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Forest Health Highlights in Washington - 2018

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FOREST HEALTH HIGHLIGHTS IN WASHINGTON - 2018

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Front cover photo: Fourth instar Douglas-fir tussock moth larvae feeding on grand fir foliage.

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SUMMARY

The 2018 aerial detection survey (ADS) was completed for over 22 million acres of forest lands within Washington, covering a variety of ownerships. In 2018 ADS recorded some level of tree mortality, tree defoliation, or foliar diseases on approximately 469,000 acres. This is similar to the 512,000 acres with damage in 2017. The area with mortality attributed to bark beetles was approximately 235,000 acres and 115,000 acres with mortality were due to bear damage or root disease. Relative to 2017, tree mortality decreased for all major bark beetle species except fir engraver. The area with conifer defoliation was approximately 28,200 acres, primarily caused by balsam woolly adelgid and western spruce budworm. Approximately 16,300 acres had some level of disease damage, primarily larch needle cast and bigleaf maple decline. 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:

2017: 512,000 acres **2016:** 407,000 acres **2015:** 338,000 acres **2014:** 543,000 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. Precipitation in Washington was below normal during summer and fall 2018, but above normal in spring. Monthly average temperatures were above normal during the summer and near normal in spring and fall. According to the US Drought Monitor, from mid-July through October in 2018, southeast Washington was in severe drought condition and the rest of the state was either in moderate drought or abnormally dry condition.

The approximately 120,000 acres with **pine bark beetle** activity recorded in 2018 was a decrease from the 191,000 acres in 2017. The most significant increases occurred in northern Ferry County, eastern Okanogan County, and Chelan County. **Mountain pine beetle** damage increased to approximately 101,300 acres but is still below the ten-year average of 158,000 acres. Mortality of Ponderosa pines due to **western pine beetle** decreased to approximately 16,700 acres, but after 2017, remains the second highest level in ten years. **Fir engraver** caused mortality in true firs (Abies species) was recorded on approximately 71,200 acres in 2018, the highest level since 2009. Recent drought conditions and effects of past defoliation by western spruce budworm are likely drivers of the increase.

An outbreak of **Douglas-fir tussock moth** (DFTM) has caused severe defoliation on approximately 1,900 acres in Kittitas and Chelan counties. This is the first observation of DFTM defoliation in Washington since 2012 and the first in Kittitas County since aerial surveys began in 1947. **Western spruce budworm** defoliation, primarily in northeast Washington counties, decreased significantly to approximately 7,500 acres, which is the lowest level observed in the state since 1970. A new outbreak of **western hemlock looper** has caused light to moderate intensity defoliation on approximately 870 acres in south Whatcom and north Skagit counties. This area experienced a similar sized outbreak in 2011-2012.

Larch needle cast (Meria laricis) damage in western larch was observed on approximately 4,900 acres, primarily in the central and south Cascade Mountains. Crown discoloration and **dieback in bigleaf maple** was observed on approximately 6,100 acres, primarily in lowlands of southwest Washington and in the south Puget Sound area.

2018 WEATHER AND DROUGHT CONDITIONS

Precipitation

The statewide annual precipitation average for 2018 was 41.24". This is 0.79" less than the 1901-2000 mean of 42.03" and falls in the range of normal statewide annual average precipitation. However, seasonal below normal precipitation was observed in summer and fall 2018.

For most climate divisions across the state, January to March precipitation was near normal with only slightly above average values recorded for the San Juan Islands, Olympic rain shadow (Sequim, Port Ludlow, Whidbey Island, Anacortes), the Okanogan Highlands, and northeastern counties of Ferry, Stevens, Pend Orielle, and northern Spokane (Table 1). April to June experienced widespread above average precipitation values owing mostly to an extremely wet April (the 3rd wettest on record). During the summer period, frequent high-pressure systems yielded warm, dry conditions that resulted in seasonal drought concerns across most climate divisions. The effects were greatest east of the Cascade crest with all five climate divisions reporting large deficits between -0.96" and -2.12" of normal. The east slopes, Okanogan and Big Bend region, and northeastern counties average precipitation values for June to September fell in the top 10% driest conditions on record,

Table 1. 2018 observed (Obs.) and departure from normal (Dept.) average precipitation values (in inches) for all Washington climate divisions. Departure values are the difference from the 20th century average. "Normal" is defined as those values that fall between 33% above or below the 1901-2000 mean. "Slightly drier or wetter" values fall between 33-66% above or below the mean, and "much drier or wetter" values fall between 66-99% of the mean. Record values represent the maximum and minimum outliers in the range of observed values.

	Jan.-March		April-June		July-Sept.		Oct.-Dec.		Annual	
	Obs.	Dept.	Obs.	Dept.	Obs.	Dept.	Obs.	Dept.	Obs.	Dept.
W. Olympics Coastal	36.81	-3.70	18.63	+3.14	7.01	-1.82	45.13	+1.69	107.58	-0.68
NE Olympic San Juans	11.24	+2.43	5.42	+0.58	2.44	-0.96	10.81	+0.10	29.91	+2.14
Puget Sound Lowlands	16.32	+1.53	8.17	+0.92	3.03	-1.44	16.27	-0.54	43.79	+0.47
E. Olympics Cascade Foothills	27.54	+0.95	12.93	+1.24	4.43	-2.08	27.91	-1.09	72.81	-0.98
West Slopes Cascades	33.54	+1.56	13.96	+1.07	4.50	-2.71	33.60	-0.67	85.60	-0.75
East Slopes Cascades	13.99	+0.09	6.09	+0.74	1.07	-1.85	13.42	-1.37	34.57	-2.39
Okanogan Big Bend	5.20	+1.38	3.41	+0.25	0.29	-1.43	4.15	-0.28	13.05	-0.08
Central Basin	3.12	-0.18	2.48	+0.40	0.06	-0.96	3.45	-0.31	9.11	-1.05
Northeastern	8.67	+2.14	6.43	+0.94	1.02	-2.12	7.39	+0.15	23.51	+1.10
Palouse Blue Mountains	6.07	-0.10	5.42	+0.78	0.40	-1.86	5.63	-0.96	17.52	-2.14

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

while the Columbia Basin, Palouse Prairie, and Blue Mountains experienced record dry conditions. In late September, the upper-air pattern changed towards more transient low-pressure systems, bringing on cooler, wetter fall-like conditions that persisted through October. In November, only 40-70% of normal precipitation was recorded, putting a damper on October to December precipitation averages. December was about normal to slightly above normal for most divisions.

In all, 2018 balanced out to be a fairly normal year (53rd driest year on record, measured since 1895) for precipitation, but should be considered much drier compared to last year's statewide precipitation average of 48.73" (a difference of 7.49"). When compared to the last ten years of annual precipitation values for Washington (Table 2), 2018 is the closest to the historical mean and one of four normal years during the period.

Table 2. Annual average precipitation values, anomalies from the historic average, and climatological rankings for Washington state (2009 – 2018)

Year	Annual Avg. Precipitation	Anomaly from 1901-2000 mean	Climatological Ranking
2018	41.24	-0.79	Normal
2017	48.73	+6.70	Slightly wetter
2016	49.14	+7.11	Slightly wetter
2015	43.25	+1.22	Normal
2014	48.80	+6.67	Slightly wetter
2013	35.68	-6.35	Slightly drier
2012	52.87	+10.84	Much wetter
2011	43.82	+1.79	Normal
2010	47.32	+5.29	Slightly wetter
2009	39.90	-2.13	Normal

Temperature

The average annual temperature across Washington was 48.0°F in 2018. This is 1.9°F warmer than the 20th century average of 46.1°F and 1.2°F warmer than 2017. 2018 was 2.0°F cooler than 2015, the warmest year on record.

As shown in Table 3, above normal temperatures were recorded across all climate divisions during each season in 2018. January was extremely warm, with a statewide average temperature of 35.3°F or 6.9°F above normal (or the 1901-2000 mean). February and March saw a return to normal temperatures and several weeks of below average temperatures leading to only slightly above average warmth for the first three months of 2018. Near normal conditions persisted through late April but were replaced by above normal temperatures in May, which ended up being the second hottest May on record for Washington. The summer period of July to September was also fairly warm with all climate divisions seeing temperature anomalies of +1.0°F or higher. The entirety of western Washington experienced much warmer conditions than normal (about 2.0°F to 3.2°F) during this same period. Largely, this warmth (and the simultaneous precipitation drought mentioned previously) can be attributed to stagnant, high-pressure conditions aloft that were present for much of the summer. October to December was again slightly warmer than normal across all climate

Table 3. 2018 observed (Obs.) and departure from normal (Dept.) average temperature values (in Fahrenheit) for all Washington climate divisions. Departure values are the difference from the 20th century average. "Normal" is defined as those values that fall between 33% above or below the 1901-2000 mean. "Slightly warmer or cooler" values fall between 33-66% above or below the mean, and "much warmer or cooler" values fall between 66-99% of the mean. Record values represent the maximum and minimum outliers in the range of observed values.

	Jan.-March		April-June		July-Sept.		Oct.-Dec.		Annual	
	Obs.	Dept.	Obs.	Dept.	Obs.	Dept.	Obs.	Dept.	Obs.	Dept.
W. Olympics Coastal	40.3	+0.9	52.2	+2.0	60.2	+1.9	45.0	+1.6	49.9	+1.6
NE Olympic San Juans	42.1	+1.2	55.3	+2.5	62.8	+3.2	47.0	+2.3	51.8	+2.3
Puget Sound Lowlands	41.9	+1.0	55.7	+2.0	64.0	+2.7	46.1	+1.4	51.9	+1.8
E. Olympics Cascade Foothills	38.9	+1.2	52.9	+2.1	62.1	+2.5	43.5	+1.6	49.4	+1.8
West Slopes Cascades	32.6	+1.6	48.0	+2.2	58.4	+2.3	37.8	+1.9	44.2	+2.0
East Slopes Cascades	30.7	+2.5	49.2	+2.3	59.7	+2.0	35.3	+1.9	43.7	+2.2
Okanogan Big Bend	32.8	+2.2	55.9	+1.6	66.1	+1.1	37.6	+1.4	48.1	+1.6
Central Basin	38.6	+3.5	59.5	+2.3	68.9	+1.3	41.2	+1.5	52.0	+2.2
Northeastern	30.2	+2.3	52.1	+1.7	62.2	+1.3	35.1	+1.8	44.9	+1.8
Palouse Blue Mountains	36.2	+2.6	55.8	+2.6	65.9	+1.8	39.9	+1.3	49.4	+2.1

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

Table 4. Annual average temperature values, anomalies from the historic average, and climatological rankings for Washington state (2009 – 2018)

Year	Annual Avg. Temperature	Anomaly from 1901-2000 mean	Climatological Ranking
2018	48.0	+1.9	Much warmer
2017	46.8	+0.7	Normal
2016	48.6	+2.4	Much warmer
2015	50.0	+3.8	Record warmest
2014	48.4	+2.2	Much warmer
2013	47.2	+1.0	Slightly warmer
2012	47.1	+0.9	Slightly warmer
2011	45.5	-0.6	Slightly cooler
2010	47.1	+1.0	Slightly warmer
2009	46.4	+0.2	Normal

divisions. 2018 was the 12th warmest year on record and much warmer than 2017. When examining the last ten years of annual average temperature values for Washington (Table 4), 2018 was the fourth warmest but still 2.0°F cooler than the record average temperature of 50°F set in 2015. Seven of the last ten years have been warmer than normal.

Snowpack

Snow water equivalent (SWE) is a useful snowpack measurement 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 to the most recent climatology from 1981 – 2010.

SWE values on 1 January 2018 were about 96.5% of normal across the state or about 21.9% less than the same date in 2017. Mostly, below average snowpack was present across the Central and Southern Cascades with above average snowpack extending along the Canadian border from the North Cascades to Stevens County. From February to April, cooler average temperatures allowed for more precipitation to fall as snow in mountainous regions, leading to widespread above average snowpack and a statewide average that was 125% of normal on 1 May 2018. By 1 June, most areas were trending below normal, especially in the Cascades where May temperatures had been 5-10°F warmer than average and precipitation only 30-70% of normal. Snowpack continued to melt through low- to mid-elevation zones during June and by 1 July, snow was only recorded in the North Cascades, Mount Rainier area, and portions of the Southern Cascades. When compared to the previous few years of SWE departures values, 2018 was a slight below normal year (statewide departure from normal was 86.5% on 1 June 2018), much lower than 2017 (142.7%) but still higher than both 2016 (41.9%) and 2015 (7.7%).

Drought

At the start of 2018, there were no drought concerns statewide. Normal to above normal precipitation across much of the state kept really any drought concerns from developing until the first week of June when the U.S. Drought Monitor classified the western half of the state as 'abnormally dry'. By the beginning of July, this was expanded this to include the southern Cascades and portions of the Columbia Basin. Through the summer, persistent above average temperatures and much below normal precipitation totals gradually resulted in the entirety of the state being listed as experiencing some form of drought. By mid-September, 17.3% of the state was experiencing severe drought, 42.8% experiencing moderate drought, and 39.8% experiencing abnormally dry conditions. Interestingly, the worst drought conditions were experienced in southwestern counties, especially Lewis, Pacific, Clark, Wahkiakum, Cowlitz, and Skamania and not in the Columbia Basin or Palouse, although there were some season effects on grass and agricultural lands. Drought concerns gradually relaxed towards October as the dominant summer high-pressure conditions yielded in favor of more transient, cooler and moister systems. However, by the end of 2018, approximately 72% of the state was still experiencing slight to moderate drought. This included moderate concerns for the Okanogan Highlands, southern Cascades, Columbia Gorge, and the lower Columbia Basin extending into the Blue Mountains as well as slight drought conditions elsewhere east of the Cascade crest and minor portions of the Pierce, Thurston, and Lewis Counties.

Wind and Icing Events

Severe thunderstorms on June 25 in the Republic area of northern Ferry County resulted in scattered areas with numerous large-diameter wind-thrown trees, road closures, and property damage. Otherwise, there were no major windstorms or icing events to report for 2018. No significant or widespread damage to forestlands was reported or identified. Localized damage from these types of events may have occurred.

WILDFIRE

According to data compiled by the Northwest Coordination Center (NWCC) and Washington State Department of Natural Resources (DNR), wildfires burned 438,834 acres in Washington during the 2018 fire season which spanned April to October (Fig. 1). This total acres burned amount is considered an above-average wildfire season that is slightly higher than last year with nearly 60,000 (13%) more acres burned compared to last season (2017 – 381,000 acres). There was a total of 1,744 fires during 2018, of which 67 were considered "large fires" per the NW Coordinating Group (NWCG) defi-

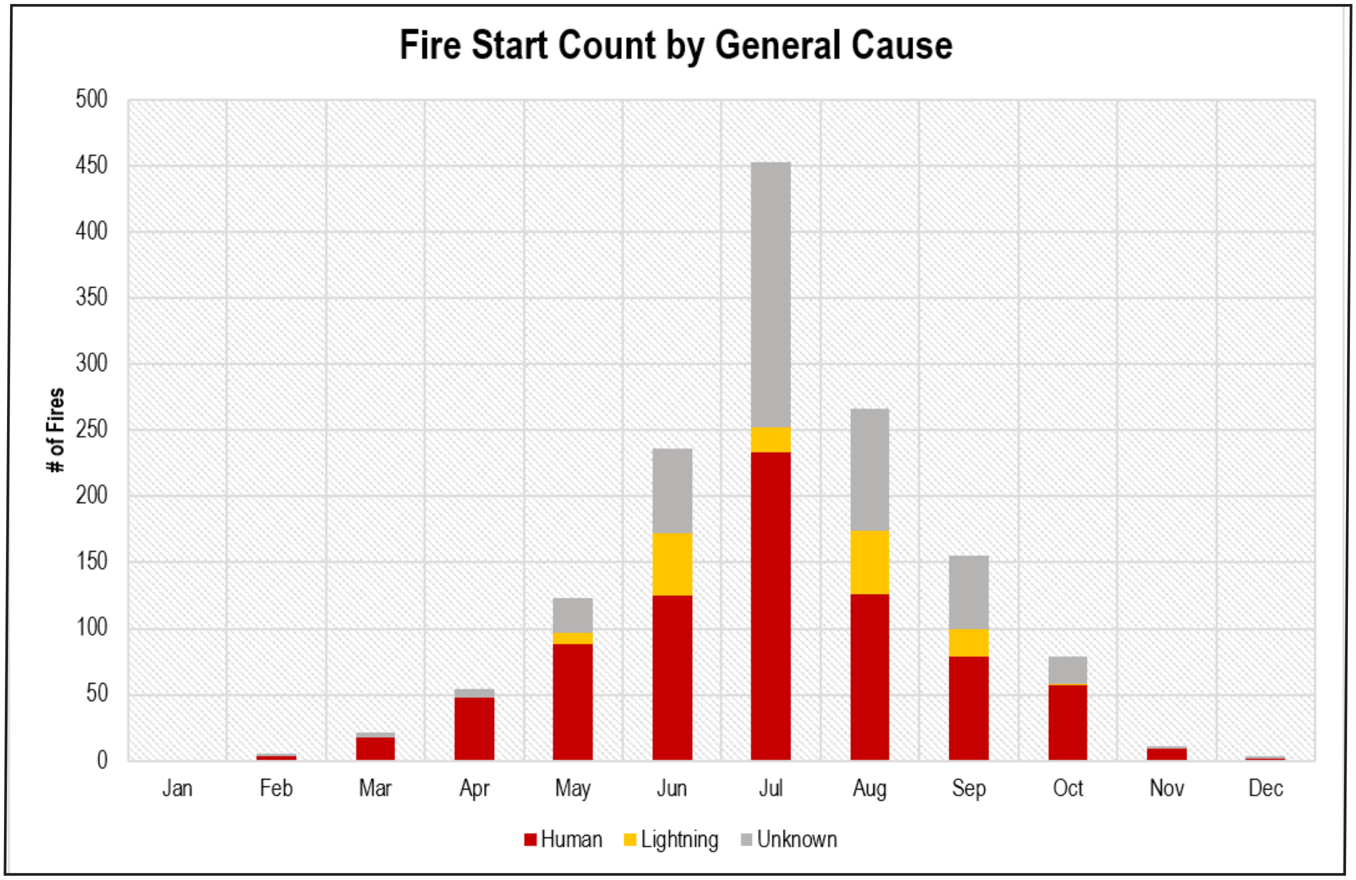


Figure 1. Number of fire starts by month in 2018 in Washington.

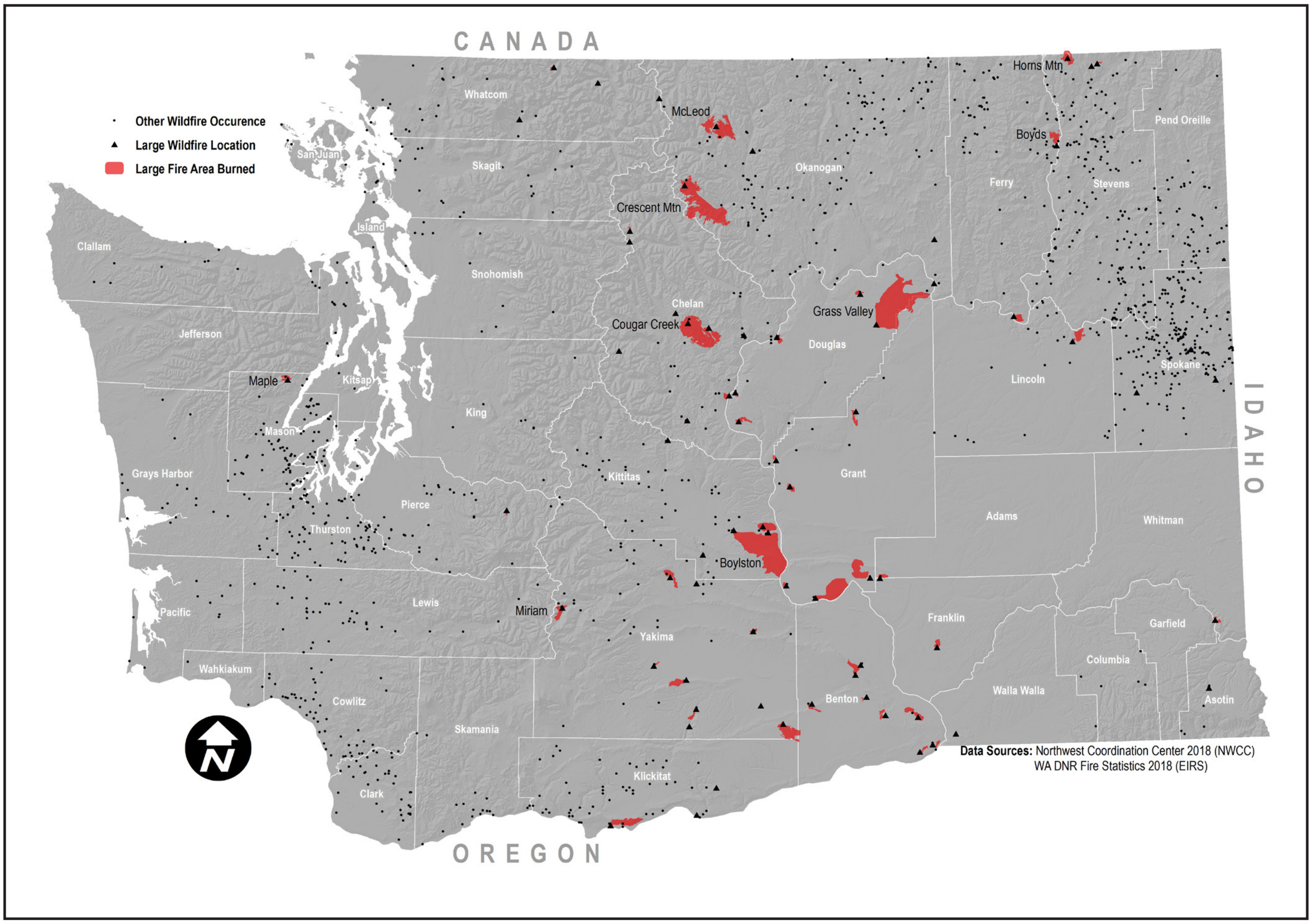


Figure 2. Location of wildfires that occurred in Washington in 2018. (Map by Kirk Davis, Washington State Department of Natural Resources)

nition of having burned greater than 100 acres of forestland or 300 acres of brush/grasses (Fig. 2). This is an increase of 10 large fires (~15% more) from last year.

The average large fire size for 2018 was approximately 6,300 acres, which is a reduction in roughly 800 acres from last year, but with an increase in fire occurrence this number is expected to be lower than the previous year. Estimates for the wildfire causes in 2018 were 10% caused by lightning, 34% undetermined, and the remaining 56% human-caused. Estimates for large fire fuel types burned were 45% grassland, 24% timber, 23% shrub-steppe, and 8% other (i.e. agricultural lands, urban areas).

The two largest wildfires during the 2018 season were the Grass Valley fire (started on Aug. 11th burned 75,573 acres) and Boylston fire (started on July 19th burning 71,200 acres); combined they represent exactly one-third of the total area burned for the year. These two fires were fairly similar; both burned primarily in brush or grasses and were controlled or contained within 5 days. The next three largest wildfires occurred in the Okanogan-Wenatchee National Forest: the Crescent Mountain (52,609 acres), Cougar Creek (42,712 acres), and McLeod (24,411 acres) fires, all of which were caused by lightning, burned in timber fuel types, and continued to burn late into the fall season. One other notable large wildfire for the 2018 season was the Maple fire (3,312 acres) which burned in the Olympic National Forest in western WA and represents the largest wildfire on the Olympic Peninsula in at least 10 years.

AERIAL DETECTION SURVEY

Methods

The annual insect and disease aerial detection survey (ADS) in Washington was conducted by the USDA Forest Service (USFS) in cooperation with WDNR. 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 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 sketchmapping experience. If more than one agent is present in a polygon, codes are separated by an exclamation point (!). When interpreting data and maps, 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.

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.

New "percent-class" method for recording damage intensity

2018 was the first year observers adopted new federal ADS data collection standards and use of new software and digital mobile sketch mapping (DMSM) tablets in Washington State. When observers record a point of damage (area less than 2 acres), they assign an estimate of number of trees affected, as was done in previous years. However, observers are no longer assigning ADS polygons estimates of trees per acre (TPA) affected as a measure of damage intensity. Damage polygons are now assigned a **"percent-class"** value representing one of five different ranges of **percent of treed area affected** (Table 5). This change applies to mortality agents only. Defoliation polygons are assigned values for intensity of within-crown defoliation (L-Light, M-Moderate, H-Heavy) that were used in previous years. 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 (Fig. 3). This method equates a single large-crowned tree with a similar canopy area of tightly spaced small-crowned trees. Using percent-classes increases the likelihood that an observer will choose an accurate intensity value, increases consistency between observers, and improves potential comparisons with other remote sensing technologies. More information on DMSM and percent-class methods 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 TPA data from previous years. 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 2018, USFS Region 6 (Oregon and Washington) converted all the percent-class polygons 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 page 39). Converted TPA data was used for the change in tree mortality map on page 12. All 2018 ADS mortality polygons that appear on Region 6 quadrangle reporting maps and in downloadable GIS datasets (see page 38) use calculated TPA values as intensity modifiers. As in previous years, points still display number of damaged trees observed and defoliation polygons still display within-crown defoliation modifiers (L-Light, M-Moderate, H-Heavy).

Table 5. Percent of treed area affected classes used for ADS 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%)

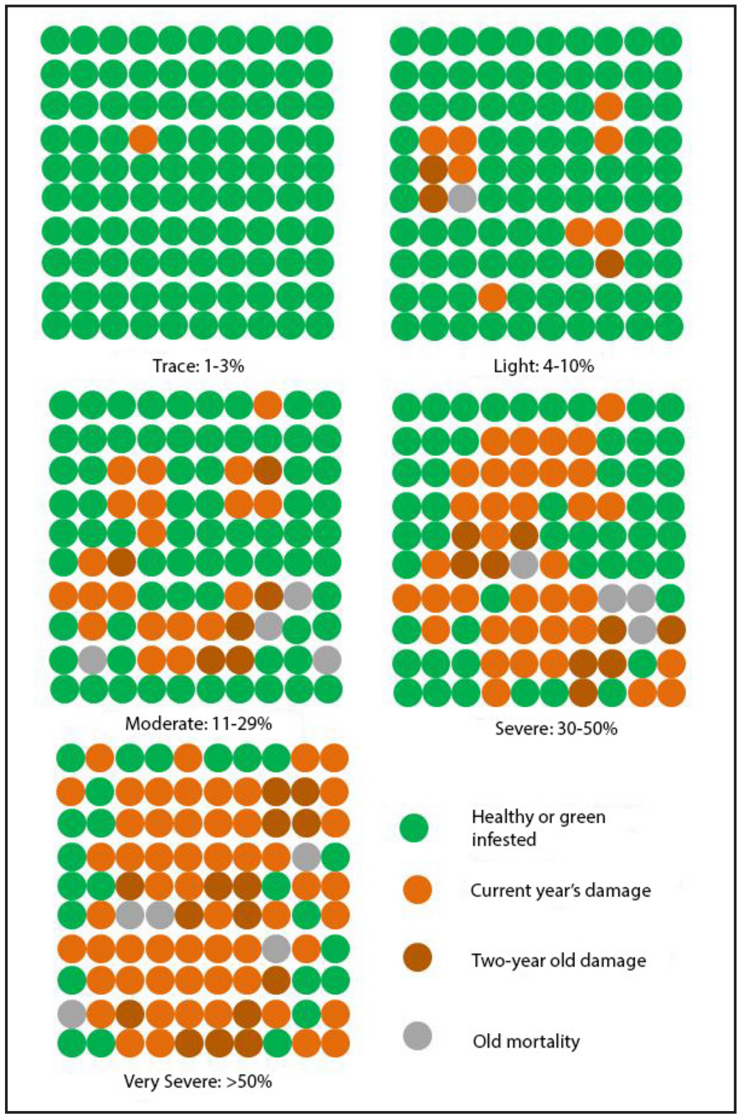


Figure 3. Representation of five damage intensity percent-classes used in aerial detection survey. Values represent the percent of current year's recently killed or currently defoliated trees in relation to the total forested acres within the polygon.

2018 Aerial Survey Conditions

Smoky conditions and temporary flight restrictions around active wildfires in 2018 prevented observers from conducting any flights for a month from early August to early September. Fortunately, due to earlier than normal onset of damage signatures, observers were able to cover a majority of the survey area prior to the onset of poor visibility in eastern Washington. Improved visibility, favorable weather, and fewer flight restrictions allowed observers to complete the survey by the end of September (Fig. 4). Approximately 50,000 acres were not flown in the footprints of two large 2017 wildfires: the Diamond Creek fire in north central Washington along the Canadian border and the Norse Peak fire east of Mt. Rainier.

Areas burned by wildfire are not mapped until the second year following the fire because fire-related mortality cannot be distinguished from other types of damage from the air. Persistent wildfire smoke during September flights in Chelan, Okanogan, and Ferry counties likely reduced the amount of visible defoliation signatures recorded in the these areas.

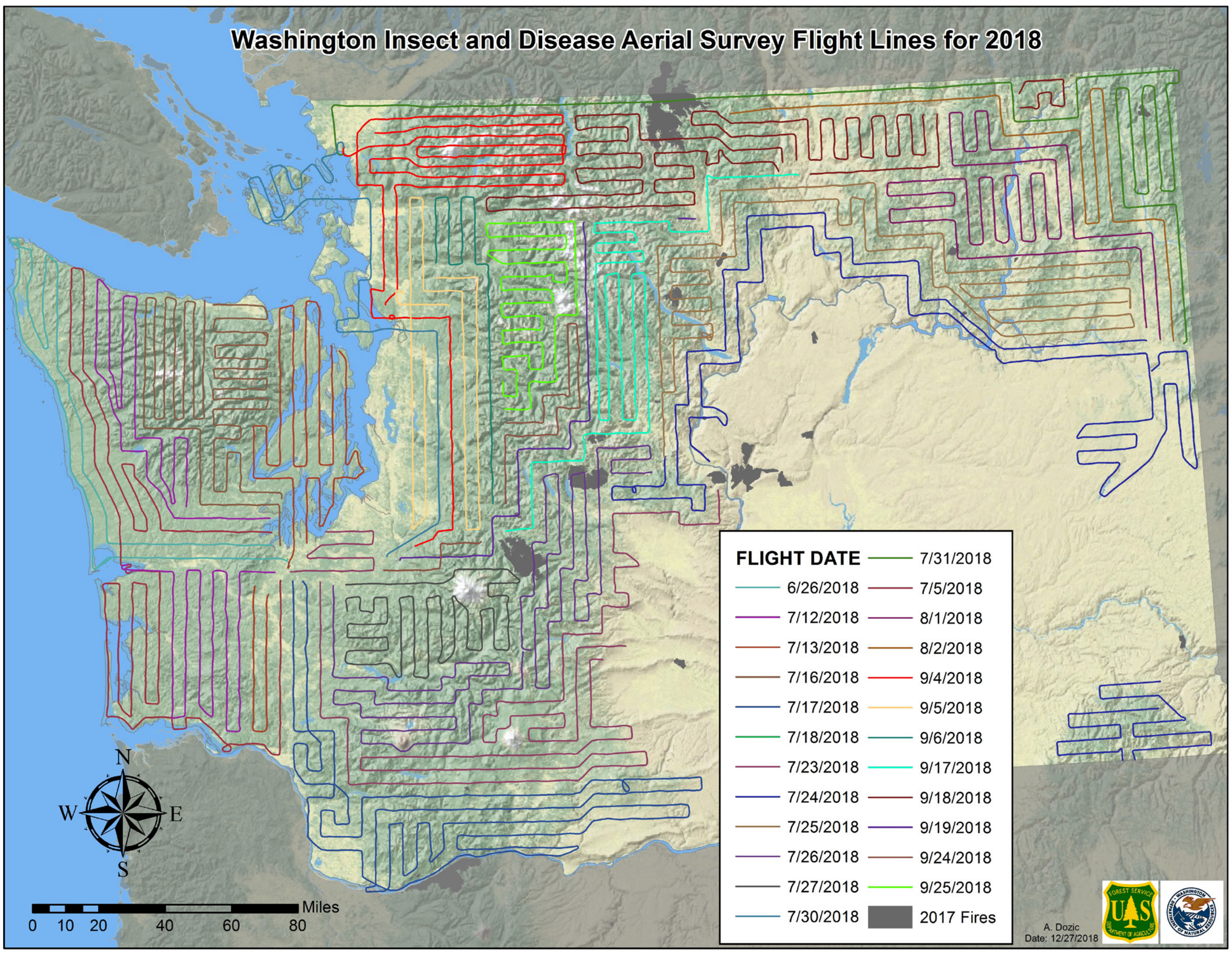


Figure 4. Washington insect and disease aerial survey flight lines for 2018. (Map by Aleksandar Dozic, Washington State Department of Natural Resources)

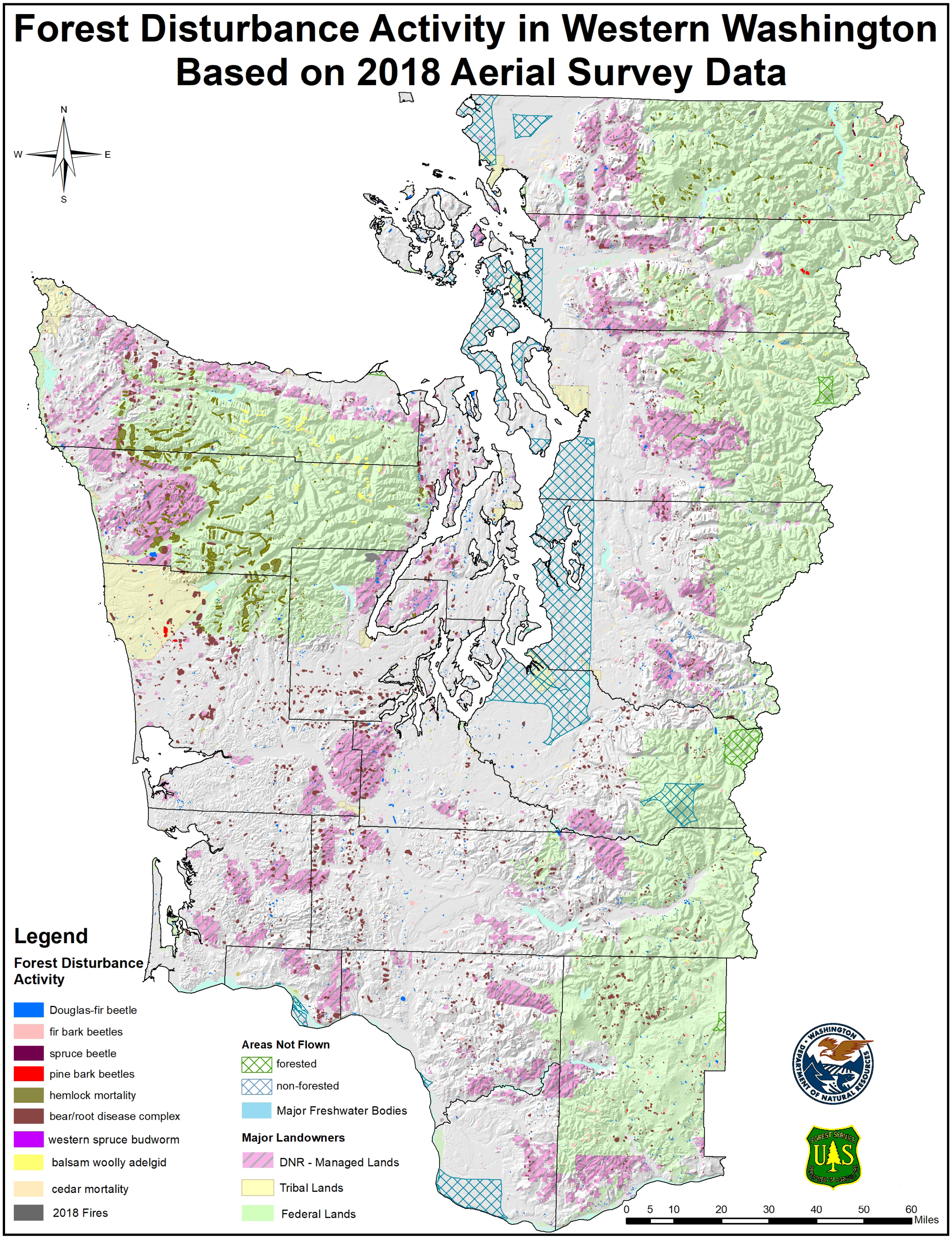


Figure 5. Forest disturbance map of western Washington composed from 2018 aerial survey data. (Map by Aleksandar Dozic, Washington State Department of Natural Resources)

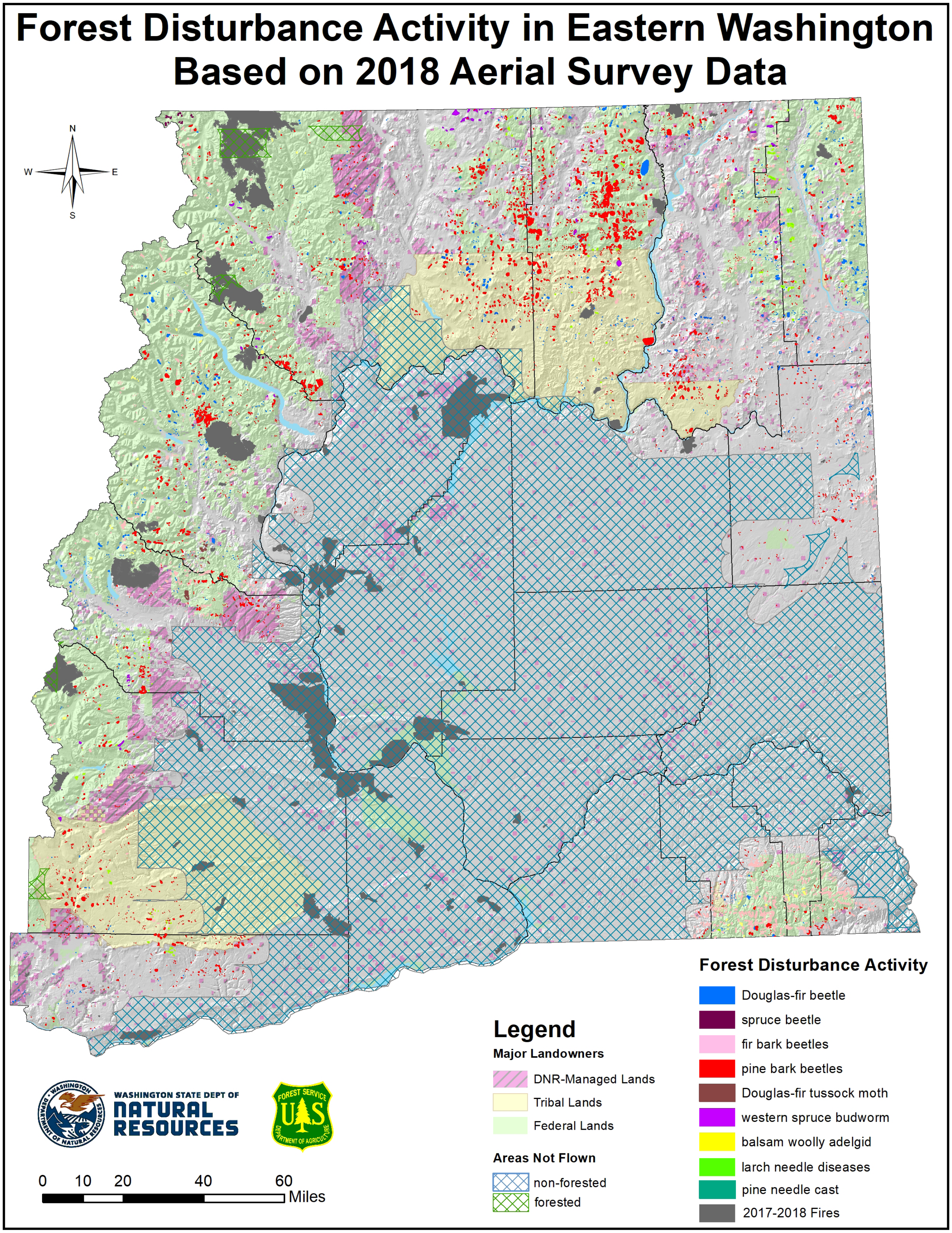


Figure 6. Forest disturbance map of eastern Washington composed from 2018 aerial survey data. (Map by Aleksandar Dozic, Washington State Department of Natural Resources)

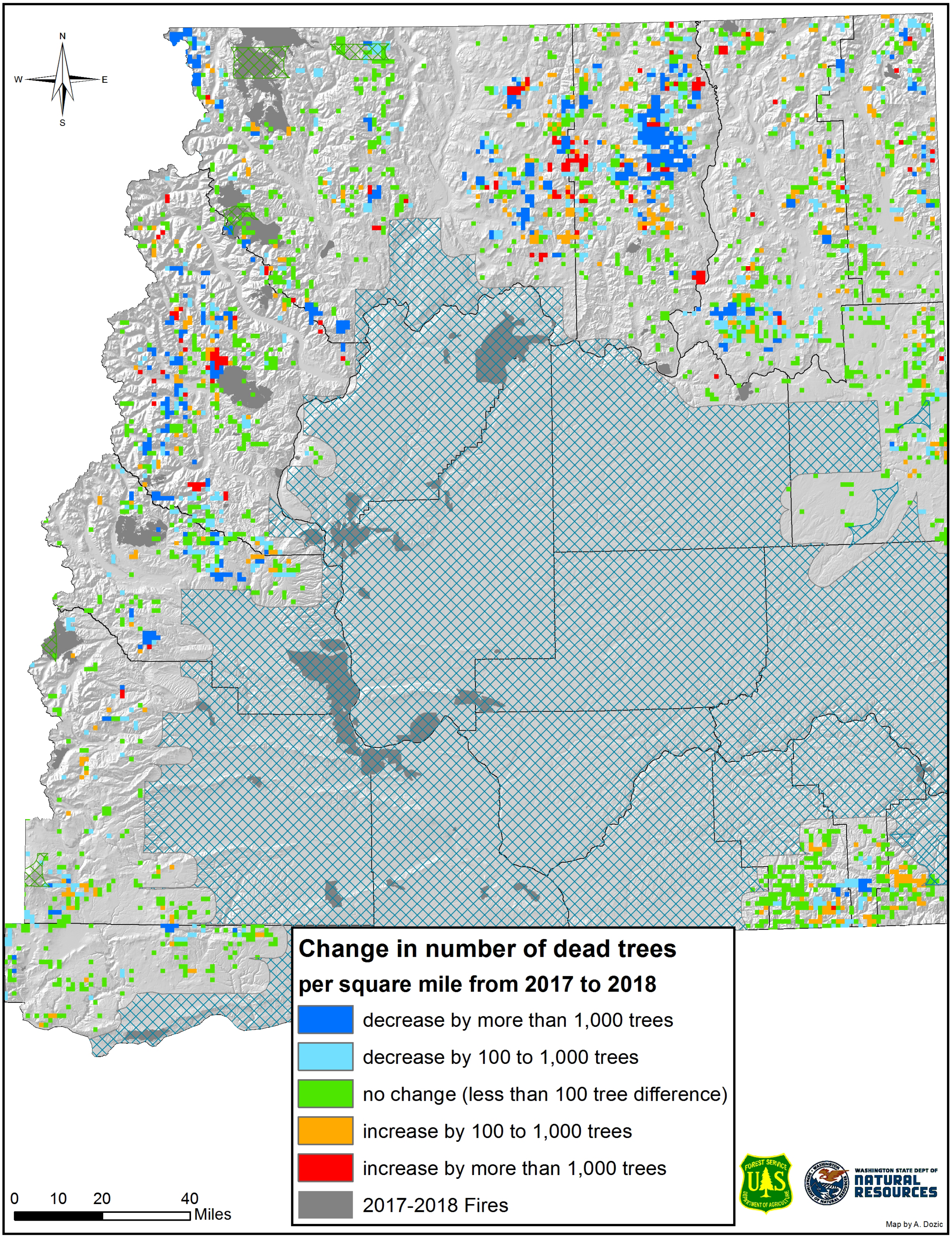


Figure 7. Change in tree mortality levels recorded by aerial survey in eastern Washington between 2017 and 2018. See page 8 for TPA conversion methods. (Map by Aleksandar Dozic, Washington State Department of Natural Resources)

20-YEAR FOREST HEALTH STRATEGIC PLAN

Forest health is defined in state statute as "the condition of a forest being sound in ecological function, sustainable, resilient, and resistant to insects, diseases, fire and other disturbances, and having the capacity to meet landowner objectives" (RCW 76.06). According to this definition, broad swaths of eastern Washington forestland are in an unhealthy state. An analysis by The Nature Conservancy and the United States Forest Service identified 2.7 million acres of forestland in Central and Eastern Washington requiring natural disturbance or active management to create forest structures more resilient against insects, diseases and wildfires (Haugo et al. 2015).

In 2016, the Legislature directed DNR to develop a forest health strategic plan to "treat areas of the state forestland that have been identified by the department as being in poor health." DNR determined that to meet the intent of the Legislature, and to address the forest health issue in a meaningful way, it was necessary to take a broad view of "treat areas of state forest lands," and to adopt a guiding philosophy of "all lands, all hands." This DNR guiding philosophy means the agency aims to address forest health issues at a landscape-scale and in coordination with all landowners to ensure forest health treatments advance in a coordinated, strategic fashion.

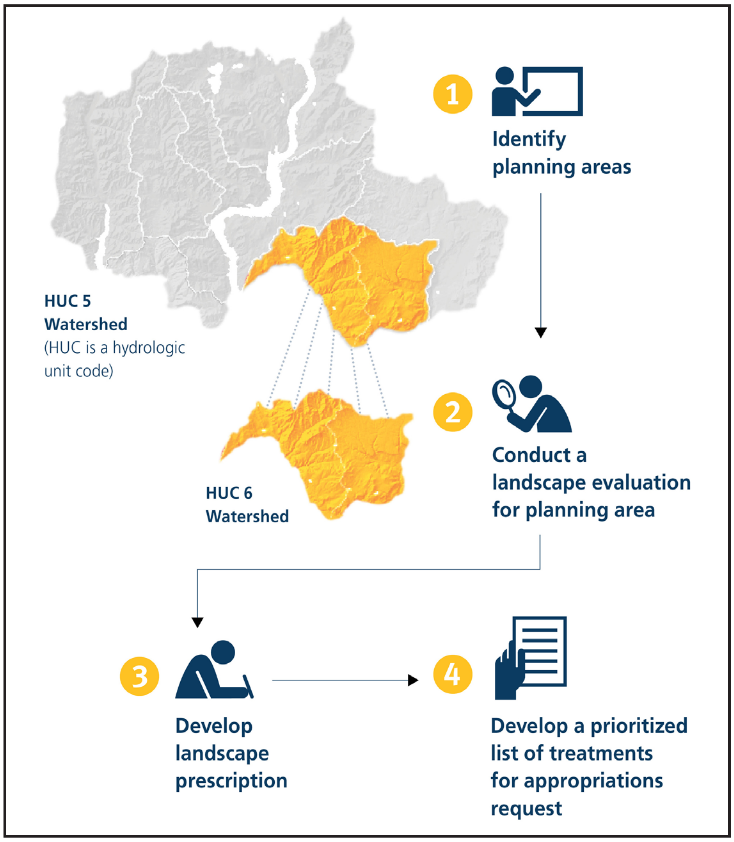


Figure 8. Major steps of Senate Bill 5546 (forest health assessment and treatment framework) to accomplish the treatment goals of the 20-Year Forest Health Strategic Plan.

The 20-Year Forest Health Strategic Plan is the high-level framework guiding the State of Washington's work and investments to improve forest health, help forests adapt to projected climatic changes, and achieve forest-related ecological, economic, and social benefits in Central and Eastern Washington. The overarching strategy is to maximize the effectiveness of forest health treatments by coordinating, planning, prioritizing, and implementing forest management activities across large landscapes. The plan sets a goal of treating 1.25 million acres over the next 20 years to improve the resilience of forests in eastern Washington. The authority and direction contained in SB 5546 guides DNR's efforts to improve forest health across all ownerships in large landscapes. SB 5546 requires DNR to create a Forest Health Assessment and Treatment Framework that assess a minimum of 200,000 acres of fire prone lands each biennium and identifies forest health treatment needs across all lands. SB 5546 also provides legislative direction and tools to help achieve the state's treatment goals across all lands.

The first step of the Forest Health Assessment and Treatment Framework was to select which priority watersheds the state will analyze for forest health treatment needs across all lands and focus its forest health investments. DNR identified its priority planning areas based on a data-driven analysis of HUC 6 (Hydrologic Unit Code) watersheds in the region, as well as feedback from forest collaboratives, tribes, relevant federal and state agencies, the Forest Health Advisory Committee and other stakeholders. DNR selected 12 forest health planning areas for the 2018 planning cycle to analyze for forest health treatment need. An additional 21 forest health planning were selected for the 2020 planning cycle and will be analyzed in 2019 and 2020 (the 2020 planning cycle) with results reported by December 2020. The 2018 forest health planning areas contain over 1 million acres of forestland and the 2020 planning areas contain over 1.65 million acres of forestland.

For the 2018 planning areas, DNR conducted landscape evaluations to assess forest health conditions and determine treatment needs across all lands. A landscape evaluation is a data driven approach to understanding the current condition of a landscape and its level of resilience to future natural disturbances, including climatic change. A primary result of the landscape evaluation is a summary of vegetation changes relative to historical reference conditions, current fire and drought risk, and wildlife habitat needs. The information and data from a landscape evaluation is then synthesized into a landscape prescription that describes and quantifies the shifts in vegetation conditions and pattern that are needed to move the landscape into an ecologically resilient condition and significantly reduce fire risk to communities.

DNR is employing the landscape evaluation and prescription process to assess the forest health treatment needs in the forest health planning areas as required by SB 5546. The purpose of the landscape evaluation and prescription is to set high-level forest health treatment targets for each planning area so that the state, landowners, and stakeholders understand the level of treatment needed to create resilient forest conditions, work together to implement landscape-scale treatments, and provide a benchmark to track progress on achieving treatment goals. Landscape evaluations and prescriptions do not mandate treatment targets or types for specific landowners. Instead, they provide recommendations and benchmarks for the planning area as a whole. Individual landowners then conduct their own field assessment, planning, and decision-making processes to determine the treatments they can implement to achieve overall landscape goals while meeting their own management objectives and regulatory requirements.

Based on the landscape evaluations and prescriptions for the twelve 2018 planning areas, DNR estimates that 286,220 to 430,120 acres of treatments are needed to move these landscapes into a resilient condition (Table 6). Across all of the 2018 planning areas, this equates to treating approximately 30-40% of the forested area.

A combination of mechanical treatments, prescribed fire, and managed wildfire will be needed to accomplish the identified treatment needs. Based on tree size class and canopy cover information from the landscape evaluations, the majority of the acres needing forest health treatments are commercially viable, although commercial viability ultimately depends on multiple factors. This means the cost of mechanically treating the forest stand can be covered by the revenue generated from the trees removed from the stand and potentially generate some revenue to help cover some costs of follow-up treatments such as prescribed fire. However, individual landowners will determine treatment types by taking into account their on-the-ground conditions, objectives, and constraints.

The implementation of the forest health treatment needs identified through the landscape

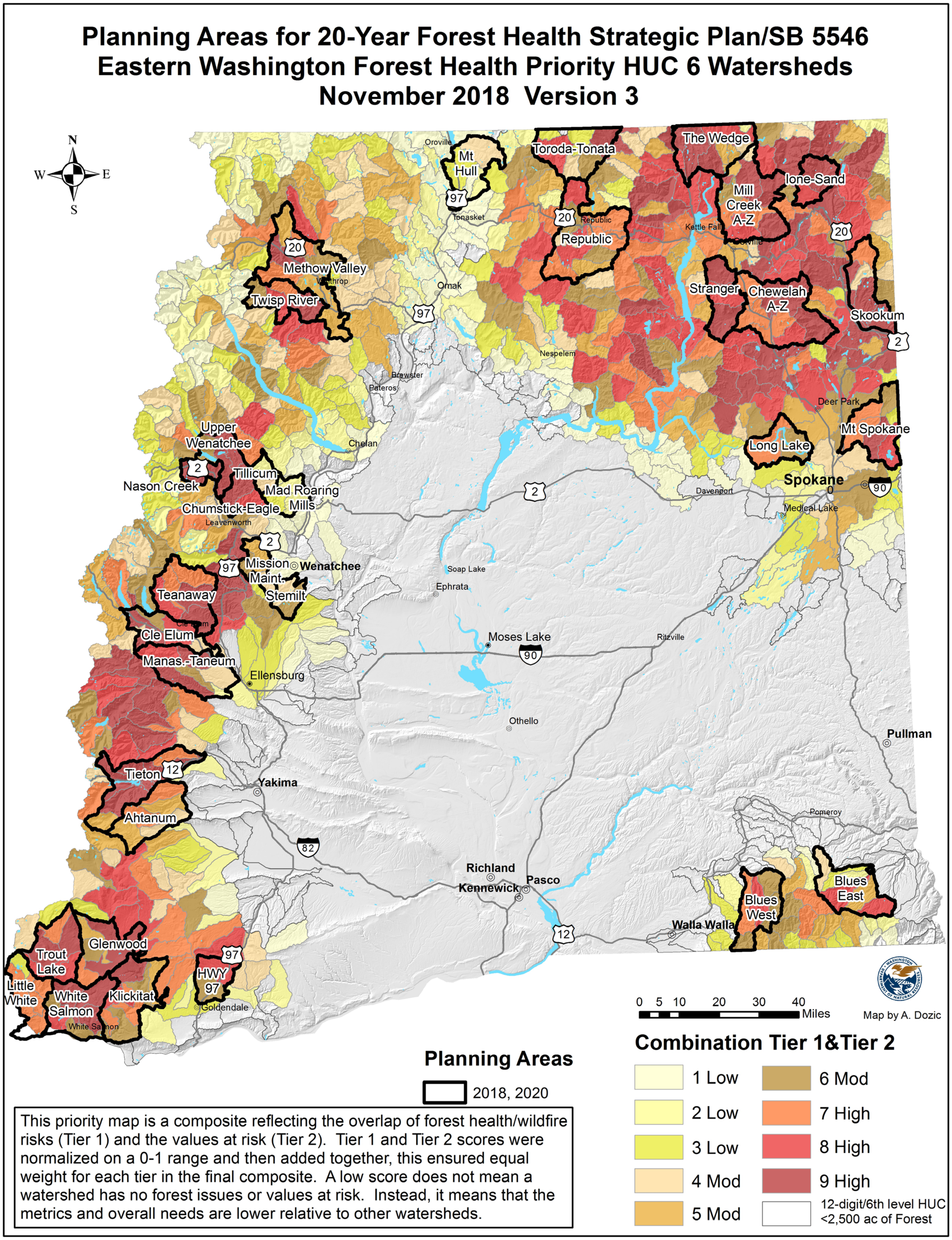


Figure 9. 2018 and 2020 planning areas for the 20-Year Forest Health Strategic Plan and Senate Bill 5546, and forest health HUC 6 watersheds priority rankings.

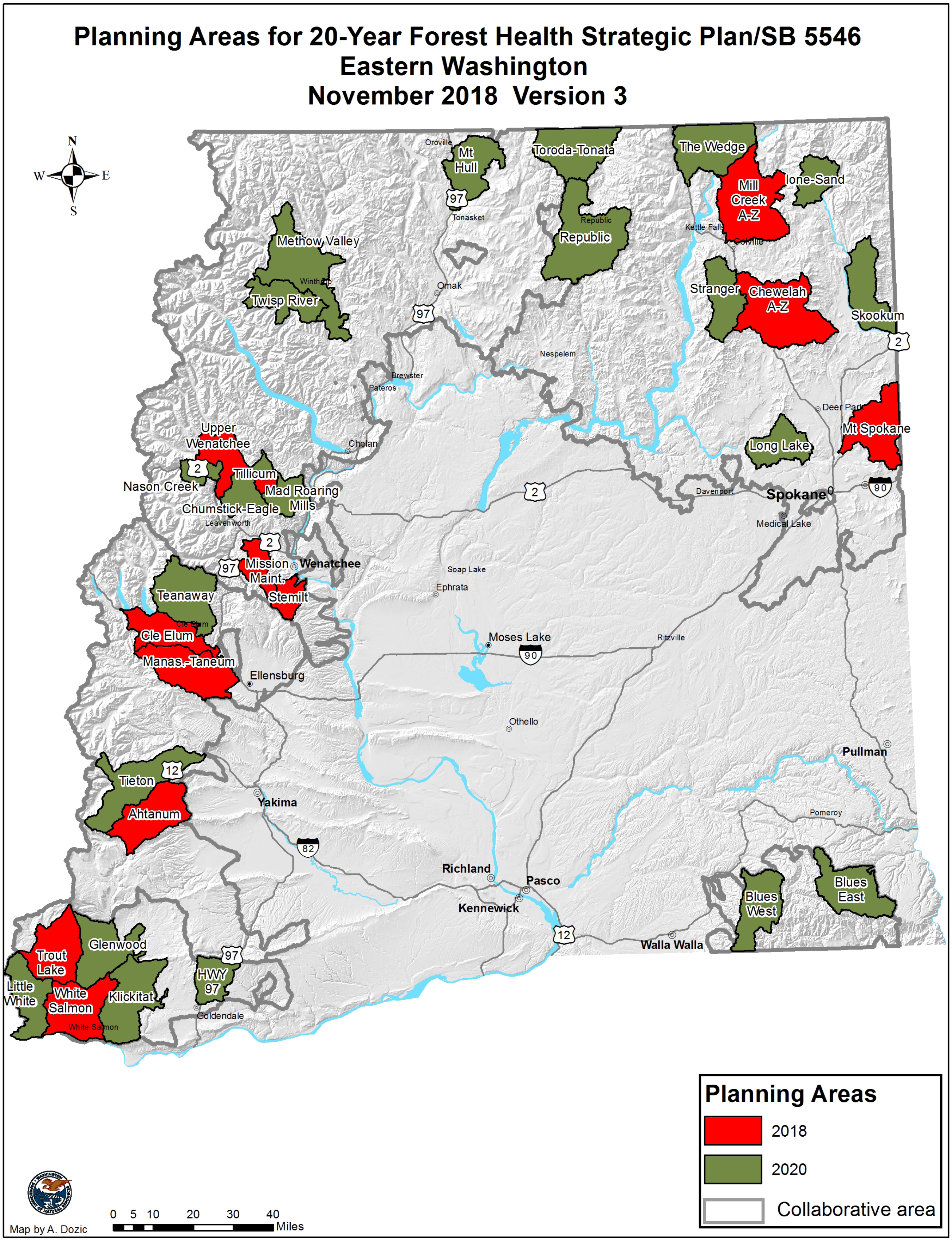


Figure 10. 2018 and 2020 planning areas for the 20-Year Forest Health Strategic Plan and Senate Bill 5546.

evaluation process for each planning area will likely take several biennia to accomplish. The pace and scale of implementation will be driven by some common and unique factors for each planning area such as: ratio of commercial versus non-commercial treatments, forest product markets, access, capacity of land managers and contractors, and funding levels for non-commercial treatments.

The efforts of the 20-Year Forest Health Strategic Plan and the Forest Health Assessment and Treatment Framework are complimentary and additional to the substantial existing forest health work already underway by the U.S. Forest Service, other federal agencies, tribes, state agencies, private landowners and others. Significant forest health treatments have been completed or planned in the forest health planning areas prior to the creation of the strategic plan. Being designated as a forest health planning area focuses additional resources for remaining forest health needs and provides monitoring of forest conditions to track achievement of landscape forest health goals over time.

Table 6. Forest health treatment needs for the 2018 forest health planning areas

	Forest Structure Class (acres)		
Planning area	**Small Dense[1]**	**Medium-Large Dense[2]**	**Large-Medium Open[3]**
Chewelah A-Z	2,000 - 3,500	45,500 - 66,500	3,500 - 8,000
Mill Creek A-Z	1,000 - 2,000	54,000- 72,000	2,000 - 6,000
Mt Spokane	500 - 1,000	21,000 - 29,000	4,000 - 8,500
Upper Wenatchee	-	15,000 - 25,000	500 - 2,000
Stemilt	-	6,200 - 7,900	3,000 - 5,700
Manastash-Taneum	3,500 - 6,500	11,000 - 19,000	2,000 - 4,000
Cle Elum	1,500 - 3,000	14,000 - 20,000	2,500 - 5,500
Ahtanum	2,000 - 2,500	13,000 -18,500	4,000 - 8,000
Trout Lake	-	17,500 - 31,000	1,000 - 2,000
White Salmon	500 - 1,000	35,000 - 48,000	2,500 - 6,000
Total	11,000 - 19,500	232,200 - 336,900	25,000 - 55,700
Subtotal	268,200 - 412,100 acres		
Tillicum	7,614 acres		
Mission Maintenance	10,406 acres		
Grand Total	**286,220 - 430,120 acres**		
Anticipated Treatment Type	[1]Non-commercial thinning and fuels treatment. May also be prescribed fire or managed wildfire in some areas.		
	[2]Commercial thinning and fuels treatment where possible. May be non-commercial, prescribed fire, managed wildfire or regeneration harvest in some areas.		
	[3]Maintenance treatments: prescribed fire or mechanical fuels treatments.		

INSECTS

Bark Beetles

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

Pine bark beetle activity recorded by aerial survey decreased in 2018 to approximately 120,000 acres compared to 191,000 acres in 2017 (Fig. 11). Pine mortality due to **mountain pine beetle** (MPB) was recorded on 101,300 acres, a decrease from 165,200 acres in 2017 and below the ten-year average of 158,000 acres. Relative to 2017, MPB-caused mortality decreased for all hosts except western white pine (Table 7). The 59,300 acres with lodgepole pine mortality attributed to MPB was approximately half the amount recorded in 2017 and similar to another recent low level observed in 2015. The most concentrated areas of lodgepole and ponderosa pine mortality occurred in the Colville National Forest in northern Ferry County and eastern Okanogan County. Mortality was also elevated in Chelan County and within the Okanogan-Wenatchee National Forest.

Mortality of ponderosa pine due to **western pine beetle** (WPB, Fig. 12) decreased to approximately 16,700 acres in 2018, similar to the 18,700 acres observed in 2017. Both 2017 and 2018 were the highest levels 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 Spokane, Ferry, Okanogan, Yakima, and Klickitat counties.

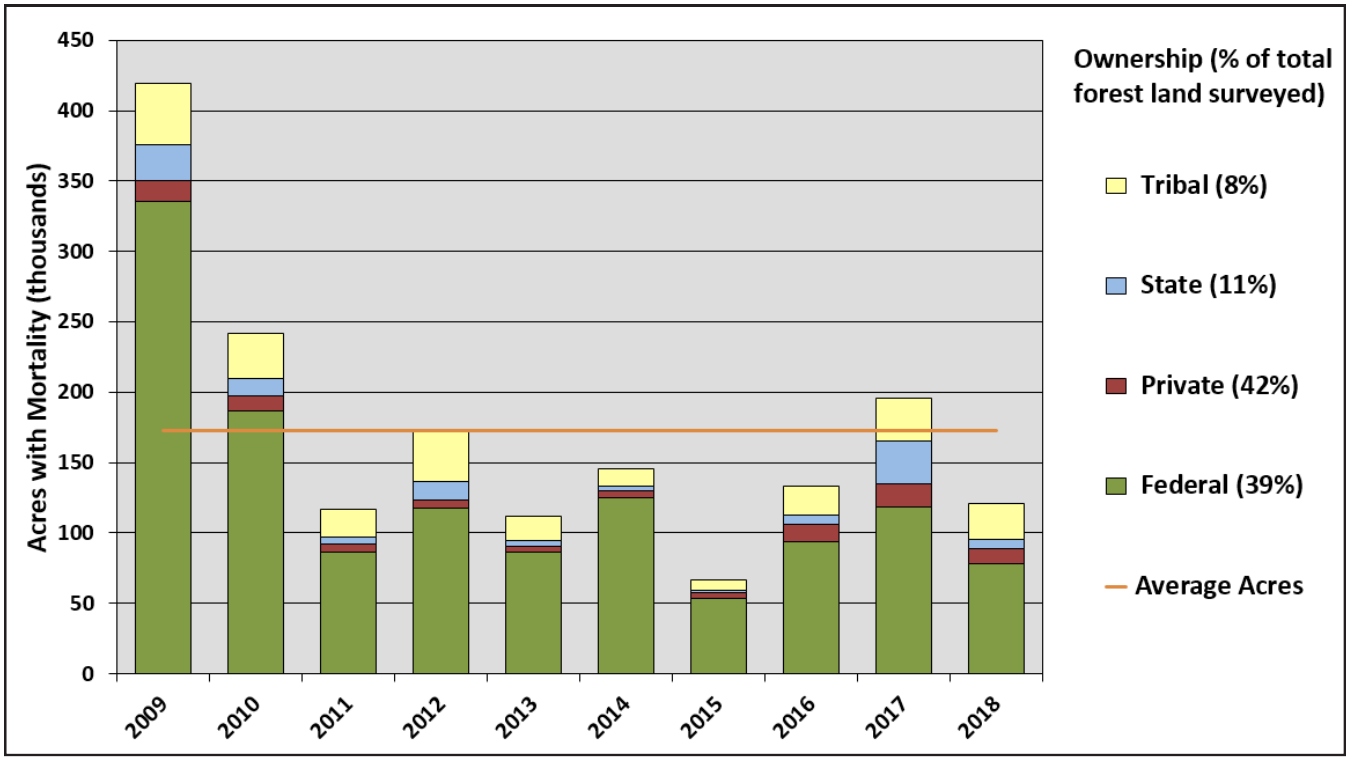


Figure 11. Ten year trend for total acres affected by pine bark beetles in Washington.

Table 7. Acres observed in aerial survey with pine bark beetle damage in Washington

Beetle species	Host(s)	2018 acres with mortality*	2017 acres with mortality*
Mountain pine beetle	Lodgepole pine	59,300	126,400
Mountain pine beetle	Ponderosa pine	42,000	46,500
Mountain pine beetle	Whitebark pine	720	1,400
Mountain pine beetle	Western white pine	1,000	170
Western pine beetle	Ponderosa pine	16,700	18,700
Pine engravers (Ips species)	All pines	1,100	2,500
	Totals:	**120,000 (footprint)***	**191,000 (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.*

Pine mortality attributed to **Ips pine engravers** was observed on approximately 1,100 acres in 2018, well below the 2,500 acres observed in 2017, but similar to the 10-year average of 900 acres. Ponderosa pine was the most common species affected. Outside of the Columbia River Gorge area, *Ips pini* was the agent responsible for mortality.

California Five-spined Ips (*Ips paraconfusus* Lanier)

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

DNR has coordinated a statewide survey since 2011 to determine the extent of CFI range throughout Washington (Fig. 13). With cooperator assistance, both CFI and Ips pini baited traps were deployed at 7 locations in 7 counties in 2018. CFI was collected for the first time in Mason County (Shelton), Grant County (Moses Lake), and Walla Walla County (Walla Walla) in 2018. These new county records are pending verification by a

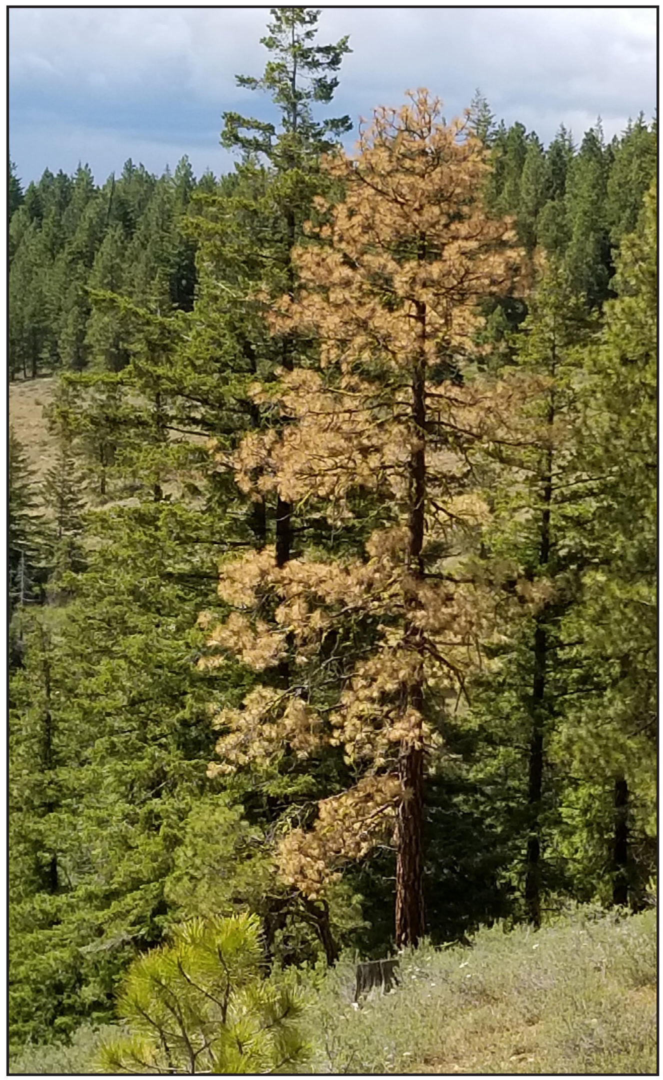


Figure 12. Ponderosa pine killed by western pine beetle near Naches.

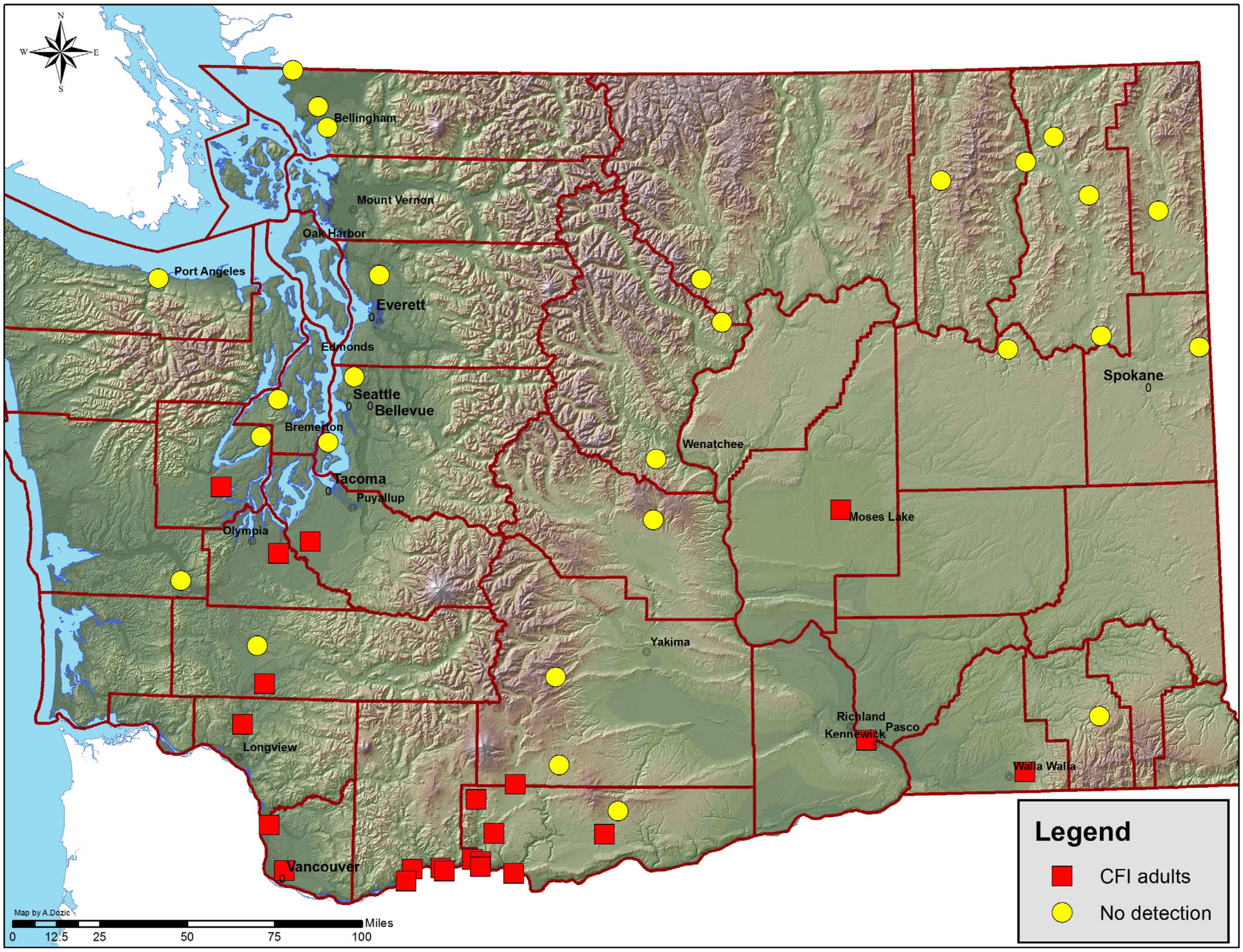


Figure 13. California five-spined Ips monitoring trap locations in Washington, 2010-2018. (Map by Aleksandar Dozic, Washington State Department of Natural Resources)

taxonomist. To date, CFI has been collected in 12 counties in Washington (Benton, Clark, Cowlitz, Grant, Klickitat, Lewis, Mason, Pierce, Skamania, Thurston, Walla Walla, and Yakima). From Vancouver, the known range of CFI in Washington extends 120 miles north to Mason County and 210 miles east to Walla Walla County.

CFI-caused ponderosa mortality has not been observed in western Washington and trap catches have been relatively low. Surveys for CFI in Washington will be discontinued in 2019.

Douglas-fir Beetle (*Dendroctonus pseudotsugae* Hopkins)

Approximately 26,700 acres with Douglas-fir beetle (DFB) caused mortality were observed statewide in 2018, nearly half of the 48,900 acres recorded in 2017 and close to the ten-year average of 31,000 acres (Fig. 14). Scattered areas of DFB-caused mortality were detected throughout the east slopes of the Cascades, the Blue Mountains, and in northeast Washington.

The highest concentrations were in Skamania, Klickitat, King (Snoqualmie Pass area), Kittitas, Chelan, and Pend Oreille counties. Decreases are likely related to recent reductions in the amount of suitable

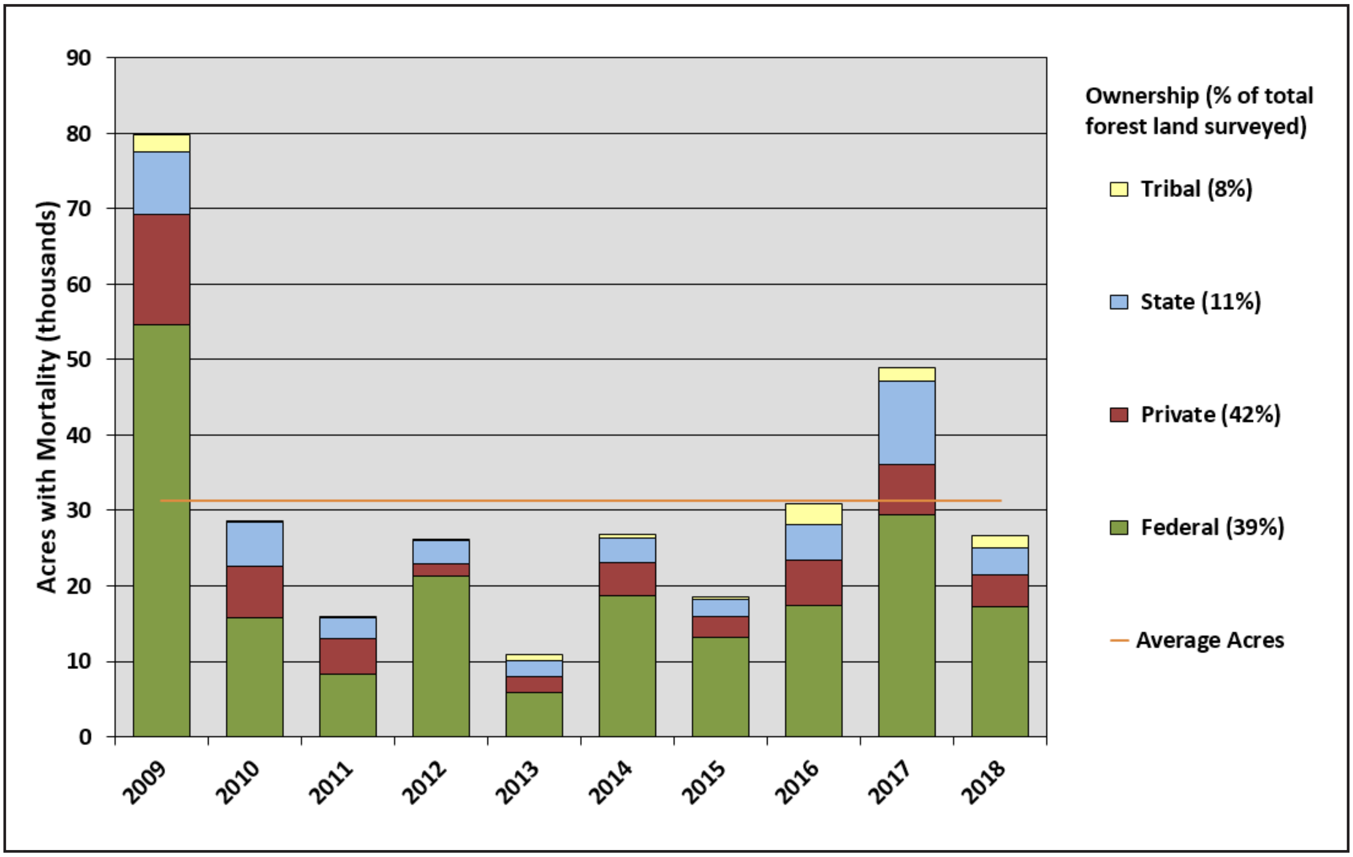


Figure 14. Ten year trend for total acres affected by Douglas-fir beetle in Washington.

breeding material generated by windstorms and wildfires (Fig. 15).

Figure 15. Windthrown Douglas-fir in northeast Washington in 2018.

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

In 2018, damage due to secondary bark beetle species in Douglas-fir increased to approximately 3,700 acres, the second highest level recorded in the history of the Washington aerial survey. 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 (Fig. 16).

Attacks by these species usually occur in small diameter Douglas-fir trees or the tops and branches

Figure 17. Damage to young Douglas-fir from secondary bark beetles.

Figure 16. Secondary bark beetle gallery in young Douglas-fir.

of larger trees, resulting in a patchy pattern of dieback in mature Douglas-fir tree crowns (Fig. 17). 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.

Secondary bark beetles species have been recorded on over 1,000 acres in Washington for the past three years. This increased activity is likely due to the extreme drought conditions in 2015, followed by summer drought conditions that have occurred from 2016-2018.

Secondary Bark Beetles in western redcedar (*Phloeosinus* species) and western hemlock (*Scolytus tsugae* (Swaine), *Pseudohylesinus tsugae* Swaine, and *Pseudohylesinus sericeus* (Mannerheim))

In recent years there has been an increase in reports and observations of dead or dying western redcedar and western hemlock in Washington. Evidence of bark beetle activity is frequently seen on close examination of these damaged trees. There are at least three different cedar bark beetle species in the genus *Phloeosinus* that specialize in feeding on western redcedar in the Pacific Northwest. In western hemlock, the most important bark beetles are hemlock engraver (*Scolytus tsugae*, Fig. 18), *Pseudohylesinus tsugae*, and silver fir beetle (*Pseudohylesinus sericeus*). In western redcedar and western hemlock, these bark beetles rarely develop outbreak populations that aggressively attack healthy trees.

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 2018 period. Drought damaged and beetle-killed western hemlock are difficult to

Left: Figure 18. *Scolytus tsugae* gallery in western hemlock. Right: Figure 19. Damage to western hemlock from secondary bark beetles near Granite Falls.

detect in aerial survey since they rapidly drop needles after the crown turns red (Fig. 19). However, damaged western redcedar remain discolored longer. In 2018, the Washington aerial detection survey mapped approximately 10,600 acres with damage using a new "dying cedar" code. The most concentrated areas of western redcedar damage were in northwest Washington in the Cascade foothills and Puget Sound areas. Late in the season, after aerial survey was completed, noticeable increases in the number of damaged western redcedar were reported in the San Juan Islands.

Fir Engraver (*Scolytus ventralis* LeConte)

Figure 20. Grand fir killed by fir engraver in northeast Washington.

Fir engraver can attack all species of true fir (*Abies*) in Washington, but the primary hosts in Washington are grand fir and noble fir (Fig. 20). Fir engraver caused mortality, primarily in grand fir, occurred on approximately 71,200 acres in 2018, the highest level since 2009 and above the ten-year average of 49,500

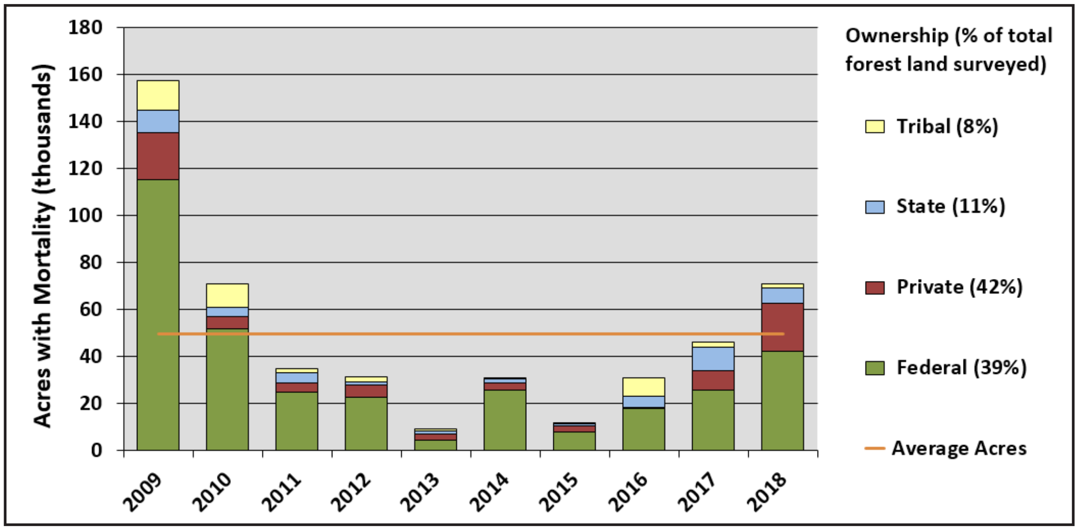


Figure 21. Ten year trend for total acres affected by fir engraver in Washington.

acres (Fig. 21). Recent drought conditions are likely an important driver of the increase, in addition to effects of defoliation by the western spruce budworm in the central Cascades. 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 the Okanogan-Wenatchee National Forest in Kittitas and Chelan counties; Ferry, Stevens, and Pend Oreille counties; and in the Umatilla National Forest in the Blue Mountains.

Spruce Beetle (*Dendroctonus rufipennis* Kirby)

For over a decade, spruce beetle outbreaks have had significant impacts to high elevation stream bottom stands of Engelmann spruce in western Okanogan and eastern Whatcom counties. Mortality due to spruce beetle decreased for the second year in a row, down to about 1,300 acres, the lowest level since 1999 (Fig. 22). A new area with mortality detected in 2017 in northwest Okanogan County along the Cascade crest near the Canadian border does not appear to have expanded.

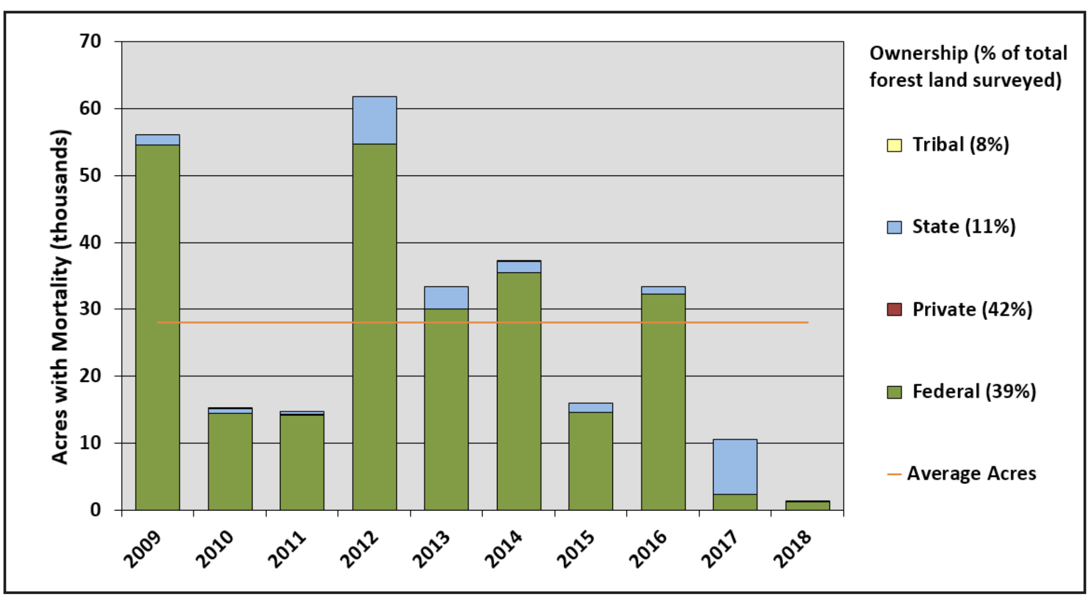


Figure Insects 22. Ten year trend for total acres affected by spruce beetle in Washington.

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 forests of Washington. Acres with WBBB-caused mortality decreased to approximately 13,300 acres in 2018; near the 10-year average of 10,500 acres, but well below the 26,000 acres recorded in 2017.

Defoliators

Western Spruce Budworm (*Choristoneura freemani* Razowski)

Figure 23. Western spruce budworm adult and larval chewing damage on grand fir.

In 2018, only 7,500 acres with western spruce budworm (WSB) defoliation were recorded in Washington, primarily in northeast counties (Fig 23). This was a significant decrease from the 40,400 acres observed in 2017 and the lowest level observed in the state since 1970 (Fig. 24). 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. Some of the decrease in area observed may be due to wildfire smoke obscuring trace defoliation signature in these areas. The outbreak in the central Cascades has collapsed

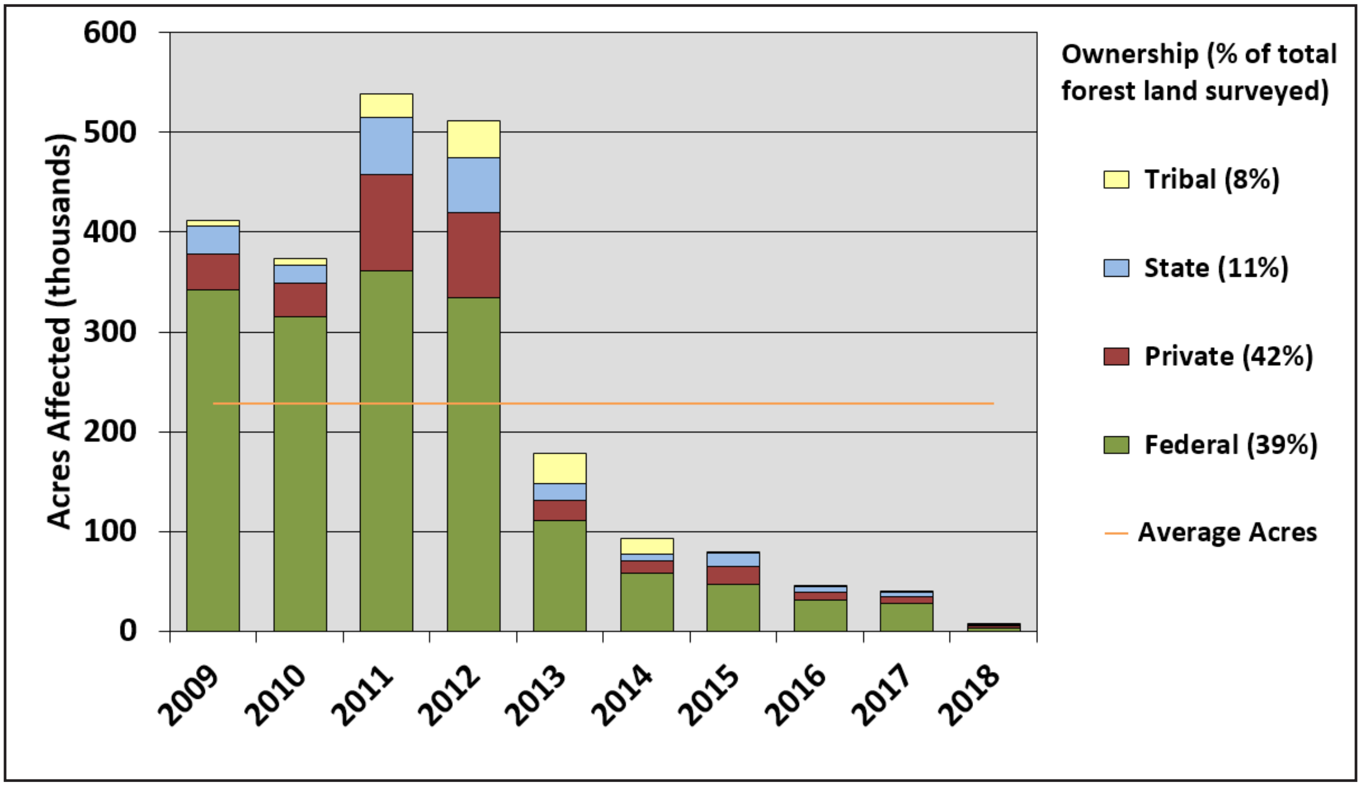


Figure 24. Ten year trend for total acres affected by western spruce budworm in Washington.

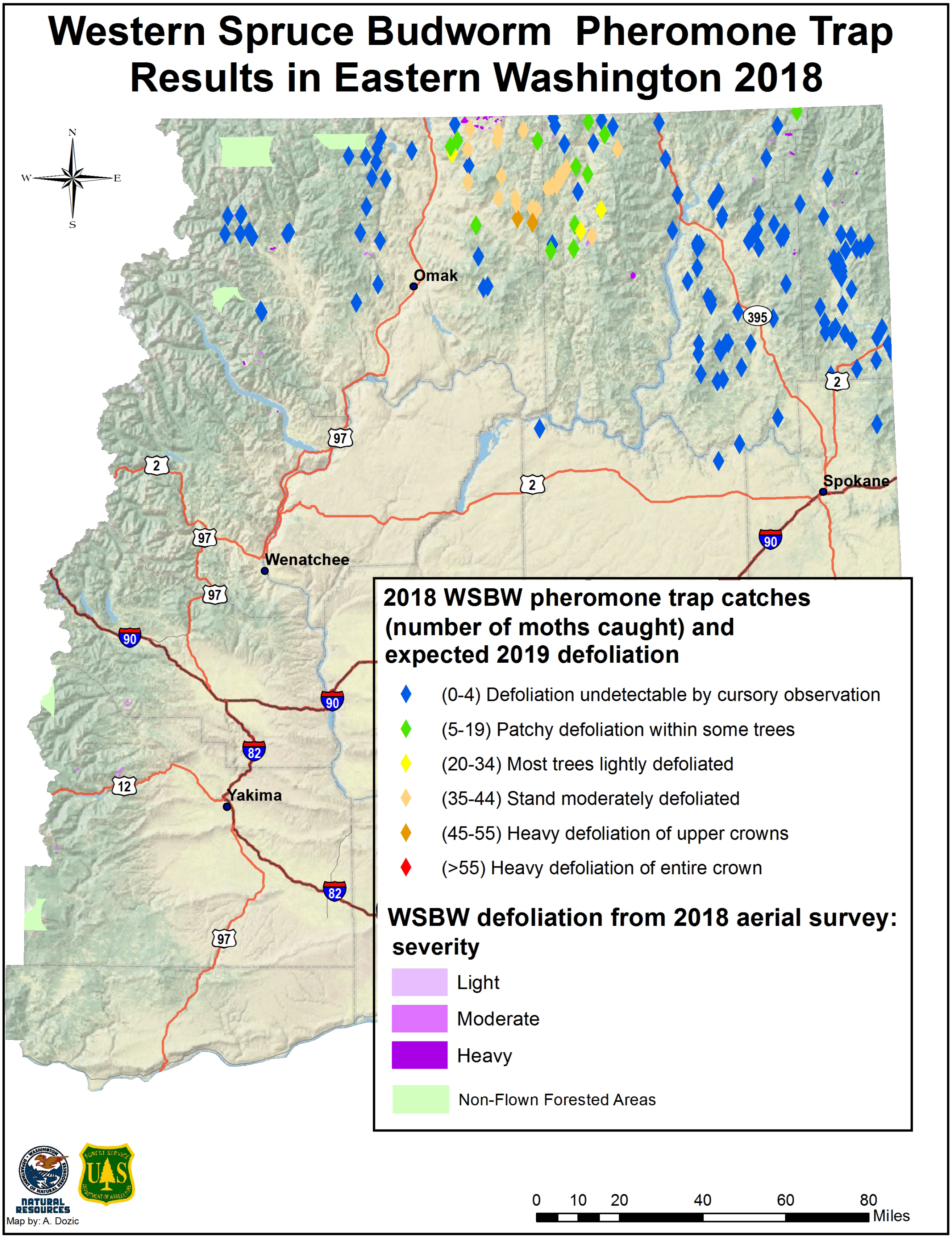


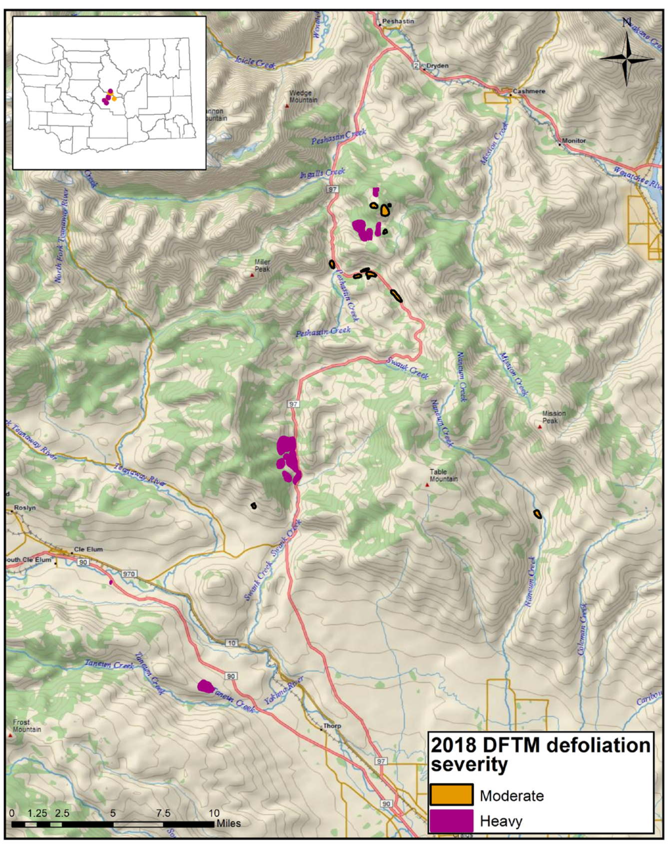
Figure 25. Western spruce budworm pheromone trap catch results for 2018, expected 2019 defoliation, and defoliation detected by the 2018 aerial detection survey. (Map by Aleksandar Dozic, Washington State Department of Natural Resources)

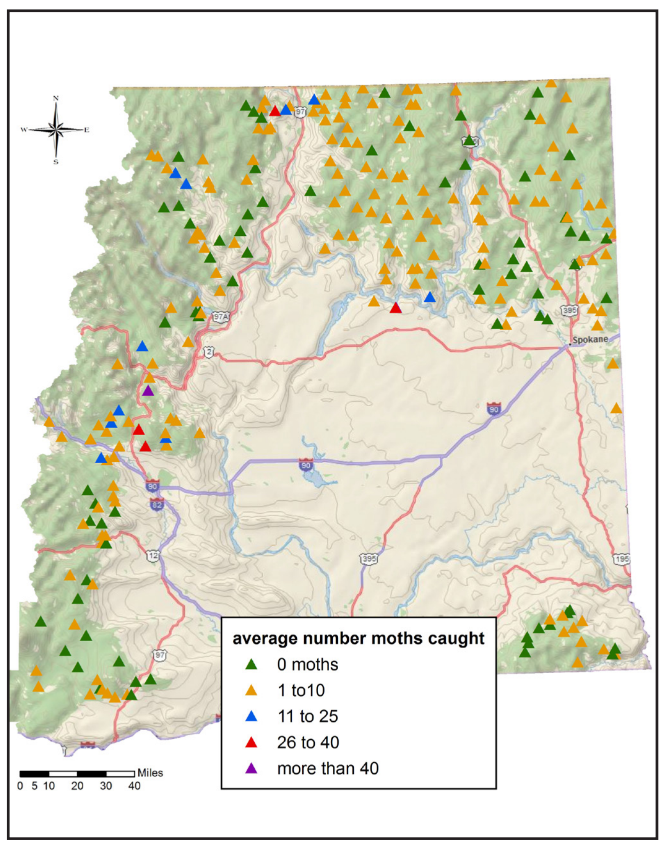
(Kittitas and Chelan counties). Very little new WSB defoliation was recorded in this area in 2018 and caterpillars collected from branch samples were primarily Douglas-fir tussock moth. Douglas-fir beetle and fir engraver damage is still elevated in this area, likely related to a decade of defoliation stress and recent droughts.

WSB pheromone traps were placed at 162 locations across eastern Washington (Fig. 25). Pheromone trapping for WSB in central Washington was discontinued until high populations return. Trap results in eastern Okanogan and northern Ferry counties generally indicate moderate defoliation expected in 2019. Trap catches in Stevens and Pend Oreille counties remain too low to predict defoliation levels for 2019, likely because many are located outside the scattered defoliation areas.

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

As predicted by an increase in pheromone trap catches, observations of sentinel trees, and caterpillar activity, an outbreak of Douglas-fir tussock moth (DFTM) has caused severe defoliation on approximately 1,900 acres in Kittitas and Chelan counties in 2018 (Fig. 26). This is the first observation of DFTM defoliation in Washington since 2012 and the first in Kittitas County since aerial surveys began in 1947 (Fig. 29). 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. Populations of generalist predators and parasites that increased during the budworm outbreak may contribute some control to DFTM popu-





Left: Figure 26. Areas with Douglas-fir tussock moth defoliation recorded by aerial survey in Chelan and Kittitas counties in 2018. Right: Figure 27. Douglas-fir tussock moth pheromone trap catch results for Washington in 2018. (Maps by Aleksandar Dozic, Washington State Department of Natural Resources)

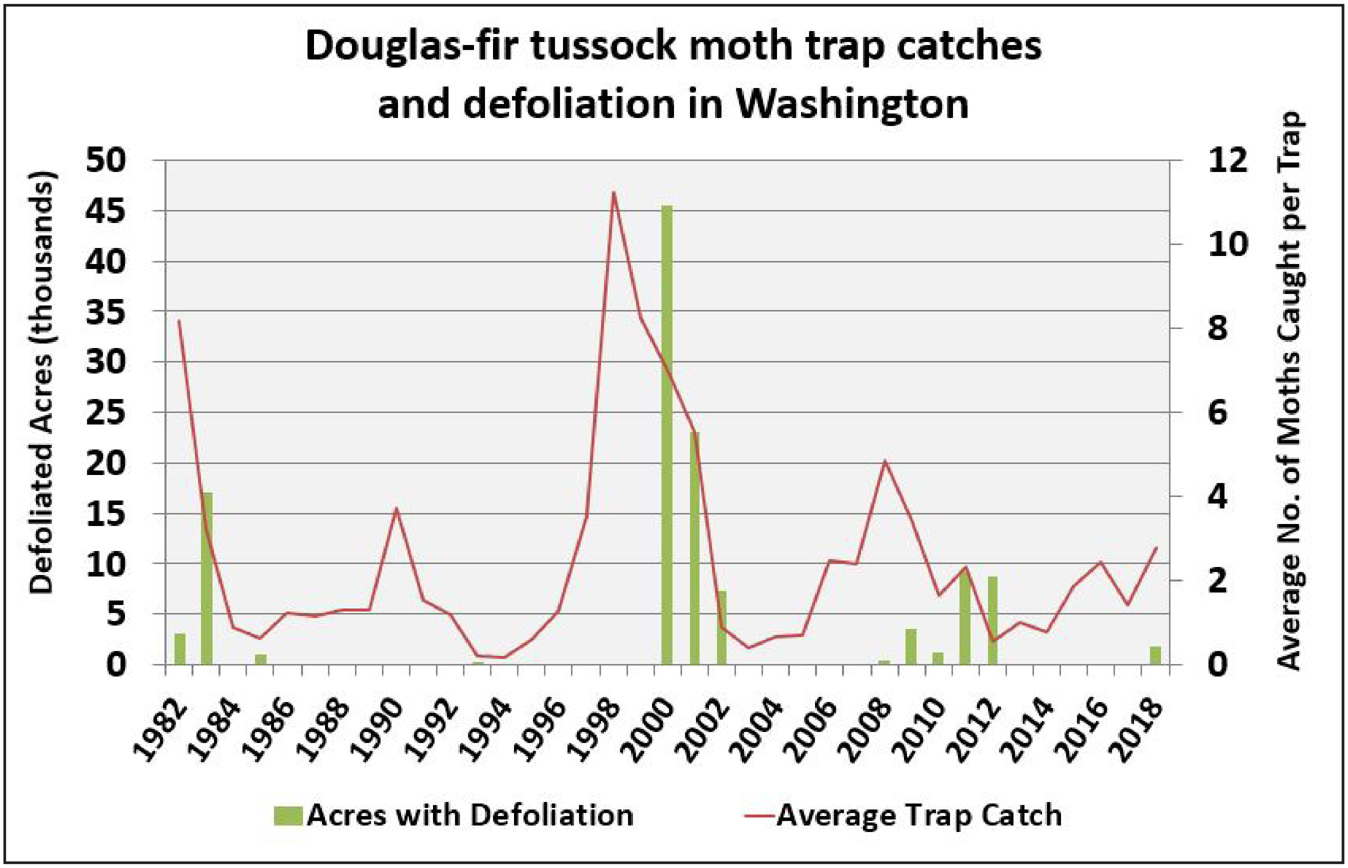


Figure 28. Douglas-fir tussock moth pheromone trap catches and observed defoliation, 1982-2018.

lations. DFTM egg masses were collected from defoliated areas in fall 2018 and will be examined for levels of nucleopolyhedrosis virus (NPV) by USFS staff in Wenatchee (Fig. 30). 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 (Fig. 27 & Fig. 28). For more information on the

Left: Figure 29. Heavy defoliation of Douglas-fir crowns from Douglas-fir tussock moth near Ellensburg.
Right: Figure 30. Douglas-fir tussock moth egg mass and cocoons on Douglas-fir foliage.

Early Warning System, go to: https://www.fs.usda.gov/detail/r6/forest-grasslandhealth/?cid=fsbdev2_027373.

2018 trap catches remain elevated in the current outbreak area and have increased in some areas of Okanogan County which indicate higher likelihood of more DFTM defoliation developing in 2019. High trap catches do not always correlate with location of future defoliation.

Western hemlock looper (*Lambdina fiscellaria lugubrosa* (Hulst))

A new outbreak of western hemlock looper (WHL) has caused defoliation on approximately 870 acres in south Whatcom and north Skagit counties. This area experienced a similar sized outbreak in 2011-2012. Ground observations around Baker Lake in the Mt. Baker-Snoqualmie National Forest indicate light to moderate defoliation of western hemlock and adjacent vegetation. Although WHL larvae were most abundant, false hemlock looper (*Nepytia canosaria*) larvae were also collected in the area. Defoliation is likely to spread and increase in intensity during 2019.

Larch Defoliation

Defoliation by larch needle cast (*Meria laricis*), which often appears as discolored lower crowns, was mapped on approximately 4,900 acres in 2018, an increase from 3,300 acres in 2017. The most concentrated areas of this damage occurred in the central and south Cascade Mountains. In 2018, discolored whole crowns of western larch were observed on approximately 2,100 acres. This aerial survey signature is indicative of both larch needle blight (*Hypodermella laricis*) and larch casebearer (*Coleophora laricella*). Ground checks indicate larch needle blight is the primary cause of damage. The blight/casebearer signature was observed on 18,000 acres in 2017.

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

In 2018, the Washington State Department of Agriculture (WSDA) deployed nearly 30,000 gypsy moth pheromone traps in Washington State, including detection and delimiting traps for both European gypsy moth (EGM) and Asian gypsy moth (AGM). Delimiting traps are placed on a more tightly spaced grid than standard detection traps. They are used to verify eradication of a population or to determine the location of a potential infestation. Fifty-two (52) adult male gypsy moths have been collected and have undergone DNA analysis for determination of either Asian or European genotypes. 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. Fifty-one moths (51) have been identified as EGM and one as AGM. No additional life stages were found at the detection sites.

WSDA conducted a gypsy moth eradication project in the spring of 2018 treating 300 acres in Pierce County and 1,000 acres in Kitsap County with the bacterial insecticide *Bacillis thuringiensis* var. *kurstaki* (Btk). For more information on btk, go to: https://agr.wa.gov/plantsinsects/insectpests/gypsymoth/btk/whatisbtk.aspx.

WSDA is proposing aerial applications of Btk at four sites in western Washington in the spring of 2019; approximately 740 acres at two sites in Kitsap County, 270 acres in King County, and 700 acres in Snohomish County. Post-treatment high density delimitation traps will be placed in and around the treated areas for two to three years following the treatments.

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. Most of the damage visible from the air is to subalpine fir in high elevation forests (Fig. 31). In 2018, approximately 13,300 acres with damage was observed, less than half the 46,400 acres recorded in 2017 and the lowest level since 2000. The most recent decade has averaged 33,000 acres of BWA damage per year (Fig. 32). BWA damage, primarily to subalpine fir and Pacific silver fir, was recorded at high elevations of 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 2,700 acres with some host mortality attributed to BWA damage in 2018. Approximately 13,300 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 31. Subalpine fir mortality from balsam woolly adelgid infestation.

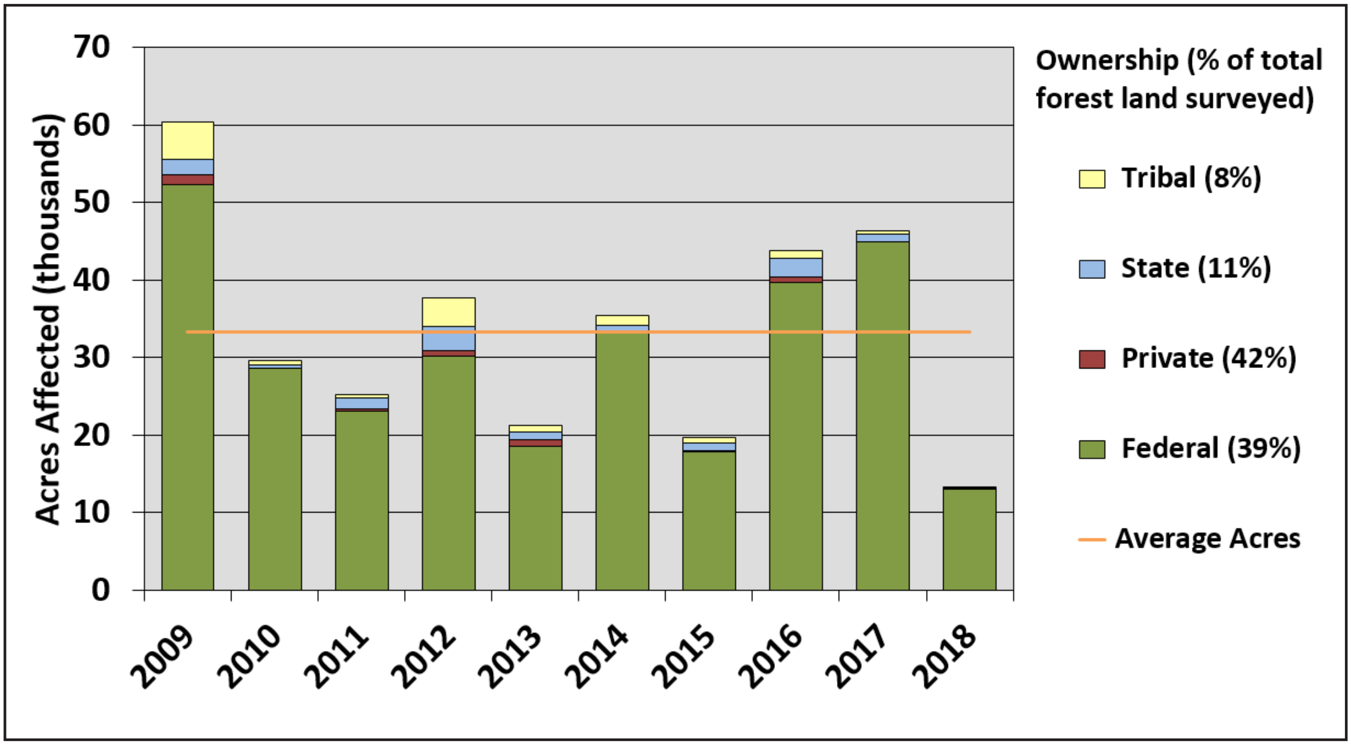


Figure 32. Ten year trend for total acres affected by balsam woolly adelgid in Washington.

ANIMALS

Bear Damage

Aerial survey records scattered, pole-sized, newly dead trees as 'bear damage' (Fig. 33). Based on ground checking observations, bear girdling and root disease are the primary causes of this type of damage. Drought stress, porcupines or mountain beavers may also play a role. Bears strip tree bark in spring. 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 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.

Figure 33. Young conifer mortality from bear damage and/or root disease as seen from the air.

Approximately 115,300 acres with bear damage mortality were observed in 2018, above the 81,200 acres mapped in 2017 (Fig. 34). The ten year average of acres with bear damage in Washington is 186,000.

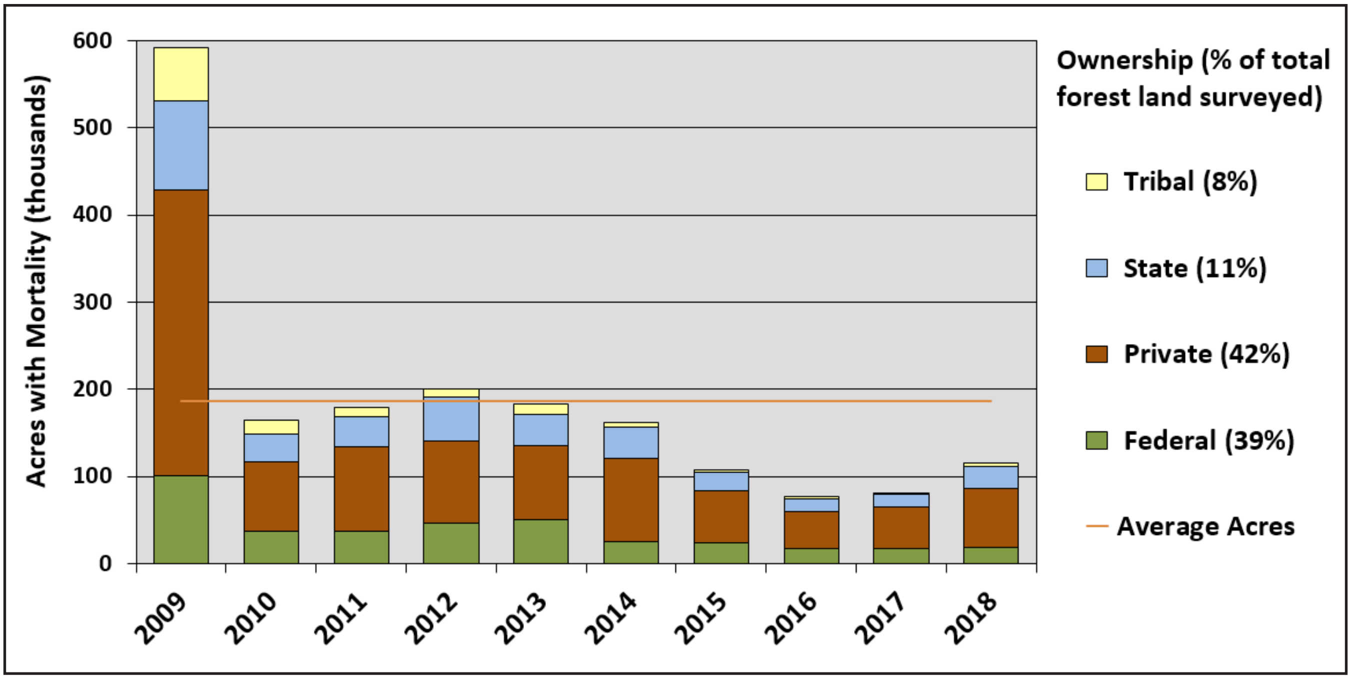


Figure 34. Ten year trend for acres affected by bear damage and/or root disease in Washington.

DISEASES

Foliar and Branch Disease

Swiss Needle Cast on Douglas-fir (*Phaeocryptopus gaeumannii* (Rohde) Petrak)

The fungus that causes Swiss needle cast (SNC) *Phaeocryptopus gaeumannii*, is found throughout the range of its only host, Douglas-fir. Swiss needle cast causes premature foliage loss, and defoliation of infected trees can reduce growth, alter wood properties and affect stand structure and development. In 2018, the State Legislature provided funding for a survey to assess the incidence and severity of SNC in coastal Washington. In late April and May, an aerial survey, covering 2.7 million acres of forest land along the coast, mapped 79,000 acres of Douglas-fir with obvious symptoms of SNC (Table 8). This is a marked decrease from the 247,500 acres mapped in the 2016 aerial survey and the 349,700 acres mapped in the 2015 survey. Severely symptomatic stands were generally located near Forks and Neah Bay, to the north, and Ilwaco along the southwest corner of the survey area (Fig. 35). The cause of the decrease in mapped acres since 2015 remains uncertain but is likely a combination of environmental factors influencing infection patterns and foliar retention, in addition to site and soil characteristics affecting water retention and nutrition.

Twenty six ground plots, across the range of the aerial survey, were assessed for SNC incidence and severity, determined by counting pseudothecia on the needles and foliage on the branches. Across all sites, the average percent of occluded stomates was 16% for two-year-old needles, while foliar retention averaged 2.3 years. The amount of disease causing fungus in the foliage and the amount of foliage retained on sample trees has remained relatively stable across the years of the survey. Given that Douglas-fir is the only host of SNC, forest managers may select 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. Read the 2018 SNC aerial and ground survey report for coastal Washington at: https://www.dnr.wa.gov/publications/rp_2018_swiss_needle_cast_report.pdf.

Table 8. Total acres with Swiss Needle Cast symptoms mapped during the aerial survey, by year

	Severe SNC Symptoms		Moderate SNC Symptoms		Total Acres Mapped	
Year of Survey	% of total acres mapped	Severe SNC Acres	% of total acres mapped	Severe SNC Acres	% of total acres mapped	Severe SNC Acres
2018	< 1%	6.000	3%	73,000	3%	79,000
2016	< 1%	14.000	10%	234,000	10%	248,000
2015	1%	19.000	13%	332,000	14%	351,000
2012	< 1%	6.000	8%	222,000	9%	228,000

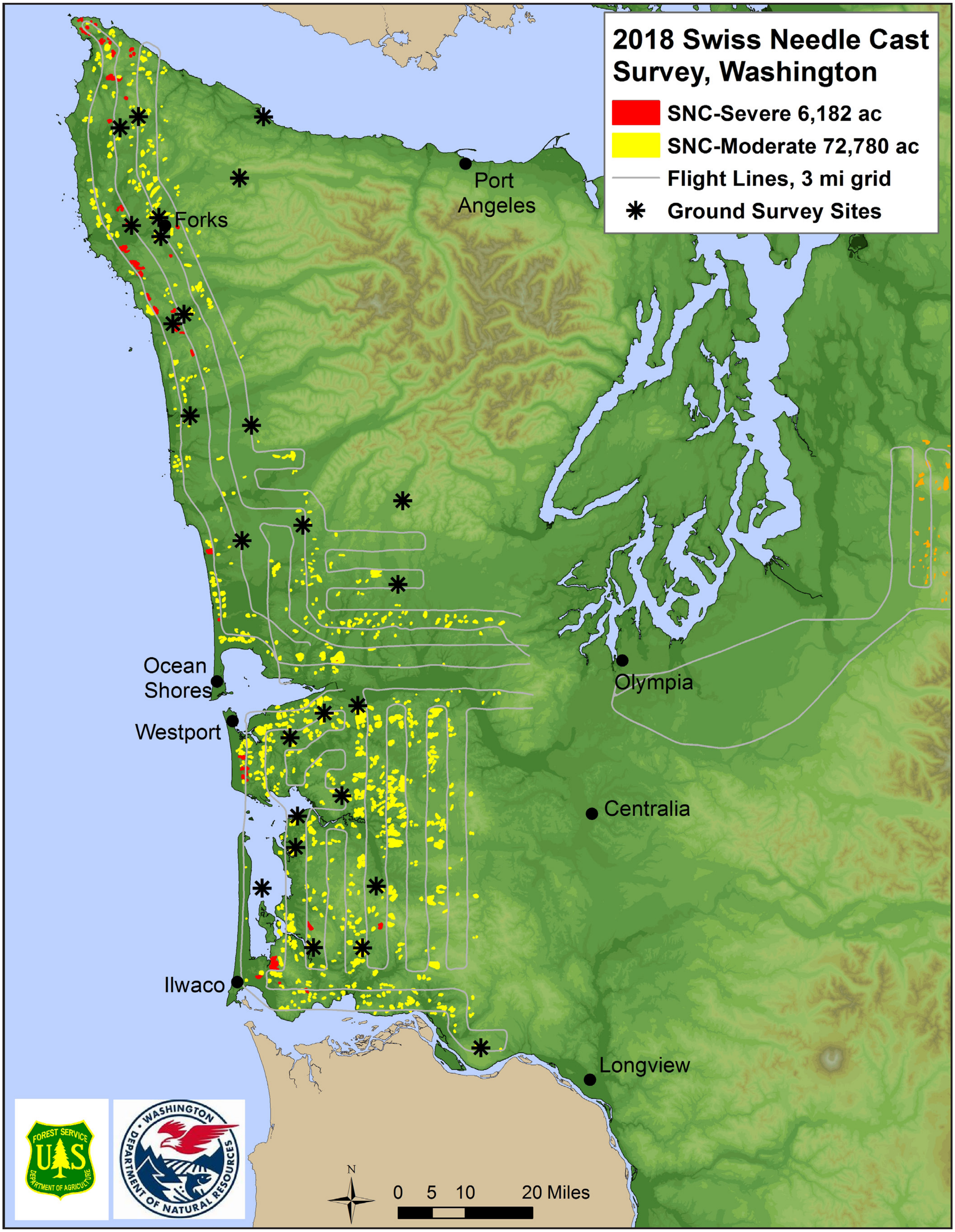


Figure 35. Map of 2018 Swiss Needle Cast aerial survey, including ground plot locations. (Map by Amy Ramsey, Washington State Department of Natural Resources)

Bigleaf Maple Decline and Mortality

There has been no sign of recovery of sick and dying bigleaf maple (*Acer macrophyllum* Pursh) trees, a decline that forest pathologists at DNR and elsewhere have been investigating throughout western Washington since 2010. Symptoms of decline include partial to entire crown dieback, discoloration and reduced leaf size, loss of leaves and tree death (Fig. 36). Previous investigations into the cause of the decline focused on specific pathogens, including *Armillaria*, *Phytophthora*, *Pythium*, *Verticillium*, *Neonectria*, *Nectria* and *Ganoderma*, but none of these organisms have been found frequently enough in declining or dead trees to suggest that they are primarily responsible for the decline.

Since 2017, with funding provided by USDA NIFA McIntire-Stennis Cooperative Forestry Program, scientists from the University of Washington have been investigating the spatial patterns and environmental variables associated with bigleaf maple decline. Soil and leaf samples, tree cores, and other measurements and observations were collected from forest plots throughout the range of bigleaf maple in western Washington (Fig. 37). While the results of the study failed once again to implicate a specific pathogen or pollutant as the cause of decline, the study did find a strong correlation between the decline of bigleaf maple and increased human development (roads), higher summer temperatures and more extreme summer droughts. Increased human habitation, activity and development, as well as predicted increases in summer temperature and drought, could lead to increased mortality of *A. macrophyllum* in the future.

More details about this project can be found at: Betzen, J.J. 2018. Bigleaf maple decline in western Washington. M.S. Thesis, Univ. of WA.

Figure 36. Bigleaf maple trees exhibiting symptoms of decline, including partial to entire crown dieback, discoloration and reduced leaf size, loss of leaves and tree death.

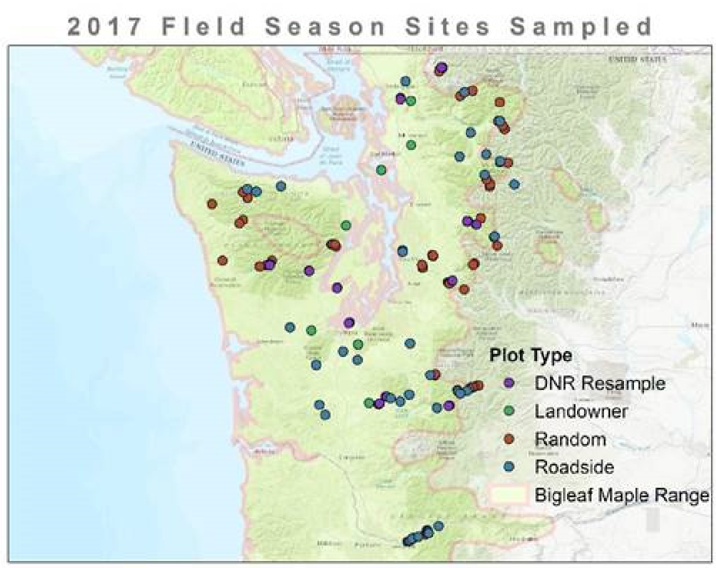


Figure 37. Locations of sites and range of *Acer macrophyllum* in Washington. (Map by Jake Betzen, University of Washington)

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 southern 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 caused disease and Pr spread, 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 southern Oregon and California has not been observed. For a current list of susceptible hosts, go to: https://www.aphis.usda.gov/plant_health/plant_pest_info/pram/downloads/pdf_files/usdaprlist.pdf

With funding provided by the USFS, the National *Phytophthora ramorum* Early Detection Survey of Forests, ten waterways in five counties (Clallam, Jefferson, King, Kitsap and Snohomish) were surveyed for the pathogen using a rhododendron leaf filled baiting bag method. Most sampled waterways in western 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 (Fig. 39). 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.

Figure 38. Video made by Washington State University.

2018 Phytophthora ramorum survey activities at The Bloedel Reserve, Bainbridge Island

The Washington State Department of Agriculture conducted six surveys for *Phytophthora ramorum* at the Bloedel Reserve on Bainbridge Island in 2018. The surveys focused on two managed areas of the Reserve where detections of *P. ramorum* had occurred in 2015/2016. Perimeter surveys of the native host vegetation surrounding the previous positive sites were also conducted. A total of 920 samples were collected in 2018. Of those, a single water bait sample was confirmed to be positive in July 2018. The water bait was from a pond below a previous positive area at the Reserve. All other plant and water bait samples collected in 2018 were negative for the pathogen. For more information about the Bloedel Reserve and the ongoing work to contain and eradicate *Phytophthora ramorum*, a video (Fig. 38) was produced by Washington State University. The video can be viewed at: https://www.youtube.com/watch?v=iLFBFrGMHno&feature=youtu.be

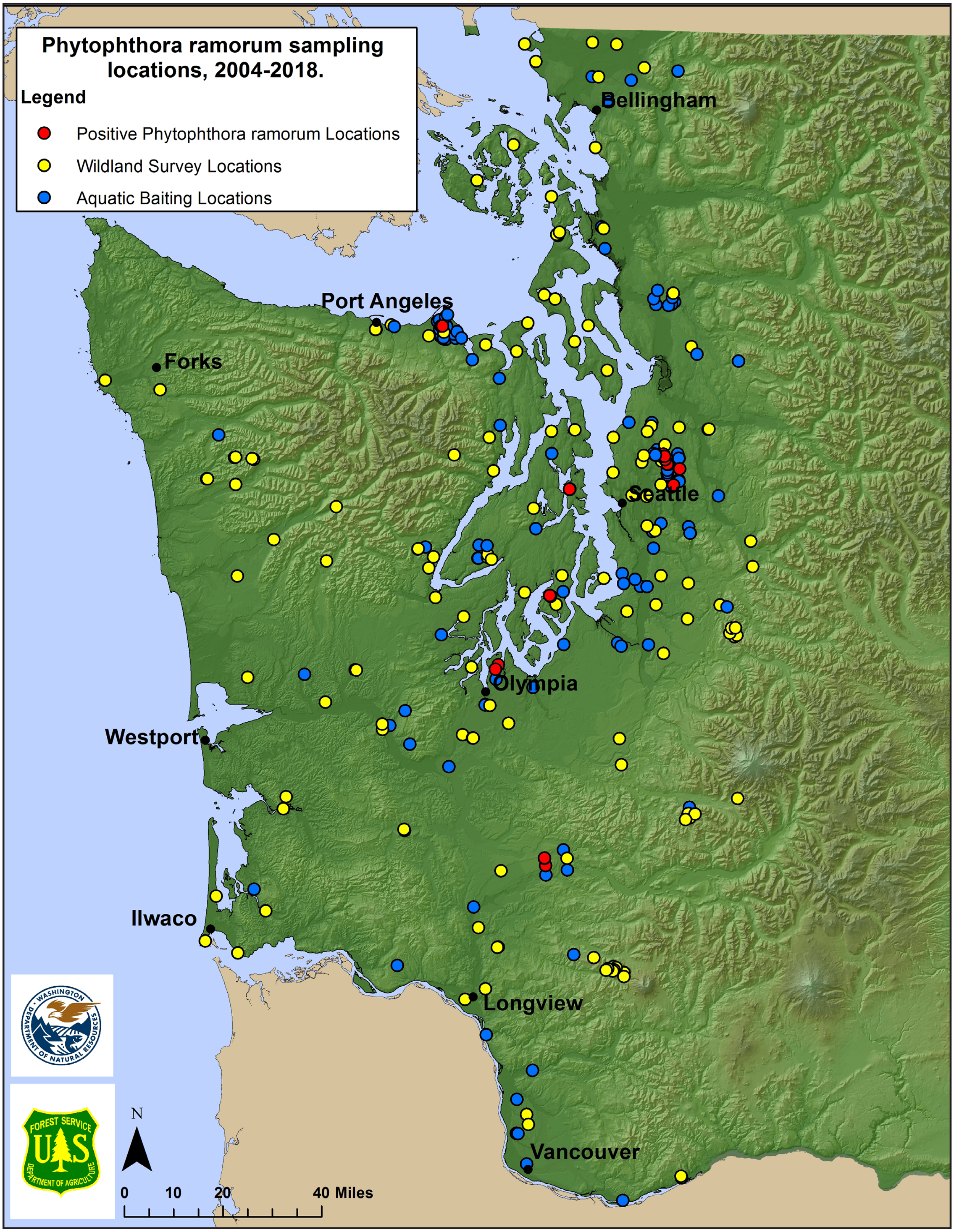


Figure 39. Washington State Department of Natural Resources Phytophthora ramorum monitoring, detection and survey sites, 2004-2018. (Map by Amy Ramsey, Washington State Department of Natural Resources)

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 publicly 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

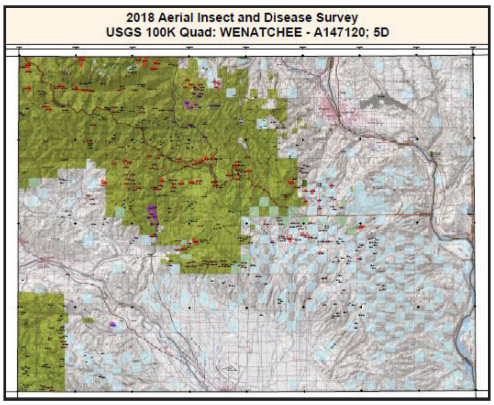


Figure 40. Example PDF map of the Wenatchee quad for 2018.

Traditional insect and disease survey quadrangle maps from 2003 to 2018 are available for download as PDF files (Fig. 40) at: www.fs.usda.gov/goto/r6/fhp/ads/maps

Click on the year of interest under "Aerial Detection Survey Quad Maps" (Fig. 41). Scroll down to view an interactive map of all the available quads from Oregon and Washington. Simply click the quad map you want and it will download the PDF. Polygons are colored to reflect damage type and are labeled 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

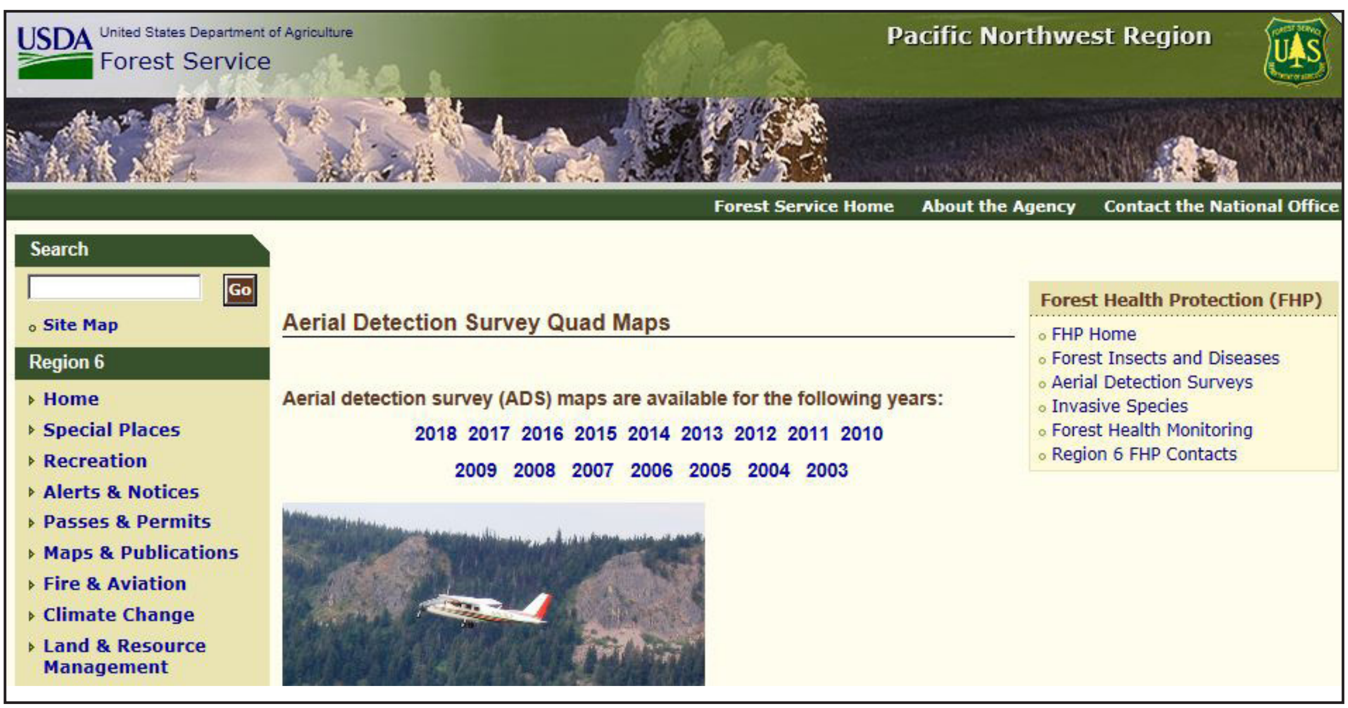


Figure 41. Aerial survey maps and data on USFS Region 6 Forest Health Protection website.

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

2011 to 2017 annual aerial survey data and the 15-year cumulative mortality data product are available from Washington 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 base maps 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.

Customized electronic maps (PDF, JPG, etc.) of draft data can be created with a variety of background layers 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" to generate a file. Output PDFs are geo-referenced 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 2017, known as "Forest Health Aerial Survey 1980-2017," under "Forest Disturbance" at: http://data-wadnr.opendata.arcgis.com

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 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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