



United States Department of Agriculture

# Forest Health Highlights in Washington—2016



*Celebrating 70 years  
of Aerial Survey*

Washington State Department of Natural Resources  
Forest Health Program  
March 2017



**WILDFIRE**

for the greatest good

**Pacific Northwest Region  
Forest Health Protection**

# Forest Health Highlights in Washington—2016

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**Front cover:** *“Celebrating 70 years of aerial survey” design by Stevie Ruda, USDA Forest Service.*

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## Summary

2016 was the 70th year the aerial detection survey (ADS) was flown in Washington. Recent surveys, including this year, cover most of the 22.4 million acres of forestland in the state. In 2016 ADS recorded some level of tree mortality, tree defoliation, or foliar diseases on approximately 450,000 acres. This is an increase from the 338,000 acres reported in 2015. Approximately one million acres were not surveyed in 2016 due to numerous large fires in 2015. 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. Tree *mortality* was recorded by ADS on approximately 338,000 acres, of this 243,000 acres were attributed to bark beetles and 77,000 acres to bear damage or root disease. Relative to 2015, tree mortality increased for all major bark beetle species. The area with conifer *defoliation* recorded by ADS was approximately 100,000 acres, similar to the 99,000 acres reported in 2015. Almost all defoliation recorded was caused by western spruce budworm, which decreased, and balsam woolly adelgid, which increased. Approximately 12,000 acres recorded by ADS had some level of *disease* damage, primarily bigleaf maple decline and needle casts in pines and western larch. It should be noted that disease damage is significantly underrepresented in the ADS data because symptoms are often undetectable from the air. Previous annual totals for all damage agents were:

**2014:** 543,000 acres

**2013:** 593,000 acres

**2012:** 1,080,000 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 2016, but above normal in spring and fall. Monthly average temperatures were above normal in spring and summer. According to the US Drought Monitor, all of Washington was in an abnormally dry condition during summer 2016, with the southwest and southeast areas of the state experiencing moderate drought at times.

Approximately 2.4 million trees were recorded as recently killed in 2016.

The approximately 126,000 acres of **pine bark beetle** activity recorded in 2016 was nearly double the 65,200 acres in 2015. **Mountain pine beetle** damage increased to approximately 111,700 acres but is still below the ten-year average of 180,000 acres. Mortality of ponderosa pines due to **western pine beetle** increased to approximately 12,900 acres, more than double the amount in 2015.

Mortality due to **Douglas-fir beetle** increased relative to 2015, to approximately 30,600 acres. This was the highest level since 2009, the peak year of an outbreak related to severe coastal windstorms.

Acres with **western spruce budworm** defoliation in eastern Washington decreased for the second year in a row to approximately 46,300 acres, the lowest level since 2002. Outbreak activity in central Washington appears to be declining but is still increasing in the northeast.

A special **Swiss needle cast** survey was conducted in coastal western Washington in the late spring of 2016. Approximately 250,000 acres with symptoms were observed.

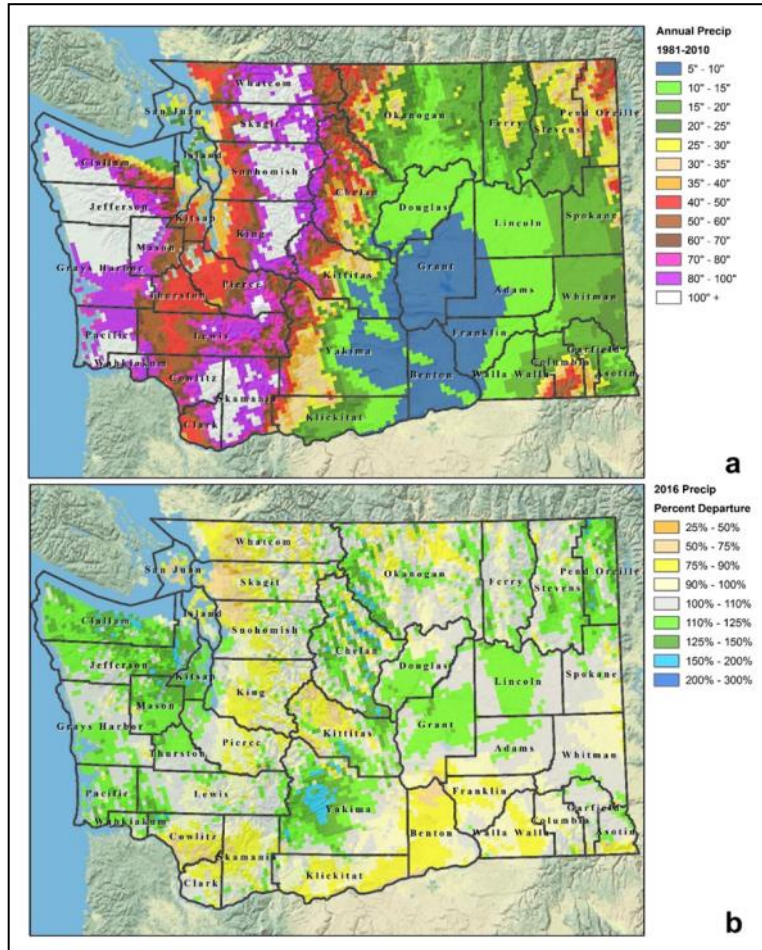
Defoliation from other conifer **needle cast diseases** was recorded on 5,400 acres, of which 2,900 acres were on western larch and 2,500 acres were on ponderosa pine and lodgepole pine.

Crown dieback and decline symptoms in **bigleaf maple** were observed on 4,100 acres, an increase from the 2,800 acres recorded in 2015.

**Bear damage** signature recorded by aerial survey dropped to approximately 77,200 acres, down from 107,500 recorded in 2015 and the lowest area recorded since 2001.

# 2016 Weather and Drought Conditions

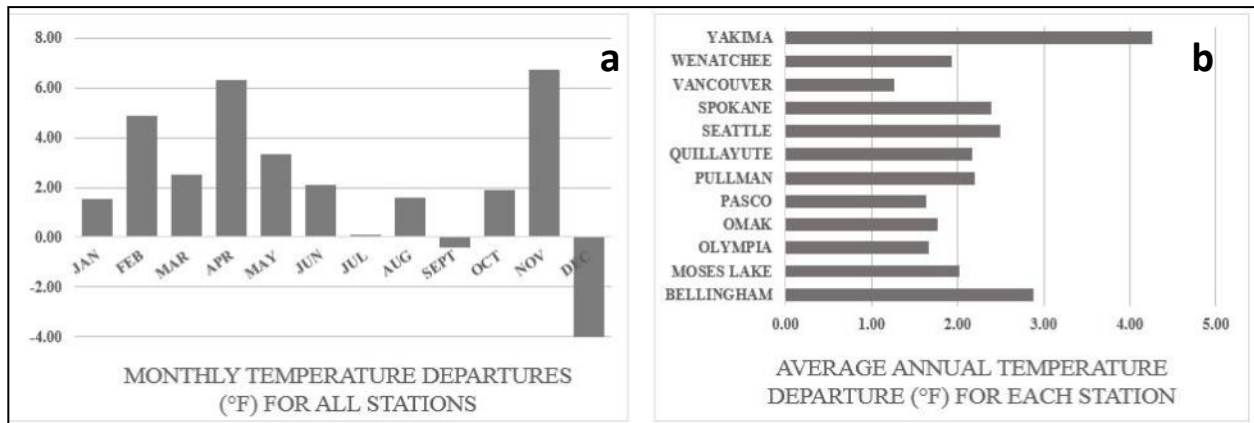
**Precipitation Observations.** Rainfall amounts were mostly average or slightly above average across the state, with a few exceptions (Fig. 1b). Scattered locations in the Palouse and Okanogan Highlands, the Columbia Gorge, southwest interior counties of Skamania, Cowlitz, and Clark, the Central Cascades, and the northwest counties of Whatcom, Skagit, and Snohomish experienced 50 – 90% of normal rainfall. Most of the Olympic Peninsula and Pacific Coast trended higher than normal, generally between 110 – 150%. The Southern Cascades were much higher, seeing upwards of 16” – 20” more rainfall than normal. Seasonal rainfall was mostly above average for the generally cooler months (Jan – Mar and Oct – Dec) and nearly the opposite for the warmer period of April to September. For April, rainfall totals statewide were between 25 – 50% of normal, which was likely a factor in the early start of wildfire season during the first week of May. After a near normal June and July, August saw little precipitation with some areas of the Columbia Basin seeing none. In late summer, most areas around the state were between 25 – 90% of normal. Then, heavy rains in October helped end fire season as many areas saw 4” – 8” above normal rainfall. 2016 rainfall was a relief after the historic drought and fire season of 2015.



**Figure 1.** Average annual total precipitation for the climatological period 1981 – 2010 (a). Percent departure from normal precipitation for 2016 (b). Data sources: National Weather Service Advanced Hydrologic Prediction Service.

**Temperature Observations.** Departures from normal climatological temperatures for select stations indicate greater monthly variations. Especially prominent were the months of April and November, where average temperature departures were in excess of 6°F (Fig. 2a). September and December were generally cooler than average across all stations sampled, and all stations also showed positive departures, indicating a much warmer year than normal (Fig. 2b). Yakima and Bellingham saw the warmest conditions compared to other stations, showing departures of +4.26°F and +2.88°F, respectively.

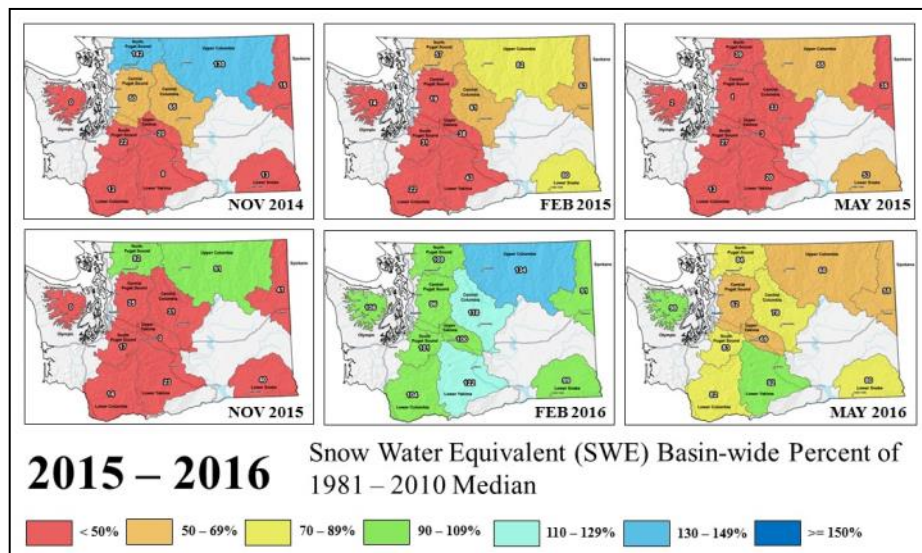




**Figure 2.** 2016 monthly temperature departures for all stations (a) and the average annual departure for each station (b). Data source: National Weather Service.

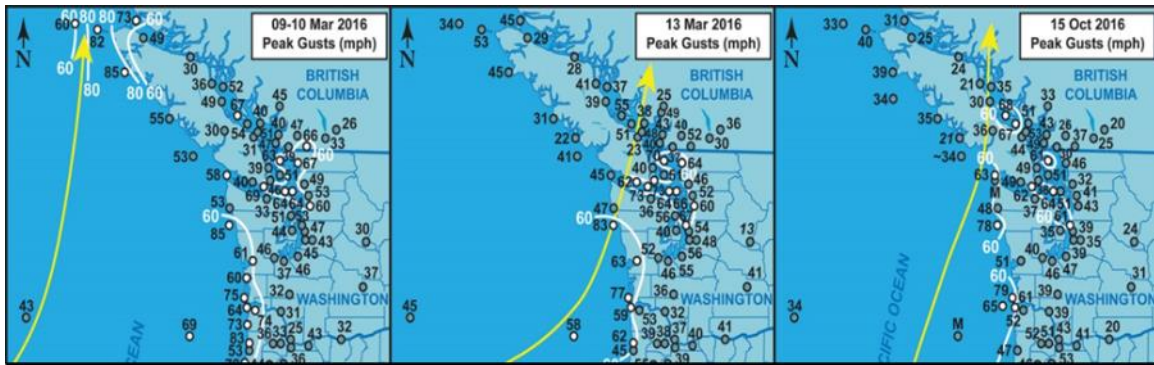
**Snowpack.**

Snow water equivalent (SWE) data (the amount of water content available should snowpack be melted instantaneously) for 2016 shows considerable improvement over 2015 (Fig. 3). Almost all basins were below 50% with three of the eleven Washington basins reporting single digit SWE values by May 2015. The lack of runoff led to record low fuel moisture values for most of the Eastern Cascades and Okanogan County, helping create conditions for the extreme wildfires that were experienced from July to September. In 2016, above average snowfall yielded SWE values near or above normal by February. As noted earlier, April precipitation was only about 25 – 50% of normal statewide, and warming seasonal temperatures caused a slight dip in snowpack, resulting in May SWE values of between 60 – 90% of the climatological median. In all, statewide snowpack averages were about 200% higher than 2015.



**Figure 3.** Comparison of snow water equivalent values from 2015 to 2016. Data source: National Resource Conservation Service.

**Wind Events.** During 2016, three notable western Washington wind events occurred (Fig. 4). The first took place from March 9 – 10 with gusts in the range of 60 to 80 mph that struck the south and central Washington coast. For the Puget Sound Lowlands, gusts of 40 – 50 mph were reported while 60 – 70 mph winds were observed in Whatcom, Skagit, and Snohomish counties. In the following days on March 13, another system brought gusts of 60 – 80 mph to the Pacific Coast, 45 – 55 mph for the Puget Sound Lowlands, and between 50 – 60 mph from Everett to Vancouver, BC. These two wind events resulted in widespread downed trees across the Puget

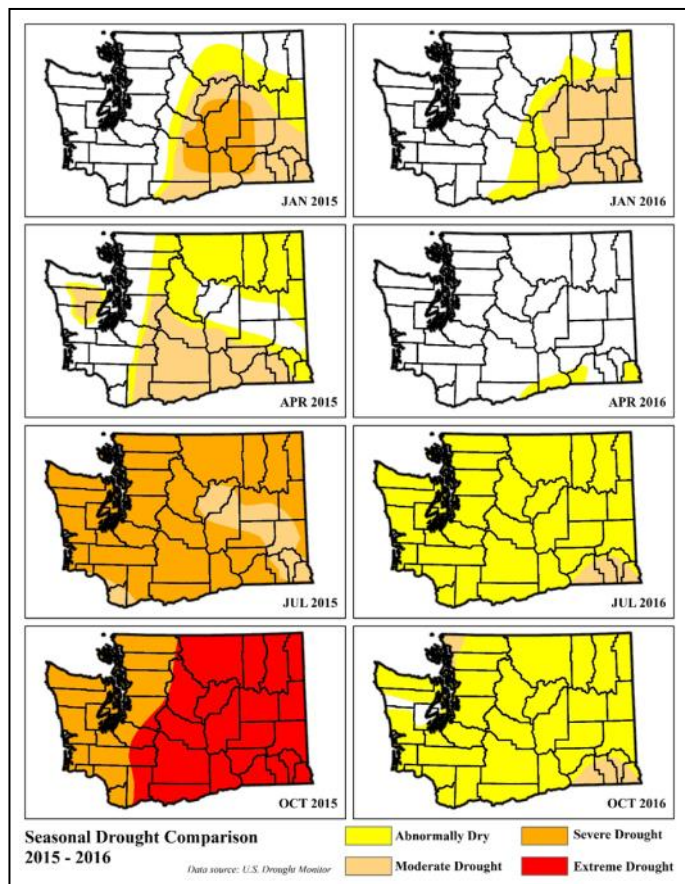


**Figure 4.** Major western Washington windstorms of 2016. Each map details the storm path and recorded peak wind gusts. Maps source: Office of the Washington State Climatologist.

Sound and especially near Bellingham from the first system. On October 14, a windstorm formed from the remnant of Typhoon Songda and on a path towards the Pacific Northwest, was expected to rival the 1962 Columbus Day Storm. However, factors including deintensification of the system in warmer waters near land and proximity to other storm systems, resulted in less severe conditions than forecasted. For most areas, peak gusts were between 35 – 50 mph, with some exceptions of 50 – 60 mph gusts along the coast.

**Note:** Wind information was summarized from analyses provided by Dr. Wolf Read of the Office of the Washington State Climatologist. For more information, see <http://www.climate.washington.edu/stormking/>

**Drought.** Compared to 2015, drought conditions in 2016 were relatively mild (Fig. 5). In January, about one quarter of the state was experiencing moderate drought conditions with another 14% considered abnormally dry. These areas were mostly the Columbia Basin, Palouse, Columbia Gorge, and the Blue Mountains. Seasonal rainfall averages of 100 – 150% from January – March provided needed moisture to these regions, resulting in only scattered locations of abnormally dry conditions in the Columbia Gorge and Blue Mountains by April. However, low spring rainfall resulted in the entire state being abnormally dry with moderate drought conditions in the Blue Mountains by April. This pattern continued for much of the summer, yielding nearly the same conditions through early October. Towards the end of October, La Niña would help create a deluge of precipitation for the Pacific Northwest, completely alleviating any drought concerns for Washington by the end of the year.



**Figure 5.** Comparison of drought conditions from 2015 to 2016. Data source: U.S. Drought Monitor.



## Drought Damage

A severe drought in 2015 resulted in widespread damage evident by late summer. Many affected conifers remained green for months as the weather cooled over winter. Then with record-breaking heat in spring 2016, delayed symptoms became more noticeable and widespread. Symptoms included entirely red crowns, red tops, and scattered red branches (Fig. 6). This was hard to notice in western hemlock, because many dying hemlocks dropped foliage without color change. At the end of summer 2016, unusual levels of western redcedar mortality were reported (Fig. 7). These trees likely had a delayed response to the previous year's drought conditions. The 2016 aerial survey showed increases in ponderosa pine killed by western pine beetle and grand fir killed by fir engraver. Attacks by these bark beetle species often increase following drought events.

The Washington Department of Natural Resources (WDNR) Forest Health Program examined conifers with drought symptoms at sites throughout the state and many showed little indication of being killed by primary pathogens, insects or other animals. In many cases, there were not even signs of opportunistic wood infesting insects in the lower stem, so most likely drought was the primary cause of mortality. When galleries were found in the main stem, they were most often wood borers which only enter conifers that are dead or dying from other causes. In Douglas-fir and ponderosa pine, secondary bark beetles were rarely seen in the lower stem of mature trees, only in small-diameter trees. In the rare cases where mature trees were felled, secondary bark beetles were often found in small-diameter tops and branches. In pines, these were primarily Ips pine engravers. In northeast Washington and north Idaho, damaged Douglas-firs had high numbers of *Scolytus monticolae*, a secondary engraver beetle. In western Washington, secondary bark beetles found in Douglas-fir were either Douglas-fir engraver, *Scolytus unispinosus*, or Douglas-fir pole beetle, *Pseudohylesinus nebulosus*. Galleries and adults of secondary bark beetles were found in lower stems of western redcedar (cedar bark beetles, *Phloeosinus* species) and western hemlock (silver fir beetle, *Pseudohylesinus sericeus*). See page 17 for more information on secondary bark beetle activity in 2017.



Glenn Kohler, Washington DNR

**Figure 6.** Douglas-fir and ponderosa pine damaged by drought conditions and secondary bark beetles in Klickitat County.



Julie Sackett, Washington DNR

**Figure 7.** Drought-caused mortality in young western redcedar.



## Weather Related Damage

**Parch Blight.** On the west slopes of Snoqualmie and Stevens passes, noticeable browning of conifer branch tips was reported in April 2016. With the onset of unusually early sunny, hot days in spring, conifer needles were induced into active respiration and lost water that wasn't replaced through cold soils. Needles were desiccated as a result and turned brown or red, giving the crown a scorched appearance. Hot, dry east winds funneled through mountain valleys increased needle desiccation, especially on the east side of tree crowns. This type of desiccation damage is sometimes referred to as "parch blight." The damage was evident in Douglas-fir, western redcedar, and western hemlock (Figs. 8-10). It was especially noticeable in Douglas-fir along Interstate 90 between North Bend and the Snoqualmie Pass summit (Fig. 9). A significant amount of western hemlock was damaged along US Highway 2 between Gold Bar and Skykomish (Fig. 8). Desiccation damage does not typically harm unopened buds, so affected trees lost some older foliage but most recovered. By the time aerial survey was flown starting in July, the damage was not visible. A similar event occurred in the Columbia River Gorge in spring 2015.



Al McGuire, Washington DNR

**Figure 8.** Foliage loss in western hemlock from desiccation damage near Gold Bar.



Glenn Kohler, Washington DNR

**Figure 9.** "Parch blight" desiccation damage to Douglas-fir in the Snoqualmie Pass area in spring 2016.



Glenn Kohler, Washington DNR

**Figure 10.** "Parch blight" damage in western redcedar.

## Wildfire

According to data compiled by the Northwest Coordination Center (NWCC) through December 2016, wildfires in Washington burned approximately 293,717 acres in 2016. This was well below the 1.09 million acres burned in 2015, the most severe wildfire season on record in Washington, but still above average. There were 39 large fires that burned at least 100 acres in forested land or 300 acres of grass or brush. The largest fire was the Range 12 at 176,600 acres in grassland and brush east of Yakima. Other large fires were Snake River southwest of Pullman, Cayuse Mountain north of Davenport (Fig. 11), and Spokane Complex south of Spokane. 87% of the 1,272 fires reported were human-caused and the remaining 13% were lightning-caused.

Aerial detection survey observers record wildfire damage to forests in two instances: if the fire is smaller than 100 acres, or two years after a large fire occurred and dying trees are still observed. In 2016, aerial observers recorded approximately 9,400 acres of current year small fires or 2014 wildfire damage with related subsequent mortality.



Washington DNR

**Figure 11.** Cayuse Mountain wildfire in Lincoln County, 2016.



# 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 (Fig. 12). Two observers (one on each side of the airplane) look out over a two-mile swath of forestland and mark on a digital sketchmapping computer 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 the number of trees affected. Photos are rarely taken. 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. In areas with heavy mortality, on-ground trees per acre (TPA) killed are commonly 2-3 times greater than estimates made from the air.

ADS observers are trained to recognize various pest signatures and tree species. Newer satellite photography showing recent management activity allows observers to place the damage polygons more accurately on their computer screens. There is always at least one observer in the plane who has three or more years of sketchmapping experience.

Each damage area (polygon) is assigned a code for the damage agent. These codes are defined in the legend of the aerial survey maps. The agent code is followed by number of trees affected; number of trees per acre affected; or intensity of damage (L-Light, M-Moderate, H-Heavy). 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 agent code 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 direct 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.

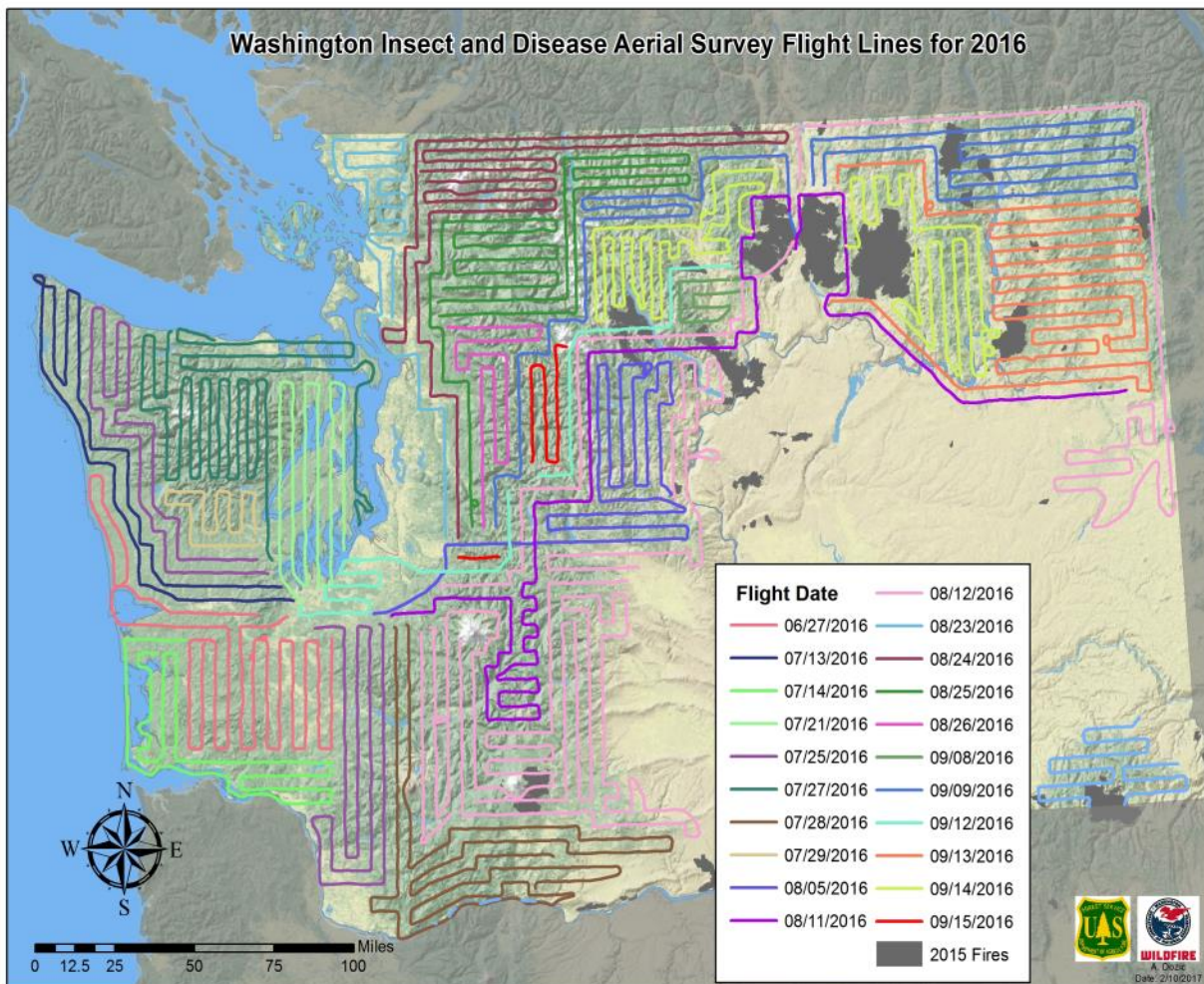


Aleksandar Dozic, Washington DNR

**Figure 12.** Washington Department of Fish & Wildlife aircraft used for Washington aerial survey in 2016.

## 2016 Aerial Survey Conditions

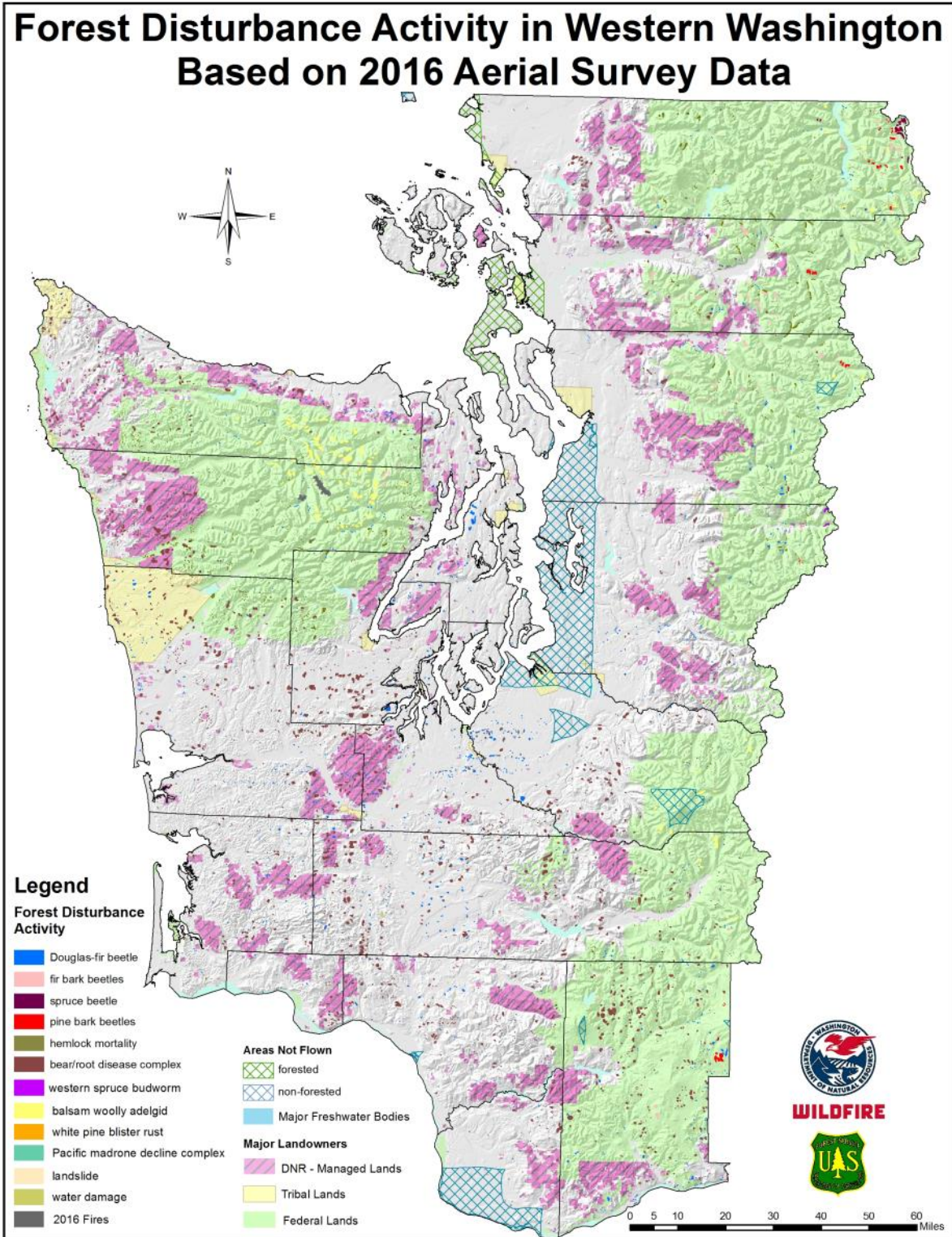
No large wildfires in 2016 influenced flights of the aerial detection survey. Approximately one million acres that would have normally been surveyed were not flown in 2016 due to numerous large fires in 2015 (Fig. 13). Because it is difficult to distinguish mortality caused by fire from mortality caused by insects or disease, areas burned by wildfire are not mapped until the second year following the fire. Because drought damage was so widely reported in 2015 and 2016, an effort was made by observers to map drought damage as a secondary agent. However, it was difficult to distinguish from other types of mortality, such as from bark beetles. Symptoms unique to drought, such as branch flagging, were difficult to see from the air. In most years, the forested area around Joint Base Lewis-McCord (JBLM) is not flown by aerial survey due to challenges with airspace coordination. After coordination with JBLM staff, aerial observers managed to survey 180,000 acres around the base in 2016. A sample of damage polygons was ground checked with JBLM staff. The aerial survey program hopes to continue with this effort in the future.



**Figure 13.** Washington insect and disease aerial survey flight lines for 2016. Map by: Aleksandar Dozic, Washington DNR.



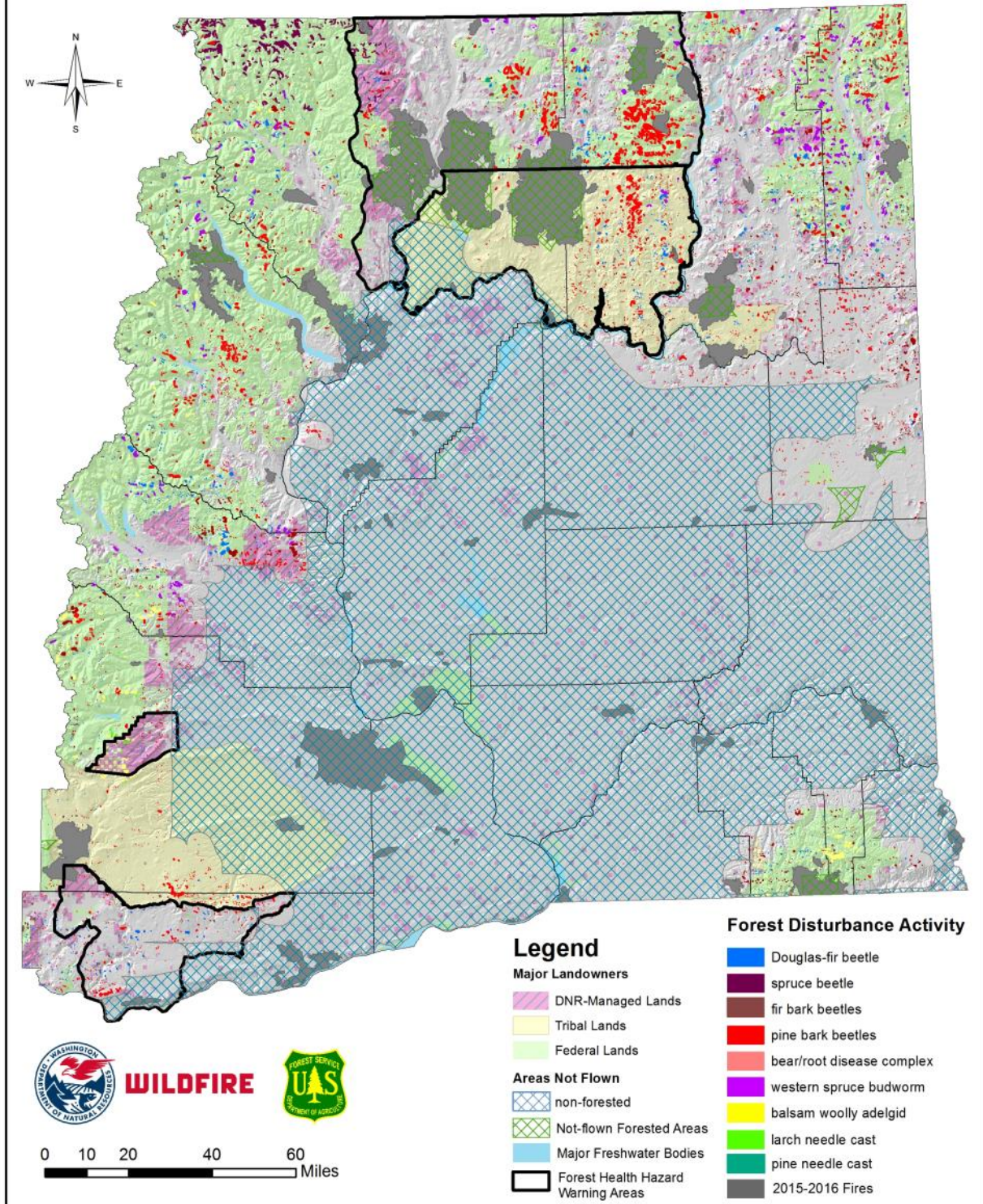
## 2016 Aerial Survey Summary Maps



**Figure 14.** Forest disturbance map of western Washington composed from 2016 aerial survey data. Map by: Aleksandar Dozic, Washington DNR.

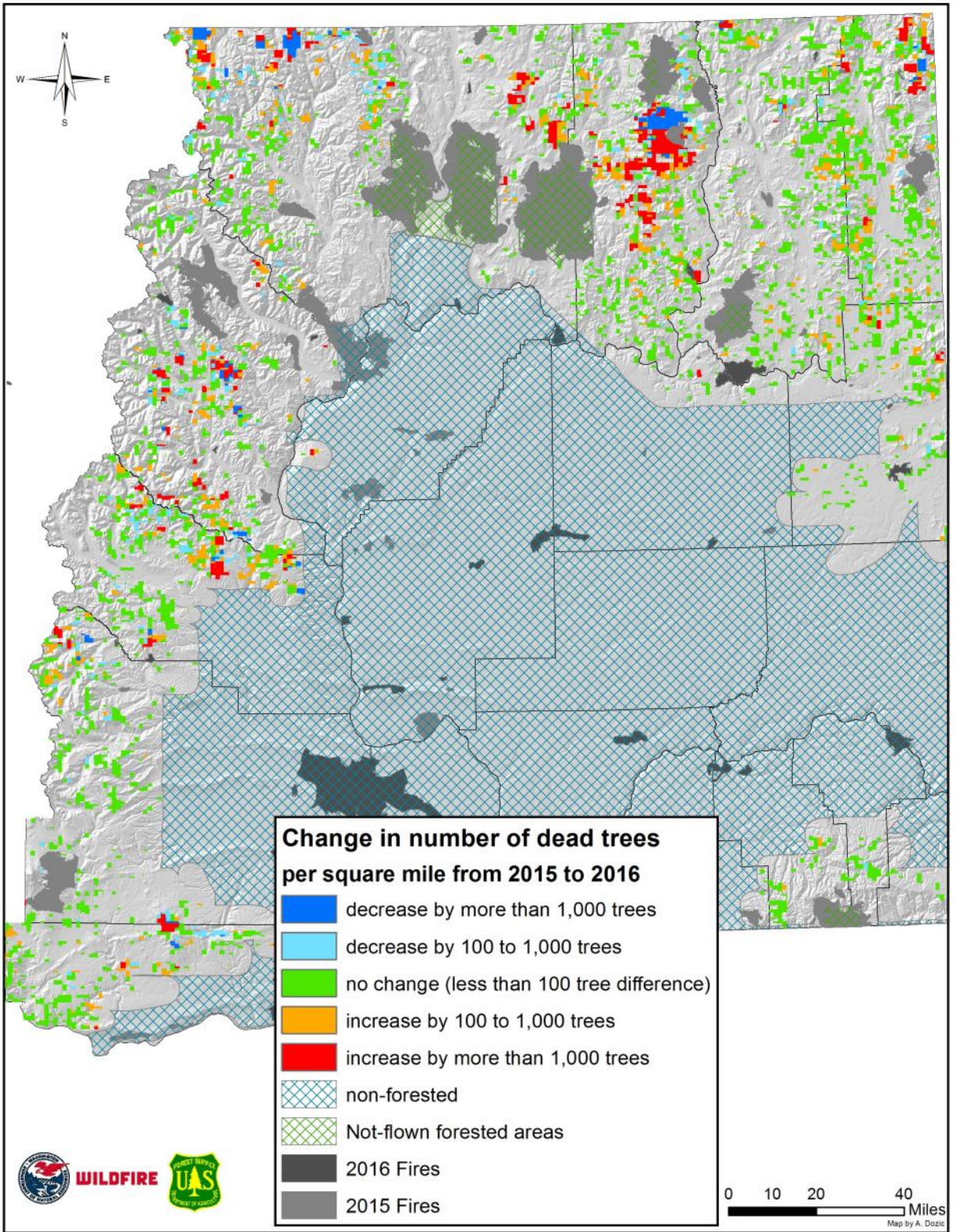


# Forest Disturbance Activity in Eastern Washington Based on 2016 Aerial Survey Data



**Figure 15.** Forest disturbance map of eastern Washington composed from 2016 aerial survey data.  
Map by: Aleksandar Dozic, Washington DNR.





**Figure 16.** Change in tree mortality levels recorded by aerial survey in eastern Washington between 2015 and 2016. Map by: Aleksandar Dozic, Washington DNR.

# Insects

## Bark Beetles

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

**Pine bark beetle** activity recorded by aerial survey nearly doubled in 2016 to approximately 126,000 acres compared to the 65,200 acres in 2015 (Fig. 18). The number of pine trees estimated to have been killed by pine bark beetles was 1.74 million in 2016; 2.5 times greater than the 670,000 trees in 2015 (Table 1). Pine mortality due to **mountain pine beetle (MPB)** was recorded on 111,700 acres, an increase from 2015 but still below the ten-year average of 180,000 acres.



Glenn Kohler, Washington DNR

**Figure 17.** Groups of ponderosa pines killed by western pine beetle near Deer Park in 2016.

The majority of MPB-caused mortality was in lodgepole pine (91,100 acres), almost double the area recorded in 2015 (54,000 acres). Relative to 2015, MPB-caused mortality of ponderosa pine and whitebark pine also increased in 2016, while mortality due to MPB decreased in western white pine. The 27,200 acres with ponderosa mortality attributed to MPB was the highest level since 2010. The most concentrated areas of lodgepole and ponderosa pine mortality due to MPB occurred in the Colville National Forest in northern Ferry County and central Chelan County near Lake Chelan and within the Okanogan-Wenatchee National Forest (Figs. 15 & 16). Areas with mortality of ponderosa pines due to **western pine beetle (WPB)** increased to 12,900 acres, the highest level since 2008 (Fig. 17). Severe summer drought

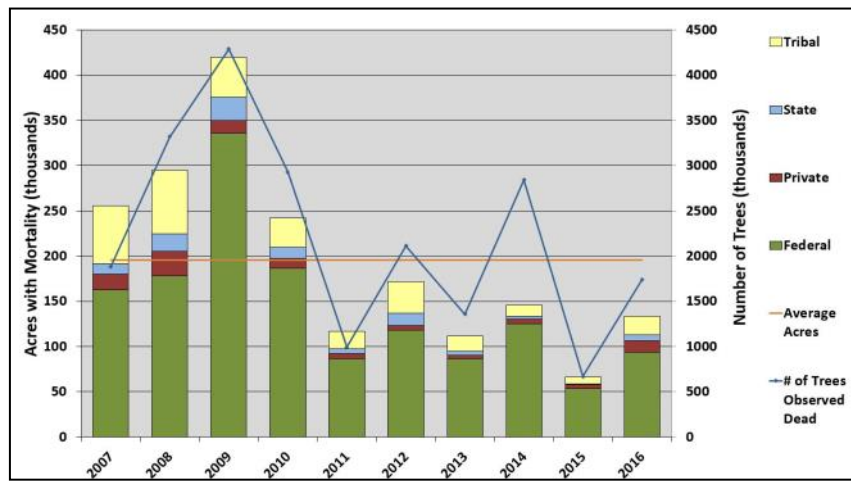
**Table 1.** 2016 statewide acres affected and estimated number of pine bark beetle-killed trees.

Beetle species	Host(s)	Acres with mortality*	Estimated number trees killed
mountain pine beetle	lodgepole pine	91,100	1,607,000
mountain pine beetle	ponderosa pine	27,200	81,800
mountain pine beetle	whitebark pine	240	1,300
mountain pine beetle	western white pine	90	120
western pine beetle	ponderosa pine	12,900	34,400
pine engravers ( <i>Ips</i> species)	all pines	2,100	11,900

\*Multiple host species can be recorded in a single area, therefore the sum of each pine bark beetle is greater than the total footprint of all beetles.



conditions of 2015 are likely an important driver of the increase. WPB-caused mortality was also scattered and widely dispersed across south central and northeastern WA including Klickitat, Yakima, Kittitas, Ferry, Stevens, and Spokane counties. The 2,100 acres with pine mortality attributed to *Ips pine engravers* was the highest in the last ten years.



**Figure 18.** Ten year trend for total acres and number of trees affected by pine bark beetles in Washington.



Glenn Kohler, Washington DNR

**Figure 19.** 'Y'-shaped egg galleries of CFI.

### California Fivespined Ips (*Ips paraconfusus* Lanier)

California fivespined Ips (CFI), a pine engraver beetle (Fig. 19) 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. Seven years of CFI outbreaks in the Columbia River Gorge have resulted in unusually high levels of ponderosa pine mortality exacerbated by outbreaks of western pine beetle, damage by red turpentine beetle, and bluestain fungi associated with all three bark beetle species. Hundreds of ponderosa pines have been killed by CFI each year in the Gorge area since 2010. Outbreaks are being driven by ample breeding material generated by wildfires, storm damage, harvest activity, and drought conditions. Mild temperatures may have increased survival of overwintering beetles. WDNR has coordinated a statewide survey since 2011 to determine the extent of CFI range throughout Washington. With cooperators assistance, both CFI and *Ips pini* baited traps were deployed at 17 locations in 12 counties in 2016. To date CFI has been collected in seven Washington counties (Klickitat, Skamania, Clark, Cowlitz, Lewis, Thurston, and Pierce). CFI populations are very low at detection sites in western Washington north of Vancouver and CFI-caused ponderosa mortality has not been observed in those areas. CFI's known range has extended 100 miles north and 80 miles east. Over 13,000 CFI and 10,000 *Ips pini* specimens were collected during the trapping surveys. Ponderosa pine is the preferred host of both *Ips* species, but trap survey data shows they rarely overlap in high numbers at the same locations. 48 other bark beetle species have been collected.

## Douglas-fir Beetle (*Dendroctonus pseudotsugae* Hopkins)

Approximately 30,600 acres with Douglas-fir beetle (DFB) caused mortality were observed statewide in 2016, up from 18,500 acres in 2015 (Figs. 14 & 15). This was the highest level since 2009, the peak year of a western Washington DFB outbreak related to severe coastal windstorms (Fig. 22). Scattered large areas of DFB-caused mortality were detected throughout the east slopes of the Cascades and northeast Washington. Increases may be associated with the recent drought and chronic defoliation by the western spruce budworm in some areas (Fig. 20).



Glenn Kohler, Washington DNR

**Figure 20.** Damage from Douglas-fir beetle and western spruce budworm in Kittitas County.

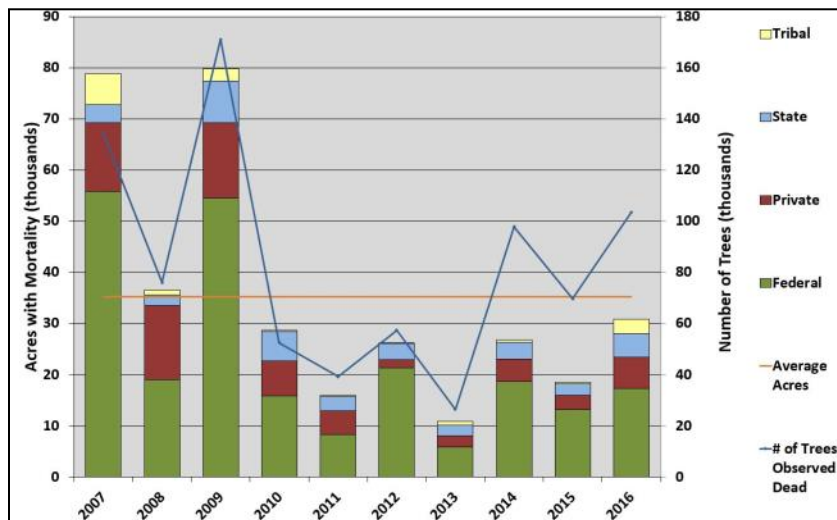
In spring 2015, a 25 acre area of WDNR land in Klickitat County was treated using the Douglas-fir beetle repellent pheromone MCH (Fig. 21). A “high dose” application method was used which tripled the normal number of bubble capsules placed at each release point, reducing time needed for application (Ross et al. 2015). A 2016 evaluation of the treated stand found four trees killed by DFB since the application, all of which were near the edge or outside the treatment area.



Glenn Kohler, Washington DNR

**Figure 21.** Applying MCH bubble capsules.

*Ross, D.W., K. Gibson, and G.E. Daterman. 2015. Using MCH to protect trees and stands from Douglas-fir beetle infestation. USDA Forest Service, FHTET-2001-09, Morgantown, WV.*



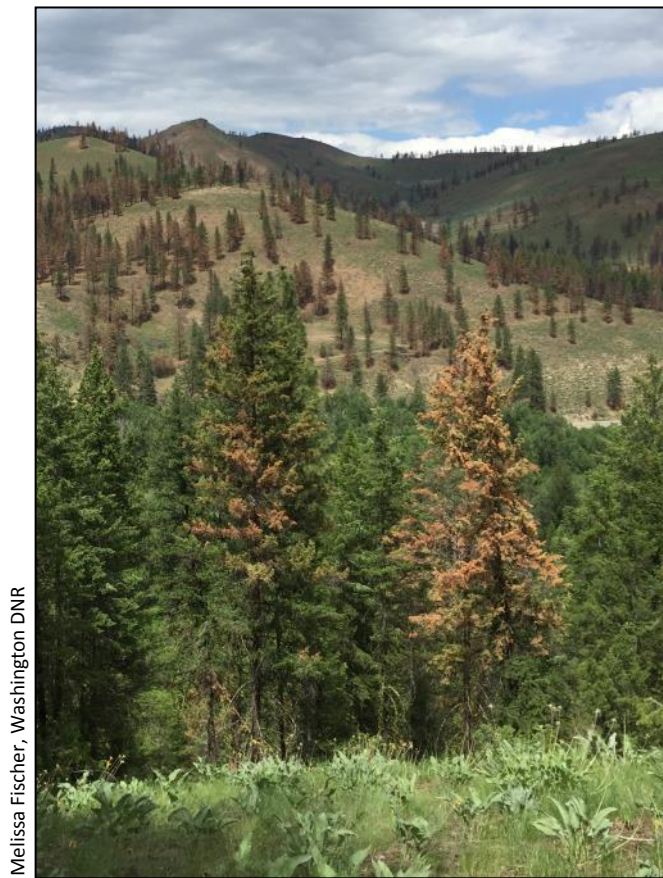
**Figure 22.** Ten year trend for total acres and number of trees affected by Douglas-fir beetle in Washington.



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

The Douglas-fir engraver, Douglas-fir pole beetle, and *Scolytus monticolae*, which has no common name, are secondary bark beetles that commonly build-up in Douglas-fir logging slash and attack small Douglas-fir trees and the tops and branches of larger trees during droughty periods (Fig. 23). These species may also be attracted to Douglas-fir that have been attacked by the more aggressive Douglas-fir beetle (*Dendroctonus pseudotsugae*) and/ or trees with root rot infections. The three species are frequently found together within the same tree. Their egg/ larval galleries look very similar and are often intermingled (Fig. 24).

Damage due to these species increased significantly in 2016 to 4,100 acres; the highest level recorded in the history of the Washington aerial survey. This increase is likely due to the 2015 drought. Northeast Washington and Idaho found high numbers of *S. monticolae*, whereas sampled trees in Western Washington contained either Douglas-fir engraver or the Douglas-fir pole beetle. Activity by these species is likely to decrease over time as drought conditions are alleviated.



**Figure 23.** Damage to Douglas-fir from secondary bark beetles.



**Figure 24.** Douglas-fir pole beetle larval galleries.

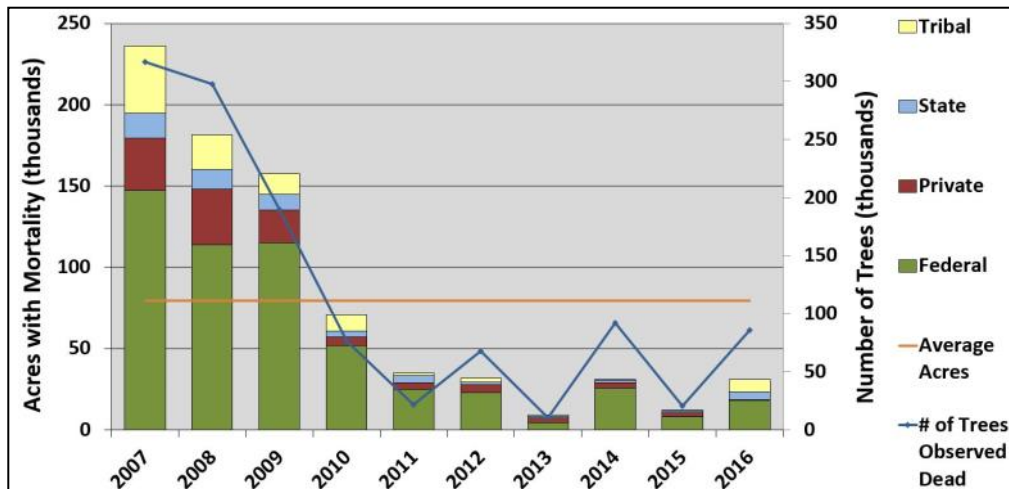
## Fir Engraver (*Scolytus ventralis* LeConte)

Fir engraver can attack all species of true fir (*Abies*) in Washington, but the primary hosts in Washington are grand fir and noble fir. Some mortality due to fir engraver was recorded in 30,800 acres in 2016, a significant increase from 11,700 acres in 2015; similar to 2014 but well below the ten-year average of 79,500 acres (Fig. 26). The most affected areas were northwest Washington and Kittitas, Yakima, Stevens, and Pend Oreille counties (Fig. 25). As with western pine beetle, recent summer drought conditions are likely an important driver of the increase.



Glenn Kohler, Washington DNR

**Figure 25.** Grand fir in the Naneum State Forest killed by fir engraver in 2016.



**Figure 26.** Ten year trend for total acres and number of trees affected by fir engraver in Washington.

## Western Balsam Bark Beetle (*Dryocoetes confusus* Swaine)

Western balsam bark beetle (WBBB; Fig. 27), often in conjunction with balsam woolly adelgid, is an important driver of subalpine fir mortality in high elevation forests of Washington. The 9,200 acres with WBBB-caused mortality in 2016 was the highest level since 2010. This ends a declining trend over the last ten years in area with WBBB-caused mortality from a recent peak of 56,000 acres in 2007.



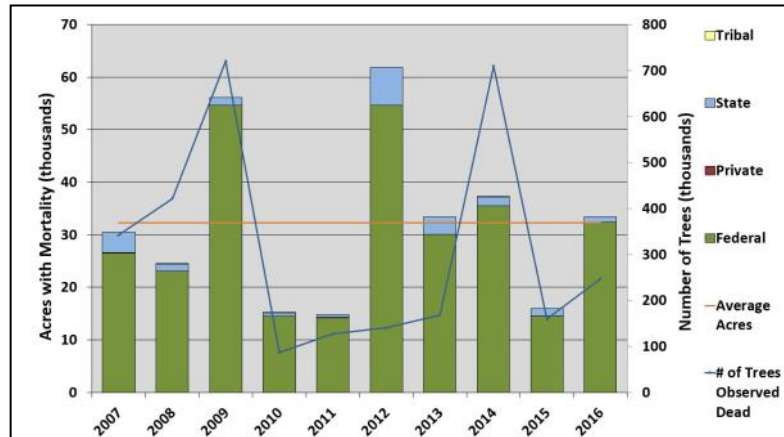
Scott Tunnock, USDA Forest Service, Bugwood.org

**Figure 27.** Western balsam bark beetle gallery.

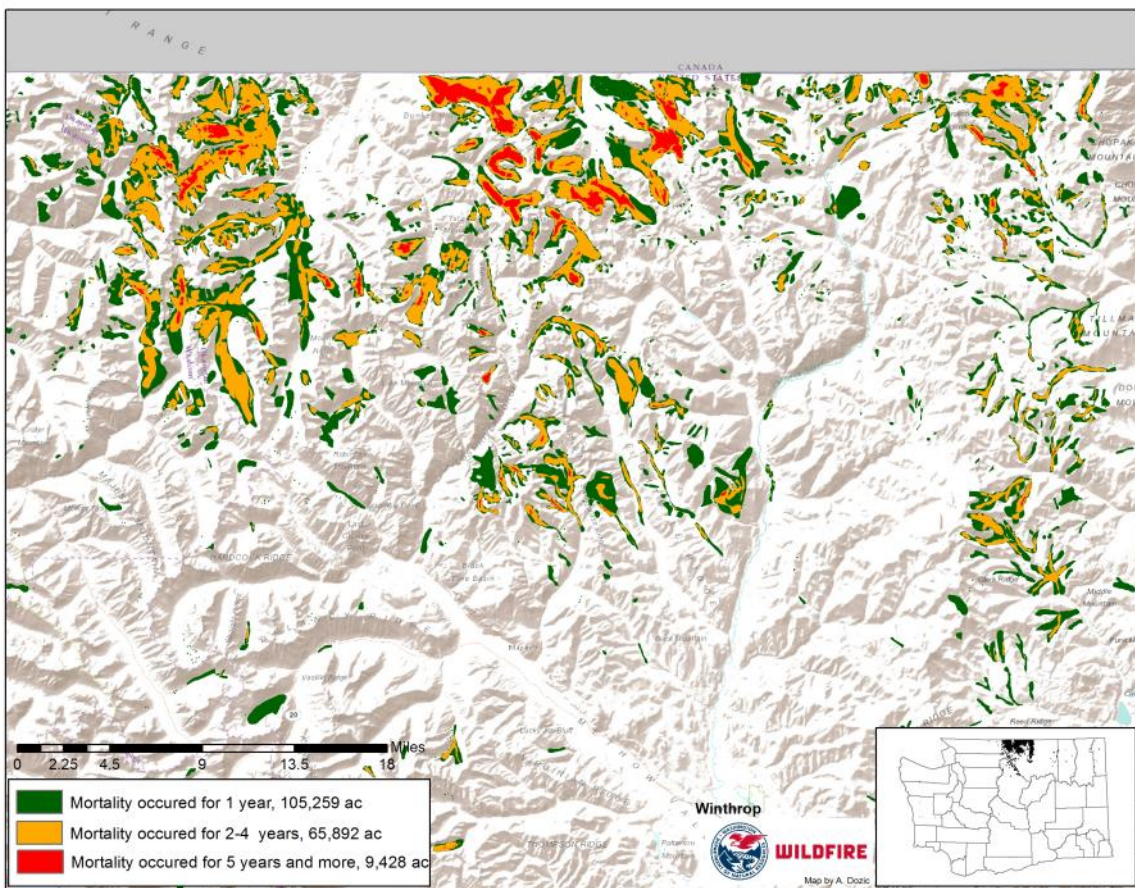


## Spruce Beetle (*Dendroctonus rufipennis* Kirby)

The 33,500 acres affected by spruce beetle (SB) in 2016 was double the 16,000 acres mapped in 2015 and similar to the level in 2013 and 2014 (Fig. 28). The majority of SB-caused mortality occurred in western Okanogan and eastern Whatcom counties in the vicinity of the Loomis State Forest and the Pasayten Wilderness within the Okanogan-Wenatchee National Forest. In this area spruce beetle impacts high elevation stream bottom stands of Engelmann spruce (Fig. 29).



**Figure 28.** Ten year trend for total acres and number of trees affected by spruce beetle in Washington.



**Figure 29.** Cumulative mortality from spruce beetle recorded in Okanogan County by aerial survey, 2007 to 2016. Map by: Aleksandar Dozic, Washington DNR.

## Defoliators

### Western Spruce Budworm (*Choristoneura freemani* Razowski)

In 2016, areas with western spruce budworm (WSB) defoliation (Figs. 30 & 31) recorded in the aerial survey decreased to approximately 46,300 acres; well below the 79,000 acres recorded in 2015 and the lowest total since 2002 (Fig. 32). Mid-elevation forests of Kittitas, Okanogan, Ferry, Stevens, and Pend Oreille counties have been most heavily affected by this outbreak. WSB defoliation was very light and caterpillar activity was less evident in many areas of Kittitas County that have been heavily impacted by WSB in the last decade. The outbreak in this area is showing signs of decline. After several consecutive years of defoliation in the central and north Cascades, subsequent mortality from Douglas-fir beetle and fir engraver are becoming more common.

Pheromone trap catches in northern Kittitas County indicate light to moderate defoliation in 2017, a decrease in intensity as the outbreak declines (Fig. 33). WSB activity in northeast Washington continues to increase.

Trap catches in eastern Okanogan and northern Ferry counties indicate moderate to heavy defoliation in 2017. The 28,000 acres of defoliation mapped in Ferry, Stevens, and Pend Oreille counties was similar to 2015 and trap catches in this area remain low (Fig. 33).



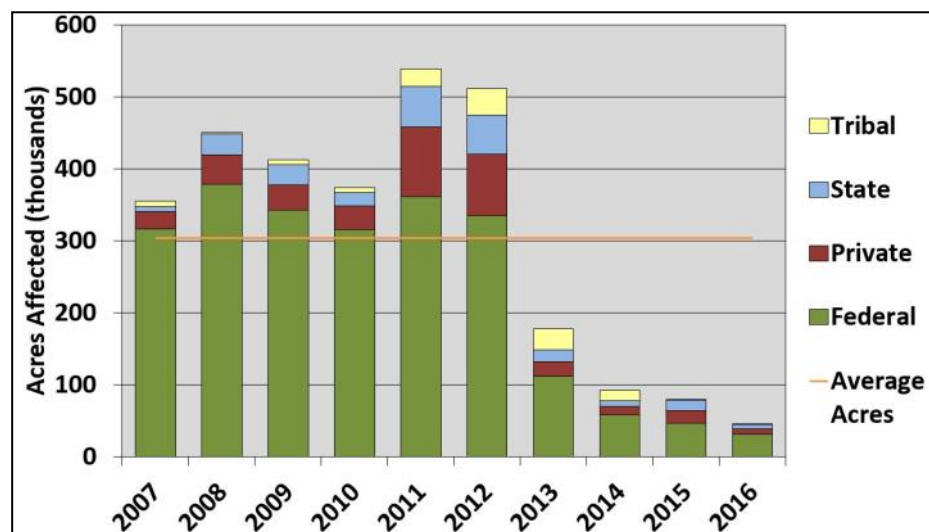
Glenn Kohler, Washington DNR

**Figure 30.** Western spruce budworm defoliation in Douglas-fir with unaffected ponderosa pine.



Mike Johnson, USDA Forest Service

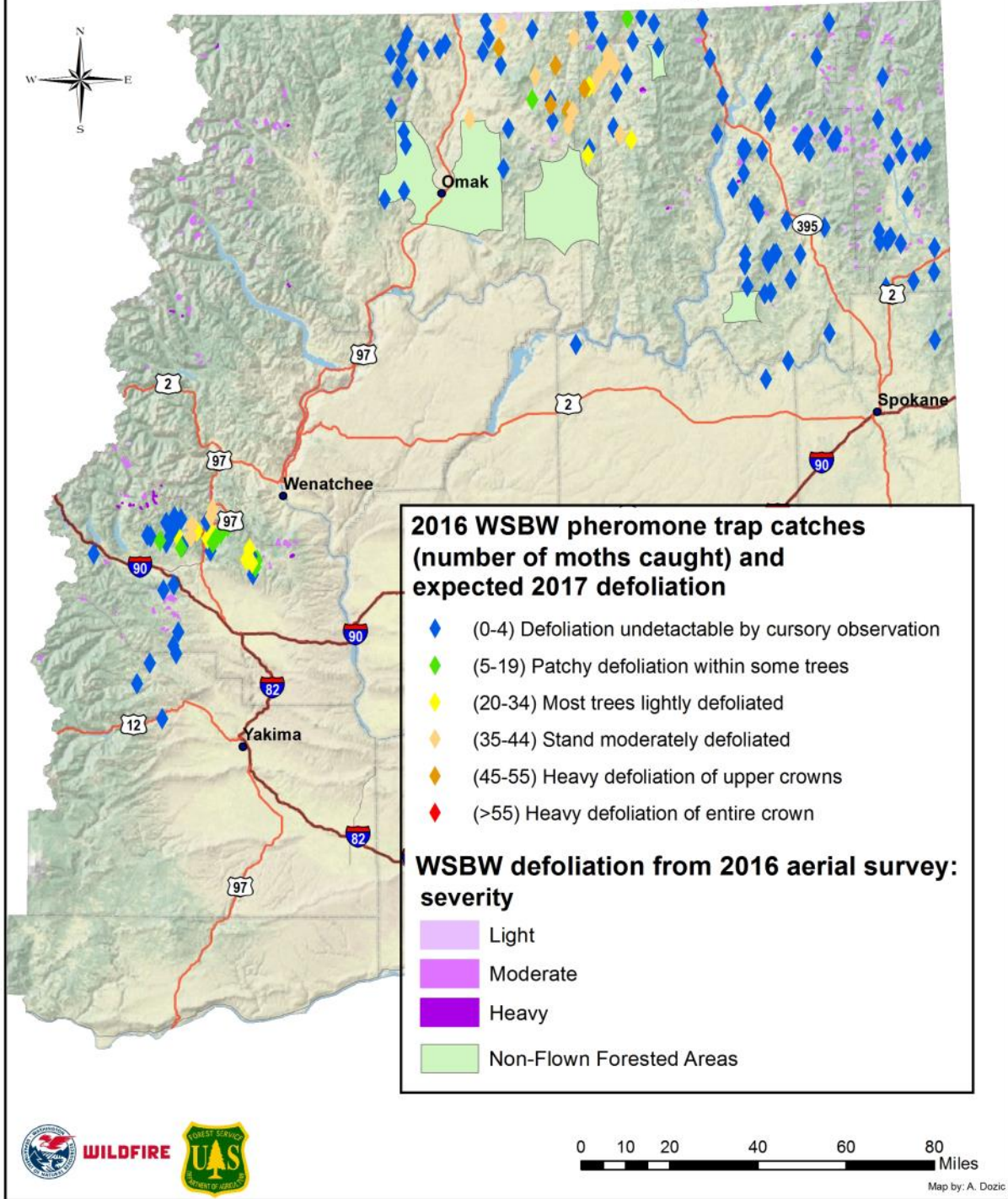
**Figure 31.** Western spruce budworm pupa on western larch.



**Figure 32.** Ten year trend for total acres affected by western spruce budworm in Washington.



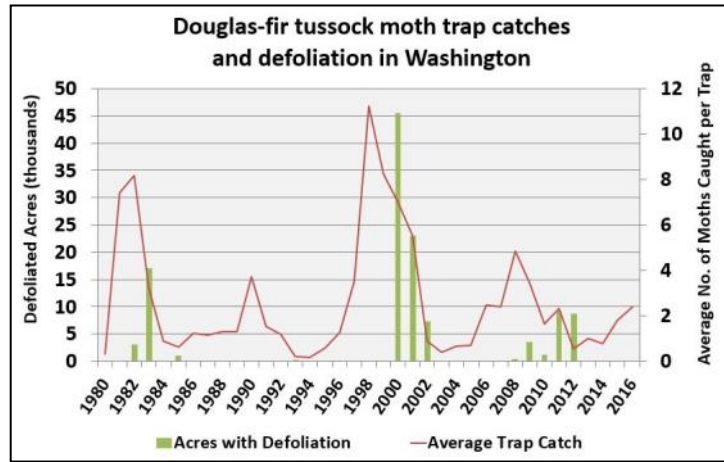
# Western Spruce Budworm Pheromone Trap Results in Eastern Washington 2016



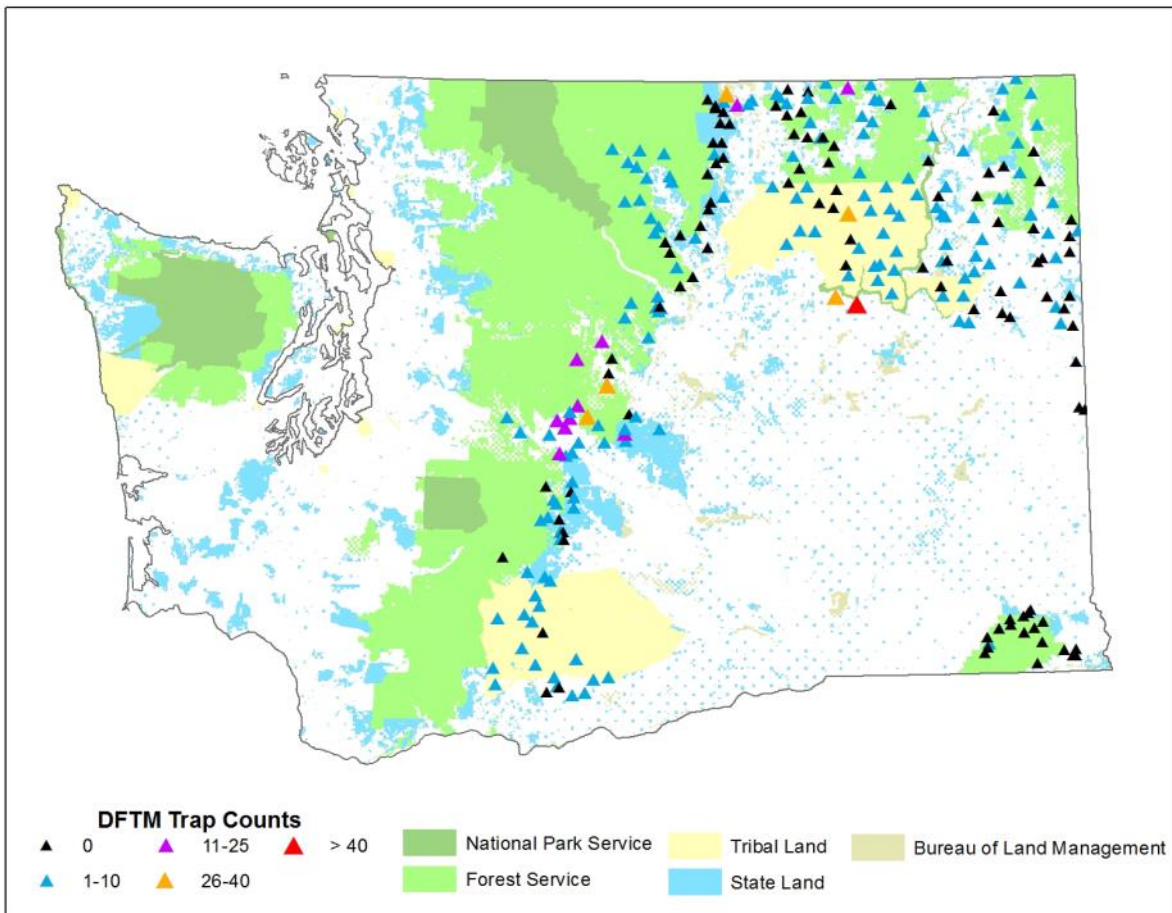
**Figure 33.** Western spruce budworm pheromone trap catch results for 2016, expected 2017 defoliation and defoliation detected by the 2016 aerial survey. Map by: Aleksandar Dozic, Washington DNR.

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

There was no Douglas-fir tussock moth defoliation recorded in 2016 (Fig. 34). The last year with any significant defoliation was in 2012 in the Umatilla National Forest in the Blue Mountains. The interagency network of “Early Warning System” pheromone traps at approximately 250 locations in WA continued to be monitored annually (Fig. 35). Trap catches have increased in several areas which may indicate higher likelihood of defoliation occurring in the next few years. The last outbreak began in 2008. Outbreaks typically last 2–4 years.



**Figure 34.** Douglas-fir tussock moth pheromone trap catches and observed defoliation, 1980 to 2016.



**Figure 35.** Douglas-fir tussock moth pheromone trap catch results for Washington in 2016.  
Map by: Zack Heath, USDA Forest Service.



## Conifer Defoliating Sawflies (Family Diprionidae)

Sawfly larvae can be found on conifer foliage between June and August. They feed together as a group and look very much like caterpillars (Fig. 36), but are in fact wasps in the order Hymenoptera, which also includes ants and bees. Sawfly larvae can be differentiated from caterpillars by the presence of six or more pairs of prolegs, whereas caterpillars have five or less.



Mike Johnson, USDA Forest Service

**Figure 36.** Sawfly larvae feeding on ponderosa pine.

The majority of conifer sawfly species feed on old needles which are only partially consumed, leaving needle stubs (Fig. 37). As the damaged foliage dries, it turns a reddish color and is visible from the air. In 2016, approximately 810 acres of sawfly defoliated ponderosa pine were observed from the air, primarily in Okanogan and Ferry counties. Heavily defoliated ponderosa pine were also reported in areas of the Loomis State Forest. Approximately 310 acres of true fir with sawfly defoliation were also mapped in 2016. Outbreaks such as these usually last two years at most with little or no tree mortality because new foliage and buds are not damaged.



Melissa Fischer, Washington DNR

**Figure 37.** Defoliation of older ponderosa pine foliage by sawfly larvae.

## Larch Casebearer (*Coleophora laricella* Hübner) NON-NATIVE

Larch casebearer (LC) is a well-established exotic insect that feeds on the foliage of western larch. No defoliation attributed to LC was recorded in the 2016 aerial survey; the third year in a row. The last outbreak of LC in Washington affected 16,000 acres in 2011. Because larch re-foliates annually, it takes several years of damage to cause serious injury to larch.

Previous annual total acres with defoliation from larch casebearer were:

2015: 0      2014: 0      2013: 730      2012: 1,700      2011: 16,000

## Western Tent Caterpillar (*Malacosoma californicum* (Packard))

Only 260 acres of western tent caterpillar (WTC) defoliation was mapped in 2016, similar to the 140 acres in 2015. The recent western Washington outbreak from 2012 through 2014 has collapsed. WDNR received reports of minor tent caterpillar activity in Mason and Kitsap counties. Primary hosts include cottonwood, other poplars, and red alder. WTC outbreaks are cyclical and rarely last more than a few years.

Previous annual total acres with defoliation from western tent caterpillar were:

2015: 140      2014: 1,700      2013: 6,100      2012: 8,400      2011: 180

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

In 2016, the Washington State Department of Agriculture (WSDA) placed 28,395 gypsy moth pheromone traps in Washington. 12,975 of these were for European gypsy moth (EGM) detection and delimiting and 15,420 were for Asian gypsy moth (AGM) detection and delimiting. A total of 25 gypsy moths were collected from 9 counties: Clark (1), Cowlitz (1), King (7), Kitsap (8), Kittitas (1), Mason (1), Pierce (4), Spokane (1), and Thurston (1). This is a decrease from the 42 moths caught in 2015. All moths collected in 2016 were the North American variety of EGM from the established European population in the eastern United States. No Asian gypsy moths were caught in 2016 following a record catch of 10 AGM in 2015, the first trapped in Washington since 1999.

WSDA conducted a gypsy moth eradication project in spring 2016, treating 10,450 acres with the bacterial insecticide *Bacillus thuringiensis* var. *kurstaki* (B.t.k.) using fixed-wing aircraft (Fig. 38). Six of the sites were treated for AGM and one site (Seattle) was treated for an EGM population. Treatment areas were located in King, Pierce, Thurston, and Clark counties. Three applications per site were completed between April 16 and May 3.



Washington Department of Agriculture

**Figure 38.** Fixed-wing application of B.t.k. in western Washington, spring 2016.

Following B.t.k. treatments, WSDA placed 10,477 traps for delimitation around AGM treatment areas. None of the moths caught in summer 2016 were located in the treated areas. Delimitation trapping around treatment areas will continue in 2017. No eradication projects are planned for 2017.



## Aspen Leaf Miner (*Phyllocnistis populiella* Chambers)

The aspen leaf miner is a defoliator of quaking aspen. Adults are small, white moths whose larvae feed between the epidermal layers of aspen leaves during the summer. The larvae feed in a snake-like pattern resulting in a conspicuous serpentine mine that contains a thin black line of frass in the center (Fig. 39 & 40). The mined leaves give aspen crowns a silvery appearance (Fig. 41). Eventually the leaves desiccate, turn brown, and drop prematurely.

In 2016, approximately 650 acres with aspen damage of this type were mapped in Ferry, Stevens, and Pend Oreille counties. Historically, this insect has not been a significant pest in Washington State, but areas in Alaska and British Columbia have seen large outbreaks in recent years. Leaf mining insects tend to thrive in years associated with warm, dry weather, therefore the increase in leaf mining activity in 2016 is likely due to drought conditions in 2015. While damage by this leaf miner is mostly aesthetic, sustained annual defoliation can result in reduction in tree growth, branch dieback, and top kill, but mortality is unlikely.



Whitney Cranshaw, Colorado State University, Bugwood.org

**Figure 39.** Aspen leaf miner larva between leaf epidermal layers with black frass trail.



Melissa Fischer, Washington DNR

**Figure 40.** Aspen leaf miner damage pattern in quaking aspen leaves.



Melissa Fischer, Washington DNR

**Figure 41.** Quaking aspen crowns defoliated by aspen leaf miner.

## Branch and Terminal Insects

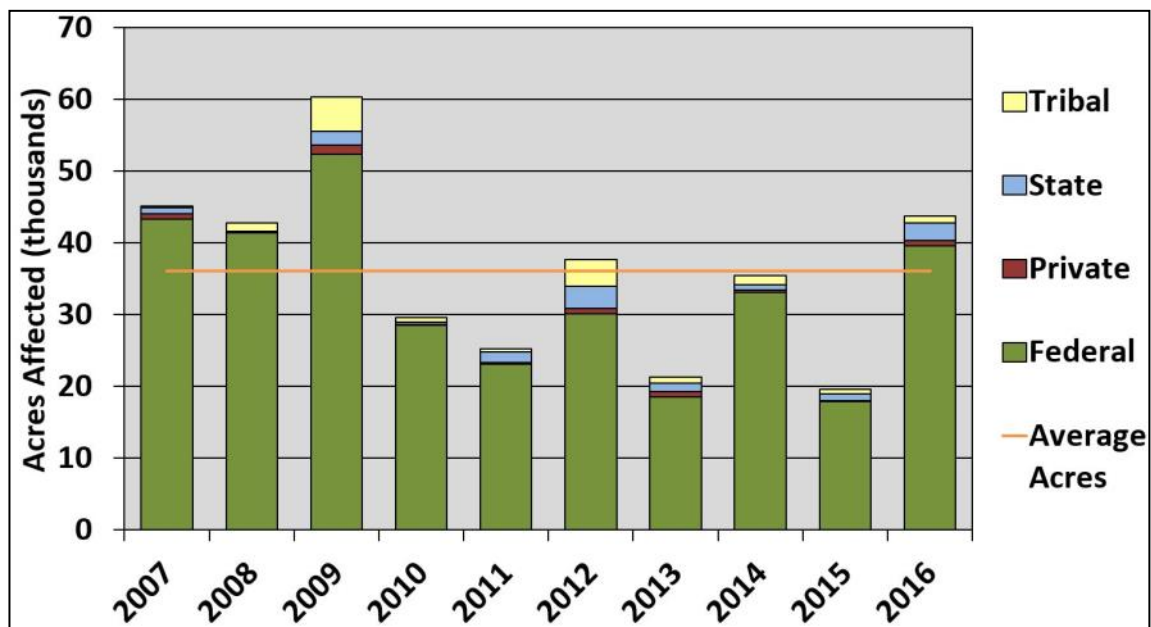
### Balsam Woolly Adelgid (*Adelges piceae* Ratzeburg) NON-NATIVE

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. Most current damage is recorded in subalpine fir in high elevation forests throughout Washington (Fig. 42). In 2016, approximately 43,700 acres of damage was observed, a significant increase from 19,600 acres in 2015 and above the 10-year average of 40,000 acres (Fig. 43). 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 8,600 acres with some host mortality attributed directly to BWA damage in 2016. Approximately 9,200 acres in these same high elevation areas were mapped with some western balsam bark beetle caused mortality in subalpine fir. BWA infestation can be a predisposing factor to western balsam bark beetle attack.



Glenn Kohler, Washington DNR

**Figure 42.** Mortality in subalpine fir caused by balsam woolly adelgid infestation.



**Figure 43.** Ten year trend for total acres affected by balsam woolly adelgid in Washington.



# Animals

## Bear Damage / Root Disease

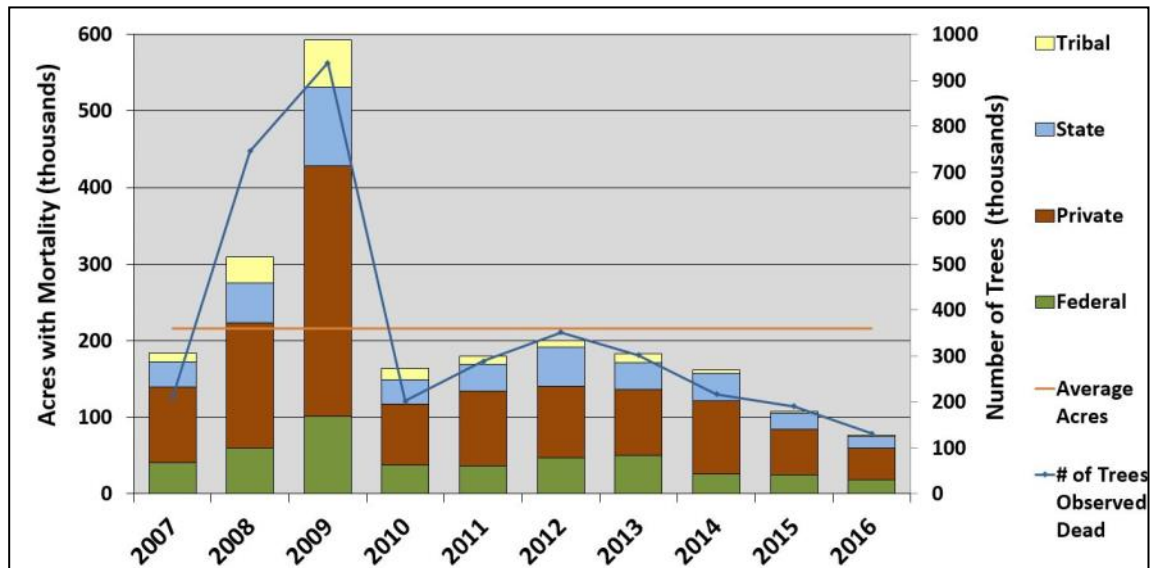
Aerial survey records scattered, pole-sized, newly dead trees as 'bear damage' (Fig. 44). Based on ground checking observations, bear girdling and root disease are the primary causes of this type of damage. Drought stress, porcupines or mountain beavers may also play a role. Bears strip tree bark in spring. It takes more than one year for the tree to die and needles to become red (visible from the air). In 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 age of trees.



Alan Mainwaring, Washington DNR

**Figure 44.** Douglas-fir mortality from bear damage as seen from the air.

Approximately 77,200 acres with bear damage mortality were observed in 2016, below the 107,500 acres mapped in 2015 (Fig. 45). The ten year average of acres with bear damage in Washington is 216,000. The average number of trees per acre (TPA) killed was similar in 2016 (1.70 TPA) and 2015 (1.77 TPA). The estimated total number of trees killed was approximately 131,000, which was less than the 191,000 trees killed in 2015.



**Figure 45.** Ten year trend for acres and number of trees affected by bear damage in Washington.

# Diseases

## Foliar and Branch Diseases

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



Amy Ramsey, Washington DNR

**Figure 46.** A Douglas-fir tree with low foliar retention, a symptom of Swiss needle cast.

The fungus that causes Swiss Needle Cast (SNC), *Phaeocryptopus gaeumannii* (T.Rohde) Petrak is found throughout the range of its only host, Douglas-fir. Swiss Needle Cast causes premature foliage loss and defoliation and can reduce growth of host trees, alter wood properties, and affect stand structure and development (Fig. 46). The disease is most damaging near the coast due to the fungi-favorable climatic (mild winters and wet, late springs) and topographic conditions.

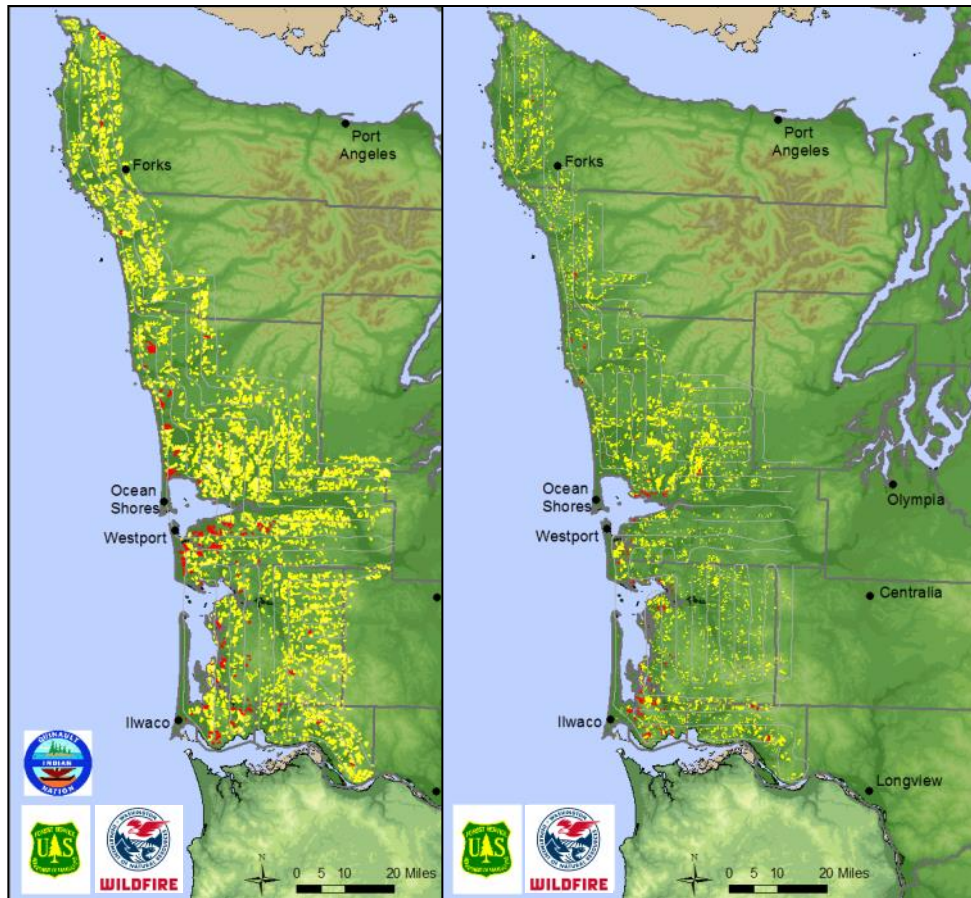
In late April and early May, 2016, an aerial survey covering 2.4 million acres of coastal Washington forestland was flown to detect and map the distribution of SNC (Table 2). Observers looked for areas of Douglas-fir forest with obvious yellow-brown foliage, a rather generic symptom that appears to be indicative of moderate to severe SNC disease. Also included in the survey were sixty-three ground sites distributed across the range of the aerial survey. These were surveyed for SNC incidence and severity, determined by counting fungal reproductive structures in the stomata of Douglas-fir needles and estimating Douglas-fir needle retention.

Foliar retention varied across the survey area with an average of 2.4 years across all sixty-three ground survey sites. It should be noted that if Douglas-fir has more than three years of foliage on its branches, then damage in the form of growth loss are likely to be minimal to none. Another metric used to measure incidence and severity of SNC is the percentage of stomata obstructed by the fungal reproductive structures growing within the host foliage.

**Table 2.** Total acres with Swiss Needle Cast symptoms mapped during the aerial survey, by year.

Year of Survey	Severe SNC Symptoms		Moderate SNC Symptoms		Total Acres Mapped	
	% of total acres mapped	Severe SNC Acres	% of total acres mapped	Moderate SNC Acres	% with SNC symptoms	Total SNC Acres
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 47.** Swiss needle cast (SNC) aerial survey results, western Washington, 2015 (left) and 2016 (right). Yellow polygons are areas mapped with moderate SNC symptoms. Red polygons are areas mapped with severe SNC symptoms. Maps by: Amy Ramsey, Washington DNR.

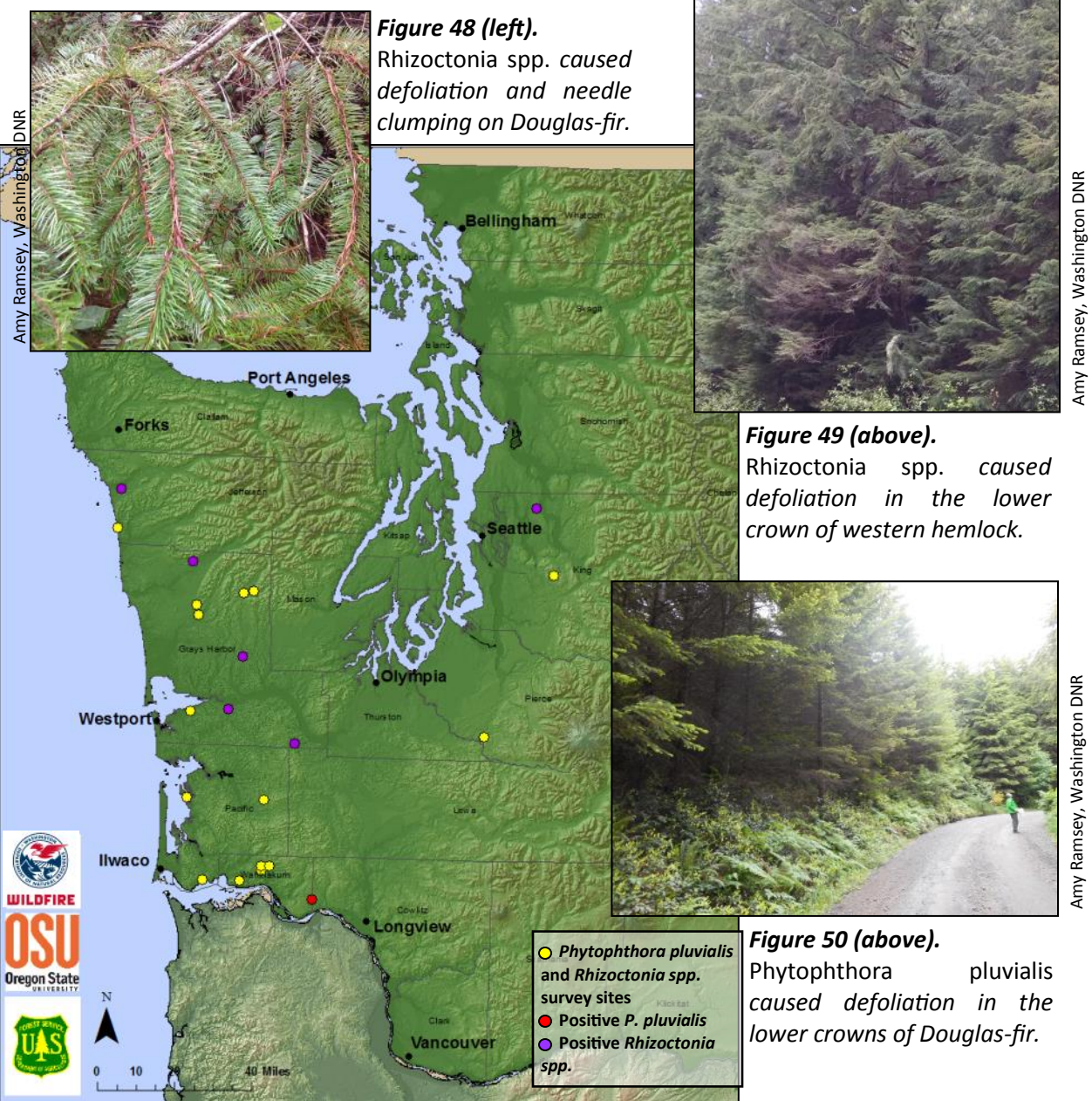
Since the stomata are responsible for gas and water exchange within a plant, significant obstruction ( $\sim >25\%$ ) of these features can result in imbalanced carbon costs and subsequent needle loss. The average percentage of occluded stomata across all sites was 1.6% for 2015 (1-year-old) foliage and 22.1% for 2014 (2-years-old) foliage. Based on ground survey data, there have been no significant changes in the incidence and severity of the disease in the past five years.

During the 2016 aerial survey, 248,000 acres of Douglas-fir were mapped with obvious symptoms of SNC (Fig. 47). This is a 30% decrease from the 350,000 acres mapped during the 2015 SNC aerial survey (Fig. 47, Table 2). Severely symptomatic stands were located near the Grays Harbor area and near Ilwaco. The cause of the decrease in mapped acres from 2015 to 2016 remains uncertain, but it is likely a combination of environmental factors influencing infections patterns and foliar retention and variations in aerially observed symptom signatures.

In response to SNC disease, Douglas-fir is the only host, therefore forest managers can grow non-host species such as red alder, western red cedar, western hemlock, and Sitka spruce in efforts to reduce damage.

***Phytophthora pluvialis* Reese, Sutton and Hansen and *Rhizoctonia* species**

*Phytophthora pluvialis* and *Rhizoctonia* species were identified on defoliated Douglas-fir in Oregon in 2015. In 2016, WDNR looked for the same pathogens by surveying twenty sites in western Washington with partially defoliated Douglas-fir and western hemlock (Fig. 51). The samples were sent to Dr. LeBoldus’ lab at Oregon State University for analysis. *Phytophthora pluvialis* was identified in Douglas-fir on one site in southwest Washington (Fig. 50). *Rhizoctonia* spp. were identified on western hemlock and Douglas-fir scattered across western Washington (Figs. 48 & 49).





## Bigleaf Maple Decline and Mortality

Forest pathologists at WDNR have been investigating crown, branch, and entire tree dieback of bigleaf maples (*Acer macrophyllum* Pursh) since 2011 (Fig. 52). At this point, we know a lot about what isn't causing the dieback, but still don't have a good handle on what is causing the dieback. In 2016, new leaf damage symptoms appeared, complicating the issue of determining the cause of the bigleaf maple decline and mortality.



Amy Ramsey, Washington DNR

**Figure 52.** Bigleaf maple dieback in the northern Cascade Mountains of Washington state.



Amy Ramsey, Washington DNR

**Figure 53.** Small, chlorotic tipped leaves of bigleaf maple next to healthy, large green bigleaf maples leaves.

The most common symptoms we have tracked in previous years include crown, branch, and entire tree dieback; clumps of shrunken leaves in the affected canopy; and heavy seed crops. This year, we are tracking and sampling from trees that have these symptoms as well as a new symptoms and signs: leaves with yellow edges, red to brown tips, and leaf hoppers (Figs. 53 & 54). Leaves displaying these were found in isolated locations in

previous years but were widespread in 2016. These symptoms are similar to bigleaf maple damage observed in California and Oregon, with the damage in California being attributed to *Xylella fastidiosa*. *Xylella fastidiosa* is a plant pathogen bacterium that colonizes its host plant's water-conducting system, the xylem, causing water stress in the host. All tests for this pathogen have been negative to date. Leaf hoppers can act as a vector for microscopic organisms, like bacterium and viruses, but at this point we are unsure of the species of the leaf hopper or whether it is contributing to the dieback or leaf symptoms we have observed this year or have seen in years past.

Through our work in previous years with cooperators including Washington State University, Oregon State University, WSDA, USFS, Oregon Department of Forestry, and funding from Animal and Plant Health Inspection Service and USFS, here is what we know:

- *Xylella fastidiosa* has not been found in any samples.
- There is a small amount of pathogenic *Phytophthora* associated with declining trees, but not enough to be the causal agent across the landscape.
- *Armillaria* root disease and decay is contributing to some of the tree dieback, but not all of it.
- The wilt disease *Verticillium* is not widespread and was found in only one sample in Washington. The positive identification was made from a bigleaf maple tree transplanted from an urban setting.
- Stem cankers caused by fungi like *Neonectria* or *Nectria* are sometimes present, but not enough to be causing the widespread damage.
- *Ganoderma*, a causal agent of heartrot, is present in some cases but also is not causing widespread damage
- There are lots of foliar fungi out there that can cause discoloration in leaves.



Amy Ramsey, Washington DNR

**Figure 54.** Leaf hopper casings on the underside of a symptomatic bigleaf maple leaves.

In addition to our investigations, a University of Washington graduate student will be working on this issue over the next two years. His study will focus on:

1) surveying the spatial extent of bigleaf maple decline and mortality and associated environmental, anthropogenic, and weather conditions;

2) using dendrochronological techniques to analyze and compare growth rates of healthy and symptomatic trees to differentiate the potential roles of abiotic and biotic drivers of the decline; and

3) determining the spatial-temporal patterns associated with bigleaf maple decline and mortality in western Washington (Fig. 55).



Amy Ramsey, Washington DNR

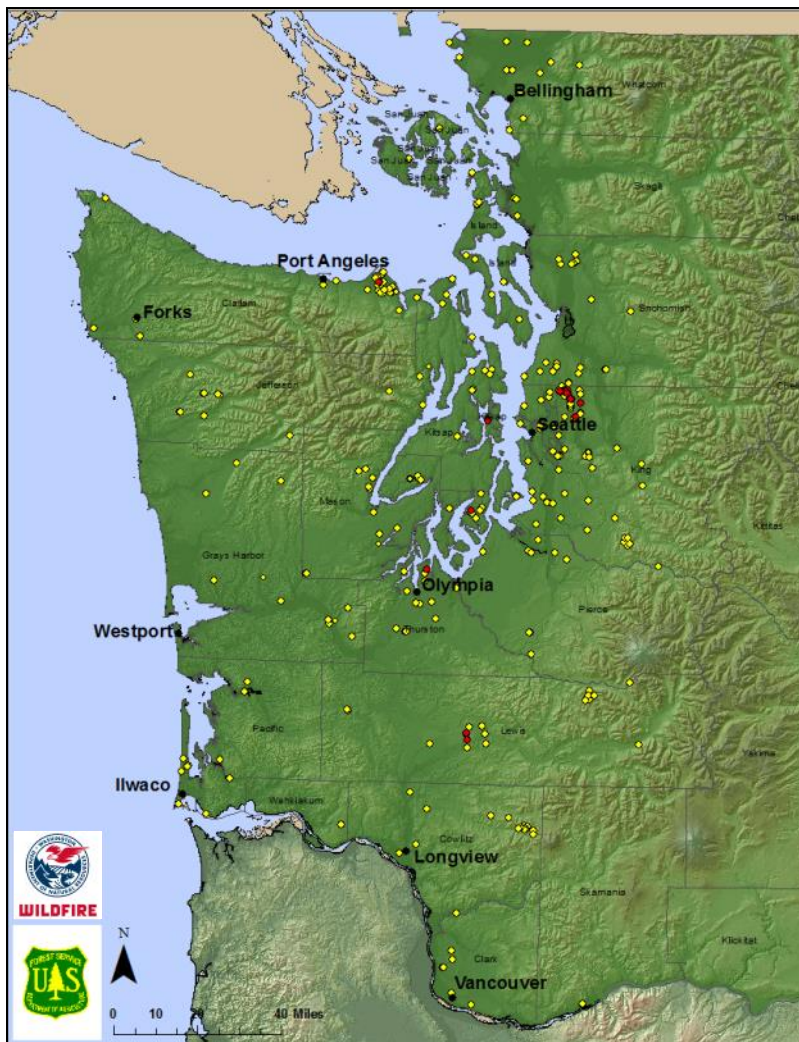
**Figure 55.** A hillside with extensive bigleaf maple decline and mortality. This raises the question as to whether there is a spatial pattern associated with bigleaf maple damage.



## Sudden Oak Death

### Sudden Oak Death (*Phytophthora ramorum* Werres et al.) NON-NATIVE

*Phytophthora ramorum*, the causal agent of Sudden Oak Death, ramorum leaf blight, and ramorum dieback, has been monitored for in waterways and forested areas in western Washington by WDNR since 2003. *Phytophthora ramorum* is a fungus-like plant pathogen that has caused extensive mortality in oak species in California and southern Oregon. With funding provided by the USDA Forest Service National *Phytophthora ramorum* Early Detection Survey of Forests, ten Washington waterways in six counties (Clallam, Grays Harbor, Jefferson, King, Lewis, and Mason) were surveyed for the pathogen in 2016. The pathogen was not detected at any of the sites.



**Figure 56.** Locations of Washington DNR *Phytophthora ramorum* monitoring and detection locations in western Washington, 2003-2016. Map by: Amy Ramsey, Washington DNR.

Surveying for *P. ramorum* in Washington forests has been ongoing since 2003 (Fig. 56). Since aquatic sampling began in 2005, *P. ramorum* has been detected in water samples from eight waterways in western WA: two in King County and one each in Clallam, Clark, Kitsap, Lewis, Pierce, and Thurston counties. All sites where positive detections have been made were associated with plant nurseries that contained plant stock infected with *P. ramorum*. Diseased plants adjacent to waterways have only been found associated with one site in Pierce County in 2010 and the plants were destroyed. Monitoring for the exotic, invasive plant pathogen, *P. ramorum*, will continue in 2017.

The US Department of Agriculture Animal and Plant Health Inspection Service (APHIS) is also involved in

Marianne Elliott, Washington State University



**Figure 57.** Clean up of *Phytophthora ramorum* infected *Camellia* plant area in Kitsap County, WA botanical garden. Inset: *Phytophthora ramorum* infected *Pieris* plant leaves.

surveying for *P. ramorum* in Washington, with a focus on plant nurseries and non-forested areas where the pathogen has been identified on diseased plant material (Fig. 57). In 2016, APHIS conducted *P. ramorum* interstate shipping certification surveys for two nurseries and both were negative for the pathogen. *Phytophthora ramorum* was detected at a Kitsap County botanical garden in 2015, and the detection and monitoring work at the garden continued in 2016. 1,338 samples were collected from the garden through plant samples and water baiting and all were negative. A single *Mahonia* plant was found infected in December, 2015 and destroyed in January, 2016. The garden continues to voluntarily mitigate *P. ramorum* infection risk by the implementation of an Integrated Pest Management fungicide spray program and by reducing native host plants in key areas. The effectiveness of all mitigation methods will be monitored over time.

## White Pine Blister Rust

### White Pine Blister Rust (*Cronartium ribicola* Fisch.) NON-NATIVE

Amy Ramsey, Washington DNR



**Figure 58.** A white pine blister rust infection with yellow, spore erupting, blisters on the main stem of a young western white pine.

Western white pine (*Pinus monticola* Dougl., WWP) is a native conifer species in western North America. The species is susceptible to the introduced fungal pathogen *Cronartium ribicola* J.C. Fisch., the causative agent of white pine blister rust (WPBR; Fig. 58). The impacts of WPBR have reduced the incidence of WWP in natural ecosystems as well as led to a reluctance in using the species in both restoration and reforestation. Research and operational programs to develop genetic resistance to WPBR have been ongoing for more than five decades in our region and with that work the progeny of thousands of parent trees have been screened for rust resistance in short-term artificial

inoculation trials. Several types of resistance have been uncovered and seed orchards have been established using the products of the earlier resistance work. Breeding programs continue to increase the level of WPBR genetic resistance.



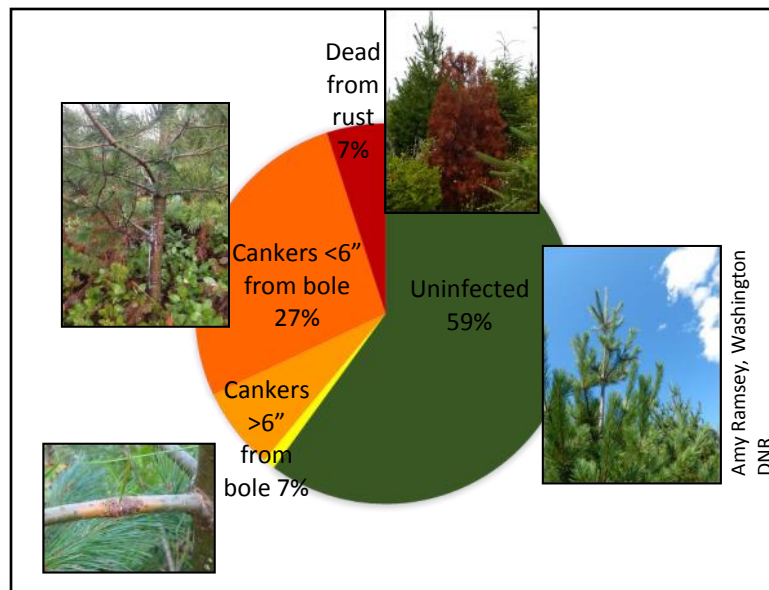
In fall 2015 and spring 2016, we examined the current WPBR incidence and impacts on WDNR state land WWP operational plantings (Fig. 59). We then compared those results to the most recent data from a series of WWP field trials examining a diverse set of WPBR resistant families and seed orchard families. Our objective was determine how WWP was performing on operationally planted sites compared to the WPBR resistant families in our field trials, in an effort to determine if seed orchards could be improved with new, more rust resistant, material.



Amy Ramsey, Washington DNR

**Figure 59.** A Washington DNR state lands unit planted with western white pine. This site was assessed for white pine blister rust.

Significant variability existed in WPBR infection levels across the 35 operationally planted WWP sites we examined. The average percent of uninfected trees among all sites was 59% (Fig. 60). An average of 34% of the trees across all sites had infections that caused, or were likely-to-cause, mortality in the near future.



Amy Ramsey, Washington DNR

**Figure 60.** The average percent of western white pine on WA DNR state lands infected with *Cronartium ribicola*, the cause of white pine blister rust. Pictures are representative of each rust caused damage category. Cankers are infections.

Twenty-seven out of 36 seedlots tested in the WPBR resistance trials had an average of less than 30% mortality or likely-to-cause mortality infections which is less than the 34% average found in the operationally WWP planted assessments. This data suggests that there are seedlots available with greater WPBR resistance levels than are currently being operationally planted. A more detailed analysis of WWP growth and WPBR resistance will be required to identify specific seedlots as good candidates for incorporating into new and existing WWP seed orchards. These trials will continue to be assessed to evaluate the resistance over time, but early indications show the potential of planting resistant WWP in many sites in Washington.

# 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 WDNR and the USFS. It is very cost effective for the amount of data collected. The publically available maps and data produced are great tools for monitoring forest disturbance events and forest management planning. They also provide excellent trend information and historical data.

## Electronic PDF Maps Available for Download

Traditional insect and disease survey quadrangle maps from 2003 to 2016 are available for download as PDF files at: [www.fs.usda.gov/goto/r6/fhp/ads/maps](http://www.fs.usda.gov/goto/r6/fhp/ads/maps)

Click on the year of interest under “Aerial Detection Survey Quad Maps” (Fig. 61). 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 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 (Fig. 62).

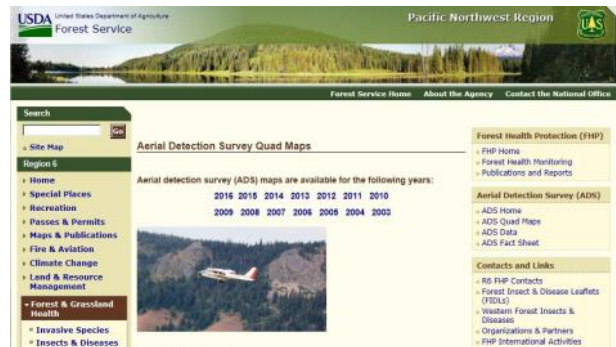


Figure 61. Aerial survey maps and data on USFS Region 6 Forest Health Protection website.

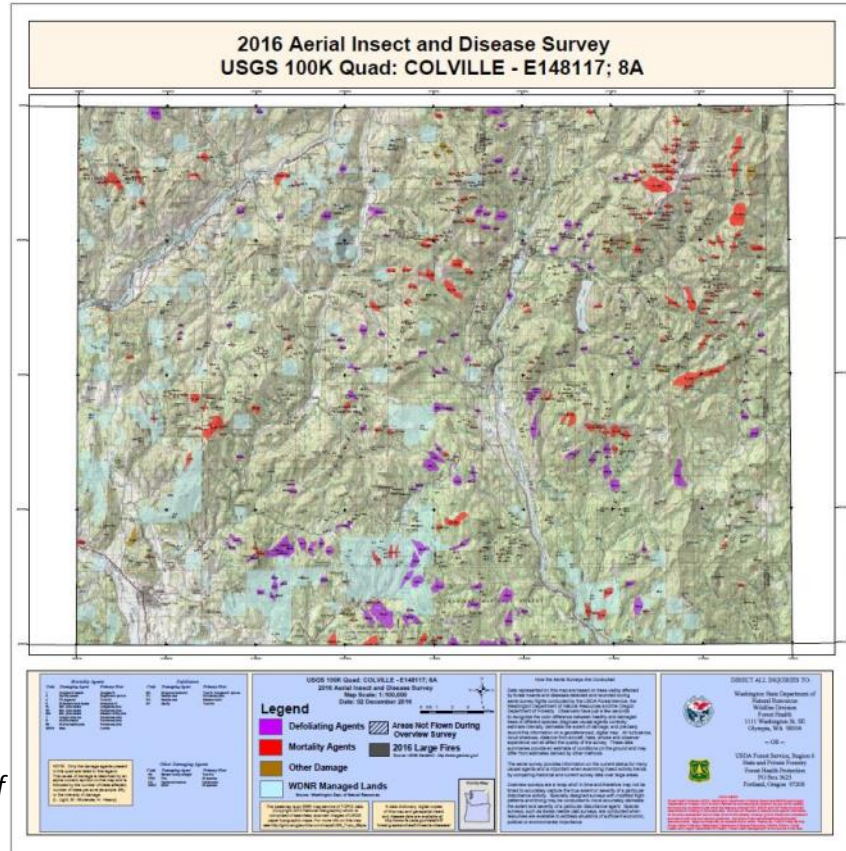


Figure 62. Example PDF map of the Colville quad for 2016.



## Interactive Map Tools

2011 to 2016 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://fortress.wa.gov/dnr/protectiongis/fmanfire/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.

Draft aerial survey data, photos and updates on major events from the current year can be viewed during the survey season using the "story map" at: <http://arcg.is/2ahJ727>

Customized electronic maps (PDF, JPG, etc.) of draft data can be created with a variety of background layers at: <https://usfs.maps.arcgis.com/apps/webappviewer/index.html?id=87d6cf9c2e1a45408ef01a357b84c811> 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.

## GIS Data Available for Download

Washington DNR also maintains downloadable GIS datasets, including aerial survey data for Washington State from 1980 to 2016, known as "Forest Health Aerial Survey 1980-2016" at: <http://www.dnr.wa.gov/GIS>, 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, WDNR research, and other forest health information are available at: <http://www.dnr.wa.gov/ForestHealth>

Historic annual highlights reports for Oregon and Washington are available at: [www.fs.usda.gov/goto/r6/fhp/highlights](http://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: [www.fs.usda.gov/goto/r6/fhp](http://www.fs.usda.gov/goto/r6/fhp)

## Forest Health Contacts

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

### Washington Department of Natural Resources — Forest Health Program

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

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### USDA Forest Service — Forest Health Protection and Monitoring Program

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### USDA Forest Service — Wenatchee Service Center

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