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Forest Health Highlights in Washington - 2019

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FOREST HEALTH HIGHLIGHTS IN WASHINGTON - 2019

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Front cover photo: Larval tracks of aspen leaf miner between epidermal layers of a quaking aspen leaf.

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SUMMARY

The 2019 aerial detection survey (ADS) was completed for over 22 million acres of forestland within Washington, covering a variety of ownerships. This survey has been conducted in Washington since 1947. In 2019, ADS recorded some level of tree mortality, tree defoliation, or foliar diseases on approximately 658,000 acres. This is an increase from the 469,000 acres with damage in 2018. The area with mortality attributed to bark beetles was approximately 401,000 acres. Approximately 46,300 acres with mortality were due to bear damage or root disease and approximately 108,000 acres were recorded with tree mortality due to other causes. Relative to 2018, tree mortality increased for all major bark beetle species except mountain pine beetle. The area with defoliation damage was approximately 80,000 acres, primarily caused by balsam woolly adelgid, aspen leaf miner, and spruce aphid. Approximately 8,200 acres had some level of disease damage, primarily bigleaf maple decline, larch needle cast, and needle cast in lodgepole pine. It should be noted that disease damage is significantly underrepresented in ADS data because symptoms are often undetectable from the air. Previous annual totals for all damage agents were:

2018: 469,000 acres **2017:** 512,000 acres **2016:** 407,000 acres **2015:** 338,000 acres

Drought conditions and warm, dry spring weather tend to increase tree stress and insect success, driving acres of damage up in both the current and following year. Wet spring weather tends to increase acres affected by foliage diseases and bear damage in both the current and following year. 2019 precipitation in Washington was below normal during winter and spring, above normal over summer, then below normal in fall. Monthly average temperatures were below normal during winter, above normal in spring and summer, then near normal in fall. According to the U.S. Drought Monitor, from late March through September in 2019, all of western, north-central, and northeast Washington was either in moderate drought or experiencing abnormally dry conditions.

The approximately 119,400 acres with **pine bark beetle** activity recorded in 2019 was similar to the 120,000 acres in 2018. The most significant increase was in mortality of ponderosa pines due to **western pine beetle** (WPB), increasing to 29,400 acres in 2019, the highest level recorded since 2006. Mortality due to **mountain pine beetle** was recorded on approximately 86,500 acres, a decrease from the 101,300 acres in 2018 and below the 10-year average of 126,000 acres. **Fir engraver** caused mortality in true firs (Abies species) was recorded on approximately 166,300 acres in 2019, the highest level since 2008.

A second year of **Douglas-fir tussock moth** damage in Kittitas and Chelan counties resulted in an increase of defoliated area from 1,900 acres in 2018 to 5,000 acres in 2019. A new outbreak in northern Okanogan County resulted in approximately 600 acres of defoliation east of the Okanogan River between Oroville and Chesaw. A widespread outbreak of **spruce aphid** along the Washington coast resulted in Sitka spruce damage on approximately 10,600 acres in 2019, the highest level of damage due to this pest since 1998. All coastal counties were affected, but the highest concentrations of damage were around Grays Harbor, Willapa Bay, and the Longbeach Peninsula. An outbreak of **western hemlock looper** has caused defoliation on approximately 5,300 acres in south Whatcom and north Skagit counties, an increase from the 870 acres with defoliation in the same area in 2018.

Larch needle cast (*Meria laricis*) damage in western larch was observed on approximately 1,700 acres, primarily in the central and south Cascade Mountains. Crown discoloration and **dieback in bigleaf maple** was observed on approximately 1,300 acres, primarily in lowlands of southwest Washington and in the south Puget Sound area.

2019 WEATHER AND DROUGHT CONDITIONS

Precipitation

The statewide precipitation average for 2019 was 33.08 inches, much lower (-8.95 inches) than the 1901-2000 climatological mean of 42.03 inches. 2019 was the ninth driest year on record and the driest for Washington since 1985.

For nearly every climate division across the state, the first three months of 2019 were drier than normal (Table 1). Along the coast and foothills of the Olympics and Cascades, average rainfall values were significantly below normal, with several weather stations showing deficits in excess of 12 inches of rain. This trend was observed to a similar degree across the entire west side of the state, prompting short-term drought concerns for the area and moderate drought concerns in the North Cascades. In late March, a rare east wind event (a critical fire weather pattern for western Washington that yields warm, very dry conditions), exacerbated the already low moisture content in dead and dormant vegetation, leading to conditions ripe for active fire behavior. Debris burning and other human activity generated 45 fires during this three-day event, highlighting a critical lack of moisture rarely seen in western Washington.

Table 1. 2019 precipitation departures (in inches) from the average precipitation from 1895 to 2019 for climate divisions across Washington. Darker red values indicate increasingly drier periods while darker blue values tend toward wetter periods.

	Jan.-March	April-June	July-Sept.	Oct.-Dec.	Annual
West Olympics Coastal	-16.53	-4.86	+3.89	-13.22	-30.82
Northeast Olympic San Juans	-3.58	-0.38	+1.31	-2.58	-5.24
Puget Sound Lowlands	-5.41	-1.23	+1.85	-3.93	-8.72
East Olympics Cascade Foothills	-10.08	-1.51	+2.61	-8.27	-17.25
West Slopes Cascades	-12.83	-0.09	+2.43	-9.18	-19.67
East Slopes Cascades	-4.40	+0.80	+1.95	-5.40	-7.05
Okanogan Big Bend	-0.80	-0.21	+1.48	-1.98	-1.51
Central Basin	+0.63	+0.33	+0.34	-1.84	-0.54
Northeastern	-1.23	-1.20	+1.05	-1.72	-3.11
Palouse Blue Mountains	-0.34	+0.76	-0.09	-2.65	-2.32

Record driest	Much drier	Slightly drier	Normal	Slightly wetter	Much wetter	Record wettest

April came with mostly above average rainfall, although May was again drier than normal. By the end of the month, most of the state's mountainous watersheds were under stress by unusually low rainfall. The gravest concerns for drought (and fire activity) were for west-side watersheds (see Drought section for map) — quite unusual for any year. By late June, a progression of low pressure systems generated numerous

rain producing events that helped precipitation deficits recover. This also suppressed fire activity for essentially the entire core season. From October to December, accumulation totals again were quite low, bringing the year to a close with below normal rainfall totals for all climate divisions. Of note, coastal areas and the western foothills of the Olympics and Cascades showed a 17 inches to 31 inches precipitation deficit for the year. 2019 was the driest year of the decade, and the driest year in the last 34 years.

Temperature

The statewide average temperature for 2019 was 46.5°F, only slightly warmer than the 1901-2000 climatological mean of 46.1°F. The year 2019 was 1.5°F cooler than 2018 and 3.5°F cooler than 2015, the hottest year on record.

January to March showed cooler than normal temperatures across the state with no major outliers (Table 2). From April to June, nearly the opposite was true with positive anomalies of 2-3°F observed. This trend in warmer than average temperatures continued through summer, although again there were no major outliers noted. From October to December, anomalies were minimal, and average temperatures hovered near normal. Annually, all west-side areas showed above normal temperature anomalies of 0.7-1.0°F for the year while east-side areas showed near normal temperatures. Averaged statewide, 2019 was a relatively normal year for average temperatures and much cooler than all years in the last decade with the exception of 2011, which was about 1°F cooler.

Table 2. 2019 temperature departures (in degrees Fahrenheit) for climate divisions in Washington compared with the average from 1895 to 2019. Darker red values indicate increasingly warmer periods. Darker blue values tend toward cooler periods.

	Jan.-March	April-June	July-Sept.	Oct.-Dec.	Annual
West Olympics Coastal	-0.3	+2.3	+2.1	-0.1	+1
Northeast Olympic San Juans	-0.1	+2.4	+1.9	0	+1
Puget Sound Lowlands	-0.6	+2.3	+1.8	-0.2	+0.9
East Olympics Cascade Foothills	-0.2	+2.3	+1.2	0	+0.8
West Slopes Cascades	+0.4	+2.3	+0.6	+0.7	+1
East Slopes Cascades	-0.6	+2.4	+0.5	+0.5	+0.7
Okanogan Big Bend	-2.5	+1.7	+0.4	-0.6	-0.2
Central Basin	-3.3	+2.1	+0.7	-0.8	-0.3
Northeastern	-1.3	+2.1	+0.8	-0.1	+0.3
Palouse Blue Mountains	-2.4	+2.5	+1.0	-0.3	+0.2

Record warmest	Much warmer	Slightly warmer	Normal	Slightly cooler	Much cooler	Record coolest

Snowpack

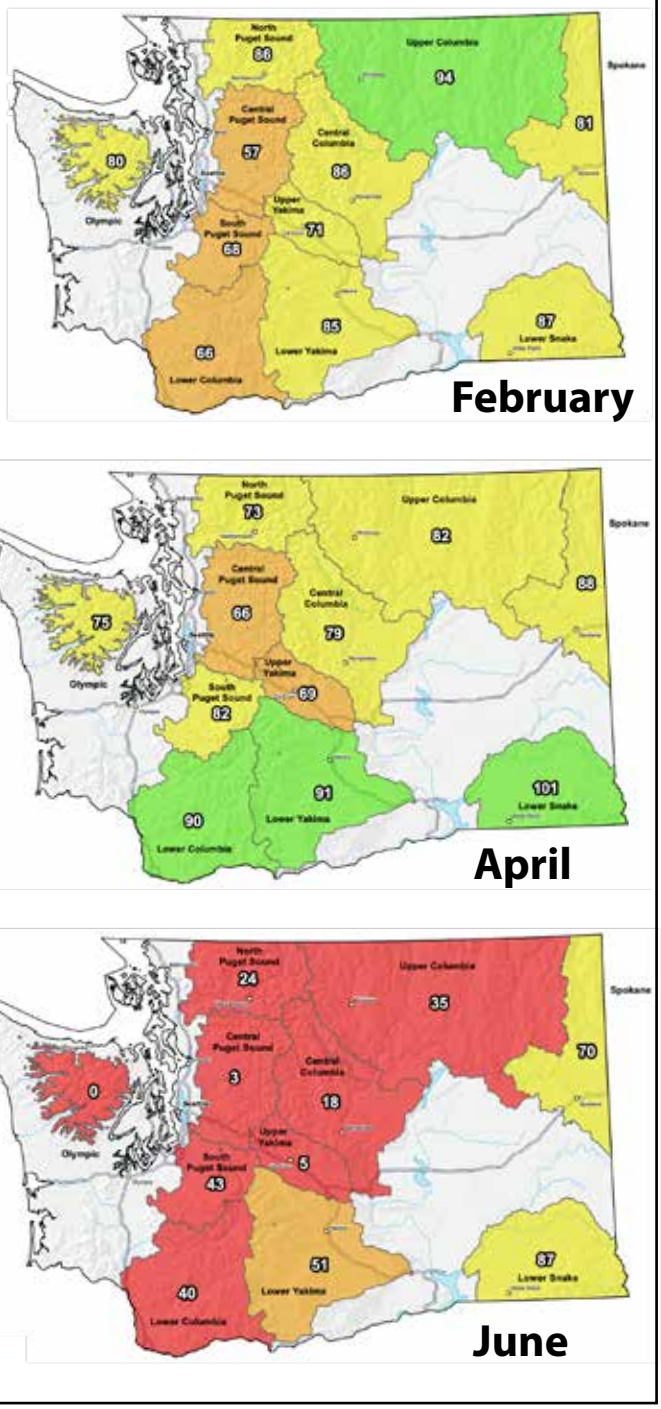
Snow water equivalent (SWE) is a useful measure of snowpack that assesses the available water content should the snow layer at an observing station be melted instantaneously. It is most commonly expressed as a percentage of normal values at a particular location (or averaged across a region) when compared with the most recent 30-year climatology from 1981 to 2010.

The average statewide SWE on Jan. 1, 2019 was about 91.9%, slightly lower than 2018 (96.5%). By February, statewide SWE was about 78.3%, reflecting lower precipitation in January (Figure 1). The most affected areas were the foothills and west slopes of the Cascades, where basin-wide values ranged 57-68% of normal.

Although there was some recovery in snowpack in March, warmer and drier conditions in April continued the trend in lower than normal snowpack with May 1, 2019 values of about 77.1%. Through May, temperatures across the Cascades were 4-5°F above normal while precipitation was about 1-2 inches lower. This resulted in significant snowmelt and runoff and by the first of June, when SWE values were only about 34.2% of normal.

When compared with the previous few years, June 1 statewide average SWE values were much lower than 2018, 2017, and 2016 (approximately 86.5%, 142.7% and 41.9%, respectively) but still higher than 2015 (about 7.7%).

Figure 1. Snowpack measurements (snow water equivalent) for February, April and June of 2019.



Drought

At the start of 2019, drought concerns were present across approximately 72.3% of the state. Moderate drought was shown for the Okanogan Highlands and southern Columbia Basin and Columbia Gorge. This trend continued through April due to lower precipitation and normal to slightly above normal temperatures. As shown with snowpack, May temperatures were much warmer for high mountain areas, leading to considerable snowmelt and fairly early runoff. This created quite the scare that the state would be heading into fire season with a more abundant grass crop and lower vegetation and soil moisture content.

On May 20, 2019, Gov. Jay Inslee declared a drought emergency for most watersheds coincident with the Cascades and Olympics (Figure 2) based on seasonal forecasts that showed low probability in achieving normal rainfall and snowpack levels before summer. The U.S. Drought Monitor around this time classified all of western Washington as experiencing moderate drought. Through June to early September, drought classifications remained mostly constant, although the Olympic Peninsula and Puget Sound areas were upgraded to severe drought in mid-June. Only 6.88% of the state (the Blue

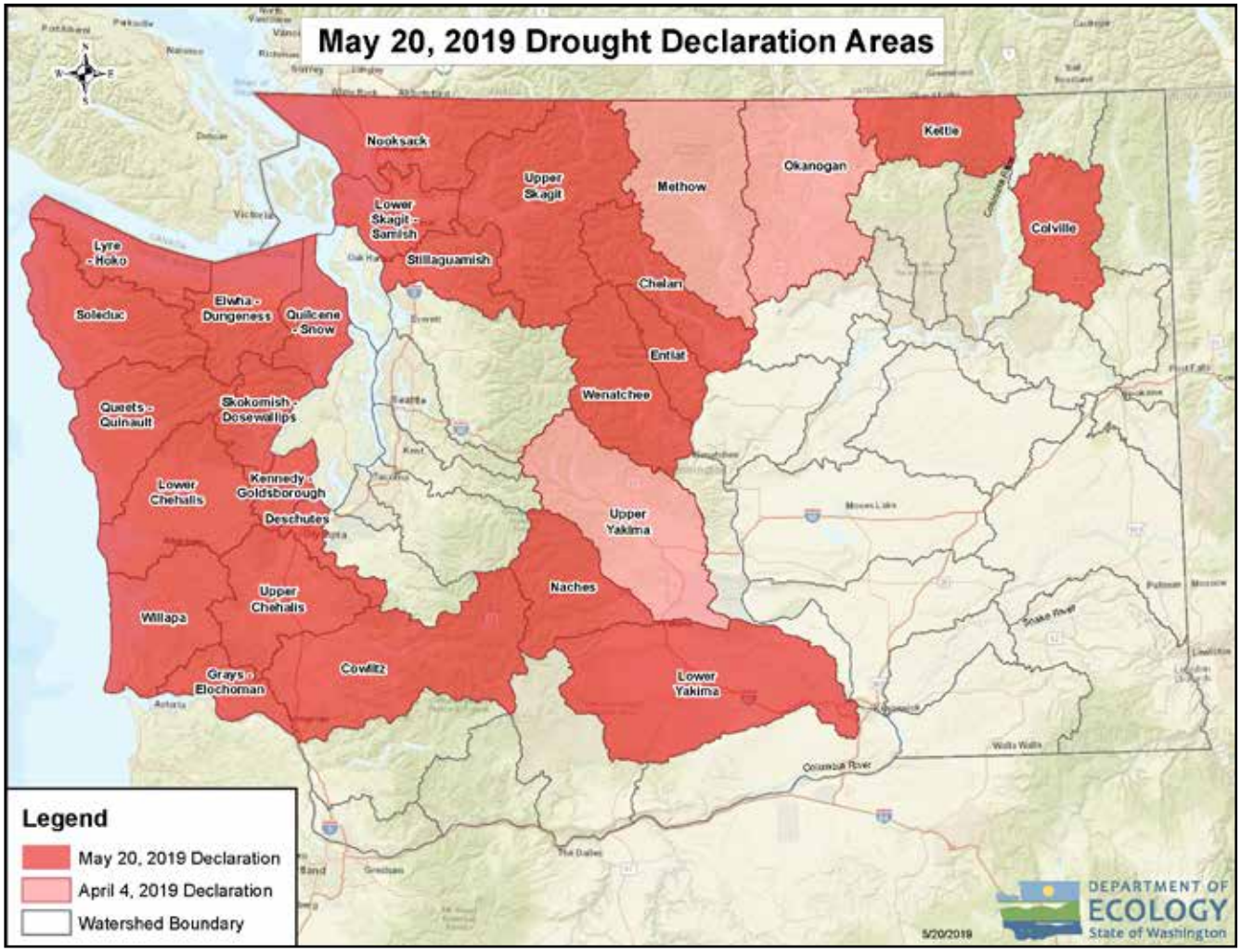
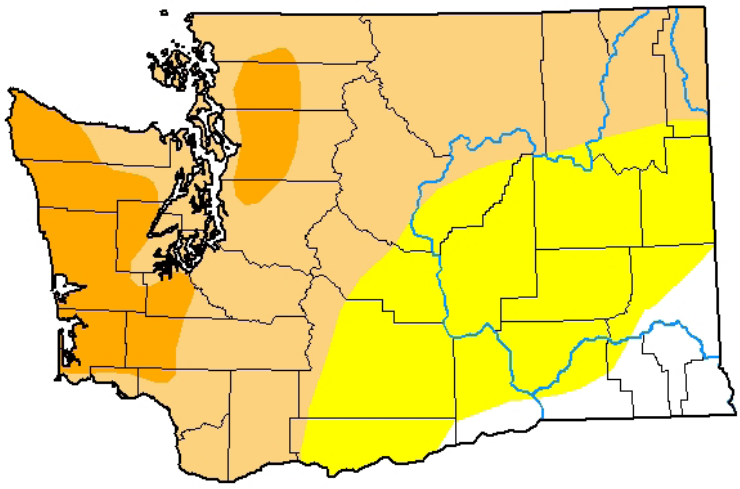


Figure 2. Drought areas declared by Gov. Jay Inslee on May 20, 2019.

Mountains and the Palouse) remained unaffected by drought during the peak of summer (Figure 3). With the major drought considerations in place, it would seem that summer precipitation was quite low, although this ended up not being the case. Instead, it was the cumulative effects of the earlier year precipitation deficits and persistent warmer than normal temperatures that, regardless of the above normal precipitation experienced statewide during the summer, kept drought concerns in the forecast. By mid-September, these concerns were mostly alleviated as fall type weather set up across the Northwest, allowing for ample cloud cover and cooler, more moist conditions. At the end of the year, drought was still present for the majority of the state, although to a lesser degree. Notably, much of the southwest, Puget Sound, and eastern Olympics ended the year under a moderate drought classification.



Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	6.88	93.12	60.87	13.58	0.00	0.00
Last Week *07-30-2019*	13.73	86.27	60.87	13.58	0.00	0.00
3 Months Ago *05-07-2019*	29.18	70.82	20.36	0.00	0.00	0.00
Start of Calendar Year *01-01-2019*	27.71	72.29	23.18	0.04	0.00	0.00
Start of Water Year *09-25-2018*	0.00	100.00	48.33	9.80	0.00	0.00
One Year Ago *08-07-2018*	0.00	100.00	46.44	6.45	0.00	0.00

Intensity:

- None
- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drought

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements.

Figure 3. Peak summer drought conditions across the state, captured Aug. 6, 2019. (Richard Tinker, CPC/NOAA/NWS/NCEP)

WILDFIRE

According to data compiled by the Northwest Coordination Center (NWCC) and Washington State Department of Natural Resources (DNR), wildfires burned 169,742 acres in Washington during the 2019 season, down from 438,834 acres burned in 2018. The total acres burned amount is considerably below the average of 329,221 acres per year over the period of 2010 to 2019.
In 2019, there were 1,395 fires statewide, down from 1,744 fires in 2018. The number of fires remained near the normal average of 1,400 fires per year from 2010 to 2019. Of the 1,395 total fires, 23 were considered large fires per the National Wildfire Coordinating Group (NWCG) definitions for size (greater than 100 acres of forestland or 300 acres of brush or grasses) or increased complexity, down from 67 large fires in 2018 (Figure 4). According to DNR wildfire data, the 2019 core season spanned from mid-May to the end of August (Figure 5), although the season started and ended slightly earlier than average. Notable in the 2019 fire season was an unusual short-term drought and an east wind

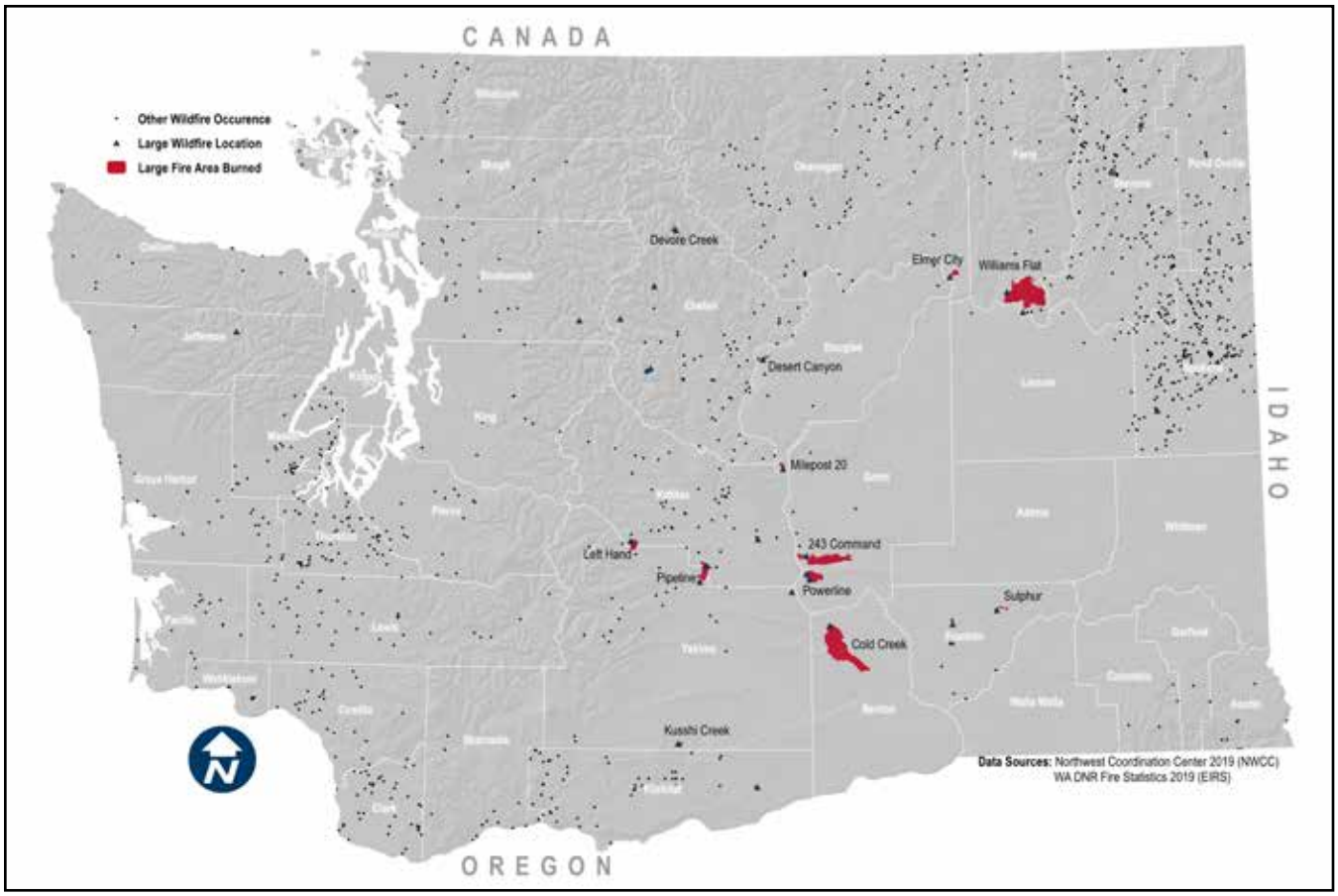


Figure 4. Wildfires that occurred in Washington in 2019. (Kirk Davis, Washington State Department of Natural Resources)

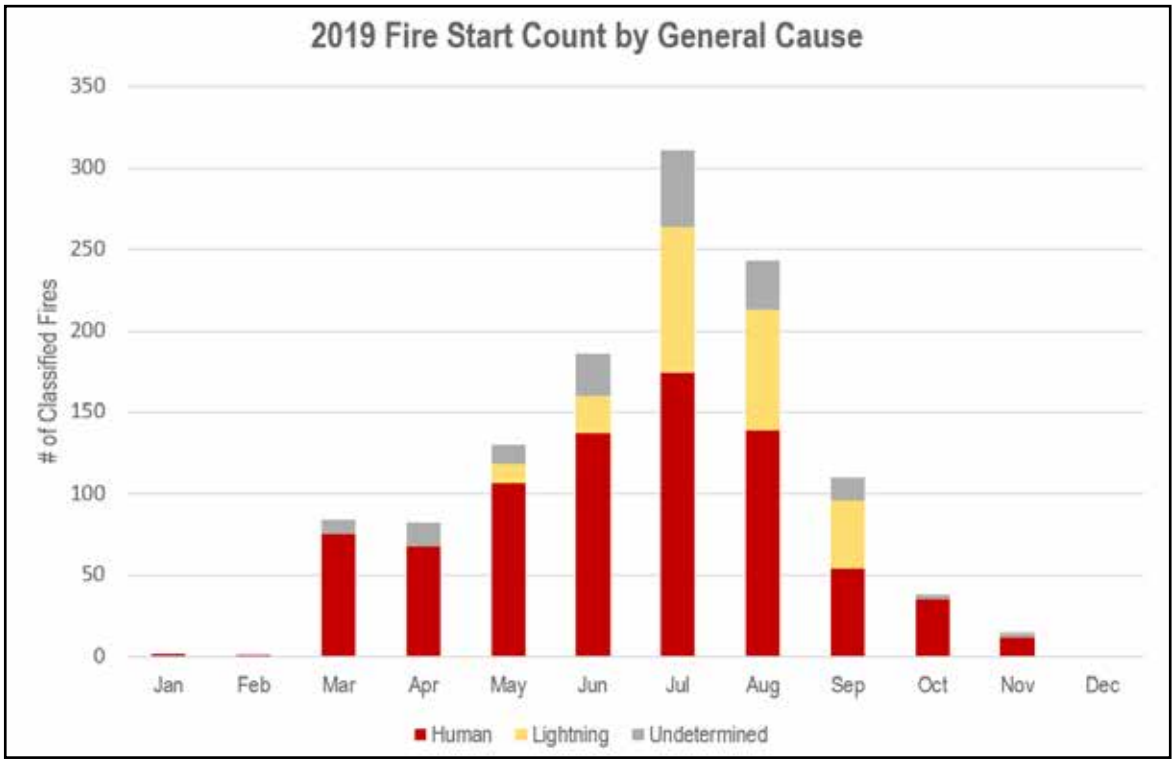


Figure 5. Number of DNR-classified fire starts by month in 2019 in Washington. Human causes include arson, debris burning, logging, miscellaneous, railroad, recreation, smokers and under investigation.

event that led to a high occurrence of human-caused fires in southwest Washington during the month of March. In total, 45 wildfires occurred during a three-day period, the majority of which were caused by escaped debris burns.

Of the 23 large fires in 2019, the average area burned was approximately 6,400 acres, which is an increase of roughly 100 acres from last year. Causes of large fires in 2019 were 70% human caused, 22% lightning and 9% unknown. Estimates for large fire fuel types burned were 43% grassland, 33% shrub-steppe, 21% forest, and 3% other (i.e. agricultural land, urban areas, wetlands).

The two largest wildfires during the 2019 season were the Williams Flats Fire, which started on Aug. 2 and burned 44,446 acres, and Cold Creek Fire, which started on July 18 and burned 41,920 acres. The Williams Flats Fire was started by lightning on the Colville Reservation, which is Bureau of Indian Affairs jurisdiction, and was contained on Aug. 5. This fire burned primarily in timber, grass, and shrub fuel types. The cause of the Cold Creek Fire is undetermined at the time of this report. It started on the Mid-Columbia National Wildlife Refuge Complex, which is the jurisdiction of U.S. Fish and Wildlife Service. The fuels were mostly grass and shrub. Combined, these two largest fires of the season represent 51% of total acreage burned in Washington in 2019.

AERIAL DETECTION SURVEY

The annual insect and disease aerial detection survey (ADS) in Washington was 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 2-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 (Figure 6). 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. Photos are rarely taken.

Figure 6. Aerial observer mapping during a flight.

Aerial Detection Survey 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. If more than one agent is present in a polygon, codes are separated by an exclamation point. 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 mortality caused by the fire from mortality 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. See page 37 for more details about ADS methodology.

Wildfire smoke was not a significant issue for the 2019 survey. However, aircraft maintenance needs and persistent clouds during August and September delayed progress. Two aircraft and crews were used simultaneously during a period of clear weather in late August to make up for these delays. The Oregon Department of Forestry and USFS provided additional observers to assist with coverage in Washington. The survey was not completed until early October when early snowfall made higher elevation observations difficult for the last two days of survey (Figure 7).

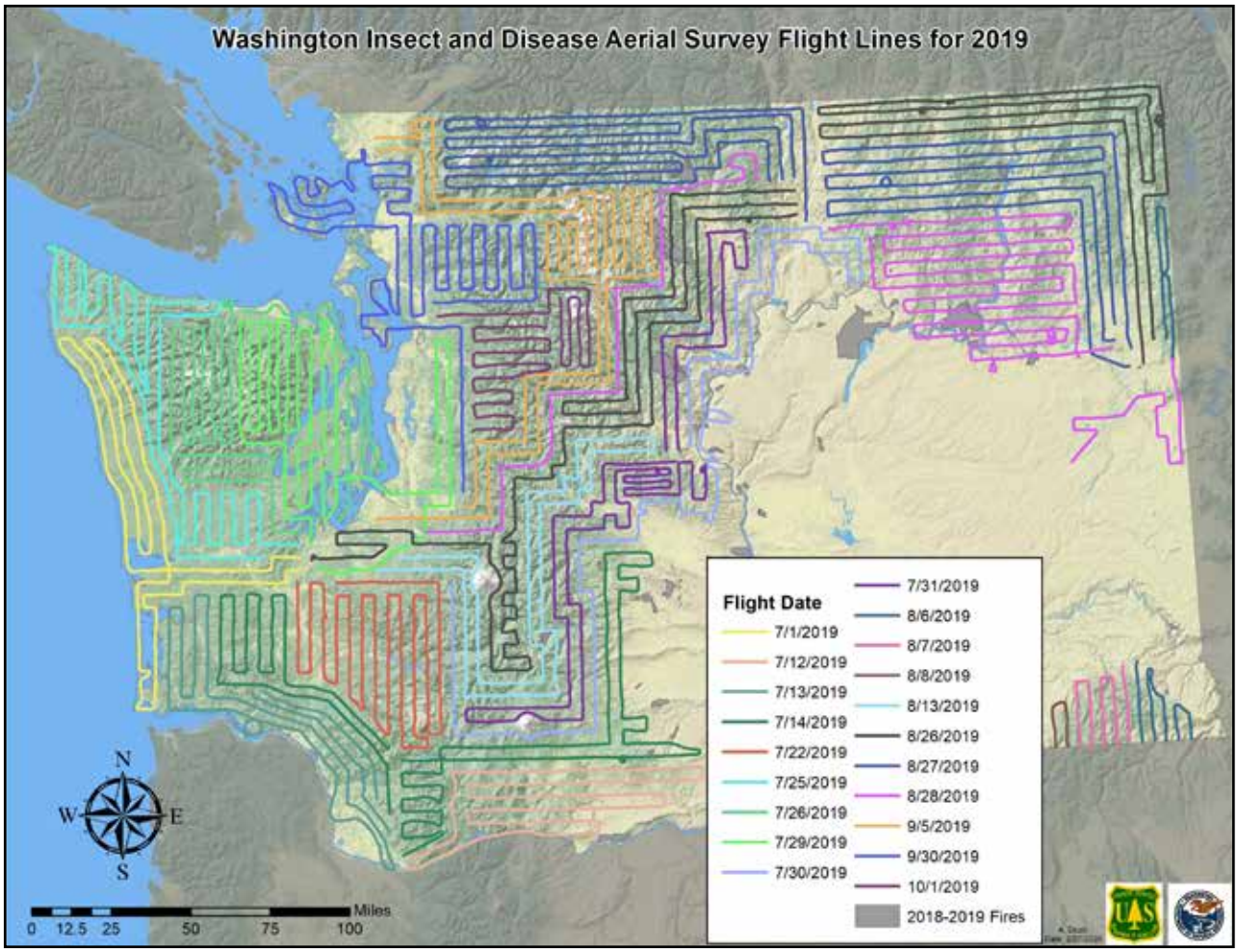


Figure 7. Washington insect and disease aerial survey flight lines for 2019. (Aleksandar Dozic, Washington State Department of Natural Resources)

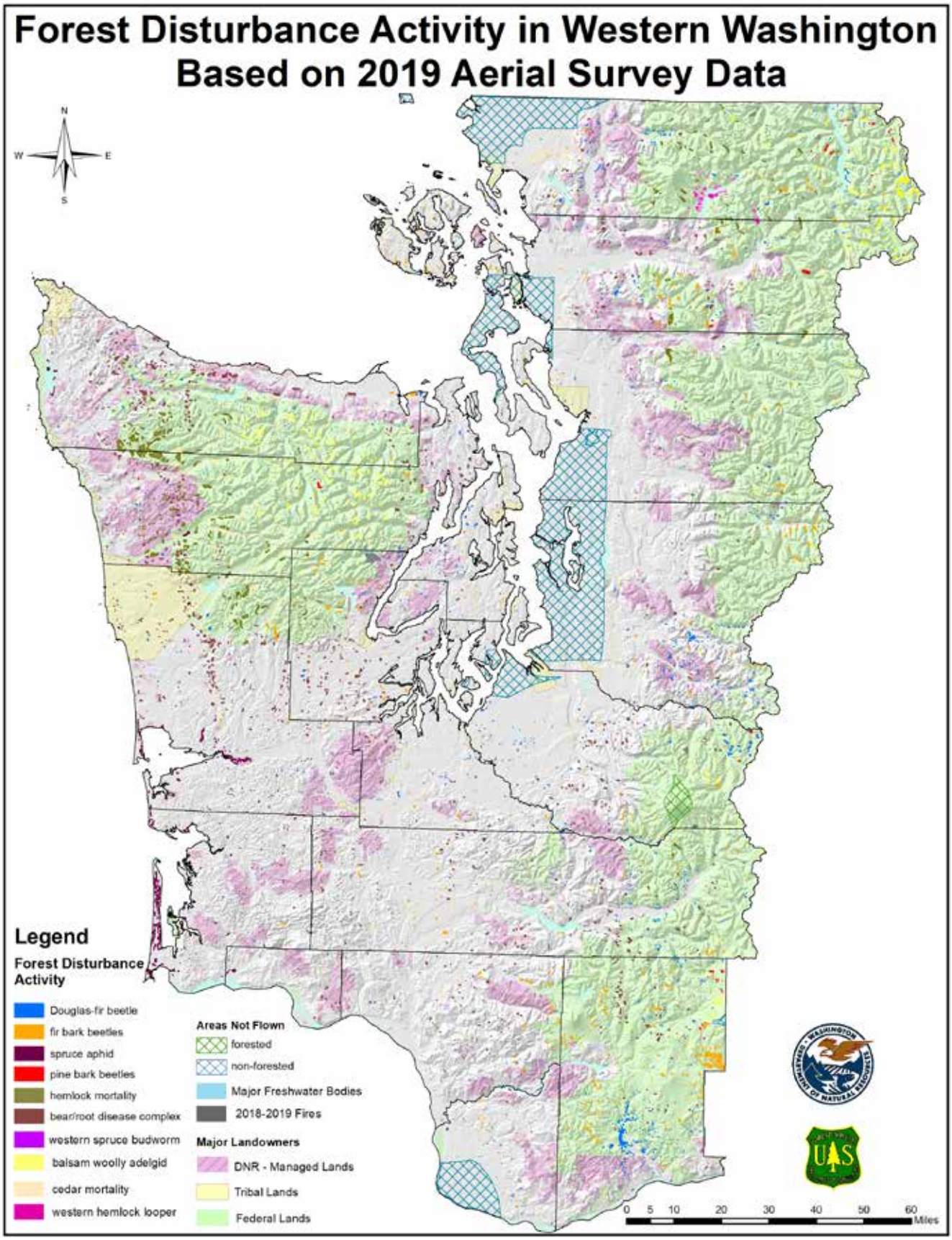


Figure 8. Forest disturbance map of western Washington composed from 2019 aerial survey data. (Aleksandar Dozic, Washington State Department of Natural Resources)

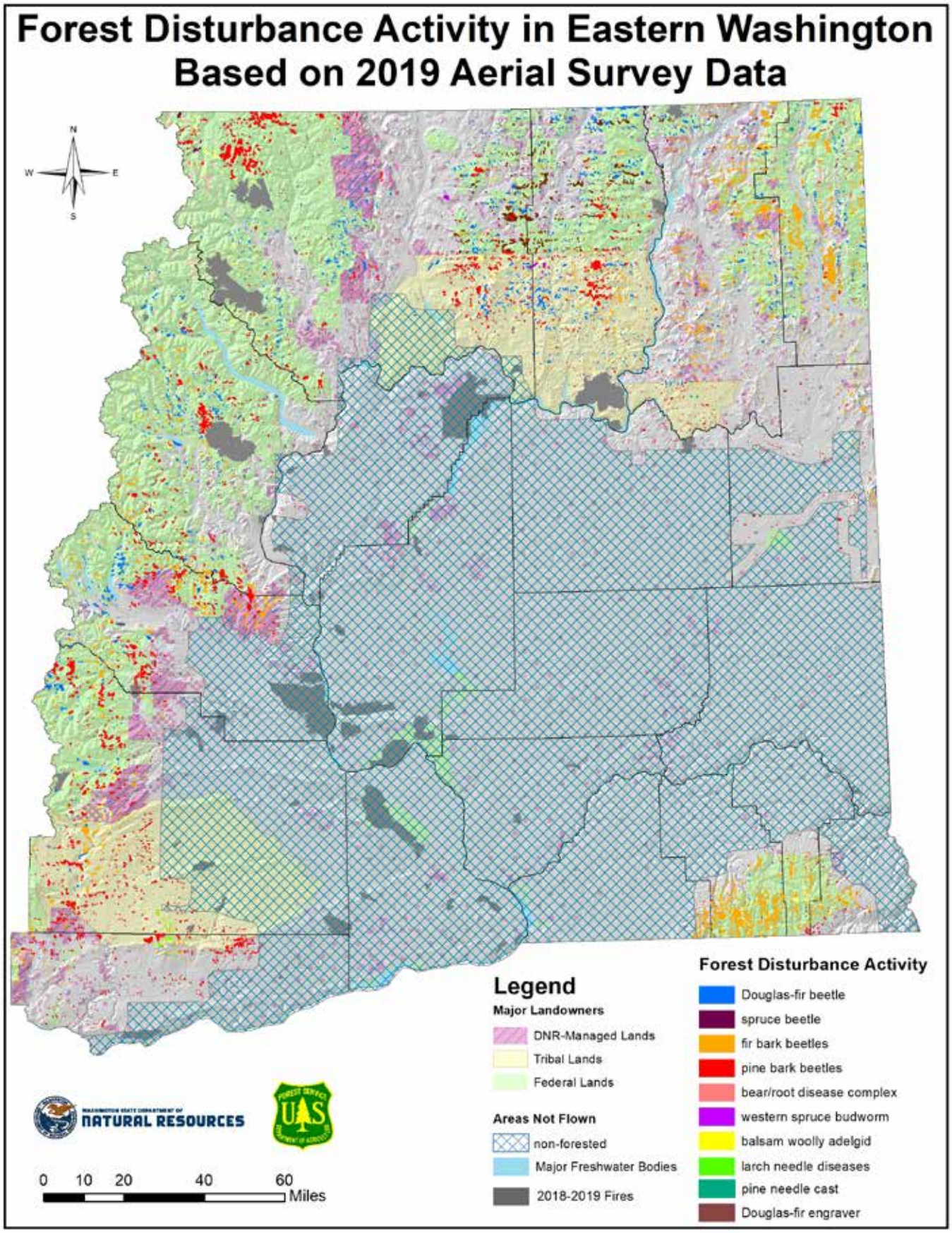


Figure 9. Forest disturbance map of eastern Washington composed from 2019 aerial survey data. (Aleksandar Dozic, Washington State Department of Natural Resources)

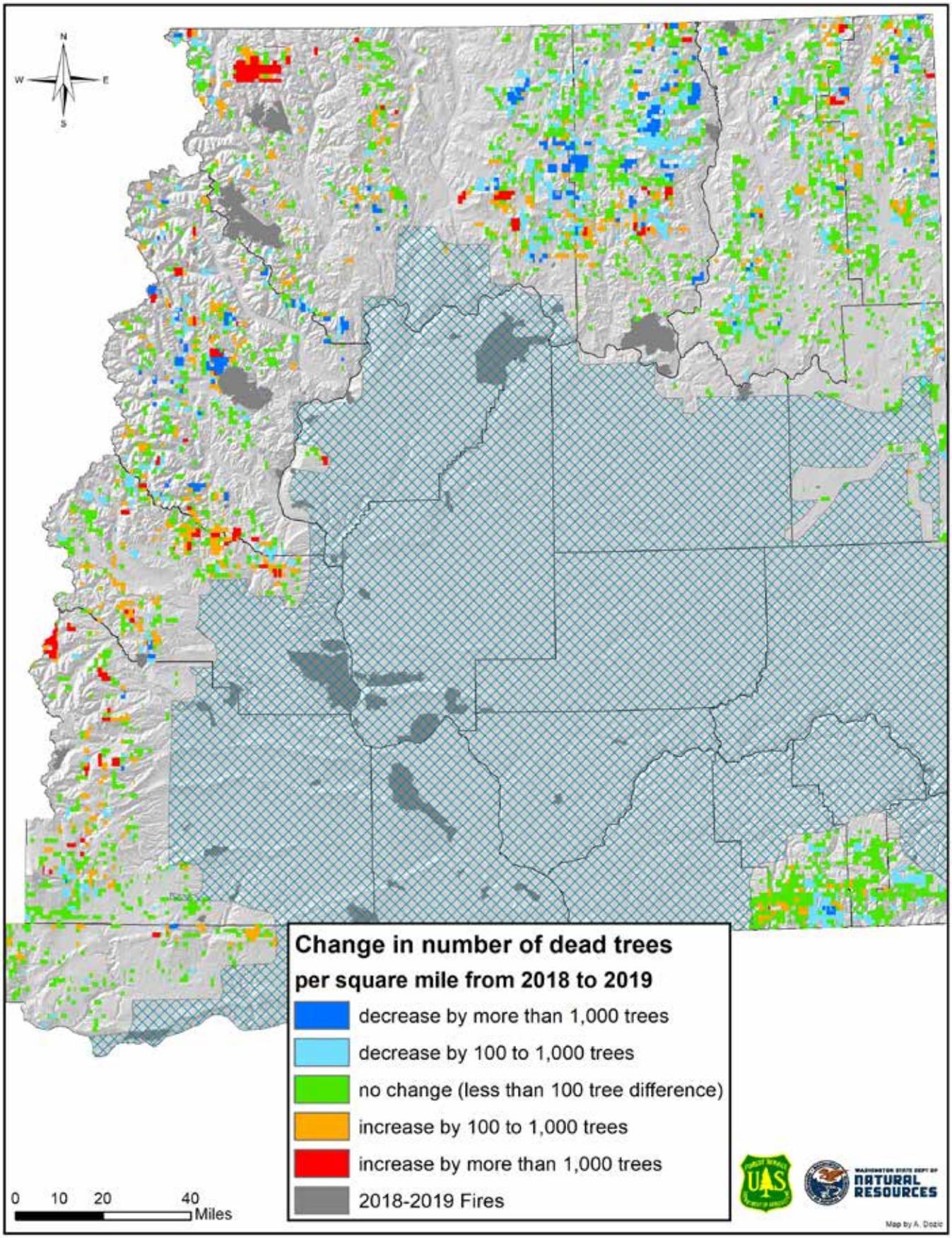


Figure 10. Change in tree mortality levels recorded by aerial survey in eastern Washington between 2018 and 2019. (Aleksandar Dozic, Washington State Department of Natural Resources)

FOREST HEALTH AND RESILIENCY DIVISION

In 2019, DNR created the Forest Health and Resiliency Division in recognition that a reorganization of agency structure was necessary to achieve DNR's mission to manage, sustain, and protect the health and productivity of Washington's lands and waters to meet the needs of present and future generations.

The Forest Health and Resiliency Division works across all lands and in the interest of all Washingtonians to sustain and increase the health and resilience of our forests and the local communities and values forests support for the well-being of people, communities, wildlife and landscapes today and into the future. The division is a combination of existing agency programs focused on forest health insect and disease monitoring, landowner assistance and wildfire preparedness, urban forestry, and forest stewardship, as well as new programs focused on prescribed fire, federal lands restoration, forest planning and landscape ecology. The division consists of staff based in Olympia as well as regional staff based primarily in the agency's northeast and southeast regions, with some staff in western Washington as well.

DEFINING FOREST HEALTH

Forest health is the condition of a forest ecosystem reflecting its ability to sustain characteristic structure, function, and processes; resilience to fire, insects and other disturbance mechanisms; adaptability to changing climate and increased drought stress; and capacity to provide ecosystem services to meet landowner objectives and human needs.

The division comprises four sections: the Planning, Science and Monitoring Section, the Landowner and Community Assistance Section, the Federal Lands Program, and the Prescribed Fire Program.

The Planning, Science and Monitoring Section continues to provide forest health insect and disease monitoring, aerial survey of forest health conditions and technical assistance to forest landowners with our forest pathologists, forest entomologists and forest health specialists. This section has also added new forest health scientists and planners to the team to analyze forest health and resiliency treatment needs across large landscapes and work with partners across all lands to plan, implement, and monitor treatments and changing conditions in support of the 20-Year Forest Health Strategic Plan for central and eastern Washington, while developing a revised Forest Action Plan.

The Landowner and Community Assistance Section combines four existing DNR programs: Landowner Assistance, Urban and Community Forestry, Forest Stewardship and Wildfire Preparedness. The Landowner Assistance and Wildfire Preparedness programs are primarily focused in the northeast and southeast regions, and there are more than 20 staff in those regions supporting cost-share forest health treatments for small, private landowners and preparing communities for wildfire. The Urban and Community Forestry Program consists of two staff based in Olympia that provide urban forestry technical, educational and financial assistance to Washington's cities and towns, counties, tribal governments, nonprofit organizations and educational institutions. The Forest Stewardship Program consists of two stewardship foresters (one in eastern and one in western Washington) and a wildlife biologist providing technical assistance to small forest landowners to help them make informed decisions for managing their land.

The Federal Lands Program focuses on using state expertise, resources and mechanisms to increase work on federal land throughout the state, primarily on National Forest System land through the use of DNR's Good Neighbor Authority Agreement (GNA) with the federal government. This section works directly with USFS personnel to implement a variety of restoration projects such as decreasing stream barriers for fish and other aquatic organisms, addressing forest road issues, timber sales, wildlife habitat enhancement and more. In addition to GNA, this program coordinates with other programs within the division and department to provide input on federal projects and as well as National Environmental Policy Act (NEPA) planning support. The program is funded through a variety of funding sources including state and federally appropriated funds, and revenue derived from restoration projects with commercial timber as a component. The program has active projects on the five major national forests in Washington with 15 dedicated staff working across the state.

The Prescribed Fire Program is a new program focused on increasing safe and effective prescribed fire in Washington state to restore forests and other ecosystems. The program focuses on prescribed fire training, participating in prescribed burns, funding prescribed burns, working with partners to promote and implement prescribed fire and monitoring the effects of prescribed fire and wildfire. The program consists of two staff: a prescribed fire program manager and a fire ecologist. A prescribed fire training coordinator will be added to the program in 2020.

FOREST ACTION PLAN

Washington's Forest Action Plan is a comprehensive review of forests across all lands — public, private, rural and urban — that offers proactive solutions to conserve, protect and enhance the trees and forests that people and wildlife depend on. In 2008, Congress tasked each state with developing a Forest Action Plan. The first Washington State Forest Action Plan was published in 2010, and a revision was released in 2017. DNR is updating Washington's Forest Action Plan and will submit it to the USFS for review in June 2020.

More than 22 million acres of Washington is forested. These forests face challenges including conversion through development or other uses, effects of climate change, drought, severe wildfires, insects and disease, and invasive species. Using the best available science, the Forest Action Plans have three primary steps: identify and evaluate forest threats; create strategies to address those threats; and build partnerships and plans to help carry out those strategies to conserve and protect our forests. The plan allows the state to receive funding from the USFS's state and private forestry programs. During the 2018 fiscal year, these programs provided more than $12.8 million to conserve and protect our state's forests. In Washington, more than 215,000 small forest landowners collectively manage 6.5 million acres of land, 12 million acres of private land are under state fire protection, and there are 558 rural fire departments. These partners, among others, benefit directly from this plan.

Revising this plan will help the state to work with partners to restore and maintain resilient landscapes, protect and enhance the value of natural resources and their benefits, encourage community wildfire preparedness and resilience, manage forests in rural and urban settings, conserve working forests, sustain a viable, diverse forest products industry, incorporate and expand DNR's 20-Year Forest Health Strategic Plan and Wildland Fire Protection 10-Year Strategic Plan.

20-YEAR FOREST HEALTH STRATEGIC PLAN

Adopted in 2017, the 20-Year Forest Health Strategic Plan for central and eastern Washington aims to restore and manage forested landscapes at a pace and scale that reduces the risk of uncharacteristic wildfires and increases the health and resilience of forest and aquatic ecosystems in a changing climate for rural communities and the people of Washington state. The plan established five goals:

- Conduct 1.25 million acres of scientifically sound, landscape-scale, cross-boundary management and restoration treatments in priority watersheds to increase forest and watershed resilience by 2037.
- Reduce risk of uncharacteristically severe wildfire and other disturbances to help protect lives, communities, property, ecosystems, assets and working forests.
- Enhance economic development through implementation of forest restoration and management strategies that maintain and attract private sector investments and employment in rural communities.
- Plan and implement coordinated, landscape-scale forest restoration and management treatments in a manner that integrates landowner objectives and responsibilities.
- Develop and implement a forest health and resilience monitoring program that establishes criteria, tools, and processes to monitor forest and watershed conditions, assess progress and reassess strategies over time.

Figure 11. A resilient dry-forest ecosystem with density variety and reduced fuels on the forest floor.

The overarching strategy is to maximize effectiveness of forest health treatments by coordinating and prioritizing forest management activities across large landscapes. The authority and direction contained in Senate Bill 5546 guides DNR's efforts to improve forest health across all ownerships in large landscapes. The bill requires DNR to create a Forest Health Assessment and Treatment Framework that assesses a minimum of 200,000 acres of fire prone lands each biennium and identifies forest health treatment needs across all lands. It also provides legislative direction and tools to help achieve the state's treatment goals across all lands.

To date, DNR has identified 33 priority planning areas that are the focus of the current implementation of the plan through shared stewardship (Figure 12). These priority planning areas cover over 3.5 million acres, where DNR is conducting individual landscape evaluations to determine the need for treatment within each. Landscape evaluations are completed for 12 priority planning areas with the remaining 21 to be completed by the end of 2020. Through these science-based evaluations we've identified over 286,220 acres where treatments are needed to move the landscape into a more resilient condition.

To ensure treatments occur, our planners are engaged in forest collaboratives across central and eastern Washington while our landowner assistance and stewardship foresters are engaging with private landowners and Fire Adapted Communities. Additionally, we are investing state resources, including through competitive all-lands restoration grants and use of Good Neighbor Authority (GNA) to increase the footprint of treatments. Approximately 1,700 acres of GNA fuels reduction projects are planned on federal lands in central and eastern Washington for the 2019-21 biennium.

Highlights of additional state investments made in 2019 to further implementation of the 20-Year Strategic Plan for eastern Washington include:

- Landowner assistance cost-share funds ($1.8 million) to work with private landowners in central and eastern Washington that DNR landowner assistance foresters are dedicating to projects.
- South Gifford Pinchot Collaborative for mechanical fuels treatments on 279 acres in the Trout Lake wildland-urban interface, prescribed burning on 565 acres, public engagement activities associated with prescribed burns, piloting DNR's treatment effectiveness monitoring protocol, supporting forest partnerships and increasing the pace and scale of forest restoration.
- Stemilt Partnership for fuels reduction treatments on 285 acres, road surveys and infrastructure support for building forest partnerships and increasing the pace and scale of forest restoration.
- Chumstick Wildfire Stewardship Coalition for outreach, assessment and fuels reduction treatments, including commercial projects, on private land in coordination with DNR's Landowner Assistance Program, community fuels reduction activities, and collaborative infrastructure support for building forest partnerships and increasing the pace and scale of forest restoration.
- North Central Washington Forest Health Collaborative for pre-sale work on 1,000 acres of USFS land and public and private boundary surveys, and collaborative infrastructure support for building forest partnerships and increasing the pace and scale of forest restoration.
- Tapash Sustainable Forest Collaborative for building forest partnerships that support and will help accelerate forest restoration across a 2.3 million acre landscape and forest restoration project planning in priority areas.
- Northeast Washington Forestry Coalition for collaborative infrastructure support for building

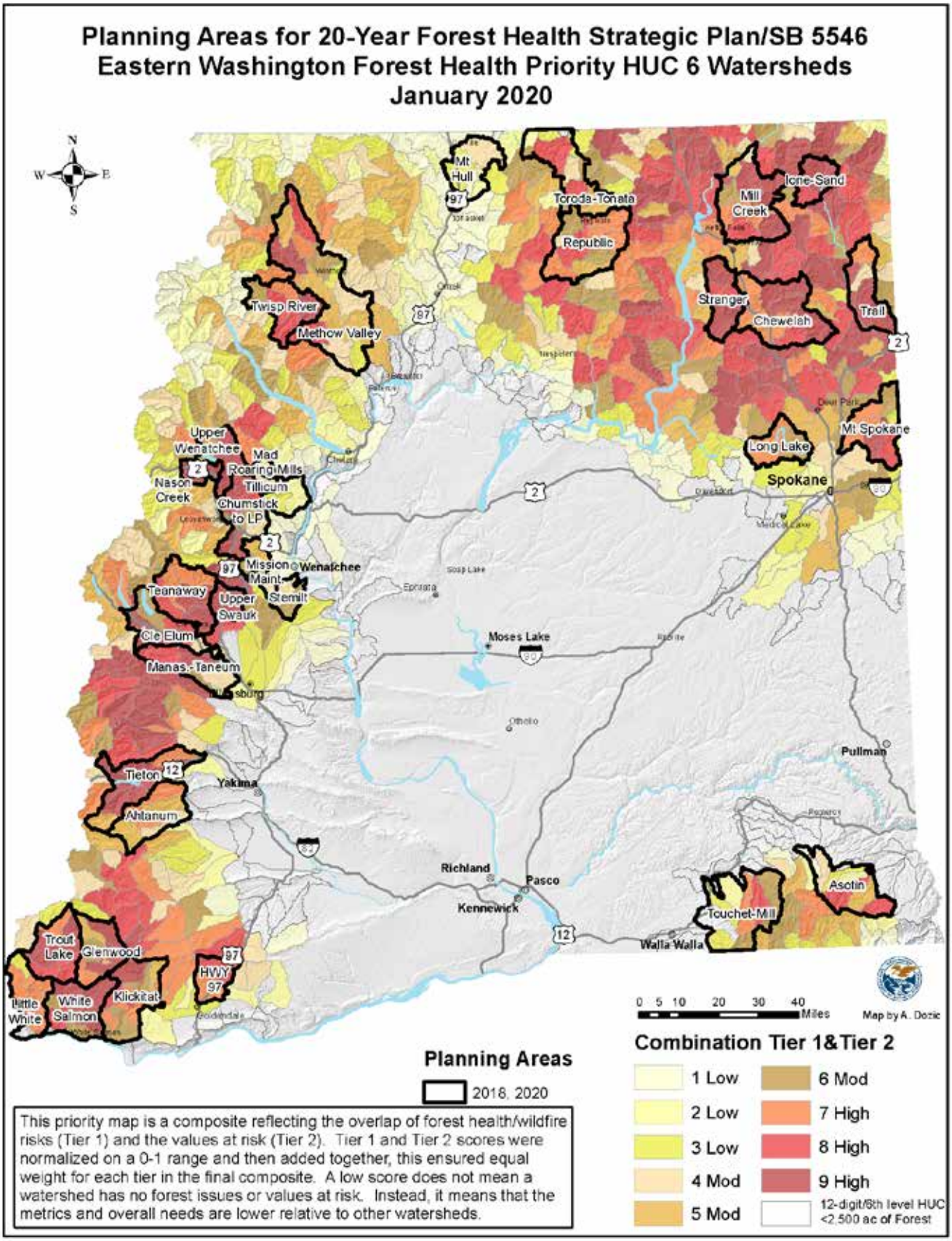


Figure 12. 2018 and 2020 priority areas for the 20-Year Forest Health Strategic Plan and Senate Bill 5546, and forest health hydrological unit code (HUC) 6 watersheds rankings. With other agencies and partners, priority area boundaries were updated in 2019. (Aleksandar Dozic, Washington State Department of Natural Resources)

forest partnerships and increasing the pace and scale of forest restoration in priority areas.

- The Confederated Tribes of the Colville Reservation for the strategic installation of beaver dam analogs in three priority planning areas to increase watershed resiliency, mitigate drought and improve aquatic conditions.
- Kalispel Tribe of Indians for the Skookum Trails project on the Colville National Forest (Pend Oreille County) to increase the pace and scale of planning across a 90,700-acre priority area.
- Okanogan-Wenatchee National Forest for fuels reduction and forest health treatments in three landscape scale priority areas: Mount Hull (Okanogan County), Tillicum (Chelan County), and Swauk Pine (Kittitas County).
- Gifford Pinchot National Forest for stand exams in the Little White priority area, and 537 acres of fuels reduction near Trout Lake (Skamania County).
- Umatilla National Forest for approximately 700 acres of fuels reduction in the Blues East priority area near Bluewood (Garfield or Asotin Counties, depending on exact acreage).

Finally, 2019 has seen significant work toward building DNR monitoring methodologies and tools to track progress toward plan goals. DNR scientists developed a stand-level forest health and fuels treatment monitoring protocol to be deployed across all projects DNR invests in and by willing partners and forest landowners beginning in 2020. DNR is working with external partners — including the University of Washington, Oregon State University, and Washington Conservation Science Institute — to establish groundbreaking monitoring datasets and tools to assess the effects of state investments in forest health. This includes increasing the understanding of the longevity of forest health treatments and the effects of treatments on water storage and supply. And, DNR is building an online platform to allow for transparent and timely tracking of forest health and fuels reduction treatments across all lands throughout the 20-Year Forest Health Strategic Plan geography.

For more information visit: www.dnr.wa.gov/ForestHealthPlan.

INSECTS

Bark Beetles

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

Approximately 119,400 acres with pine bark beetle caused mortality were recorded by the aerial survey in 2019, similar to the 120,000 acres in 2018 (Figure 14). Pine mortality due to mountain pine beetle (MPB) was recorded on 86,500 acres, a decrease from 101,300 acres in 2018 and below the 10-year average of 126,000 acres. Relative to 2018, MPB-caused mortality increased in lodgepole pine and whitebark pine and decreased in ponderosa pine and western white pine (Table 3, Figure 13). The most concentrated areas of lodgepole and ponderosa pine mortality occurred in northwest Okanogan County (Pasayten Wilderness area), central Ferry County (Sherman Pass area), Chelan County (south of Lake Chelan), and Kittitas County.

Figure 13. Mountain pine beetle larvae and galleries in western white pine.

Mortality of ponderosa pine due to western pine beetle (WPB) increased to approximately 29,400 acres in 2019, nearly double the 16,700 acres observed in 2018. This is the highest level of WPB recorded since 2006. Recent drought conditions are likely an important driver of these increases. The highest concentrations of WPB-caused mortality were in scattered areas of south Okanogan County, central Kittitas County, west Yakima County, and north Klickitat County. There has been a significant increase in requests for information on WPB damage from landowners and land managers.

Pine mortality attributed to Ips pine engravers was observed on approximately 3,900 acres in 2019, more than three times the 1,100 acres observed in 2018. Similar to WPB, this is the highest level recorded since 2006. Ponderosa pine was the most common species affected. The highest concentration of 2019 mortality was in Klickitat County. In the southern part of the county, near the Columbia River Gorge, California fivespined ips (*Ips paraconfusus*) is the most likely species responsible for mortality. In north Klickitat County and elsewhere in Washington, *Ips pini* is more common.

Table 3. Acres observed in aerial survey with pine bark beetle damage in Washington

Beetle species	Host(s)	2019 acres with mortality*	2018 acres with mortality*
Mountain pine beetle	Lodgepole pine	76,500	59,300
Mountain pine beetle	Ponderosa pine	14,000	42,000
Mountain pine beetle	Whitebark pine	900	720
Mountain pine beetle	Western white pine	300	1,000
Western pine beetle	Ponderosa pine	29,400	16,700
Pine engravers (*Ips* species)	All pines	3,900	1,100
	Totals:	119,400 (footprint)*	120,000 (footprint)*

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

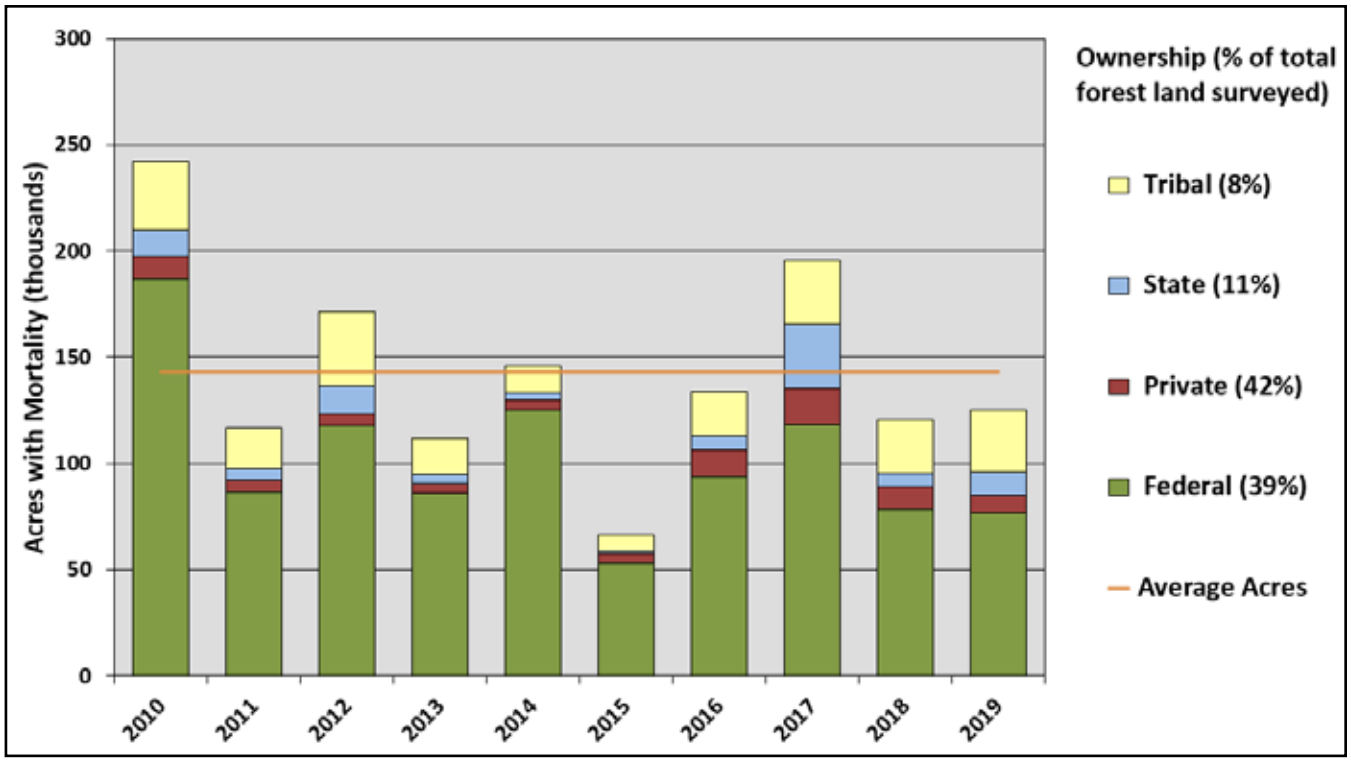


Figure 14. Ten year trend for total acres affected by pine bark beetles in Washington.

Douglas-fir Beetle (*Dendroctonus pseudotsugae* Hopkins)

Mortality due to Douglas-fir beetle (DFB) increased significantly to approximately 69,100 acres in 2019, compared with 26,700 acres in 2018. This is the highest level of damage since 2009 (80,000 acres) and well above the 10-year average of 30,000 acres (Figure 15). Scattered areas of DFB-caused mortality were detected throughout the east slopes of the Cascades, the Blue Mountains, and in northeast Washington.

High concentrations of DFB-caused mortality were detected throughout the east slopes of the central and north Cascades, eastern Okanogan County, Ferry County, and south Skamania County (Figure 16). Much of the eastern Washington mortality was associated with recent wildfire damage and recently collapsed western spruce budworm outbreaks in the central Cascades.

Figure 16. Group of Douglas-fir trees killed by Douglas-fir beetle.

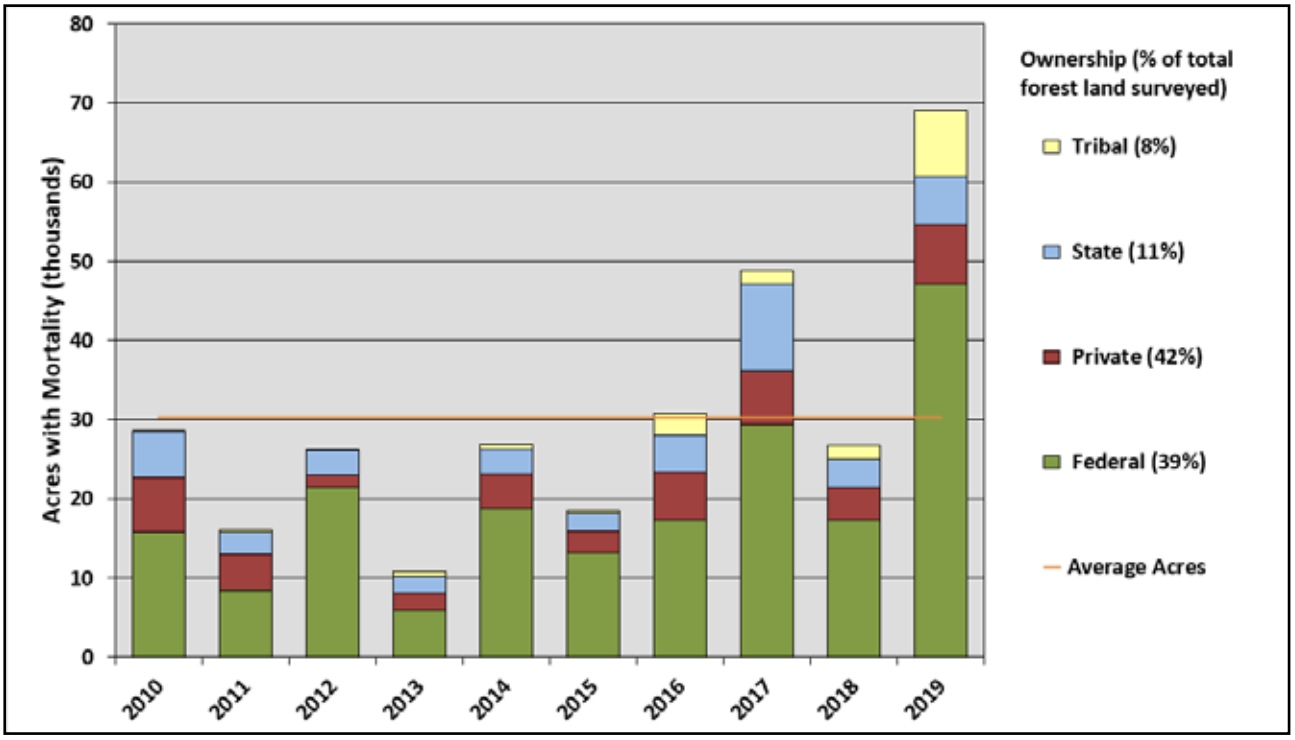


Figure 15. Ten year trend for total acres affected by Douglas-fir beetle in Washington.

Spruce Beetle (*Dendroctonus rufipennis* Kirby)

The area affected by spruce beetle in Engelmann spruce increased slightly to 1,600 acres in 2019, from 1,300 in 2018. This is still well below the 10-year average of 23,000 acres (Figure 17).

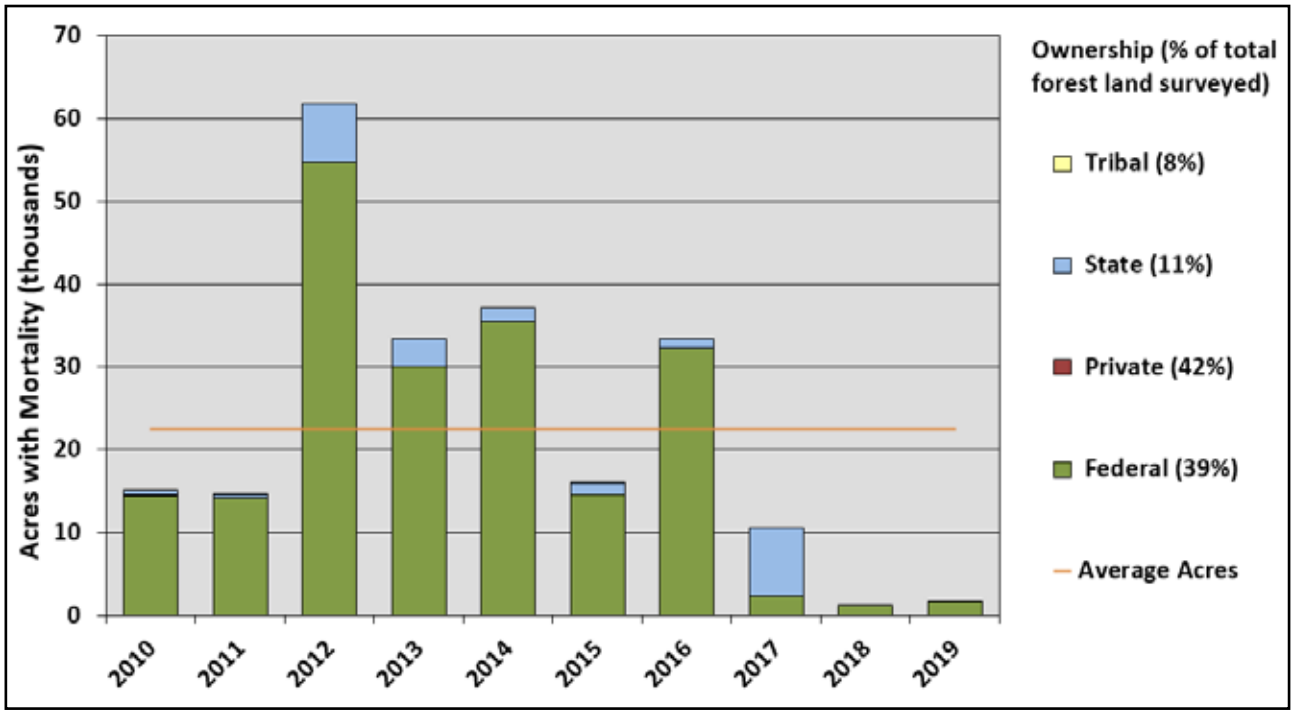


Figure 17. Ten year trend for total acres affected by spruce beetle in Washington.

A new area of approximately 650 acres with spruce beetle-caused mortality was detected on Blewett Pass near the Chelan-Kittitas county line. There is also a small area with ongoing spruce beetle activity in northwest Okanogan County along the Cascade crest near the Canadian border.

Figure 18. Fir engraver galleries in grand fir.

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 (Figure 18). Fir engraver caused mortality, primarily in grand fir, occurred on approximately 166,300 acres in 2019, more than twice the area recorded in 2018 and the highest level since 2008 (Figure 19). A notable increase of fir engraver damage was detected in scattered areas throughout western Washington. East of the Cascades, the most concentrated areas of mortality were in Stevens and Pend Oreille counties and in the Umatilla National Forest in the Blue Mountains. Recent drought conditions are likely an important driver of the increase, in addition to effects of recently collapsed western spruce budworm outbreaks in the central Cascades. There has been a significant increase in requests for information on fir engraver damage from landowners and land managers in western Washington.

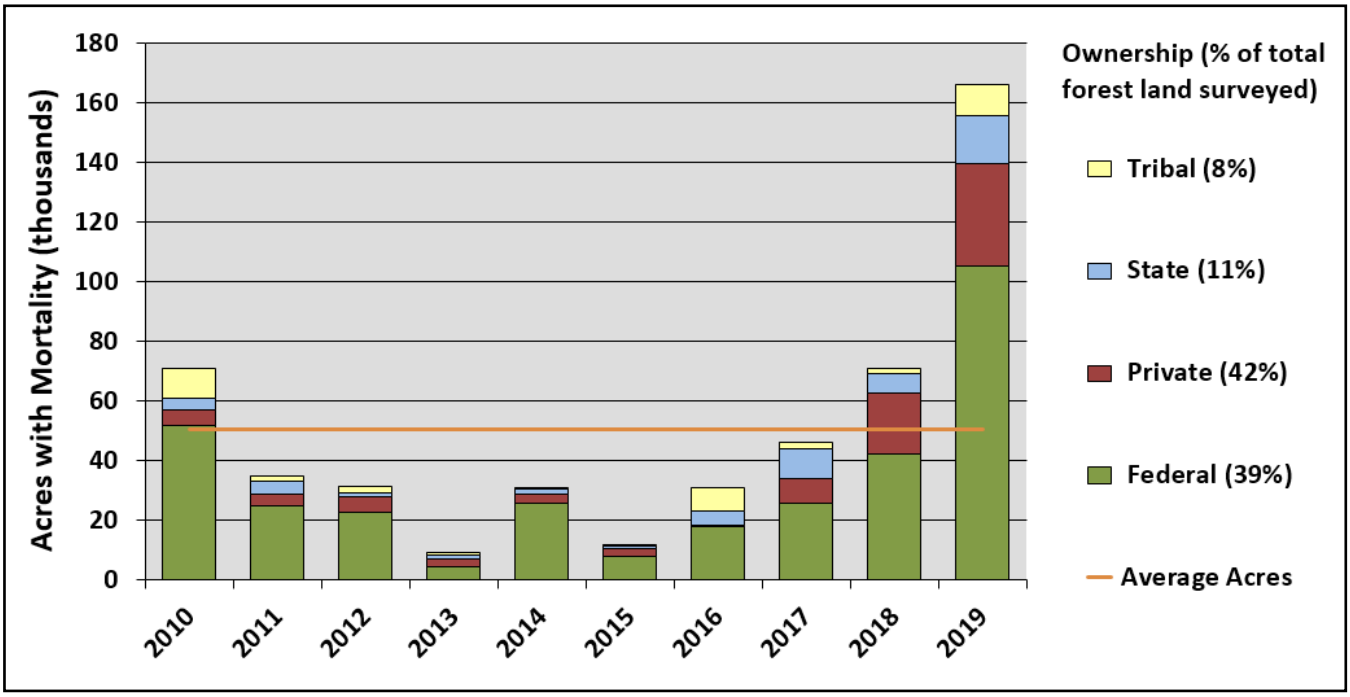


Figure 19. Ten year trend for total acres affected by fir engraver in Washington.

Silver Fir Beetle (*Pseudohylesinus sericeus* (Mannerheim))

Approximately 1,700 acres with elevated Pacific silver fir mortality due to silver fir beetle were observed in western Washington; this was the highest level in the last 10 years, but similar to 2017. The areas affected were within upper elevation west slopes of the Cascade Mountains in Whatcom, Skagit, Snohomish and King counties. Outbreaks of silver fir beetle are often associated with wind-thrown trees.

Western Balsam Bark Beetle (*Dryocoetes confusus* Swaine)

The 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 increased to approximately 22,600 acres in 2019, from the 13,300 acres recorded in 2018. The most concentrated area with damage was along the Cascade crest in western Okanogan County.

Secondary Bark Beetles in Douglas-fir (*Scolytus monticolae* (Swaine), *Scolytus unispinosus* LeConte, and *Pseudohylesinus nebulosus* (LeConte))

The amount of Douglas-fir engraver damage mapped in 2019 increased significantly to approximately 20,300 acres. This is the highest level ever recorded in the aerial survey dating back to 1969, and well above the 10-year average of 3,300 acres. The highest concentrations of damage were observed in east Okanogan County and in Ferry and Stevens counties. In eastern Washington, infested Douglas-fir contained mostly *Scolytus monticolae* (which has no common name), and a minor occurrence of Douglas-fir pole beetle (*Pseudohylesinus nebulosus*). In western Washington, trees contained the Douglas-fir engraver (*Scolytus unispinosus*) and/or the Douglas-fir pole beetle. All three species can infest the same tree and are difficult to distinguish based on their egg and larval galleries alone.

Figure 20. Damage to young Douglas-fir from secondary bark beetles.

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 (Figure 20). 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. Attacks during droughty periods are more likely to be successful and cause mortality.

Secondary Bark Beetles in Western Redcedar (*Phloeosinus* species) and Western Hemlock (*Scolytus tsugae* (Swaine), *Pseudohylesinus tsugae* Swaine, and *Pseudohylesinus sericeus* (Mannerheim))

The amount of western redcedar (WRC) mortality observed has steadily increased since a WRC mortality code was first adopted in the Washington aerial survey in 2017. Approximately 43,100 acres with damage were recorded in 2019, with the highest concentrations in lowlands and foothills of west and northeast Washington. Various damage agents have been observed in WRC, including cedar bark beetles (*Phloeosinus* spp.), wood boring beetles, and root disease. These typically secondary damage agents are likely taking advantage of recent cumulative drought stress in WRC (Figure 21). There has been a significant increase in requests for information on WRC mortality from landowners and land managers.

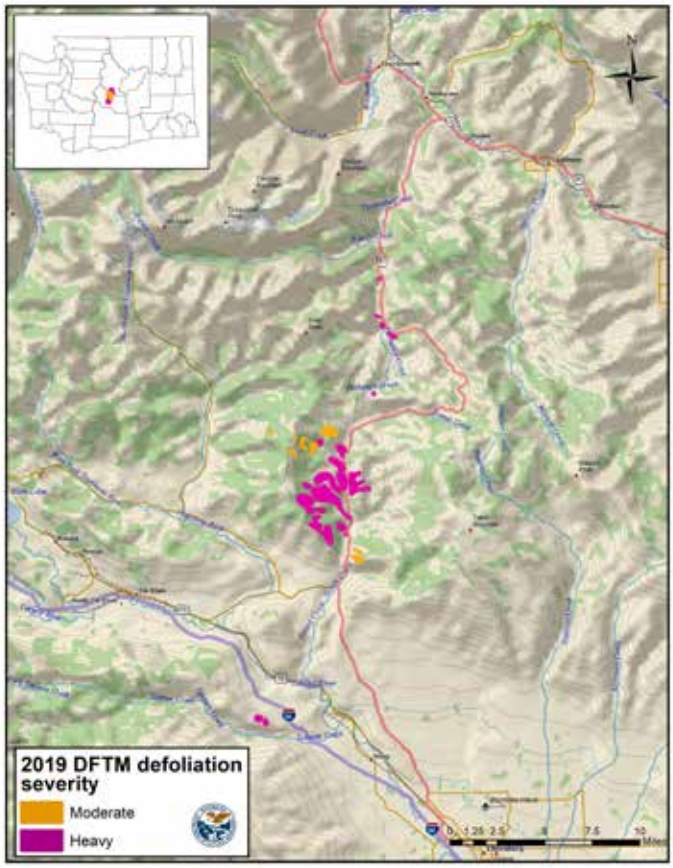
In recent years there has also been an increase in reports and observations of dead or dying western hemlock in Washington. Evidence of bark beetle activity is frequently seen on close examination of damaged western hemlock, the most important of which are the hemlock engraver (*Scolytus tsugae*), *Pseudohylesinus tsugae*, and silver fir beetle (*Pseudohylesinus sericeus*). Increases in bark beetle and generalist wood boring beetle activity in these trees is likely related to cumulative stress built up during periods of unusually hot summer droughts, most recently in the 2015 through 2019 period. Drought damaged and beetle-killed western hemlock are difficult to detect in aerial surveys because they rapidly drop needles after the crown turns red.

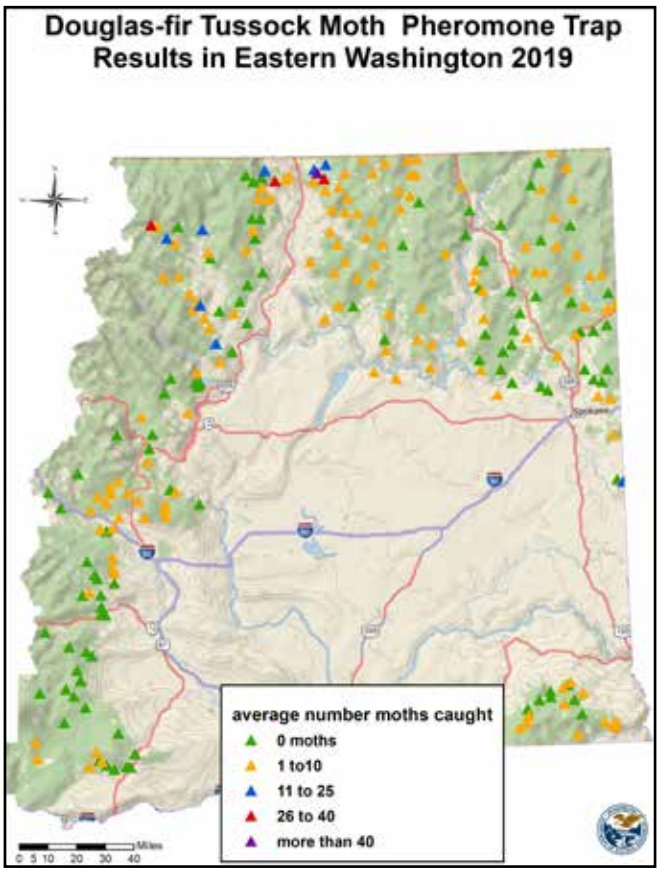
Figure 21. Damage to western redcedar from drought and *Phloeosinus* bark beetles.

Douglas-fir Tussock Moth (*Orgyia pseudotsugata* McDunnough)

A second year of Douglas-fir tussock moth (DFTM) outbreak in Kittitas and Chelan counties resulted in an increase of defoliated area from 1,900 acres in 2018 to 5,600 in 2019. New areas of defoliation totaling 5,000 acres were primarily an expansion of adjacent areas affected in 2018 along U.S. Highway 97 (Blewett Pass) and small patches south of Interstate 90 west of Ellensburg (Figure 22). This area recently experienced a decade-long outbreak of western spruce budworm, meaning stressed host trees may be more vulnerable to damage and DFTM caterpillars have less competition for food from a collapsed budworm population. Egg mass surveys and trap catches in this area indicate the outbreak has likely collapsed.

In northern Okanogan County, a new outbreak resulted in approximately 600 acres with defoliation east of the Okanogan River between Oroville and Chesaw. New egg masses were difficult to find during surveys near heavily defoliated areas in Okanogan County, so those areas are not likely to expand. New egg masses were located in one Okanogan County area with light defoliation, so some spots of increased defoliation may occur in 2020. These egg masses will be examined for levels of





Left: Figure 22. Areas with Douglas-fir tussock moth defoliation recorded by aerial survey in Chelan and Kittitas counties in 2019. Right: Figure 23. Douglas-fir tussock moth pheromone trap catch results for Washington in 2019. (Maps by Aleksandar Dozic, Washington State Department of Natural Resources)

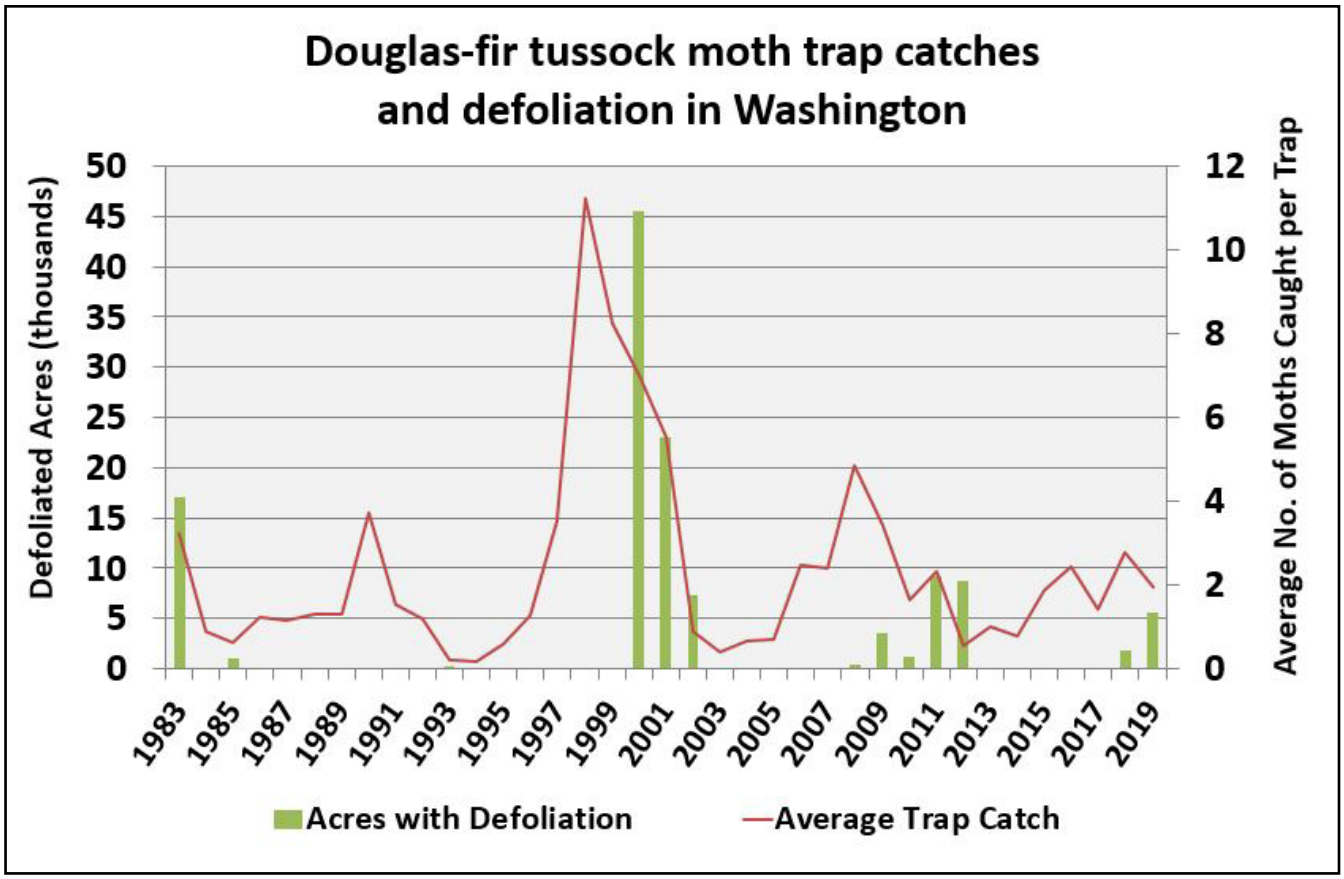


Figure 24. Douglas-fir tussock moth pheromone trap catches and observed defoliation, 1983-2019.

nucleopolyhedrosis virus (NPV) by USFS staff in Wenatchee. The NPV level in egg masses can be used to determine likelihood of natural population collapse.

The interagency network of "Early Warning System" pheromone traps at approximately 250 locations in Washington continues to be monitored annually (Figures 23 & 24). For more information on the Early Warning System, go to https://www.fs.usda.gov/detail/r6/forest-grasslandhealth/?cid=fsbdev2_027373. In 2019, trap catches increased in some areas of Okanogan County, south of Spokane, and in the Blue Mountains, which may indicate higher likelihood of DFTM defoliation developing in those areas in 2020. High trap catches do not always correlate with the location of future defoliation.

Western Spruce Budworm (*Choristoneura freemani* Razowski)

In 2019, only an approximate 1,400 acres with western spruce budworm (WSB) defoliation were recorded in Washington, primarily in northeast counties (Figure 25). This was a continued decrease from the 40,400 acres observed in 2017 and the 7,500 acres observed in 2018 and the lowest level observed in the state since 1970. Since 2012, WSB defoliation in northeast Washington has been confined to small, widespread patches around Republic, north and east of Colville, and in northeast Okanogan County. WSB pheromone traps were placed at 116 locations in northeast Washington (Figure 26). Trap results in eastern Okanogan and northern Ferry counties generally indicate patchy to light defoliation expected in 2020. Trap catches in Stevens and Pend Oreille counties remain too low to predict defoliation levels for 2020.

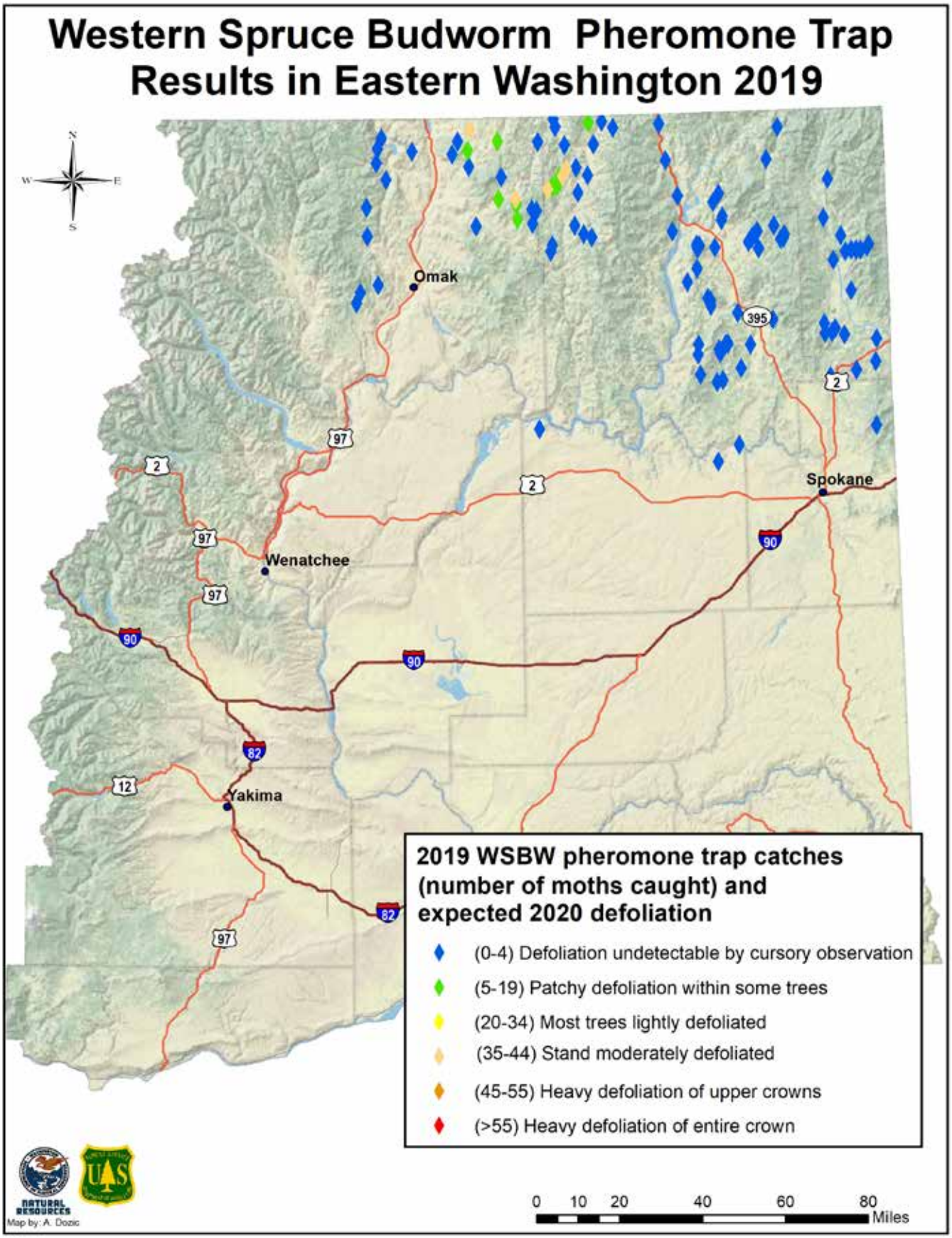


Figure 26. Western spruce budworm pheromone trap catch results for 2019 and expected 2020 defoliation. (Aleksandar Dozic, Washington State Department of Natural Resources)

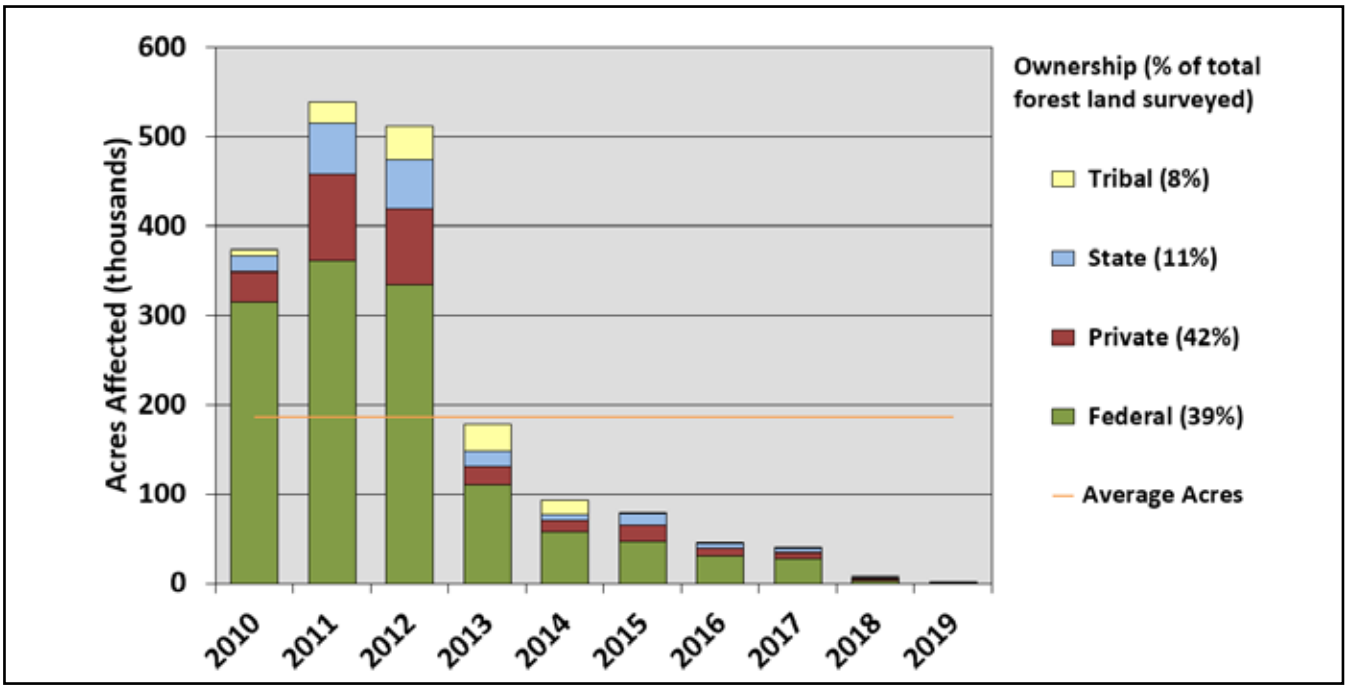


Figure 25. Ten year trend for total acres affected by western spruce budworm in Washington.

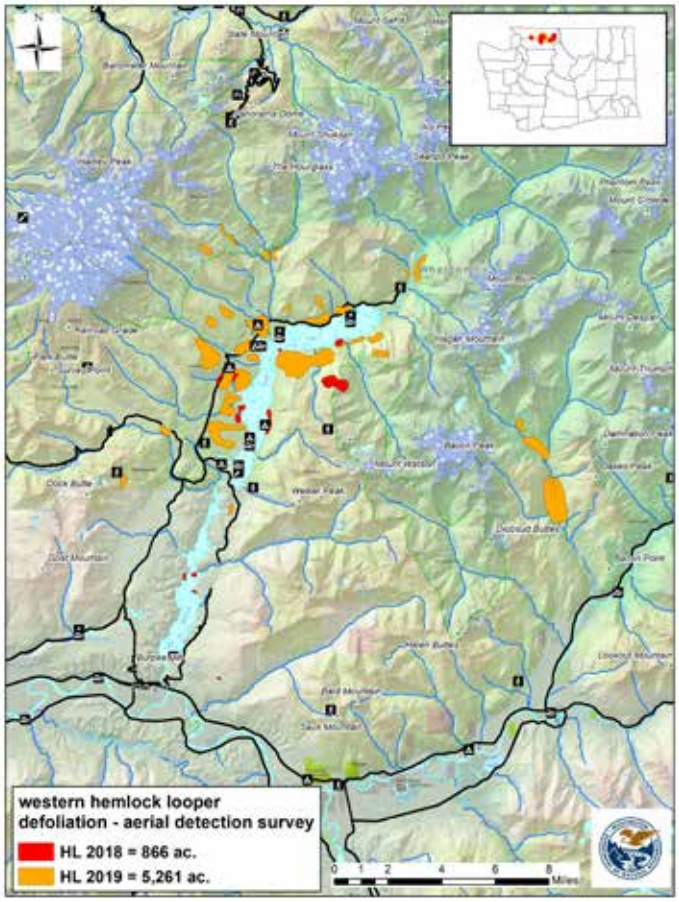
Western Hemlock Looper (*Lambdina fiscellaria lugubrosa* (Hulst))

A second year of western hemlock looper (WHL) outbreak in south Whatcom and north Skagit counties has caused defoliation on approximately 5,300 acres, an expansion from the 870 acres with WHL defoliation in the same area in 2018 (Figure 27). The majority of damage is in western hemlock and adjacent vegetation near Baker Lake in the Mt. Baker-Snoqualmie National Forest. A USFS analysis of WHL eggs collected from three Baker Lake campgrounds indicate a third year of defoliation is possible in 2020. This same area experienced a similar sized outbreak in 2011-2012.

Spruce Aphid (*Elatobium abietinum* (Walker)) NON-NATIVE

A widespread outbreak of spruce aphid along the Washington coast resulted in Sitka spruce damage on approximately 10,600 acres in 2019, this is the highest level of damage due to this pest since 1998 (12,400 acres). All coastal counties were affected but the highest concentrations of damage were around Grays Harbor, Willapa Bay, and the Longbeach Peninsula (Figure 28). Ground observations around Grays Harbor noted Sitka spruce in some areas were severely damaged and have also lost new foliage (Figure 29). The severity may be related to previous drought stress and activity of an unidentified budmoth.

Figure 29. Sitka spruce trees damaged by the non-native spruce aphid near Ocean Shores.



Left: Figure 27. Areas of western hemlock looper defoliation mapped near Baker Lake in 2018 and 2019. Right: Figure 28. Areas of spruce aphid defoliation mapped along the Washington coast in 2019. (Maps by Aleksandar Dozic, Washington State Department of Natural Resources)

Leaf Miners in Quaking Aspen and Water Birch

Approximately 21,900 acres with quaking aspen damage were mapped in eastern Washington in 2019. The damage was primarily defoliation, but also included some crown decline symptoms. Ground observations indicate the defoliation was primarily due to aspen leaf miner (*Phyllocnistis populiella*). Approximately 2,000 acres with hardwood decline (host not specified) were also observed in 2019. Some of this damage was in water birch defoliated by an unidentified leaf miner (a *Lepidoptera* possibly in the genus *Phyllonorycter*). Leaf miner larvae feed between the epidermal layers of leaves during the summer. The mined leaves

Figure 30. Leaf miner damage on a hillside in Pend Oreille County.

give aspen crowns a silvery appearance (cover photo) and birch crowns a reddish-orange appearance (Figure 30). Eventually the leaves desiccate, turn brown and drop prematurely. While leaf miner damage is mostly aesthetic, sustained annual defoliation can result in reduction in tree growth, branch dieback, and top kill, but mortality is unlikely.

Alder Flea Beetle (*Altica ambiens* LeConte)

In 2019, outbreaks of alder flea beetles caused very noticeable damage to red alders in the Puget Sound area and in some areas of southwest Washington. An unusually high number of reports from the public included descriptions of near complete alder defoliation and small black larvae in high numbers wandering onto structures. Although heavy skeletonization damage to leaves was obvious from the ground, the damage was difficult to observe from the air (Figure 31). The last reported outbreak of alder flea beetle damage was in 2013, when as many as 5,000 acres may have been affected.

Figure 31. Alder flea beetle larvae skeletonizing red alder leaves.

Larch Defoliation

Defoliation by larch needle cast (*Meria laricis*), which often appears as discolored lower crowns, was mapped on about 1,700 acres in 2019, a decrease from 4,900 acres in 2018. The most concentrated areas of damage occurred in the central and south Cascade Mountains. In 2019, discolored whole crowns of western larch, indicative of both larch needle blight (*Hypodermella laricis*) and larch casebearer (*Coleophora laricella*), were observed on 2,600 acres, similar to the 2,100 acres in 2018.

Gypsy Moth (*Lymantria dispar* Linnaeus) NON-NATIVE

In 2019, the Washington State Department of Agriculture (WSDA) deployed nearly 23,000 gypsy moth detection traps in Washington state for European gypsy moth (EGM) and Asian gypsy moth (AGM). Both European and Asian gypsy moths are a great threat to Washington's forests and urban landscapes; however, AGM feeds on a wide 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 EGM. Fourteen adult male gypsy moths were collected in 2019 and have undergone DNA analysis for determination of either Asian or European genotypes. Molecular diagnostics has identified one moth collected in a trap in Snohomish County as *Lymantria umbrosa*, Hokkaido gypsy moth (HGM); this is

the first detection of this species in the United States. HGM is considered an Asian gypsy moth and has the same female flight behavior as AGM. In their native range, HGM prefer to lay their eggs on birch and then move on to larch to feed.

WSDA conducted a gypsy moth eradication project in the spring of 2019 treating 737 acres in Kitsap County, 270 acres in King County, and 699 acres in Snohomish County with three aerial applications at each site 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/gypsy-moth/btk. WSDA is proposing aerial applications of Btk at two sites in Snohomish County in the spring of 2020: approximately 639 acres in the Boulevard Bluffs neighborhood of Everett and 672 acres in Woodway. Post-treatment high density delimitation traps will be placed in and around the treated areas for three years following the treatments.

Branch and Terminal Insects

Balsam Woolly Adelgid (*Adelges piceae* Ratzeburg)
NON-NATIVE

Balsam woolly adelgid (BWA) is a non-native sucking insect that has caused defoliation and mortality to subalpine fir, Pacific silver fir, and grand fir in Washington (Figure 32). Most of the damage visible from the air is to subalpine fir in high elevation forests. In 2019, approximately 31,000 acres of damage was observed, well above the 13,300 acres recorded in 2018. The most recent decade has

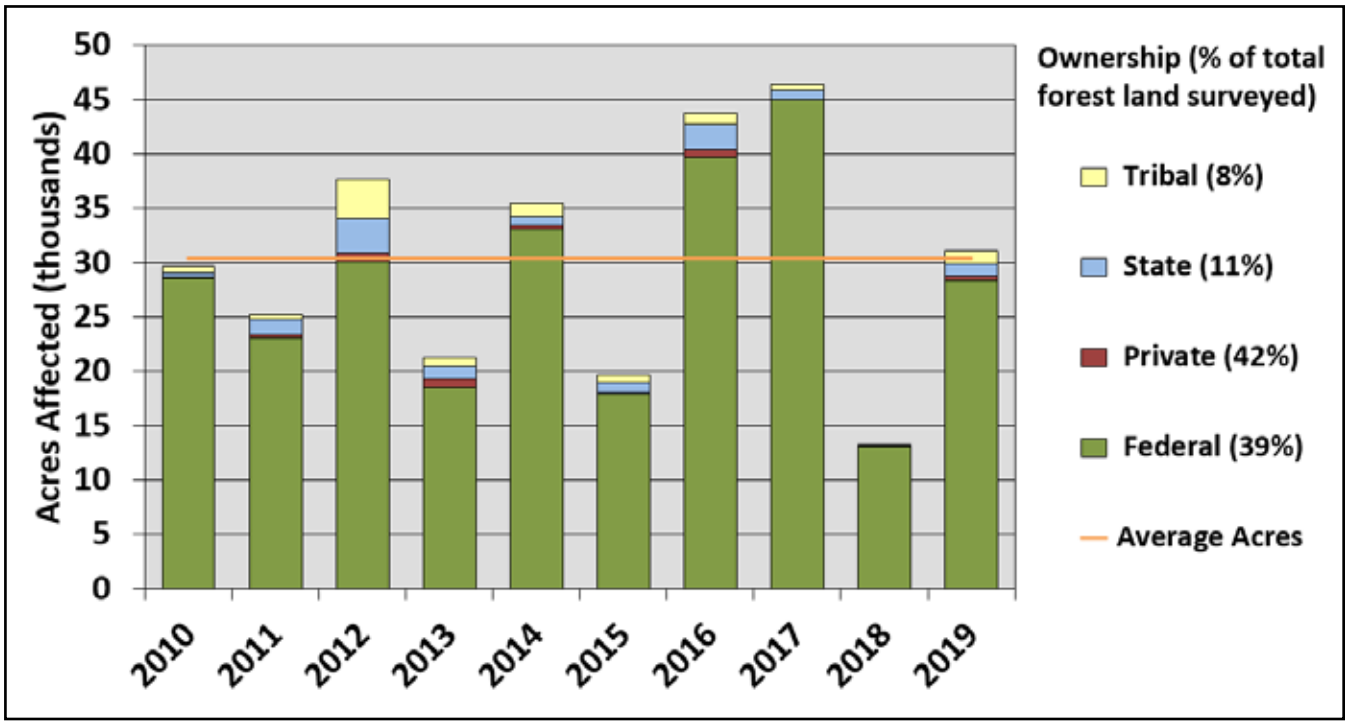


Figure 33. Ten year trend for total acres affected by balsam woolly adelgid in Washington.

averaged 30,000 acres of BWA damage per year (Figure 33). BWA damage, primarily to subalpine fir and Pacific silver fir, was recorded at high elevations in the Blue Mountains, the Olympic Mountains and in scattered areas near the crest of the Cascade Mountains and mountains of northeast Washington. There were approximately 12,000 acres with some host mortality attributed to BWA damage in 2019. Approximately 22,600 acres in these same high elevation areas were mapped with some western balsam bark beetle caused mortality in subalpine fir. BWA infestation can be a predisposing factor to western balsam bark beetle attack.

Figure 32. White, cottony ovisacs of balsam woolly adelgid on subalpine fir bark.

ANIMALS

Bear Damage

Aerial survey records scattered, pole-sized, newly dead trees as bear damage. Based on ground checking observations, 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

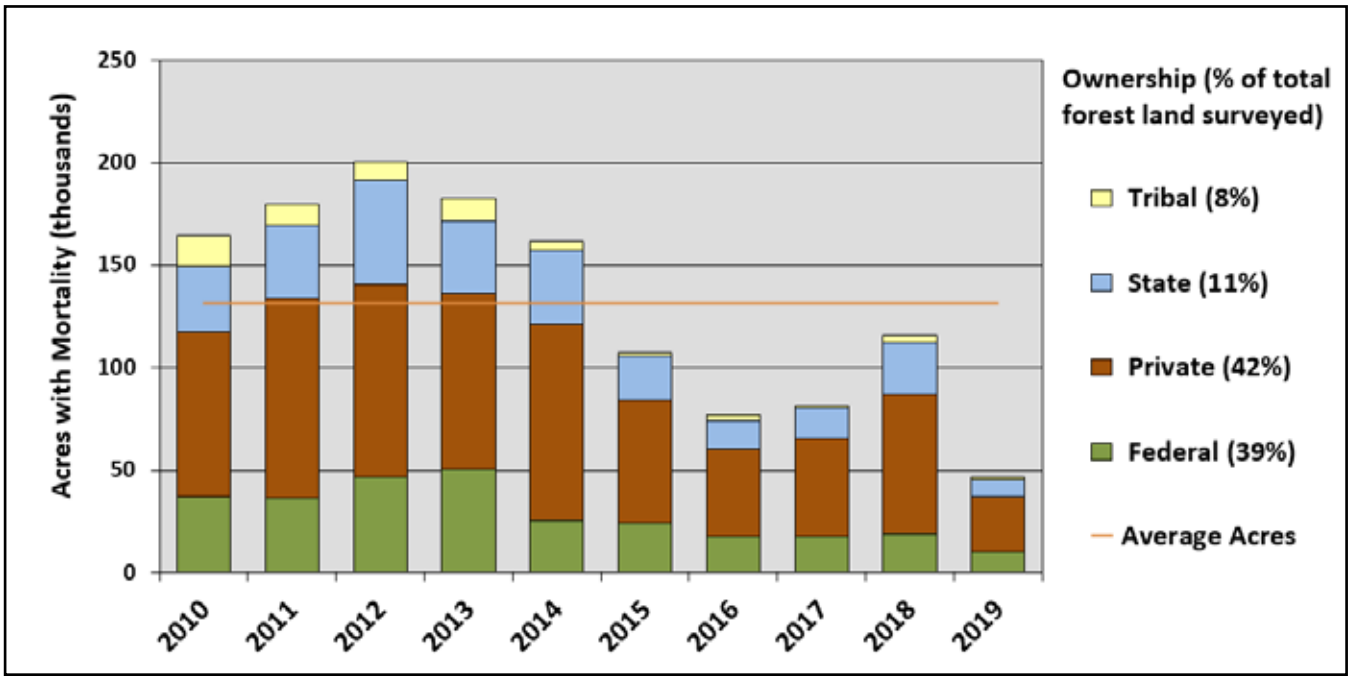


Figure 35. Ten year trend for acres affected by bear damage or root disease in Washington.

also play a role. Bears strip tree bark in spring (Figure 34).

It takes more than one year for the tree to die and needles to become red (visible from the air). In drought years, trees may fade the same year they were injured. In years with wet and cool spring conditions, the other plants 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 46,300 acres with bear damage mortality were observed in 2019, less than half the 115,300 acres mapped in 2018 (Figure 35). The 10-year average of acres with bear damage in Washington is 132,000.

Figure 34. Bark stripped from a Douglas-fir by bear activity.

DISEASES

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 other oak species in Curry County, Oregon and California. Pr can move through landscapes with wind

and wind driven rain, and can be moved long distances through transported infested nursery stock. Though western Washington remains at risk for Pr spread and Pr caused disease, due to the presence of susceptible hosts in the natural environment, suitable climatic conditions, the presence of plant nurseries with Pr infected stock and water runoff associated with contaminated nurseries, damage similar to that caused by Pr in forests of Curry County, Oregon and California has not been observed.

With funding provided by the USFS National *Phytophthora ramorum* Early Detection Survey of Forests, eleven waterways in seven counties (Chelan, King, Kitsap, Kittitas, Skagit, Snohomish, and Yakima) were surveyed for Pr in 2019 using a rhododendron leaf filled baiting bag method. Small experimental plantings of western larch (*Larix occidentalis*) in infected areas have indicated the species is at high risk for Pr infection, and other studies with western larch have demonstrated this genus can host high levels of sporulation. Therefore, waterways in natural western larch forests along the eastern slopes of the Cascade Mountains were included in this year's survey (Figure 36). Most sampled waterways in Washington are free from Pr, with the exception of the Sammamish Slough, which has regularly tested positive for Pr since its first detection in 2007 (Table 4). There are no indications that the pathogen is leaving the waterway as all vegetation samples collected in the woodlands bordering the waterway have been negative for Pr.

In July, the USDA Animal and Plant Health Inspection Service reported shipments of potentially Pr infected plants, originating from a nursery in Washington, were delivered to several Midwestern states. Lab analyses have indicated that many of the shipped plants were infected with the NA2 Pr lineage, making this the first report of the NA2 clonal lineage having been found outside of British Columbia, Washington and California. Gary Chastagner's laboratory at Washington State University, Puyallup, have been conducting steam mitigation treatments in contaminated areas at the source Washington nursery, and three rounds of baiting at seven locations have failed to detect Pr within an adjacent waterway.

Table 4. Monitoring history of streams identified by the National Early Detection Survey as positive for Phytophthora ramorum. Years with positive detections are indicated with a red square and plus sign. Years with no detection are indicated with a green square and minus sign. White squares indicate years the stream was not surveyed.

County	Waterway	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Clallam	Dungeness River									+	-	-	-			
King	Bear Creek							+	-							
King	Cottage Lake Creek								+	-						
King	Issaquah Creek										-	-	-	+		
King	Little Bear Creek							+	-							
King	Sammamish River			+	+	+	+	+	+	+	+	+	+	+	+	+
King	Woodin Creek						+	+	+							
Kitsap	Issel Creek										+	+				
Lewis	Mill Creek							+	+			-	-			
Pierce	Unnamed stream, Rosedale		+	-	+											
Thurston	Woodard Creek								-	+	-	+				
Total Positive Waterways		0	1	1	2	1	2	5	4	3	2	3	1	2	1	1
Number of Samples Taken		10	10	10	10	51	21	17	11	10	10	10	10	11	10	12

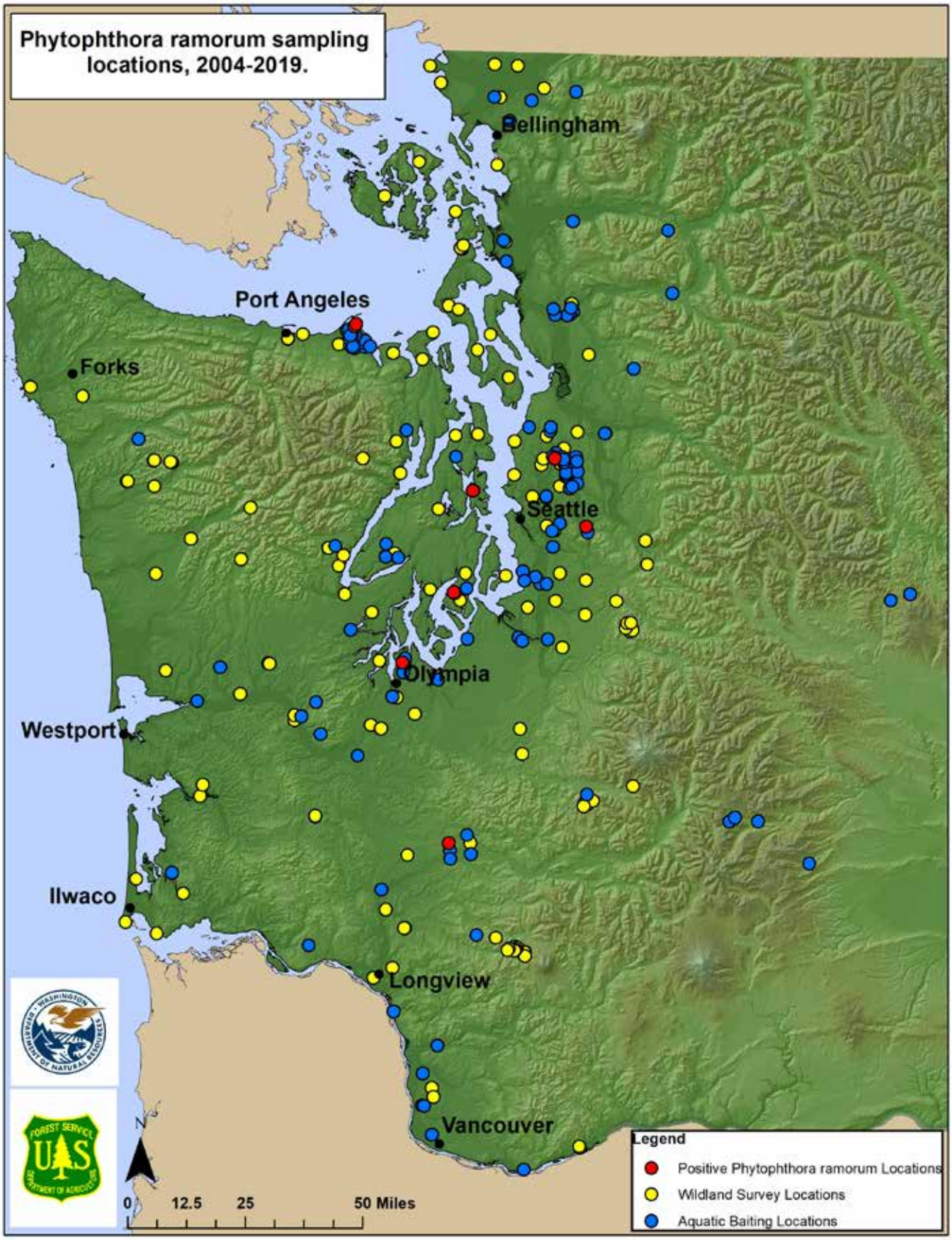


Figure 36. Washington State Department of Natural Resources *Phytophthora ramorum* monitoring, detection and survey sites, 2004-2019. (Aleksandar Dozic, Washington State Department of Natural Resources)

Root Disease Survey in Sx^{w}uytn Trail Project, Northeast Washington

The Sx^{w}uytn Trail Project is a forest and watershed restoration project that spans a 90,700-acre 20-Year Forest Health Strategic Plan priority area, including multiple land ownerships in northeast Washington (Figure 37). A recognized need for the project area is to improve forest health and resilience to reduce the further potential for insect and disease outbreaks and severe wildfires. As part of the landscape scale assessment to determine how best to manage the area to ensure a sustainable forests far into the future, the Kalispel Tribe of Indians requested a root disease survey be completed across the project area.

The survey assessed the incidence and severity of tree root disease across the forested areas of the project. Random points across four predefined vegetation classes (habitat types) were selected, surveyed for root disease and assigned a root disease severity rating (0-9). Root diseases were identified on 87% of all plots (52 out of 60) across four vegetation classes (Northern Rocky Mountain Mixed Conifer: 26 out of 26, Douglas-fir Dry: 16 out of 21, Western Redcedar and Western Hemlock: 8 out of 11, Subalpine Fir and Lodgepole Pine: 2 out of 2). Armillaria and Heterobasidion were the most common root diseases across all vegetation classes. Laminated root rot was found on only 8% (5 out of 60) of the plots, but it was causing extensive mortality (a root disease severity rating of 6.2). Where root diseases occurred, they had a substantial effect, being responsible for up to 50% canopy loss in the Douglas-fir Dry areas (a root disease severity rating of 5). Root diseases were common and damaging disturbance agents across the project area. They present serious and ongoing obstacles to achieving long-term management objectives, such as forest growth and yield, maintenance and development of old-growth structure, and wildlife habitat unless they become the focus of current and future management decisions and silvicultural prescriptions.

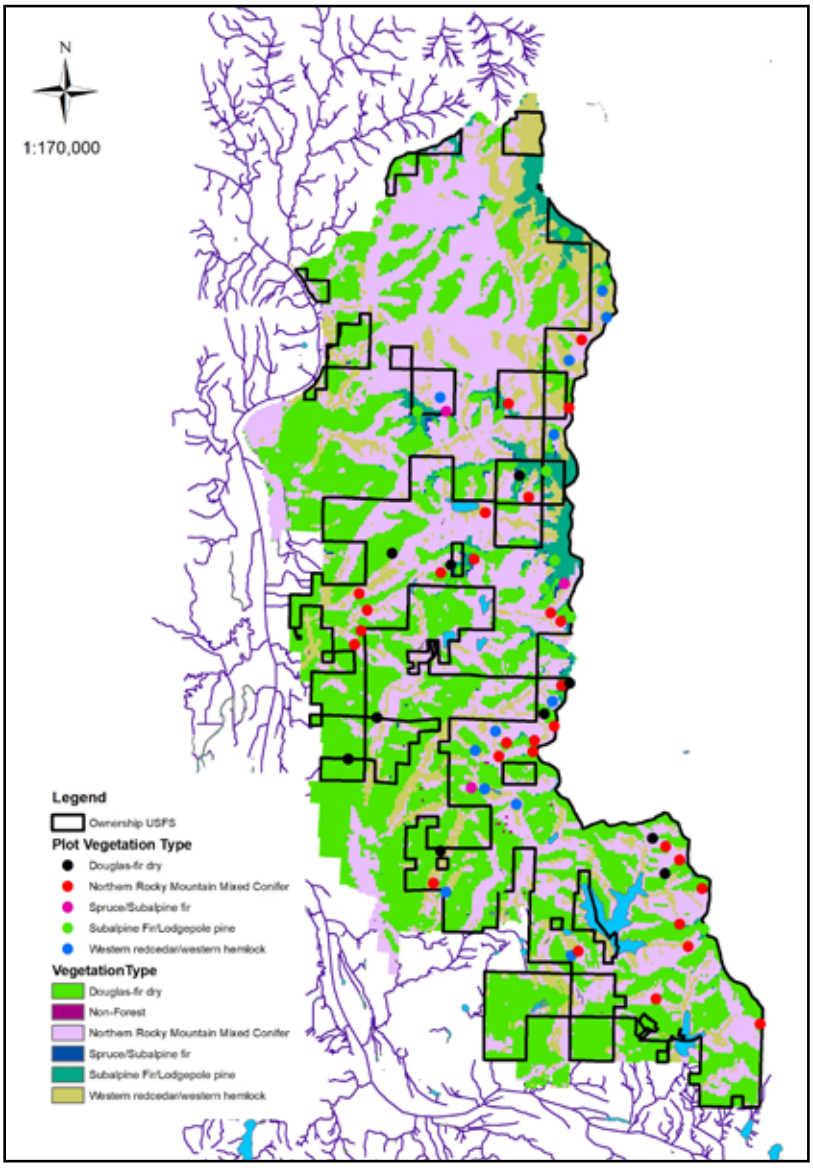


Figure 37. Trail Project area with survey points and plots overlain.

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% of the time.

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 number of trees affected. 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 at https://www.fs.fed.us/foresthealth/applied-sciences/mapping-reporting/gis-spatial-analysis/digital-mobile-sketch-mapping.shtml.

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. For more detailed information on these conversion methods, please contact the Region 6 Forest Health Protection GIS Analyst (see back cover). All 2019 ADS mortality polygons that appear on Region 6 quadrangle reporting maps and in downloadable GIS datasets (see page 39) use calculated TPA values as intensity modifiers.

Table 5. Percent of treed area affected classes used for aerial detection survey damage polygons

Percent-class code	Class name (value range)
1	Very Light (1-3%)
2	Light (4-10%)
3	Moderate (11-29%)
4	Severe (30-50%)
5	Very Severe (>50%)

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 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.

Interactive Map Tools

Annual aerial survey data from 2011 through the most current year and the 15-year cumulative mortality data product are available from DNR's interactive, web-based mapping site: "Fire Prevention and Fuels Management Mapping" at https://fmanfire.dnr.wa.gov/default.aspx. On the left side of the page, click on "Forest Health", select "Annual Aerial Survey Data" and the year of interest, then check boxes for type of damage to be displayed. Click on polygons to display agent and intensity. Various basemaps and background layers can be added. Zoom to an area of interest and click the printer icon in the upper right to create a pdf or image file of your map.

An Aerial Survey Highlights story map for the most current year in Oregon and Washington can be viewed at https://arcg.is/1m9Dbv. Scroll through the panel on the left to read short summaries and view trend charts and photos for specific damage agents. Damage polygons for some agents are displayed on the adjoining map.

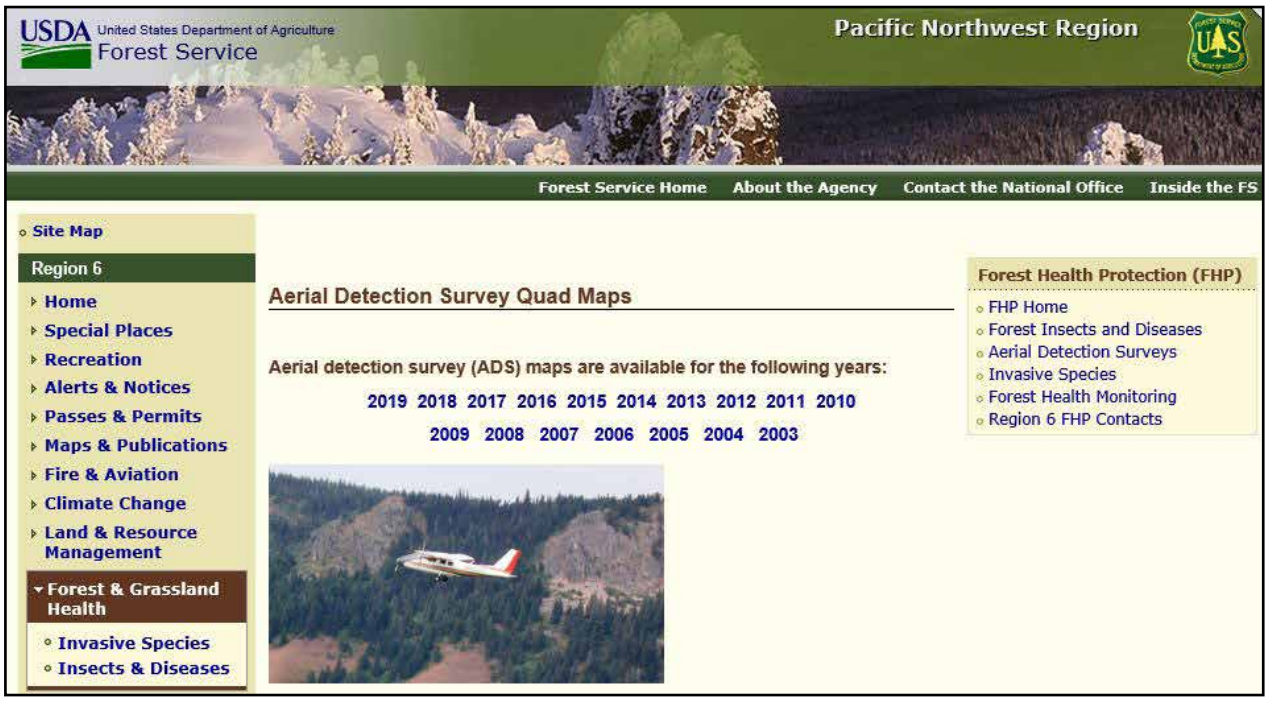


Figure 38. Aerial survey maps and data on USFS Region 6 Forest Health Protection website: www.fs.usda.gov/goto/r6/fhp/ads/maps.

Customized electronic maps (PDF, JPG, etc.) of draft data can be created with a variety of background layers from the "USFS R6 Forest Health ADS Map" at https://arcg.is/0C9aaP. Zoom in to the area of interest, click the printer icon, select the type of output you need, click 'print' and it will generate a file. Output PDFs are georeferenced for use in PDF viewer apps on mobile devices.

Electronic PDF Maps Available for Download

Traditional insect and disease survey quadrangle maps from 2003 to 2019 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 (Figure 38). Simply click 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, trees per acre 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.

GIS Data Available for Download

DNR also maintains downloadable GIS datasets, including aerial survey data for Washington state from 1980 to 2018, known as "Forest Health Aerial Survey 1980-2018" at http://data-wadnr.opendata.arcgis.com under "Forest Disturbance."

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, 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 and Hawaii and the Pacific Islands are available at www.fs.usda.gov/goto/r6/fhp/highlights.

Major insect and disease identification and management information, illustrations, and graphical trend analysis of Pacific Northwest forest health issues are available at https://www.fs.usda.gov/main/r6/forest-grasslandhealth.

FOREST HEALTH CONTACTS

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

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