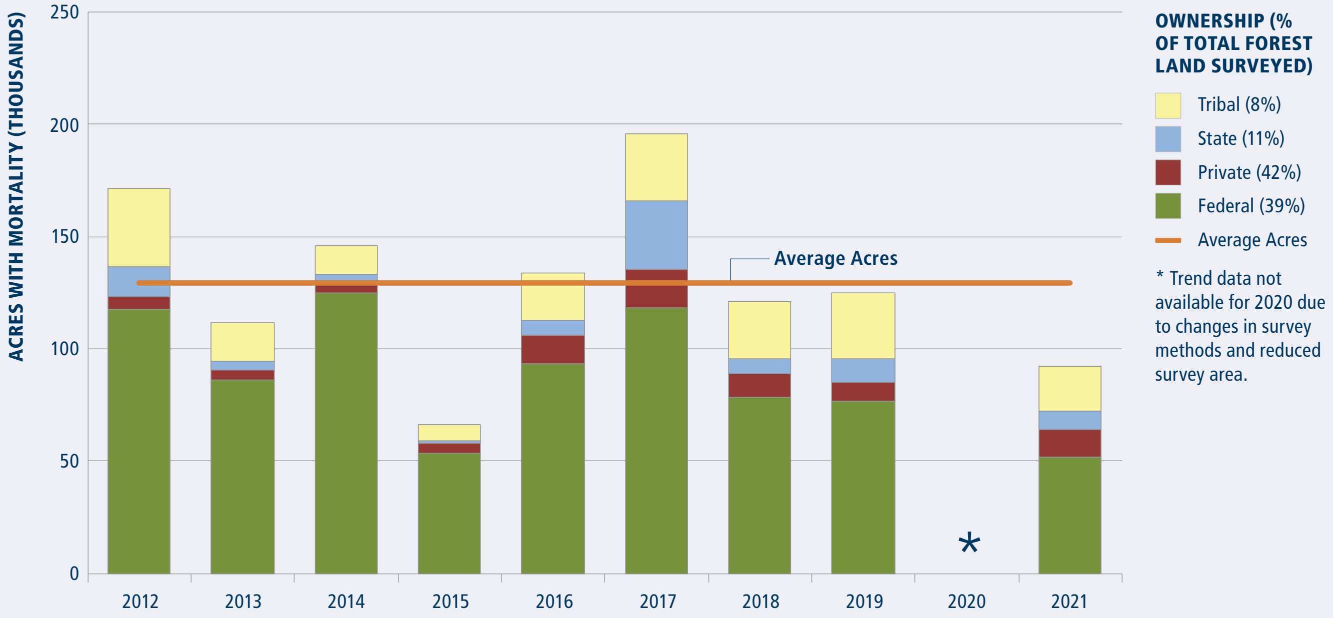
Group of young ponderosa pine killed by *Ips* pine engravers in northeast Washington.

GLENN KOHLER / DNR

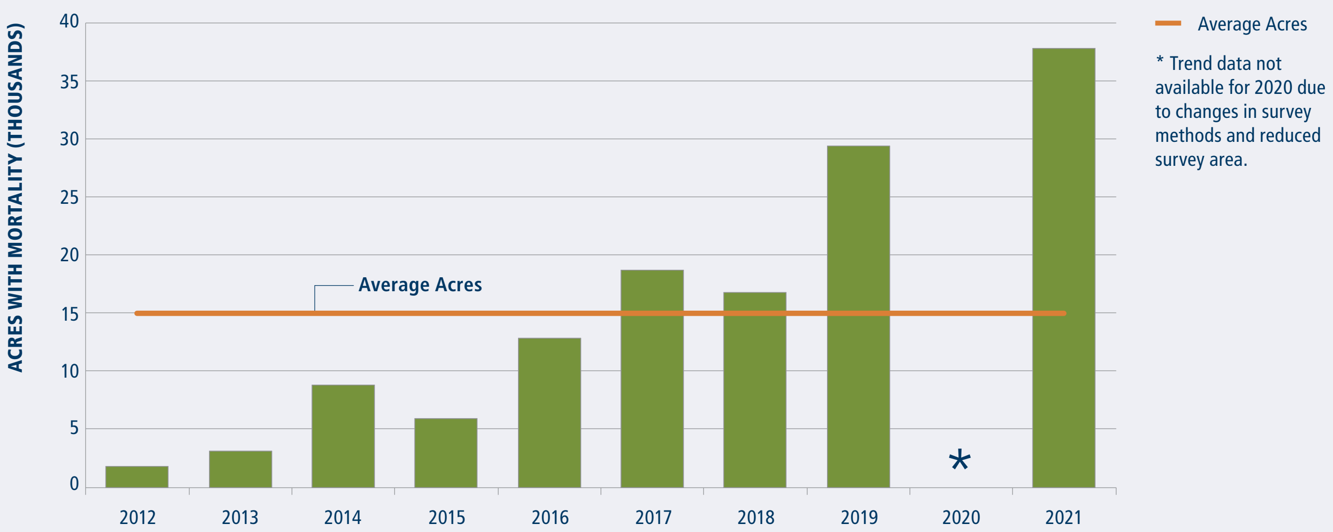
*Ips* pine engraver galleries and larvae in ponderosa pine.

**GROUND SAMPLING AND LANDOWNER REPORTS OF PINE ENGRAVER-CAUSED MORTALITY IN NORTHEAST WASHINGTON SUGGEST AN INCREASE IN ACTIVITY THAT IS LIKELY HIGHER THAN THE 1,500 ACRES MAPPED BY AERIAL SURVEY.**

## PINE BARK BEETLES 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 16.




## WESTERN PINE BEETLE 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 17.



## INSECTS | BARK BEETLES

GLENN KOHLER / DNR

# Douglas-fir Beetle

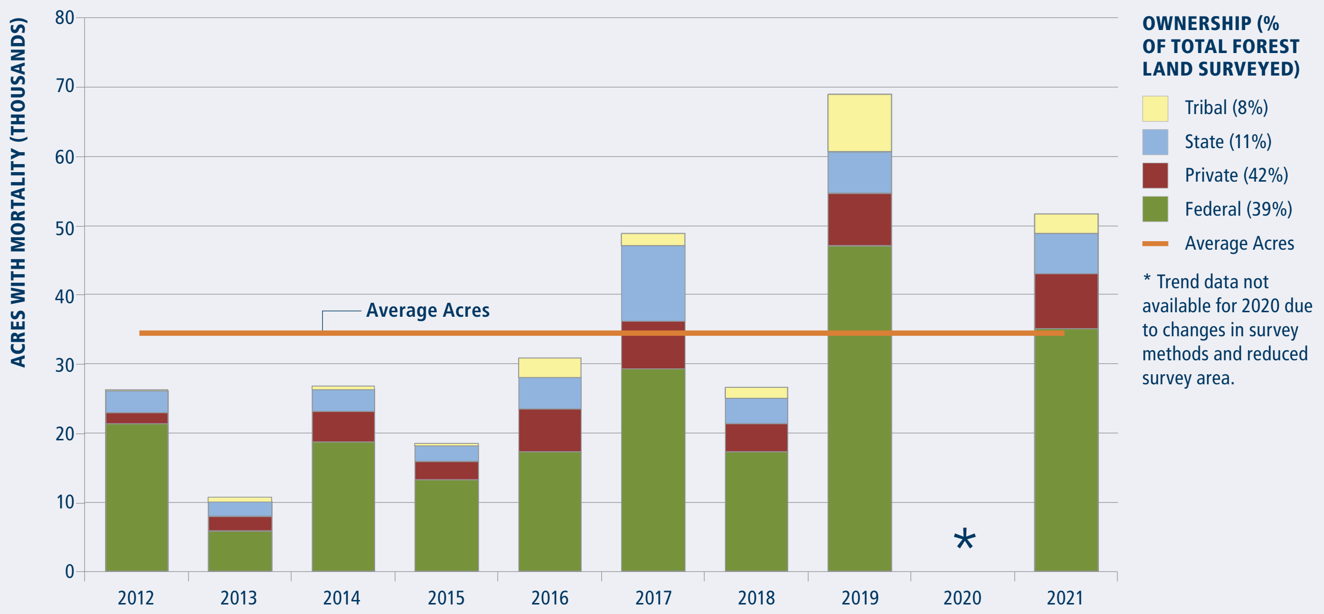
(*Dendroctonus pseudotsugae* Hopkins)

Mortality due to Douglas-fir beetle (DFB) has been increasing in recent years, reaching a ten-year high of 69,100 acres in 2019, then decreasing to 51,700 acres in 2021 (Fig. 18). The 2021 total is likely an undercount due to reduced survey area in eastern Washington around several 2021 wildfires (see Aerial Detection Survey section on page 18). Scattered areas of DFB-caused mortality were detected throughout western Washington, with higher concentrations in Skamania, Lewis, Pierce, King, Whatcom, Clallam, Jefferson, and Mason counties. In eastern Washington, the highest concentrations were in western Klickitat, Yakima, and Kittitas counties, eastern Okanogan County, throughout Ferry, Stevens, and Pend Oreille counties, and in southern Columbia County. Some of the eastern Washington mortality was likely associated with recent wildfire damage as far back as 2017 (including the Norse Peak and Jolly Mountain fires) and 2018 windstorm damage in northeast Washington that created abundant breeding material.

**Right:** Douglas-fir beetle-caused mortality in northeast Washington.

MELISSA FISCHER / DNR

**DOUGLAS-FIR BEETLE 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON**
**Figure 18.**



# Secondary Bark Beetles in Douglas-fir

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

GLENN KOHLER / DNR

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 can also be caused by two other secondary bark beetle species: Douglas-fir pole beetle (*Pseudohylesinus nebulosus*) and *Scolytus monticolae*. This group of bark beetles is called "secondary" because they are not primary killers of healthy trees, but tend to opportunistically attack trees stressed by other factors, primarily drought. 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 2021 was approximately 8,100 acres, the second highest level recorded in Washington aerial surveys since 1969, but well below the recent peak of 20,300 acres in 2019. The highest concentrations of damage were in Mason County, Clallam County, and in portions of the Cascade foothills of Skamania, Lewis, Pierce, and King 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 (Fig. 19). 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.

**Left:** Douglas-fir pole beetle (*Pseudohylesinus nebulosus*) larval galleries.

MELISSA FISCHER / DNR

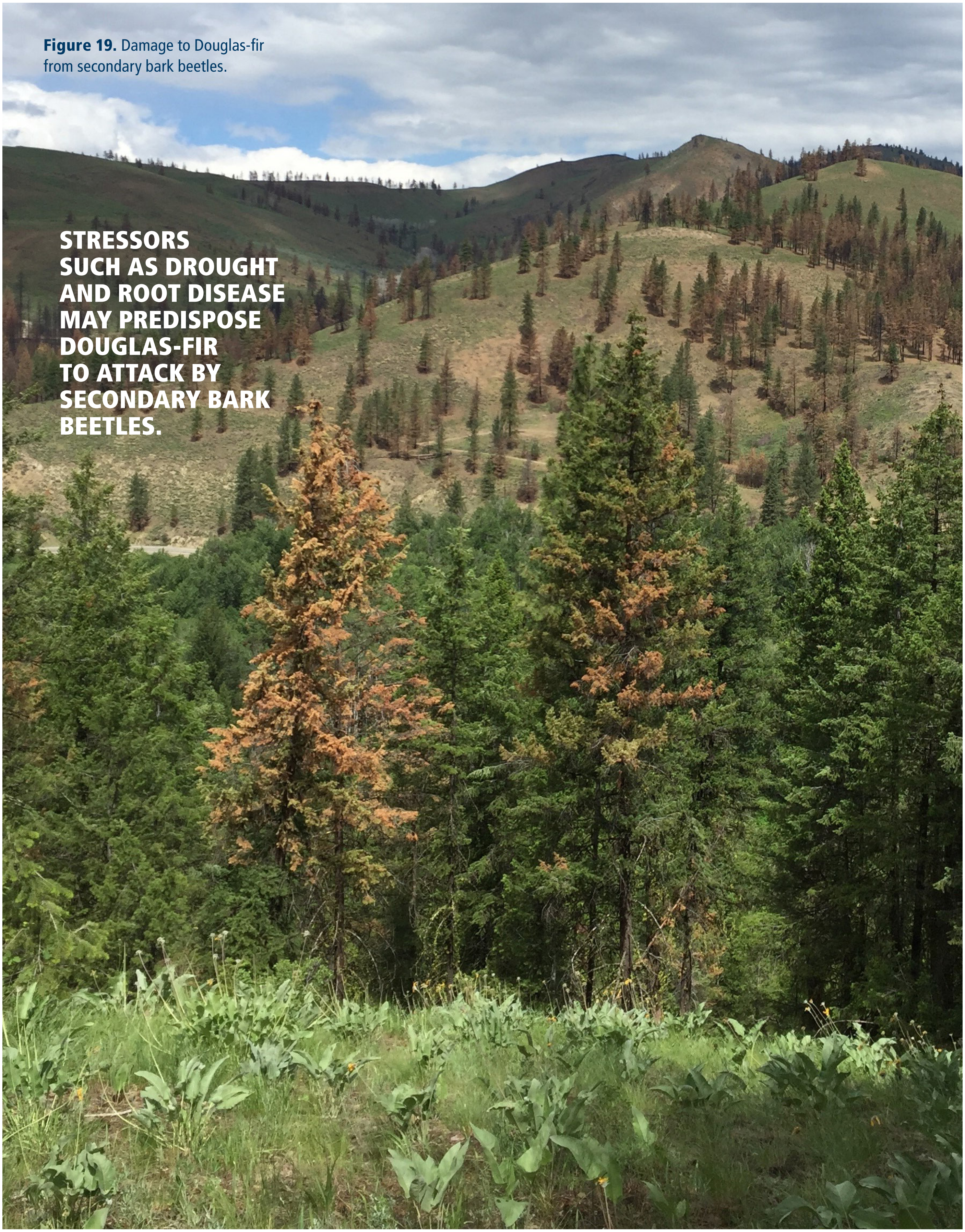



**Figure 19.** Damage to Douglas-fir from secondary bark beetles.

## INSECTS | BARK BEETLES

DAVID MCCOMB / USDA FOREST SERVICE, BUGWOOD.ORG

# Spruce Beetle

(*Dendroctonus rufipennis* Kirby)

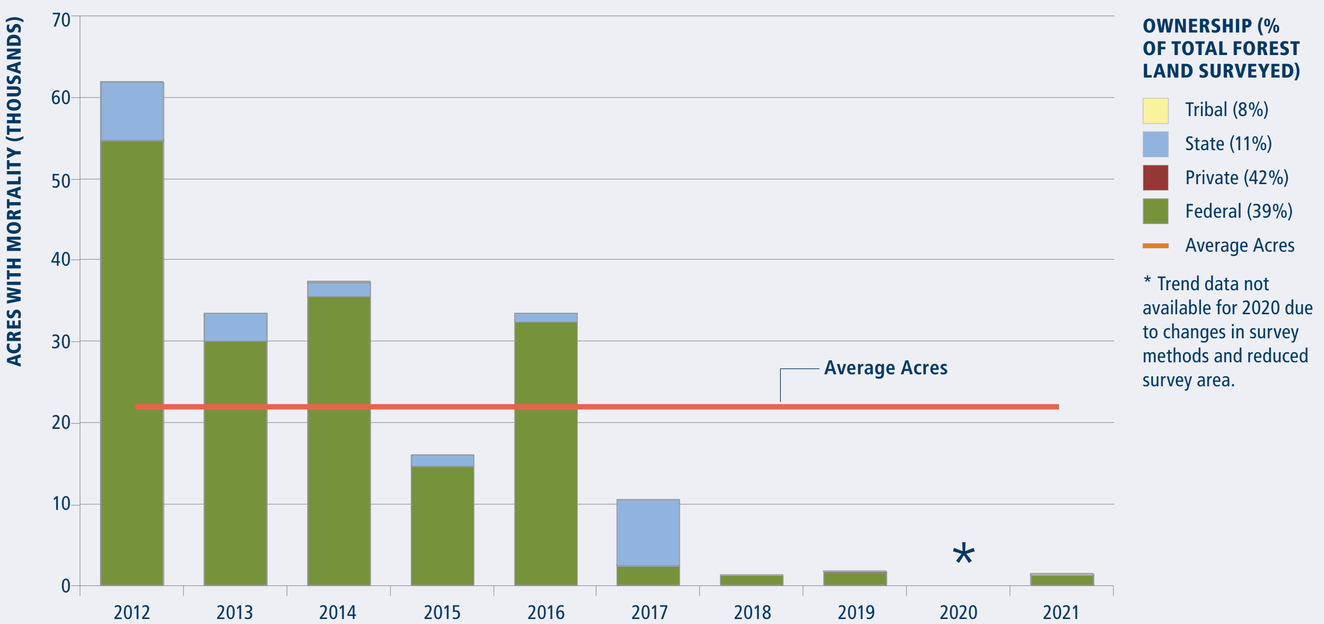
**The area affected by spruce beetle in Engelmann spruce was approximately 1,400 acres in 2021 – similar to the 1,600 acres mapped in 2019 and well below the 10-year average of 22,000 acres (Fig. 20).**

**The area affected is along the Cascade crest around the Pasayten Wilderness area in Okanogan and Whatcom counties, and south of Rainy Pass in Chelan County. This area experienced a large outbreak until 2017, peaking at over 60,000 acres with mortality in 2012. Spruce beetle activity has also been observed across the border in British Columbia.**

MIKE JOHNSON / USDA FOREST SERVICE

Spruce beetle-caused Engelmann spruce mortality in northeast Washington.

### SPRUCE BEETLE 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 20.



## INSECTS | BARK BEETLES

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

# Fir Engraver

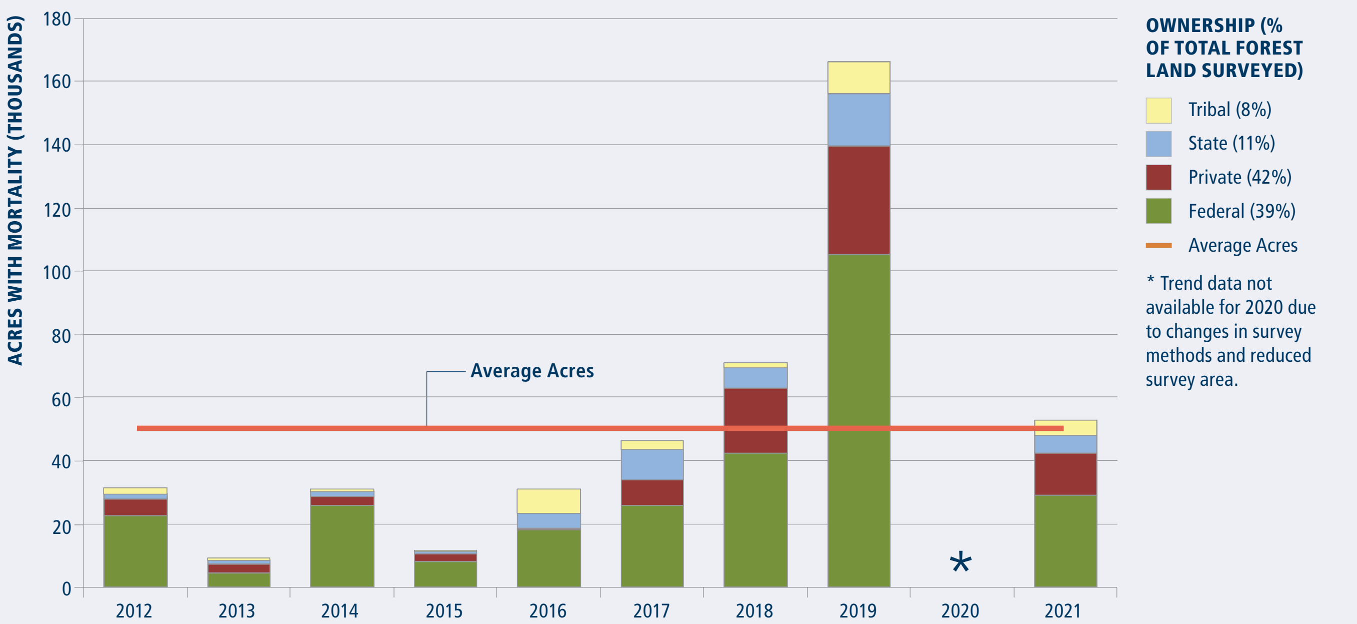
(*Scolytus ventralis* LeConte)

Fir engraver can attack all species of true fir (*Abies*) in Washington, but the primary hosts in Washington are grand fir and noble fir. Fir engraver-caused mortality, primarily in grand fir, has been steadily increasing since 2015. It reached a 10-year high of 166,300 acres in 2019, more than twice the area recorded in 2018 and the highest level since 2008 (Fig. 21). The total area with mortality decreased to 52,500 acres in 2021. This total is likely an underestimate due to reduced survey area in eastern Washington around several 2021 wildfires (see Aerial Detection Survey section on page 18). The most concentrated areas of mortality east of the Cascade Range were in and around the Yakama Indian Reservation, around the Norse Peak Wilderness area, along the border between Kittitas County and Chelan County, in the Confederated Tribes of the Colville Reservation, and throughout Stevens and Pend Oreille counties. West of the Cascades, concentrated areas of damage were recorded in Skamania, Lewis, Skagit, and Whatcom counties.

**Right:** Fir engraver galleries.

USDA FOREST SERVICE - FOREST HEALTH PROTECTION INTERMOUNTAIN REGION - OGDEN, UT, USDA FOREST SERVICE, BUGWOOD.ORG

### FIR ENGRAVER 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 21.



## INSECTS | BARK BEETLES

STEVEN VALLEY, OREGON DEPARTMENT OF AGRICULTURE, BUGWOOD.ORG

### Silver Fir Beetle

(*Pseudohylesinus sericeus* (Mannerheim))

**The silver fir beetle (SFB) 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 commonly damaged host is Pacific silver fir. In a typical year, mortality is scattered and attacks are focused on trees weakened by disease or attacks by other fir bark beetles. Outbreaks are rare, but increases in population can occur following windthrow events that generate abundant breeding material.**

**Observers mapped 800 acres in the Washington Cascades with SFB-caused mortality in 2021. The highest level of SFB mortality 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 mortality were mapped in 2021 near Ross Lake, in North Cascades National Park south of Highway 20, and around Stevens Pass.**

**IN A TYPICAL YEAR, MORTALITY CAUSED BY SILVER FIR BEETLE IS SCATTERED AND ATTACKS ARE FOCUSED ON TREES WEAKENED BY DISEASE OR ATTACKS BY OTHER FIR BARK BEETLES.**

## INSECTS | BARK BEETLES

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

### Western Balsam Bark Beetle

(*Dryocoetes confusus* Swaine)

**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. Acres with WBBB-caused mortality have been increasing since 2015 and reached 49,900 acres with damage in 2021, the highest level recorded since 2007. Other recent highs in the last decade were 26,000 acres in 2017 and 22,600 acres in 2019. The most concentrated areas with damage were along the Cascade Crest in western Okanogan County and north Chelan County, and in the Colville National Forest in northern areas of Ferry, Stevens, and Pend Oreille counties.**

GLENN KOHLER / DNR

Subalpine fir killed by western balsam bark beetle.

## INSECTS | DEFOLIATORS

GLENN KOHLER /DNR

# Douglas-fir Tussock Moth

(*Orgyia pseudotsugata* McDunnough)

No Douglas-fir tussock moth (DFTM) defoliation was recorded in Washington in 2021. A two-year outbreak of DFTM in Kittitas and Chelan counties that defoliated 1,900 acres in 2018 and 5,600 acres in 2019 has collapsed. Egg mass surveys and pheromone trap catches in the area indicated that the population was declining and no new defoliation was observed in 2020 or 2021. The damage was severe in some areas along US Highway 97 (Blewett Pass) and small patches south of Interstate 90 west of Ellensburg, resulting in mortality of Douglas-fir and grand fir hosts. A small outbreak in 2019 that resulted in approximately 600 acres with defoliation east of the Okanogan River between Oroville and Chesaw in Okanogan County also appears to have collapsed and no new defoliation was observed in 2020 or 2021. Egg masses collected in Okanogan County in fall 2019 were assessed by USFS staff in Wenatchee for levels of a naturally occurring nucleopolyhedrosis virus (NPV) that infects DFTM. The NPV level was found to be high enough to cause a natural population collapse.

The interagency network of "Early Warning System" pheromone traps at approximately 230 locations in eastern Washington continues to be monitored annually (Fig. 23). Increases in trap catch numbers may indicate outbreak events in the following years (Fig. 22). 2021 trap catches at several sites in eastern Okanogan County and northern Ferry County remain high. DFTM defoliation was not recorded in these areas in 2020 or 2021. DFTM defoliation in these areas is possible in 2022, but not likely given NPV viral load and absence of defoliation in 2021. High trap catches do not always correlate with the exact location of future defoliation, and high trap catches can be associated with declining outbreak events. Visit the USFS website more information on the Early Warning System.

GLENN KOHLER /DNR

Douglas-fir mortality and defoliation caused by a Douglas-fir tussock moth outbreak in the central Washington Cascades.

## INSECTS | DEFOLIATORS

### DOUGLAS-FIR TUSSOCK MOTH TRAP CATCHES AND DEFOLIATION IN WASHINGTON 1985-2021 Figure 22.

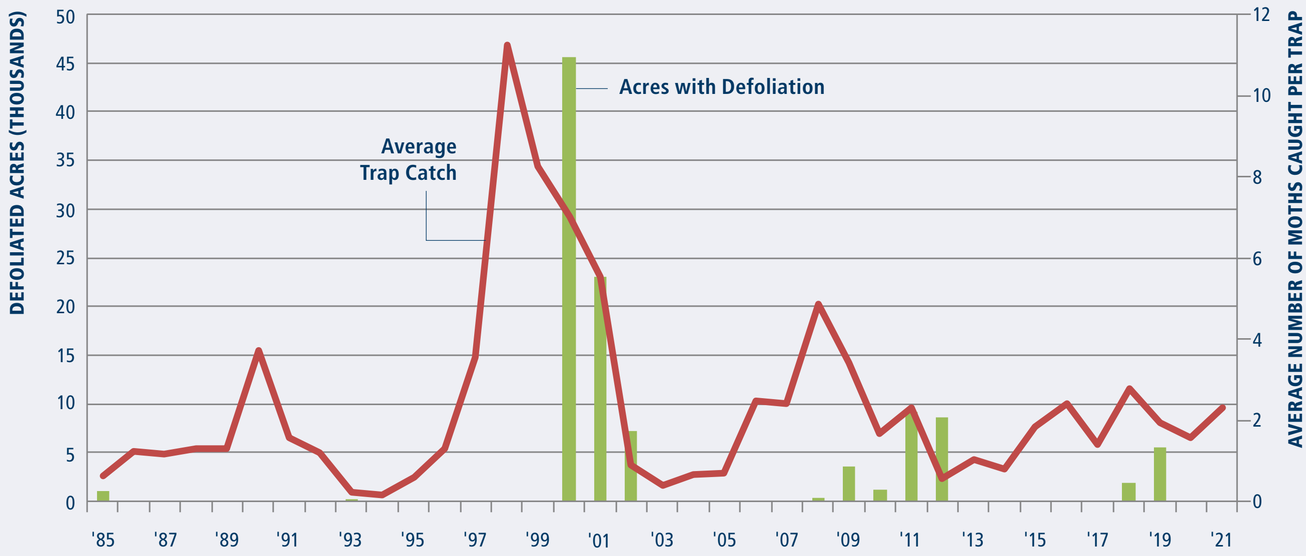



Figure 23.

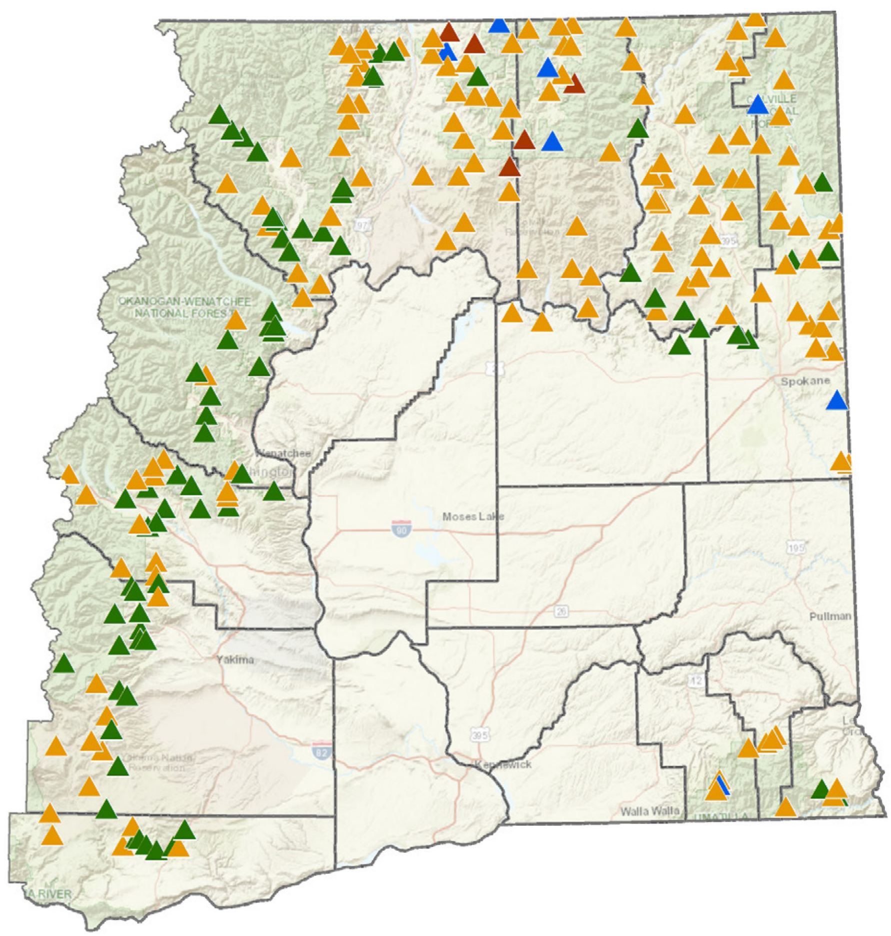
### DOUGLAS-FIR TUSSOCK MOTH PHEROMONE TRAP CATCH RESULTS IN EASTERN WASHINGTON 2021

SOURCE: USFS

- 0 Months
- 1 to 10
- 11 to 25
- 26 to 40
- More Than 40

N

40 miles



## INSECTS | DEFOLIATORS

GLENN KOHLER /DNR

# Western Spruce Budworm

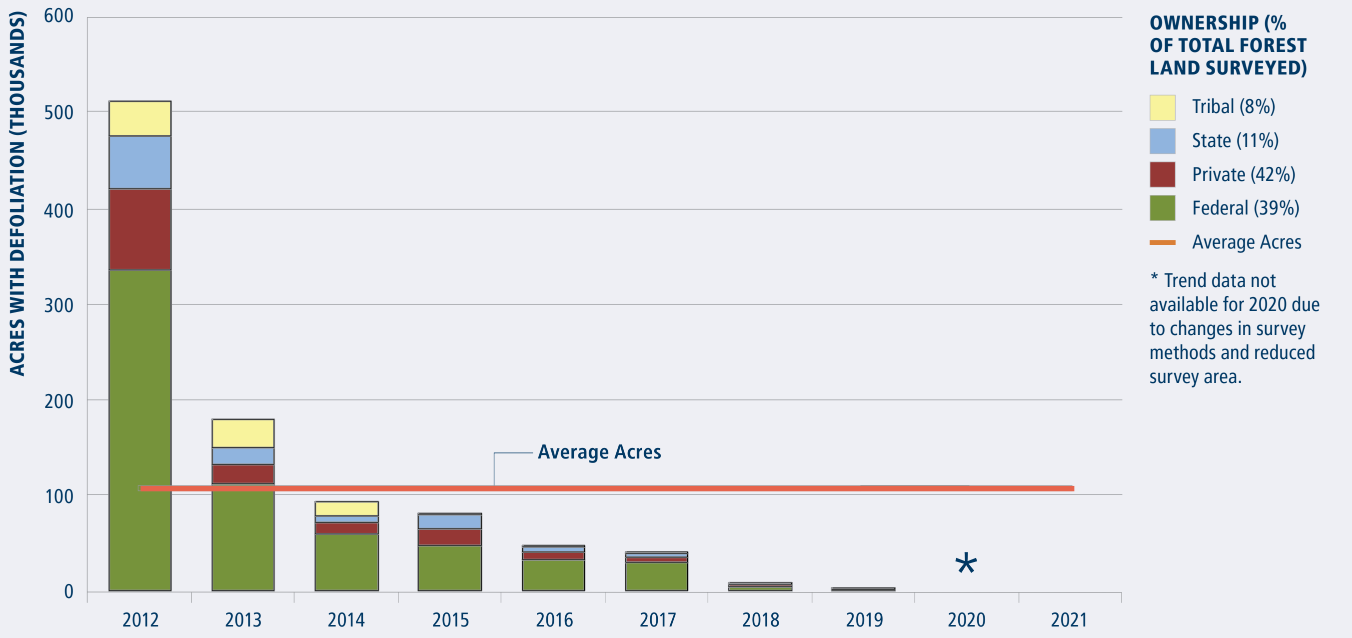
(*Choristoneura freemani* Razowski)

The total acres with western spruce budworm (WSB) defoliation in Washington has steadily declined from peak levels that eclipsed 500,000 acres in 2011 and 2012 to no damage detectable from the air in 2021 (Fig. 24). The last major outbreak in the central Washington Cascades lasted over a decade, but had declined by 2017. A short-lived and smaller outbreak in northeast Washington appears to have also declined, with a large reduction of defoliated acres in 2019. Pheromone traps were placed at 115 locations in northeast Washington in 2021 (Fig. 25). Only a few trap sites in northeast Okanogan County indicated the potential for moderate defoliation in 2022. Trap catches elsewhere remain too low to predict defoliation occurring in 2022.

MELISSA FISCHER / DNR

Western spruce budworm larva.

### WESTERN SPRUCE BUDWORM 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 24.



## INSECTS | DEFOLIATORS

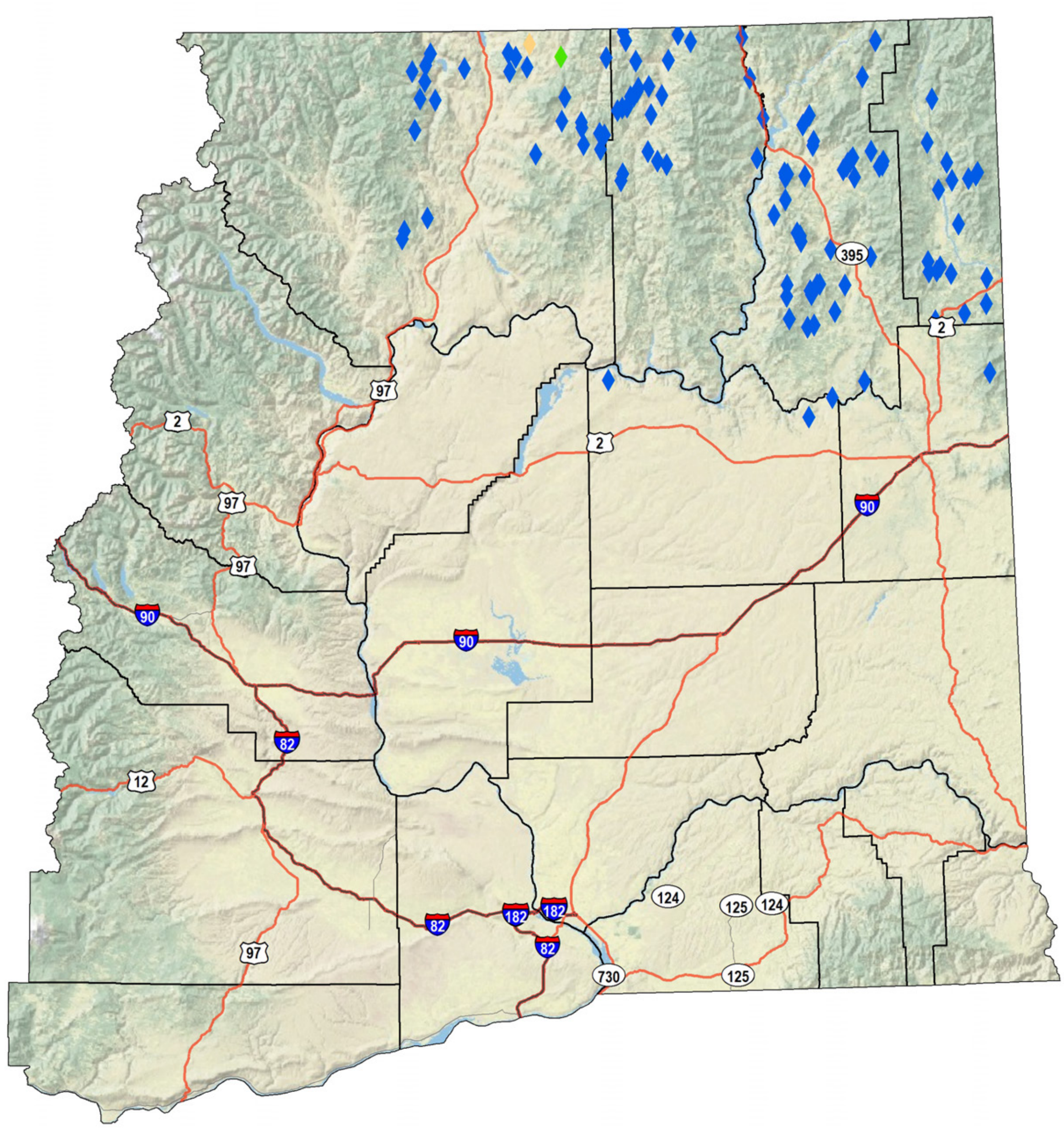



**Figure 25.**

### WESTERN SPRUCE BUDWORM PHEROMONE TRAP RESULTS IN EASTERN WASHINGTON 2021

Number of moths caught in eastern Washington for 2021 and expected 2022 defoliation.

SOURCE: DNR, USFS

- **(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 | LARCH DEFOLIATION

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

### Larch Needle Cast
(*Rhabdocline laricis*)

### Larch Needle Blight
(*Hypodermella laricis*)

### Larch Casebearer
(*Coleophora laricella*)

**Larch defoliation was mapped on approximately 3,300 acres in 2021, a decrease from the 4,300 acres mapped in 2019. Of the 3,300 acres affected, defoliation due to larch needle cast (*Rhabdocline laricis*) was mapped on approximately 2,400 acres. Foliage discoloration in the lower crown is the distinctive damage signature of larch needle cast. Discolored whole crowns of western larch, indicative of both larch needle blight (*Hypodermella laricis*) and larch casebearer (*Coleophora laricella*), were observed on approximately 900 acres.**

**FOLIAGE DISCOLORATION IN THE LOWER CROWN IS THE DISTINCTIVE DAMAGE SIGNATURE OF LARCH NEEDLE CAST.**

Larch needle cast damage in western larch.

GLENN KOHLER /DNR

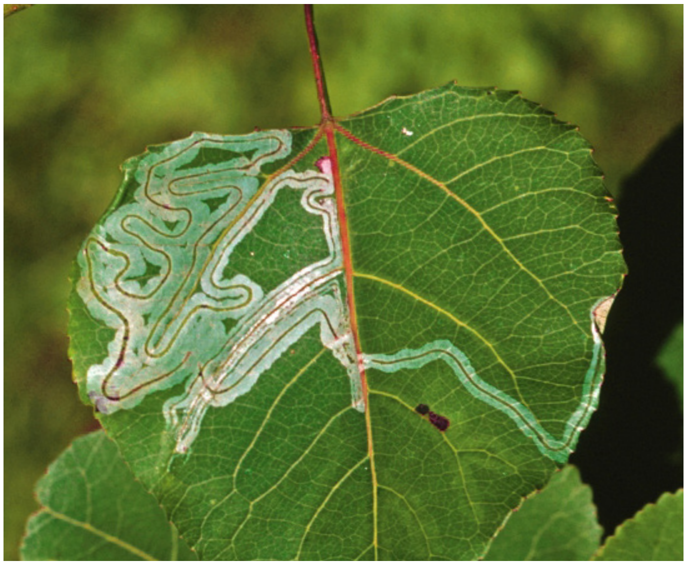
## INSECTS | DEFOLIATORS

MELISSA FISCHER / DNR

# Leafminers in Hardwoods

*(Phyllocnistis populiella)*

LEFT: MELISSA FISCHER / DNR; RIGHT: STEVEN KATOVICH / BUGWOOD.ORG



**Left:** Leafminer damage in quaking aspen leaves.

**Right:** Aspen leafminer tracks.

Observers in 2021 mapped 600 acres with quaking aspen damage and 350 acres with hardwood decline in Washington. Ground observations indicate that much of the damage was due to leafminer defoliation, but also included crown decline symptoms. Leafminers are found in several different insect orders, including Lepidoptera (moths and butterflies), Diptera (flies), Hymenoptera (wasps) and Coleoptera (beetles). The aspen leaf miner (*Phyllocnistis populiella*), a Lepidopteran, was identified as the species infesting quaking aspen. The leafminers infesting water birch and black cottonwood remain unidentified.

Leafminers feed between the epidermal layers of leaves during the summer. The mined leaves give aspen crowns a silvery appearance and birch and cottonwood crowns a reddish-orange appearance. Eventually the leaves desiccate, turn brown, and drop prematurely. While leafminer damage is mostly aesthetic, sustained annual defoliation can result in reduction in tree growth, branch dieback, and topkill. Mortality is unlikely, but can happen if defoliation events occur for many years in a row. Leafminer outbreaks are thought to be related to hot, dry weather.

**WHILE LEAFMINER DAMAGE IS MOSTLY AESTHETIC, SUSTAINED ANNUAL DEFOLIATION CAN RESULT IN REDUCTION IN TREE GROWTH, BRANCH DIEBACK, AND TOPKILL, BUT MORTALITY IS UNLIKELY.**

## INSECTS | DEFOLIATORS

JON YUSCHOCK / BUGWOOD.ORG

# Spongy Moth

(*Lymantria dispar* Linnaeus)

**NON-NATIVE**

**Same moth, new name:** *Lymantria dispar* is now known as the "spongy moth," a new common name adopted by the Entomological Society of America. The Entomological Society of America approved “spongy moth” as the new common name for the invasive forest pest *Lymantria dispar*. This name replaces the old common name, “gypsy moth,” which was removed in 2021 due to its use of a derogatory term for Romani people. The new name—derived from the common name used in France and French-speaking Canada, “spongieuse”— refers to the moth’s sponge-like egg mass, an important target for management efforts to slow the spread of the insect. The adoption of spongy moth applies to all subspecies of *Lymantria dispar* — which includes *L. dispar asiatica, L. dispar dispar*, and *L. dispar japonica*. https://entsoc.org/publications/common-names/spongy-moth

Male (left) and female (right) *Lymantria dispar asiatica.*

USDA APHIS PPQ, USDA APHIS PPQ, BUGWOOD.ORG

The Washington State Department of Agriculture (WSDA) conducted an eradication project for a detection of spongy moth from the subspecies *L. dispar asiatica* in the spring of 2021 in the Silver Lake area of Cowlitz County. A 634-acre block area was treated with three aerial applications of the bacterial insecticide *Bacillis thuringiensis* var. *kurstaki* (Btk). For more information on Btk, go to: https://agr.wa.gov/departments/insects-pests-and-weeds/insects/gypsy-moth/btk. Post-treatment high density delimitation traps were placed in and around the treated area following the Btk application and will continue to be surveyed for three years to ensure the eradication effort was successful. No moths were trapped in this area in 2021.

WSDA deployed roughly 23,000 detection traps for the spongy moth subspecies *L. dispar dispar* and *L. dispar asiatica* statewide in 2021. Both spongy moth subspecies are a great threat to Washington’s forests and urban landscapes; however, *L. dispar asiatica* feeds on a wider range of host trees, including conifers, and females are capable of flight, so the risk of rapid spread and severity of damage is higher than with *L. dispar dispar*. Five (5) adult male moths collected in Kitsap, Pierce, Snohomish, and Whatcom counties in 2021 were identified as *L. dispar dispar* and one (1) moth collected in a remote area of Stevens County was identified as *L. dispar asiatica*.

WSDA, in conjunction with USDA-APHIS-PPQ, has determined high density mass trapping and precision delimitation as the best response to the *L. dispar asiatica* detection in Stevens County. High density trapping will allow WSDA to gather additional data on the location and extent of a possible *L. dispar asiatica* infestation allowing us to implement an insecticide treatment of the area in the following year if trapping results deem it necessary. No eradication projects are planned for 2022.

## INSECTS | BRANCH AND TERMINAL INSECTS


GILLES SAN MARTIN

# Balsam Woolly Adelgid

(*Adelges piceae* Ratzeburg)

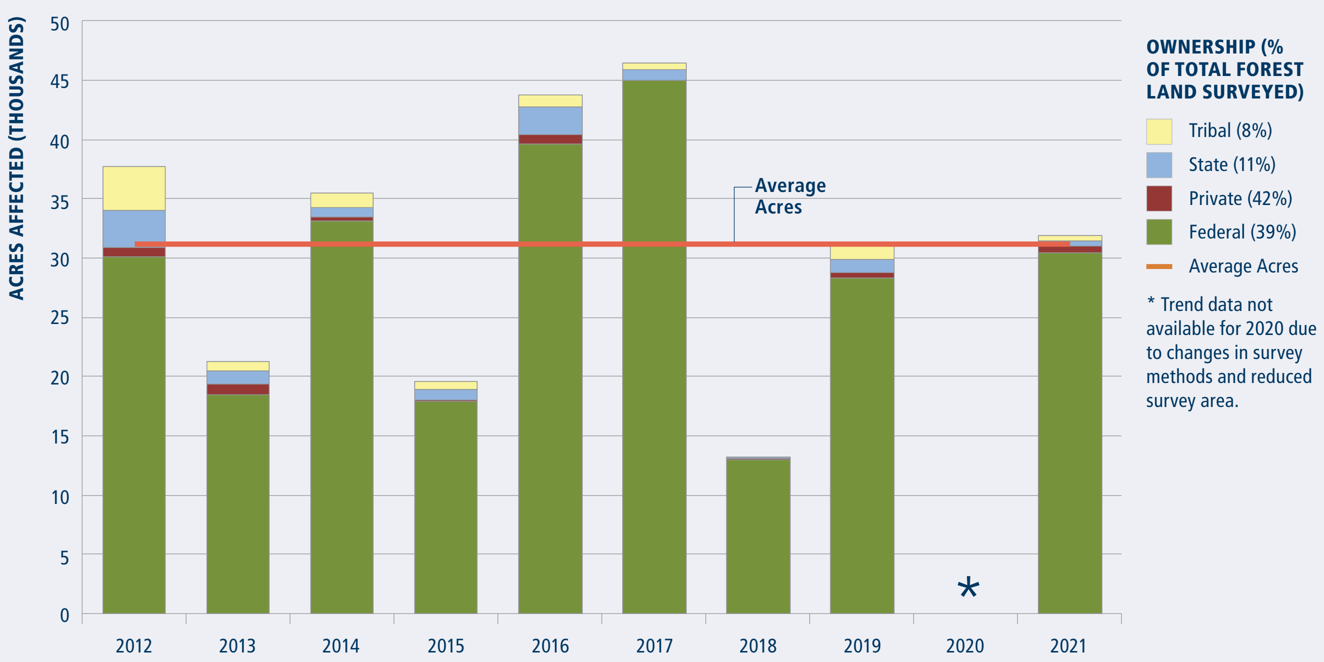
**NON-NATIVE**

Balsam woolly adelgid (BWA) is a non-native sucking insect that continues to be widespread in Washington and has caused defoliation and mortality to subalpine fir, Pacific silver fir, and grand fir. The most significant BWA damage is in subalpine fir stands at high elevation. Approximately 31,900 acres with damage were observed in 2021, similar to levels seen in 2019 and the ten-year average of 31,000 acres (Fig. 26). 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 Olympic Mountains, in scattered areas near the crest of the Cascade Mountains from Yakima County north to Whatcom County, and in the Selkirk Mountains in Stevens and Pend Oreille counties. BWA infestations are often chronic and cumulative effects may result in mortality. There were approximately 5,500 acres with some host mortality attributed to BWA damage in 2021.

Western balsam bark beetle is another important mortality agent in subalpine fir stands that may attack trees weakened by BWA infestation. Approximately 49,900 acres in these same high elevation areas were mapped with some western balsam bark beetle caused mortality in subalpine fir.

**BALSAM WOOLLY ADELGID 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON** Figure 26.



MELISSA FISCHER / DNR

Balsam woolly adelgid covering bark surfaces of a subalpine fir.

## INSECTS | APEX PREDATORS

WASHINGTON STATE DEPARTMENT OF AGRICULTURE

# Asian Giant Hornet

*(Vespa mandarinia)*
**NON-NATIVE**

WASHINGTON STATE DEPARTMENT OF AGRICULTURE

**Top:** Removal of Asian giant hornet nest.
**Bottom right:** Asian giant hornet adult.
**Bottom left:** Asian giant hornet adults emerging from a nest in the decayed lower portion of an alder tree.

In December 2019, WSDA received and verified two reports of Asian giant hornet near Blaine, Whatcom County, Washington. They eradicated the first Asian giant hornet nest in the US in late October, 2020. WSDA located and eradicated three hornet nests in 2021 — all of which were in decaying alder trees. After the removal of the third nest in late September, there were no additional hornet detections in the US. Canada found one hornet in October, in a Japanese beetle trap north of where WSDA eradicated the nests in the US. The specimen was very dried out; Canadian authorities suspect it may have been a straggler from a US nest.

A small group of Asian giant hornets can kill an entire honey bee hive in a matter of hours. While this species is not considered a disturbance agent directly affecting tree mortality, if it becomes established, this hornet will have negative impacts on the environment, economy, and public health of Washington State. Using a network of traps as well as public sightings, WSDA, cooperators, and citizen scientists are tracking the Asian giant hornet in an ongoing effort to find nests and eliminate them.

More information about Asian giant hornet in Washington can be found at https://agr.wa.gov/hornets.

## DISEASES | CANKERS

USFS

# White Pine Blister Rust

*(Cronartium ribicola)*

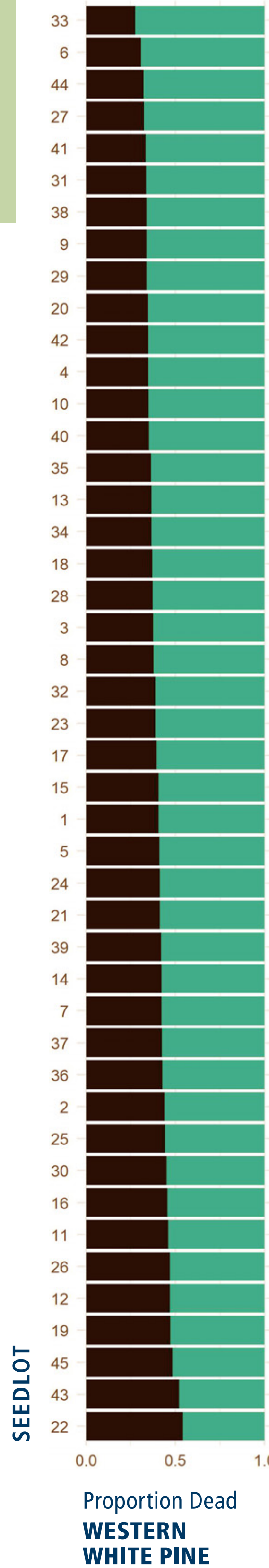
**NON-NATIVE**

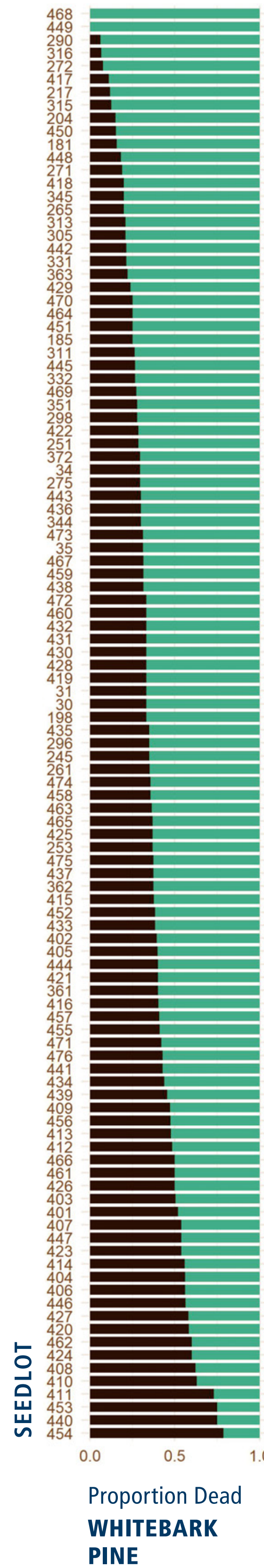
The non-native fungal pathogen *Cronartium ribicola* JC Fisch., the cause of white pine blister rust (WPBR), was accidently introduced to North America more than 100 years ago. All nine US species of white pine (five-needle pines) are highly susceptible to the disease, with mortality rates greater than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

WWP is an important economic and ecologic tree species in the Pacific Northwest, where it was once a major timber tree before being impacted by WPBR. Though never a major timber tree, WBP is considered a keystone species in high alpine ecosystems in western North America where it helps slow snowmelt, reduce erosion, and provide a high-energy food source to wildlife (including Clark's nutcracker). Because its populations are declining not only due to WPBR infections, but also to increasing pressures from mountain pine beetle, wildfire, and weather extremes caused by climate change, WBP is currently proposed for listing as 'threatened' under the US Endangered Species Act.

Natural genetic variation has fortunately provided some individual WWP and WBP families with varying degrees of resistance. To take advantage of this, breeding programs for WWP in both the US and Canada have been active for decades, with WBP programs being implemented more recently.

With the goal of determining the survival of WBP and WWP from represented families throughout western North America, long-term field research plots focused on WPBR resistance have been established throughout Washington (Fig. 29). Six field sites in western Washington were planted in 2006 and 2007 with close to 8,000 WWP seedlings from 36 different seedlots. Selected seedlots varied based on known




STATUS
Alive
Dead

### SURVIVAL OF SEEDLINGS ASSESSED DURING 2021 (RIGHT)

**Figure 27 (left).** Western white pine survival in five eastern Washington field sites, split by seedlot (45 total).

**Figure 28 (right).** Whitebark pine survival in all four high elevation whitebark pine field sites, split by seedlot (110 total).

## DISEASES | CANKERS



previously identified promising seedlots, seedling availability, and project resources. An additional six field sites were planted in 2014 and 2015 in eastern Washington with around 6,000 WWP seedlings from 45 different seedlots. Finally, four high elevation field sites were planted from 2015-2017 with over 3,000 WBP seedlings from over 100 seedlots. A subset of the planted WBP seedlings is intended to be utilized in the future as seed orchards. These collaborative projects included the Washington DNR, the U.S. Forest Service (including the Dorena Genetic Resource Center), the Confederated Tribes of the Colville Reservation, the Kalispel Tribe of Indians, and the British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development.

These long-term field sites will build upon previous natural resistance research, and help determine which seedlots should be used in future restoration and reforestation efforts.

Researchers revisited five of the eastern Washington WWP field sites and all four of the WBP field sites in 2021. Each tree at these sites was examined to ensure label retention and to record health status. Survival (alive vs. dead) of each seedlot is shown in Figs. 27 and 28 respectively for WWP and WBP. Seedlot survival is listed from those with the lowest overall level of mortality to those with the highest level. These variations in survival were attributed to abiotic stressors such as drought, animal damage such as elk rubbing, or root disease. As these seedlings age and become established, it is expected that WPBR will begin to play a more significant role in their survival, allowing inferences about WPBR resistance across an array of WWP and WBP families to be made. Please refer to the [2020 Forest Health Highlights Report] for information regarding the western Washington WWP field sites.

RACHEL BROOKS / DNR

A characteristic white pine blister rust (WPBR) canker on a whitebark pine (WBP) found close to a field site.

A whitebark pine (WBP) high elevation seedling planted at a long-term field research plot established after a wildfire.

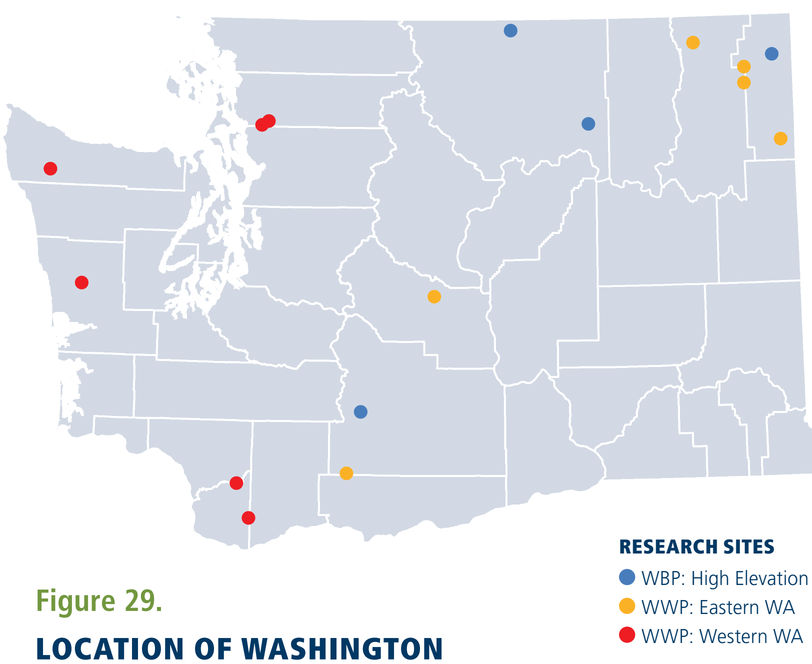



Figure 29.

**LOCATION OF WASHINGTON FIELD SITES COLOR CODED BY PROJECT TYPE**

## DISEASES | CANKERS

RACHEL BROOKS / DNR

# Sooty Bark Disease of Maple

*(Cryptostroma corticale)*

**POSSIBLY NON-NATIVE**

The fungus *Cryptostroma corticale* is thought to be native to the Great Lakes Region of the United States, where it is considered a saprophyte (only surviving on dead material and not impacting living plants).

However, in Europe, where it was accidently introduced sometime before 1945, it causes sooty bark disease (SBD) on several species of maple. On sycamore maple (*Acer pseudoplatanus*), SBD can cause wilted leaves, branch dieback, cankers (killed cambium and sapwood), stained wood, and tree death. Disease levels in Europe have been shown to increase after hot and dry summers, especially in urban areas.

The fungus, as a saprophyte or as a pathogen, causes areas of tree bark to split open and reveal stromatal tissue (a white-gray to brown-black fungal mat, Figs. 30 and 31) that releases large quantities of airborne spores. Fungal spores are allergenic, and those handling spore-covered wood should wear personal protective equipment to minimize spore inhalation. For current recommendations, refer to the [Washington State Department of Health website]().

The first record of *C. corticale* in Washington dates to 1969, where it was identified on a dead sycamore maple in Whitman County. A dead bigleaf maple (*Acer macrophyllum*) branch in Lewis County examined in 2007 was found to have *C. corticale*. In the past few years, Seattle Parks and Recreation and the Washington State University Puyallup Research and Extension Center have confirmed numerous positive samples from around the Seattle area. Additional samples have been found as far north as Bellingham (Whatcom County), as far south as Olympia (Thurston County), and as far east as Rattlesnake Lake (King County). These samples have confirmed the presence of *C. corticale* on the following tree species: field maple (*Acer campestre*), vine maple (*Acer circinatum*), fullmoon maple (*Acer japonicum*), bigleaf maple, Japanese maple (*Acer palmatum*), Norway maple (*Acer platanoides*), sycamore maple, red maple (*Acer rubrum*), horse chestnut (*Aesculus hippocastanum*), Pacific dogwood (*Cornus nuttallii*), and cherry plum (*Prunus cerasifera*).

Infected trees typically had dieback symptoms (Fig. 32) and visible fungal growth. The full distribution of this pathogen is not known, so a survey covering western Washington is planned for 2022.

The impact of this pathogen's spread onto native species is concerning. Future research is needed to determine the long-term consequences this pathogen will have on our street and forest trees.

RACHEL BROOKS / DNR

**Figure 30 (top):**
Bigleaf maple tree with sooty bark disease signs (black fungal mats) in Olympia.

**Figure 31 (middle):**
Red maple tree with sooty bark disease signs (black fungal mats) in Tacoma.

**Figure 32 (bottom):**
Dead bigleaf maple tree with sooty bark disease signs (not visible in picture) near Rattlesnake Lake (King County).

**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 (SOD), ramorum leaf blight, and ramorum dieback. Not native to North America, Pr has caused extensive mortality of tanoak and several oak species in southwestern Oregon and California. It can move through landscapes via wind and wind-driven rain, and can be moved long distances on infested nursery plant material in transit. Due to the presence of susceptible hosts, suitable climatic conditions, and plant nurseries with Pr-infected stock, Washington remains at risk for Pr spread and Pr-caused disease. However, to date, damage similar to 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, five western Washington waterways (two in King County and one each in Mason County, Lewis County, and Clark County) and six eastern Washington waterways (three in Pend Oreille County, two in Ferry County, and one in Stevens County) were surveyed for Pr using a rhododendron leaf baiting method in 2021 (Fig. 33). Western sites selected were downstream of known positive Pr locations identified by WSDA (either nursery or residential). Eastern sites were located in watersheds that contain large numbers of western larch (*Larix occidentalis*), a susceptible host for Pr. Sites were sampled six times from early March through June.

RACHEL BROOKS / DNR

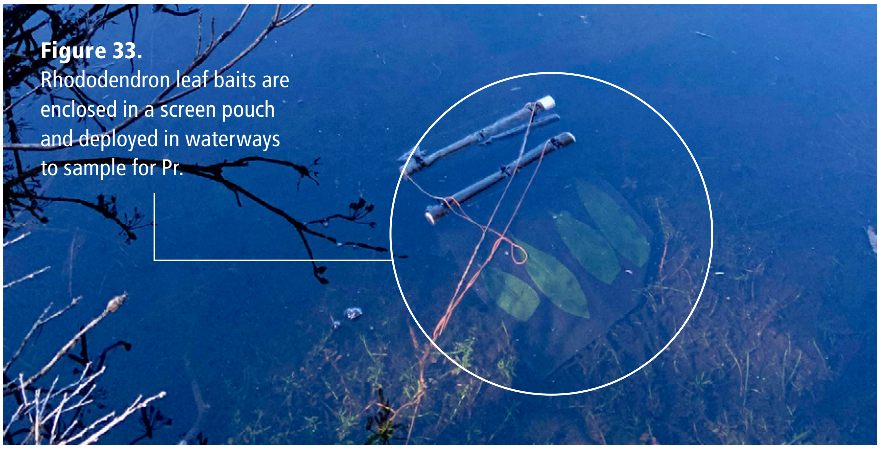


**Figure 33.** Rhododendron leaf baits are enclosed in a screen pouch and deployed in waterways to sample for Pr.

One sampling location tested positive for Pr in 2021: Mill Creek, a waterway in King County. No eastern Washington waterways were positive. Overall, most sampled waterways in Washington are free from Pr, with the exception of the Sammamish River, which has regularly tested positive for Pr since 2007 (Table 2; Fig. 34). There has been no indication to date that the pathogen is leaving the waterways, as all vegetation samples collected in the woodlands bordering these waterways have been negative for Pr, including vegetation sampled around Mill Creek in 2021.

With rhododendron leaf baiting, other non-Pr *Phytophthora* species are also sampled, but are not cultured or identified to species. To more thoroughly assess these other species present within the leaf samples, WSDA Plant Protection Division Plant Pathology and Molecular Diagnostic Lab, along with Washington State University's Puyallup Research and Extension Center (with funding from the USFS), used a next-generation molecular method (PacBio) on DNR's 2021-collected samples. In total, 12 additional *Phytopthora* species were detected in the 11 streams sampled. Of these, five species (*P. cactorum, P. pini, P. plurivora, P. cambivora*, and *P. cryptogea*) are plant pathogens that cause root rots on nursery and landscape plants, and are occasionally found in the wild. These findings are not unexpected, as drainages may be selected for sampling based on the presence of nurseries within their watershed. This technique allows for the sampling of species that are slow growing, not competitive, or not able to be cultured. This process can expand our understanding of the entire distribution of the *Phytophthora* genus, instead of just focusing on Pr.

# DISEASES | CANKERS

## TABLE 2. MONITORING HISTORY OF WATERWAYS IDENTIFIED AS POSITIVE FOR *PHYTOPHTHORA RAMORUM*

Years with positive detections are indicated with a red square and a plus sign. Years with no detection are indicated with a green square and a minus sign. White squares indicate years the stream was not surveyed. Only positive sites are included on this table.

| COUNTY | WATERWAY | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Clallam | Dungeness River and 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 |

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

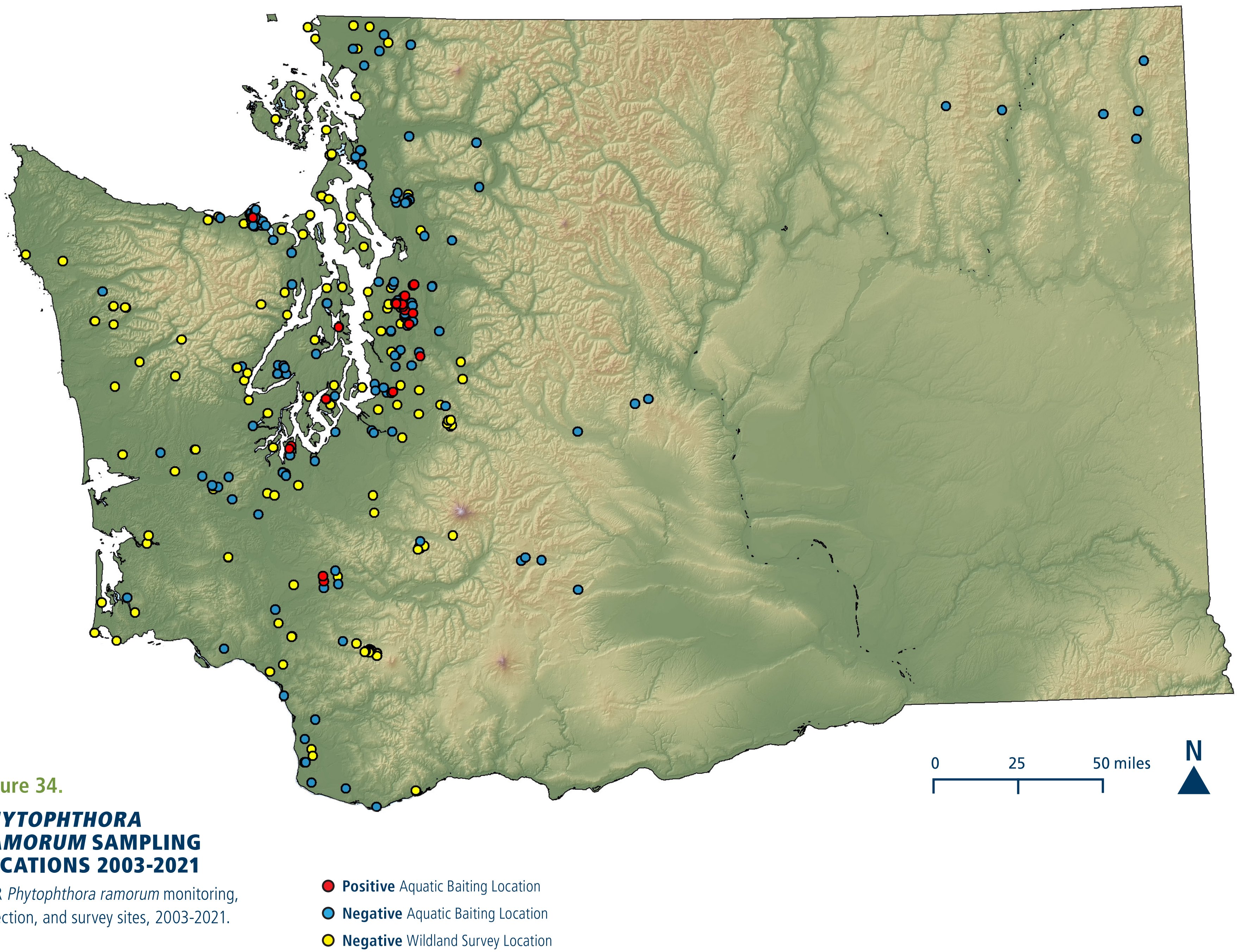


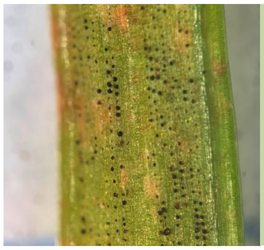

Figure 34.

***PHYTOPHTHORA RAMORUM* SAMPLING LOCATIONS 2003-2021**

DNR *Phytophthora ramorum* monitoring, detection, and survey sites, 2003-2021.

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 its only host, Douglas-fir (*Pseudotsuga menziesii*), is planted. This foliar disease rarely causes tree mortality, but can cause premature needle shed that results in sparse tree crowns and reduced growth. This native pathogen became a priority in the coastal forests of Washington and Oregon in the late 1980s and early 1990s, and more recently has become a concern in British Columbia. These areas have likely seen damage due to 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 utilization due to forest management practices.

Ground and aerial surveys monitoring this disease have been conducted in Washington State for many years. The Washington State Legislature provided funding in the 2019-2021 biennium to conduct aerial and ground surveys in spring 2020 in Washington's coastal forests. These surveys were cancelled due to COVID-19 operating restrictions and, instead, efforts focused on increased ground surveys during 2021.

Two study areas in Washington (Fig. 37) were selected for assessment during the spring of 2021: an area of several previous SNC aerial surveys ("coastal region") and an area representing active timberland between the cities of Mount Vernon, Darrington, Concrete, Bellingham, and Sumas ("NW region"). The NW region had not been previously surveyed. Fifty sampling locations were randomly selected for the coastal region and 17 for the NW region. Each selected point was visited once, and an accessible and appropriate stand no farther than four miles from the random point was chosen for sampling. Points that had no appropriate or accessible sites were excluded. In total, 48 sites in the coastal region and 15 sites in the NW region were sampled.

**Figure 35 (top).**
The underside of a Swiss needle cast-infected two-year old Douglas-fir needle. The black spheres are SNC reproductive structures (pseudothecia) occluding the needle's stomates, blocking gas exchange.

**Figure 36 (bottom).**
The underside of a healthy two-year old Douglas-fir needle without any SNC-occluded stomates.

At each site, 10 trees were selected for sample collection and measurements. Foliar retention (the amount of needles retained from each previous year cohort) was visually estimated on each tree, using a rating from 0 (no needles) to 3.6 (all 4 years of needle cohorts present). Two-year-old foliage was collected from the fourth or fifth branch whorl of each tree and taken back to the lab where SNC severity (percent stomata obstructed by the fungal reproductive structures, pseudothecia) was assessed (Figs. 35 and 36).

Though SNC severity and needle retention varied throughout the state, some trends were observed. The mean SNC severity at a site was 21.1 percent in the coastal region and 35.9 percent in the NW region. Mean foliar retention at each site was 2.52 in the coastal region and 2.93 in the NW region (Table 3). Using a t-test, both of these measurements were found to be significantly different between the regions, with the coastal region having lower levels of needle retention despite also having lower


**Figure 37.**

## 2021 SWISS NEEDLE CAST (SNC) GROUND SAMPLING RESULTS

Map displaying surveyed regions (red boundary) along with the needle retention (point size) and SNC severity results (color) of sixty-three visited sites.

SNC severity ratings. This is of note since stomata are responsible for gas and water exchange within a plant, and significant obstruction of these features can result in needle loss. This lack of association indicates other factors in addition to SNC are likely influencing needle retention at these sites. Other spatial trends can be seen on Fig. 37.

Previous surveys occurred throughout the coastal range (Table 4), but never in the NW region. Mean SNC severity measured in the coastal region in 2021 is within the previously recorded ranges while mean foliar retention is slightly higher. This indicates there has been no substantial change in the severity of SNC over this time period.

Given that Douglas-fir is the only host of SNC, forest managers may select for or plant other non-host species such as western redcedar, western hemlock, Sitka spruce, or red alder in areas where disease pressure is high. However, if Douglas-fir is retaining more than three years of foliage on its branches then growth loss is likely to be minimal.

Both aerial and ground surveys are planned for spring 2022, thanks to funding obtained from the Washington State Legislature.

RACHEL BROOKS / DNR

DNR staff assessing Douglas-fir for needle retention and collecting needles for SNC-occlusion evaluations at a field site.

**Table 3.** Number of sites, average SNC severity, and average foliar retention (0 indicates there were no needles retained and 3.6 indicates full retention of 4 years of foliage) for each region surveyed.

| REGION | NUMBER OF SITES | AVERAGE SNC SEVERITY* | AVERAGE FOLIAR RETENTION* |
|---|---|---|---|
| Coastal | 48 | 21.1 ± 1.2 (2.8 - 53.2) | 2.52 ± 0.04 (1.82 - 3.16) |
| NW | 15 | 35.9 ± 3.0 (12.5 - 62.6) | 2.93 ± 0.05 (2.43 - 3.31) |

*Mean value ± standard error (minimum site value – maximum site value)

**Table 4.** Previous ground survey results from 2018, 2016, 2015, and 2012 in the coastal region.

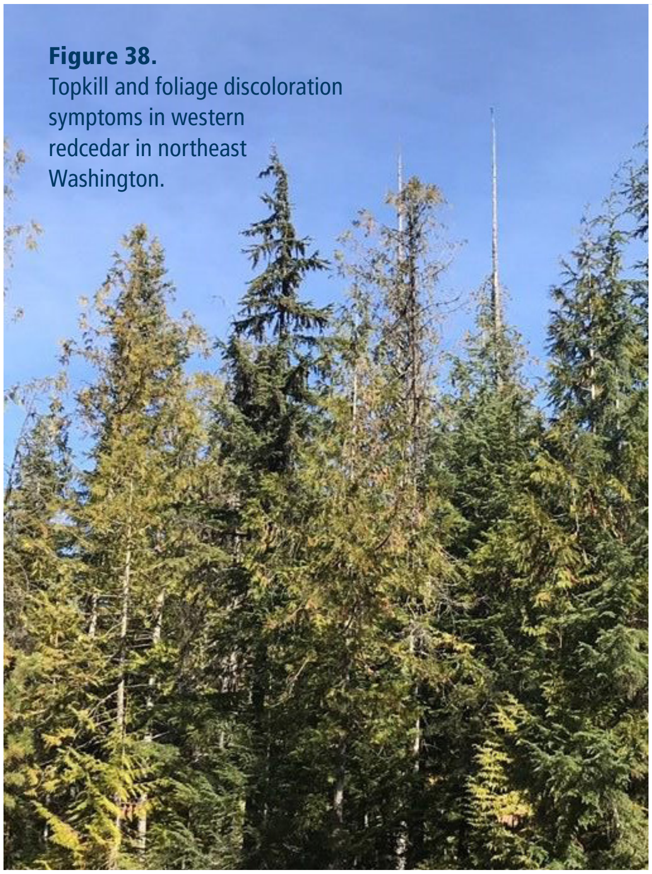
| YEAR | NUMBER OF SITES | AVERAGE PERCENTAGE OF OCCLUDED STOMATES | AVERAGE FOLIAR RETENTION |
|---|---|---|---|
| 2018 | 26 | 16.0 | 2.3 |
| 2016 | 63 | 22.1 | 2.4 |
| 2015 | 47 | 22.5 | 2.3 |
| 2012 | 75 | 15.5 | 2.2 |

# Western Redcedar Dieback Monitoring

Approximately 46,000 acres with western redcedar dieback and mortality were observed throughout Washington in 2021, an increase from the 43,100 acres last mapped in 2019. Symptoms of dieback include thinning crowns, discoloration (yellowing or browning) of the needles, heavy cone crops, branch dieback and flagging, topkill and mortality (Figs. 38 and 39).

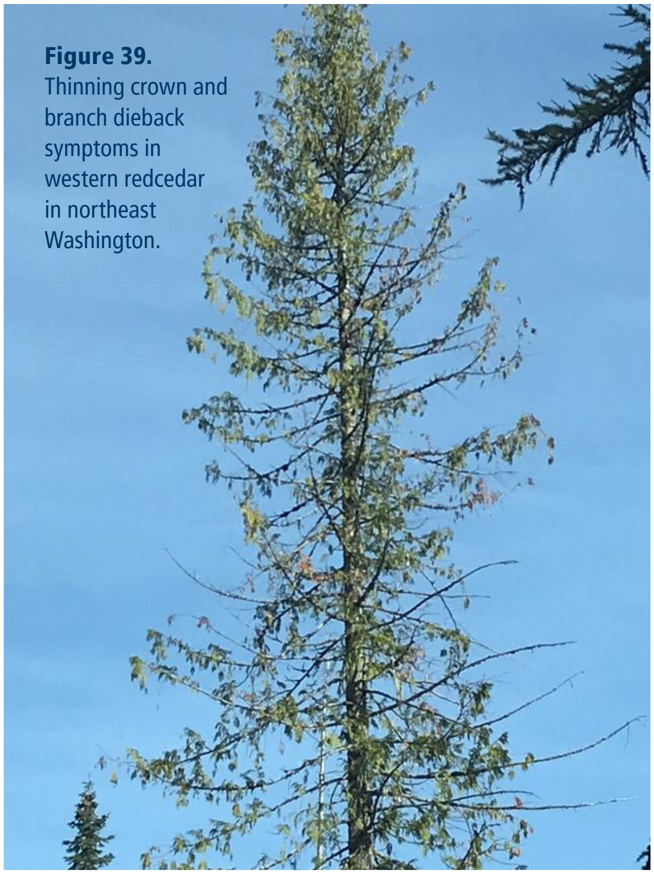
Damage agents have been observed at some sites, including cedar bark beetles (*Phloeosinus* species), wood-boring beetles, and root diseases, but these are typically secondary damage agents and are likely taking advantage of host trees that are stressed by another inciting factor. Given the wide range of damage, abiotic issues such as drought stress and higher than normal temperatures are likely causing the dieback.

Several projects are currently underway to determine the extent of western redcedar dieback throughout its range and to determine what variables may be associated with this dieback. In 2021, over 200 sites across Washington with western redcedar dieback were georeferenced. Detailed site and stand information were collected at 80 of these sites (Fig. 40). The information obtained through this work will hopefully assist in establishing the appropriate management guidelines for this species.



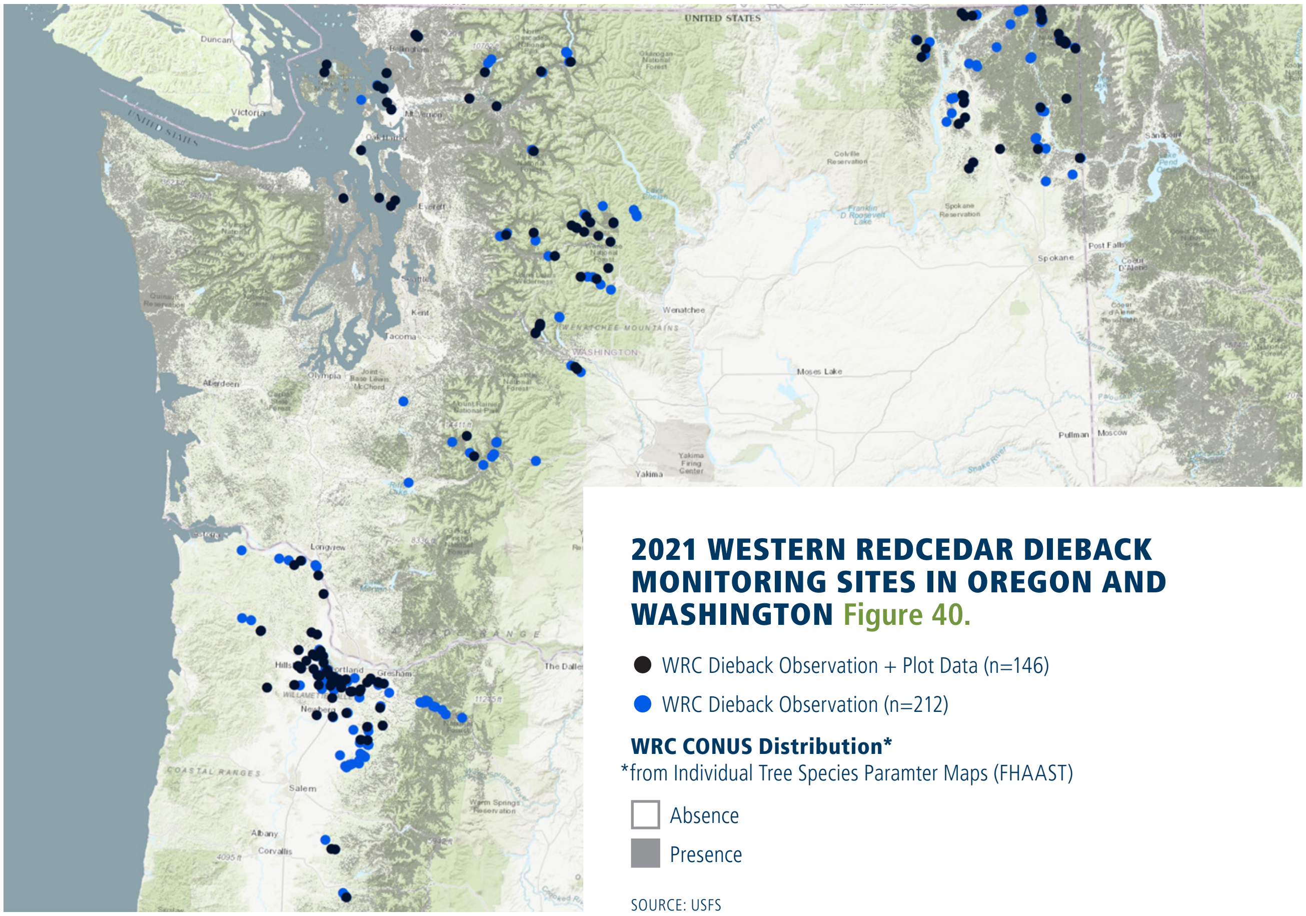
MELISSA FISCHER / DNR

**Figure 38.**
Topkill and foliage discoloration symptoms in western redcedar in northeast Washington.



MELISSA FISCHER / DNR

**Figure 39.**
Thinning crown and branch dieback symptoms in western redcedar in northeast Washington.




## 2021 WESTERN REDCEDAR DIEBACK MONITORING SITES IN OREGON AND WASHINGTON Figure 40.

- WRC Dieback Observation + Plot Data (n=146)
- WRC Dieback Observation (n=212)

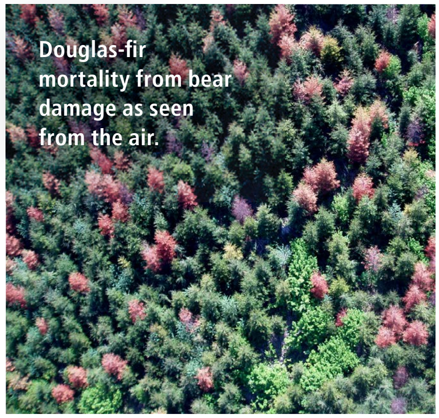
**WRC CONUS Distribution***
*from Individual Tree Species Paramter Maps (FHAAST)

- Absence
- Presence

SOURCE: USFS

## ANIMALS | BEAR DAMAGE / ROOT DISEASE

Aerial survey and "Scan and Sketch" methods record scattered, pole-sized, newly dead trees as 'bear damage'. Based on previous ground checking observations of aerial survey polygons, bear girdling and root disease are the primary causes of this type of damage. Drought damage, secondary bark beetles, or other animals (porcupines and mountain beavers) may also play roles. This damage signature is primarily seen in western Washington.



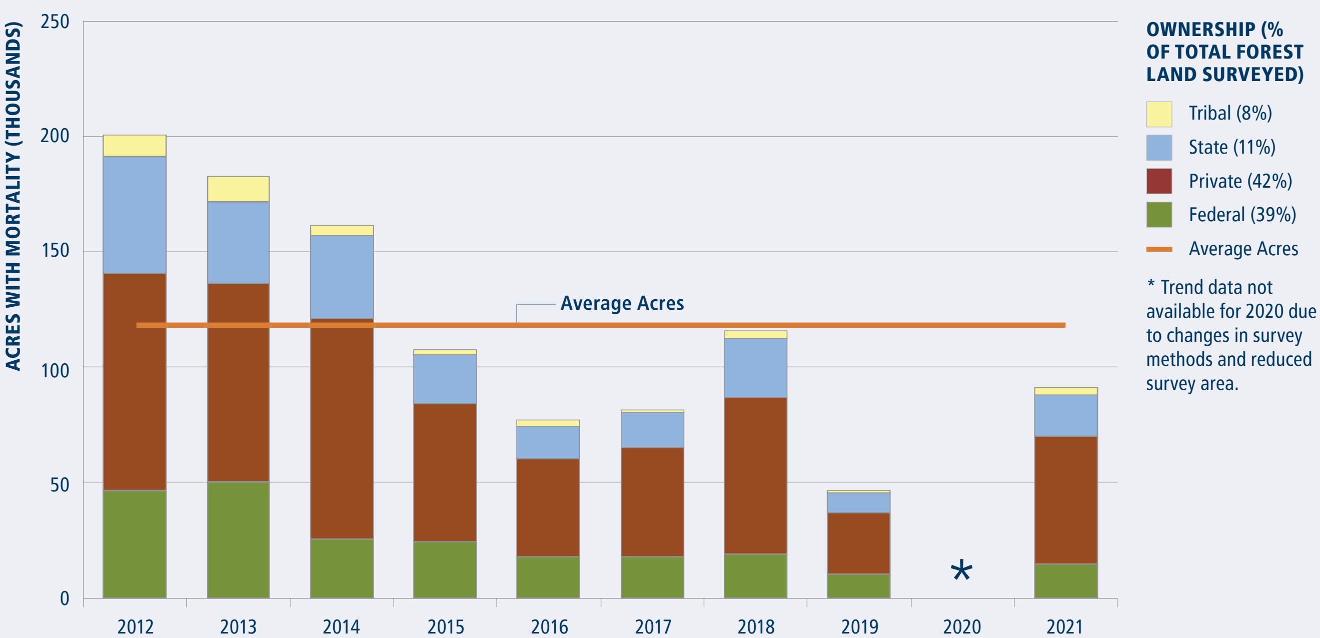
ALAN MAINWARING / DNR

Douglas-fir mortality from bear damage as seen from the air.

Bears strip tree bark in spring. Although this activity is common, our ability to detect and record the resulting damage varies quite a bit. It commonly takes more than one year for the tree to die and its needles to become red (as seen from the air). Alternatively, in drought years, trees may fade 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 feed on trees as an alternative. Also, above-average spring precipitation may delay tree needles becoming red which may result in less observed damage that year. Other factors that may influence fluctuation in bear damage acreage are local bear populations and the age of trees.

Approximately 91,300 acres with bear damage mortality were observed in 2021, nearly double the area observed in 2018 but below the ten-year average of 118,000 acres (Fig. 41). The total area observed in 2021 is likely an underestimate due to portions of western Washington that were not flown in 2021 due to lack of aircraft and crew availability. Forested areas not surveyed included eastern Pacific County and adjacent areas of Grays Harbor and Lewis counties, areas of the Cascade foothills in Snohomish County and King County, and small areas of Cowlitz and Skamania counties (see Aerial Detection Survey section on page 18). Over the last 10 years, the total area observed with damage from bears or root disease has ranged from a high of 200,000 acres in 2012 to a low of 46,300 acres in 2019.

### BEAR / ROOT DISEASE 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 41.



# Aerial Detection Survey Methodology

**Disclaimer:** It is very challenging to accurately identify and record damage observations at this large scale. Mistakes occur. Sometimes the wrong pest is identified. Sometimes the mark on the map is off-target. Sometimes damage is missed. Our goal is to correctly identify and accurately map within ¼ mile of the actual location at least 70 percent of the time.

The annual insect and disease aerial detection survey (ADS) to detect recently killed and currently damaged forest trees in Washington is conducted by the USDA Forest Service (USFS) in cooperation with DNR and has been ongoing since 1947. The survey is flown at 90-150 mph at approximately 1,500 feet above ground level in a fixed-wing airplane. Two observers (one on each side of the airplane) look out over a two-mile swath of forestland and record polygons or points on a digital, mobile sketch-mapping tablet where they see any recently killed or defoliated trees. They then code the agent that likely caused the damage (inferred from the size and species of trees and the pattern or signature of the damage) and a measure of damage intensity (see section below for more detail). Photos are rarely taken.

ADS observers are trained to recognize various pest signatures and tree species. Satellite photography showing recent management activity is displayed as a background map on tablet screens, allowing observers to place the damage polygons more accurately. There is always at least one observer in the plane who has three or more years of sketch-mapping experience. When interpreting data and maps within and accompanying this report, do not assume that the mortality agent polygons indicate every tree is dead within the area. Depending on the damage intensity modifier, only a small proportion of trees in the polygon may actually be recently killed.

The perimeters of areas burned by wildfire are added to aerial survey maps the year of the fire. The year after the fire, dead trees are not recorded within the fire perimeter. This is because from the air it can be difficult to distinguish damage caused by the fire from damage caused by insects or disease. The second summer after the fire, when immediate effects of the burn have mostly subsided, pests can be credited with the newest tree damage, and that damage is counted in the aerial survey totals.

## METHODS FOR RECORDING DAMAGE INTENSITY

Damage polygons are assigned a "percent-class" value representing one of five different ranges of percent of treed area affected (Table 5). The observer assigns 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 in the polygon, not just hosts, including current year damaged, live, and old dead trees. When observers record a point of damage (area less than 2 acres), they assign an estimate of the number of trees affected, up to 99 trees. Defoliation polygons are assigned values for intensity of within-crown defoliation (L-Light, M-Moderate, H-Heavy).

**More information on the percent-class method is available on the U.S. Forest Service website.**

**Table 5.** 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%) |

Adoption of the percent-class method presents challenges for analysis of trends and cumulative effects that include trees per acre (TPA) data used prior to 2018. In addition, summary statistics of approximate number of trees killed, such as totals and averages by agent, cannot be derived directly from percent-class data. In USFS Region 6 (Oregon and Washington), percent-class polygons are converted to a calculated TPA value using a "histogram matching" method. This method separates several recent years of historical Region 6 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 polygon size. All 2021 ADS mortality polygons in DNR's downloadable GIS datasets use calculated TPA values as intensity modifiers. Region 6 quadrangle reporting maps available as PDFs use percent treed area affected classes or tree counts as label modifiers (see next page "Data and Services section").

# Data and Services

**Every year, all forested acres in Washington are surveyed from the air to record recent tree damage. This aerial survey is made possible by the cooperation of the DNR and the USFS. It is very cost-effective for the amount of data collected. The publically available maps and data produced are convenient tools for monitoring forest disturbance events and forest management planning. They also provide excellent trend information and historical data.**

## ELECTRONIC PDF MAPS AVAILABLE FOR DOWNLOAD

Traditional insect and disease survey quadrangle maps from 2003 to 2021 are available for download as PDF files at **www.fs.usda.gov/goto/r6/fhp/ads/maps**.

Click on the year of interest under **"Aerial Detection Survey Quad Maps"** to open an interactive map of all the available quads from Oregon and Washington. Simply click on the quad map you want and it will download the PDF. Polygons are colored to reflect damage type and are labelled with a damage agent code. The code is followed by a modifier indicating number of trees affected, percent treed area affected, or intensity of damage (L-light, M-moderate, H-Heavy). Damage codes are defined in a legend in the lower left side of each quad map. PDF maps are georeferenced so the user's location will be displayed when downloaded to a mobile device with a PDF map viewing app.

## INTERACTIVE MAP TOOLS

2015 to 2021 annual aerial survey data and the 15-year cumulative mortality data product are available from Washington DNR's interactive, web-based **Fire Prevention & Fuel Management Mapping** site. On the left side of the page, click on "Forest Health", select "Annual Aerial Survey Data" and check the circle for year of interest. Then, check circles for type of damage to be displayed. Click on polygons to display agent and intensity. Various base maps and background layers can be added. Zoom to an area of interest and click the printer icon in the lower bar to create a pdf or image file of your map.

The USFS maintains current year aerial survey data in an **interactive, web-based map**. Click on the "Data Viewer" link to create customized electronic maps with a variety of background layers. For printable maps, zoom in to the area of interest and click on the PDF icon in the upper right. Output PDFs are georeferenced for use in PDF viewer apps on mobile devices.

## GIS DATA AVAILABLE FOR DOWNLOAD

Washington DNR also maintains downloadable GIS datasets, including aerial survey data for Washington State from 1980 to the most recent year, that can be found at **http://data-wadnr.opendata.arcgis.com/** under "Forest Disturbance." The USFS maintains a download site for combined Oregon and Washington **ADS data from 1947 through 2021** (including data from the ground-based 2020 insect and disease survey).

## FOREST HEALTH WEBSITES

Washington Forest Health Highlights reports are published annually and include the latest information on exotic pest problems, insect and disease outbreaks, and recent forest damage trends for Washington. Recent annual reports, Washington DNR research, and other forest health information are available at **http://www.dnr.wa.gov/ForestHealth**.

Historic annual highlights reports for Alaska, California, Oregon, Washington, Hawaii, and the Pacific Islands are available at **www.fs.usda.gov/goto/r6/fhp/highlights**.

The USDA Forest Service Forest Health Protection (FHP) program has shared responsibility for monitoring and protecting the health of forest ecosystems in the Pacific Northwest. It provides technical and financial assistance to federal resource managers in Oregon and Washington regarding insects, diseases, and unwanted vegetation in forest ecosystems. Similar assistance is provided through state forestry staffs to state and private resource managers. Learn more about USFS FHP activities at **https://www.fs.usda.gov/main/r6/forest-grasslandhealth**.

# Forest Health Contacts

## WASHINGTON DEPARTMENT OF NATURAL RESOURCES

### Forest Resilience Division

1111 Washington St SE, PO Box 47037, Olympia, WA 98504-7037

| NAME | TITLE | PHONE | EMAIL |
|---|---|---|---|
| Rachel Brooks | Forest Pathologist | (360) 522-2030 | rachel.brooks@dnr.wa.gov |
| Derek Churchill | Forest Health Scientist | (360) 902-1694 | derek.churchill@dnr.wa.gov |
| Isaac Davis | Aerial Observer and Forest Health Specialist | (360) 277-6738 | isaac.davis@dnr.wa.gov |
| Aleksandar Dozic | GIS Analyst | (360) 902-1320 | aleksandar.dozic@dnr.wa.gov |
| Melissa Fischer | Forest Entomologist (Eastern WA) | (509) 684-7474 | melissa.fischer@dnr.wa.gov |
| Chuck Hersey | Forest Health Planning Section Manager | (360) 902-1045 | chuck.hersey@dnr.wa.gov |
| Glenn Kohler | Forest Entomologist | (360) 902-1342 | glenn.kohler@dnr.wa.gov |
| Dan Omdal | Forest Pathologist | (360) 902-1692 | daniel.omdal@dnr.wa.gov |
| Will Rubin | Communications Manager | (360) 764-0854 | will.rubin@dnr.wa.gov |
| Jen Watkins | Planning, Science, and Monitoring Assistant Division Manager | (360) 338-1688 | jennifer.watkins@dnr.wa.gov |

## USDA FOREST SERVICE | Forest Health Protection & Monitoring Program

1220 SW Third Avenue, PO Box 3623, Portland, OR 97204

| NAME | TITLE | PHONE | EMAIL |
|---|---|---|---|
| Karl Dalla Rosa | Asst. Director, State and Private Forestry | (503) 808-2913 | karl.dallarosa@usda.gov |
| Justin Hof | Washington State Aerial Survey Coordinator | (503) 668-1646 | justin.hof@usda.gov |
| Blakey Lockman | Regional Forest Pathologist | (503) 808-2997 | irene.lockman@usda.gov |
| Sarah Navarro | Regional Forest Pathologist | (503) 808-2257 | sarah.navarro@usda.gov |
| Iral Ragenovich | Regional Forest Entomologist | (503) 808-2915 | iral.ragenovich@usda.gov |
| Karen Ripley | Forest Health Monitoring Coordinator | (503) 808-2674 | karen.ripley@usda.gov |

**If you have questions about forest insect and disease activity in Washington, please contact one of these regional or field offices.**

## USDA FOREST SERVICE | Wenatchee Service Center

Forestry Sciences Laboratory, 1133 N. Western Avenue, Wenatchee, WA 98801

| NAME | TITLE | PHONE | EMAIL |
|---|---|---|---|
| Darci Dickinson | Forest Entomologist | (509) 664-1724 | darci.dickinson@usda.gov |
| Brennan Ferguson | Forest Pathologist | (509) 664-9215 | brennan.ferguson@usda.gov |
| Betsy Goodrich | Forest Pathologist | (509) 664-9223 | anne.goodrich@usda.gov |

## USDA FOREST SERVICE | Westside Service Center

Mount Hood National Forest, 16400 Champion Way, Sandy, OR 97055

| NAME | TITLE | PHONE | EMAIL |
|---|---|---|---|
| Kristen Chadwick | Forest Pathologist | (503) 668-1474 | kristen.chadwick@usda.gov |
| Holly Kearns | Forest Pathologist | (503) 668-1475 | holly.kearns@usda.gov |
| Beth Willhite | Forest Entomologist | (503) 668-1477 | elizabeth.willhite@usda.gov |

## USDA FOREST SERVICE | Blue Mountains Forest Insect and Disease Service Center

Wallowa-Whitman National Forest, 3502 Highway 30, La Grande, OR 97850

| NAME | TITLE | PHONE | EMAIL |
|---|---|---|---|
| Mike Johnson | Forest Entomologist | (541) 962-8538 | jay.m.johnson@usda.gov |
| Michael McWilliams | Forest Pathologist | (541) 962-8510 | michael.mcwilliams@usda.gov |

dnr.wa.gov/foresthealth

dnr.wa.gov/foresthealth