Forest Health Highlights in Washington / 2020

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

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Washington State Department
of Natural Resources (DNR)
Forest Health and Resiliency Division
May 2021

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

Summary

In 2020, COVID-19 risk mitigation protocols affected forest health monitoring operations in Washington, including the cancellation of interagency aerial detection survey flights for the first time since 1947. Some annual forest health monitoring proceeded with minimal impact, while alternative survey methods, including a combination of ground-based surveys and remote sensing, were used in place of traditional aerial surveys to collect insect and disease damage data statewide. The alternative surveys covered approximately half of Washington's 22 million acres of forest lands across a variety of land ownerships. Areas to be surveyed were prioritized by elevated forest health risk, areas with recent damage, and availability of satellite imagery for acquisition during the survey season. As a result of this prioritization criteria, 80% of the surveyed area was in eastern Washington. See page 16 (2020 Insect and Disease Survey section) for a detailed description of the alternate methods.

Drought conditions and warm, dry spring weather tend to increase tree stress and insect success, increasing acres of damage in both the current and subsequent year. Wet spring weather tends to increase acres affected by foliage diseases and bear damage in both the current and subsequent year. 2020 precipitation in Washington was well above normal during winter and late spring, then below normal in early spring and late summer. Monthly average temperatures were above normal during winter and fall, but remained near normal the rest of the year. According to the US Drought Monitor, from April through August in 2020, the east slope Cascades and Columbia Basin was either in moderate or severe drought condition. By September, parts of those areas were in extreme drought condition and nearly all of the state was in either in abnormally dry or moderate drought condition.

In 2020, the statewide insect and disease survey recorded some level of tree mortality, tree defoliation, or foliar diseases on approximately 322,000 acres.* The area with damage attributed to mortality agents, primarily bark beetles, was approximately 265,000 acres. Approximately 9,000 acres with damage were attributed to defoliators and approximately 48,000 acres were assigned tree damage due to other causes, including 30,000 acres with unknown damage type. Previous annual totals for all damage agents, based on a survey area of approximately 22 million acres, were:

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

Summaries of acres affected by specific damage agents in 2020 are not being reported due to changes in survey methods and reduced survey area. The following are highlights of recent trends and general locations of damage detected in 2020.

DNR PHOTO FILES

Forest health is defined as the condition of a forest ecosystem reflecting its:

- ability to sustain characteristic structure, function, and processes;
- resilience to fire, insects and other disturbances;
- adaptability to changing climate and increased drought stress; and
- capacity to provide ecosystem services to meet landowner objectives and human needs.

*** Disclaimer:** Totals reported below are intended to be a snapshot of general observations in 2020 and should not be compared to prior years or trends. Due to changes in data collection methods and substantial reduction in geographic area covered by the 2020 survey, data results are not comparable to prior years.

■ **The area with mortality caused by pine bark beetles in 2018 and 2019 was approximately 120,000 acres in both years**, remaining below the 10-year average of 143,000 acres, and down from a recent peak of approximately 196,000 acres in 2017. The most significant increase recently has been in mortality of ponderosa pines due to western pine beetle and Ips pine engravers. In 2019, both reached their highest levels of damage recorded since 2006. Estimates of 2020 damage indicate the area affected by these outbreaks has continued to increase, likely related to recent drought events. In 2020, heavy mountain pine beetle mortality in lodgepole was mapped east of Mt. Rainier, between Cle Elum and White Pass in Kittitas and Yakima counties, and in the Pasayten Wilderness in north Okanogan County.

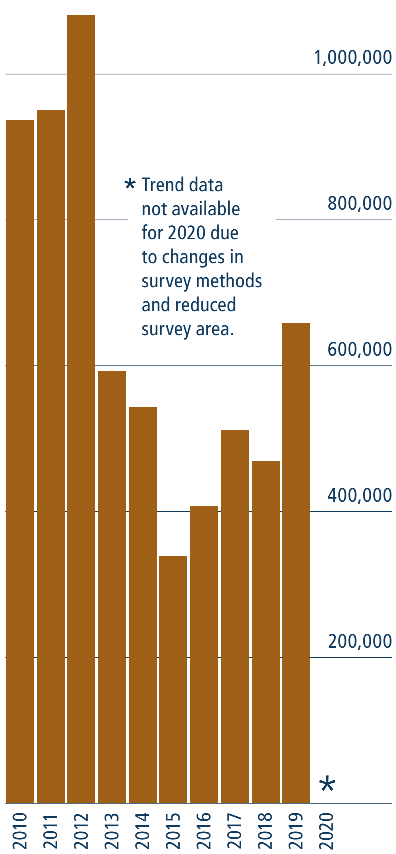
■ **Mortality due to Douglas-fir beetle has been increasing in recent years,** reaching a ten-year high of 69,100 acres in 2019, the highest level of damage since 2009. **Fir engraver** mortality, primarily in grand fir, also reached a ten-year high of 166,300 acres in 2019, the highest level since 2008. Most of the increased damage from both species has occurred in the east slopes of the Cascades and Selkirk Mountains, some of which is likely related to recent wildfires and windstorm damage for Douglas-fir beetle and drought conditions for fir engraver.

■ **Outbreaks of Douglas-fir tussock moth in Kittitas and Chelan counties (2018-2019) and in northern Okanogan County (2019) appear to have collapsed** due to natural controls with no new defoliation reported in 2020. A widespread outbreak of **spruce aphid** along the Washington coast that resulted in Sitka spruce damage on 10,600 acres in 2019 has also collapsed. 2020 was the third year of a **western hemlock looper** outbreak in the Baker Lake area in south Whatcom and north Skagit counties. Estimates indicate a likely decrease from the 5,300 acres defoliated in 2019.

■ **Following the December 2019 verification of the first-ever sighting of Asian giant hornets in the United States in northwest Washington,** both Washington and Canada had new confirmed sightings in 2020. In October 2020, Washington Department of Agriculture led a successful eradication of a documented nest site and continue to lead coordination of statewide monitoring. While this species is not considered a disturbance agent directly affecting tree mortality, if it becomes established, this hornet will have negative impacts on the environment, economy, and public health of Washington State.

■ **A non-native sooty bark disease of maple, caused by the fungus *Cryptostroma corticale*, has been detected in the Seattle area** causing dieback symptoms on horse chestnut and four species of maple, including bigleaf maple. The impact and distribution of this pathogen is not currently known in Washington, and the spread onto native maple species is concerning. *Phytophthora ramorum*, the causal agent of **sudden oak death**, continues to be found in streams associated with commercial plant nursery trade activity, but there has yet to be any indication that the pathogen is leaving the waterways and impacting bordering vegetation. Due to COVID-19 restrictions, aerial surveys for **Swiss needle cast** in Washington's coastal forests were cancelled and expanded ground survey efforts have been planned for spring 2021.

BY LAW (RCW 76.06), THE COMMISSIONER OF PUBLIC LANDS IS THE STATE LEAD FOR ALL FOREST HEALTH ISSUES. MONITORING FOREST HEALTH CONDITIONS AND CHANGES OVER TIME IS A COLLABORATIVE EFFORT.



TOTAL ACRES WITH INSECT AND DISEASE DAMAGE 2010-2019

DNR PHOTO FILES

Abiotic Disturbances Influencing Forest Health

Abiotic disturbances — disturbances caused by non-living factors — are a natural and integral part of forest ecosystems causing both positive and negative impacts. They influence forest structure, composition and function and can be important for maintaining biological diversity and facilitating regeneration. These disturbances such as wildfire, drought, landslides, flooding, and extreme weather events can cause tree mortality. Trees that survive these events may be damaged or weakened, influencing forest health conditions by making them more susceptible to declining health and attack by insects and pathogens.

Disturbances that cause mortality and damage over large areas, such as wildfire, windstorms, and drought may provide enough breeding material to increase local bark beetle populations to outbreak levels that can cause mortality in healthy trees. Drought and other disturbances that compromise tree defenses can lead to increased levels of mortality from root disease and other forest pathogens. Unseasonal extremes in spring or fall precipitation may lead to increased levels of foliar pathogens that cause diseases such as needle casts and needle blights.

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

Weather

Severe weather events that injure or kill trees often make them more susceptible to attack by insects and pathogens. Examples include windthrow, winter damage (defoliation, cracks or breakage from cold, snow or ice), heat stress, flooding, landslides and hail. Unusually wet spring or fall weather, such as occurred in late spring 2020 (Fig. 1), can increase the incidence of foliar diseases. Outbreaks of certain bark beetle species, such as Douglas-fir beetle or Ips pine engravers, follow weather or fire events that kill or injure numerous trees. This happened in northeast Washington in 2018 (see page 28). In years like 2020, when summer precipitation is at or below average and temperatures are at or above normal (Fig. 2), the number of bark beetle-killed trees may increase the following year. Typically, conifer trees killed by bark beetles do not appear red until the following year. Therefore, increases in mortality from bark beetles related to events such as drought or storms may not appear in aerial survey or remote sensing data until two years following the event.

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

Figure 1.

WASHINGTON STATE PRECIPITATION (IN.)

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

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

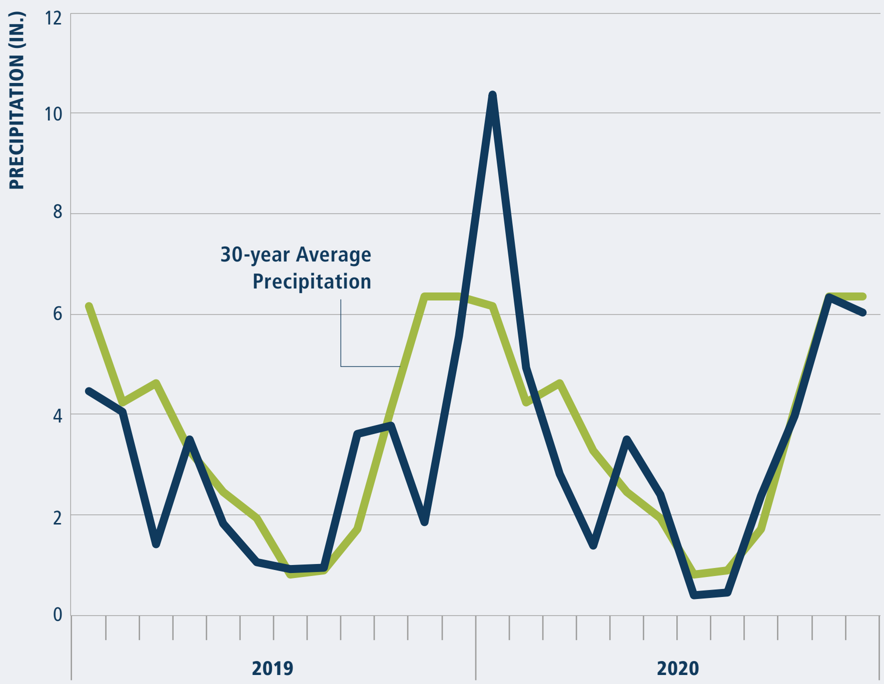
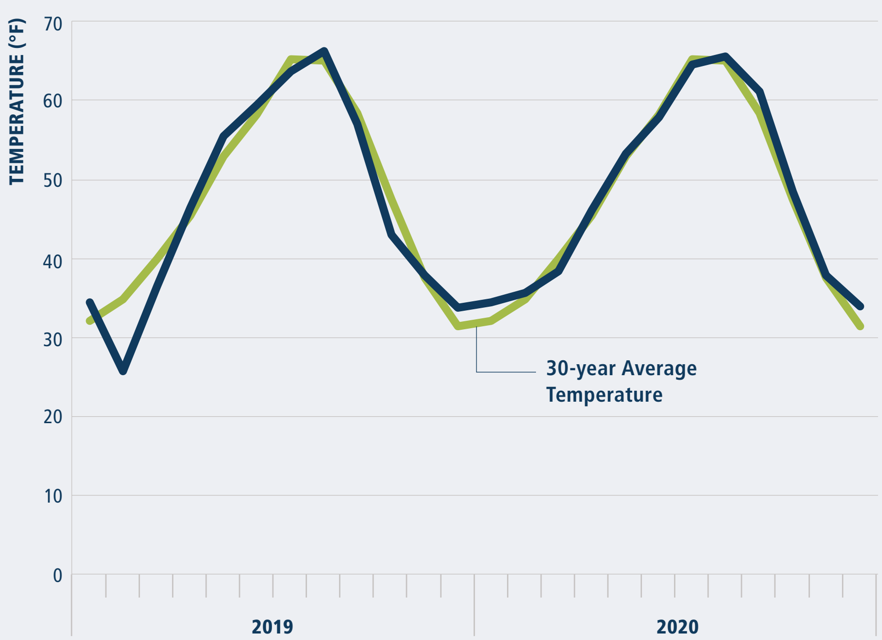


Figure 2.

WASHINGTON STATE MEAN TEMPERATURES (°F)

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

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



Drought

Precipitation in Washington was well above normal in winter 2020, followed by below normal rainfall during early spring and late summer. Monthly average temperatures in 2020 were only above normal during fall. Inadequate rainfall during the growing season may increase the potential for drought stress on trees; however, near normal temperatures can mitigate drought effects. Drought conditions in the east slope Cascades and Columbia Basin ranged from abnormally dry to moderate drought from January to March 2020. From April through August, these areas experienced moderate to severe drought conditions (Fig. 3). By late September, the Columbia Basin was in extreme drought, east slope Cascades were in moderate to severe drought, and almost the entire state was in an abnormally dry condition. Most of the worst drought conditions through 2020 were at lower elevations and, compared to state-wide extreme drought in 2015, covered a much smaller area (Fig. 4). Of the forested areas that experienced any drought conditions at all in 2020, they were primarily abnormally dry to moderate. These conditions may still increase tree susceptibility to insect and disease attacks and make them less likely to recover from damage.

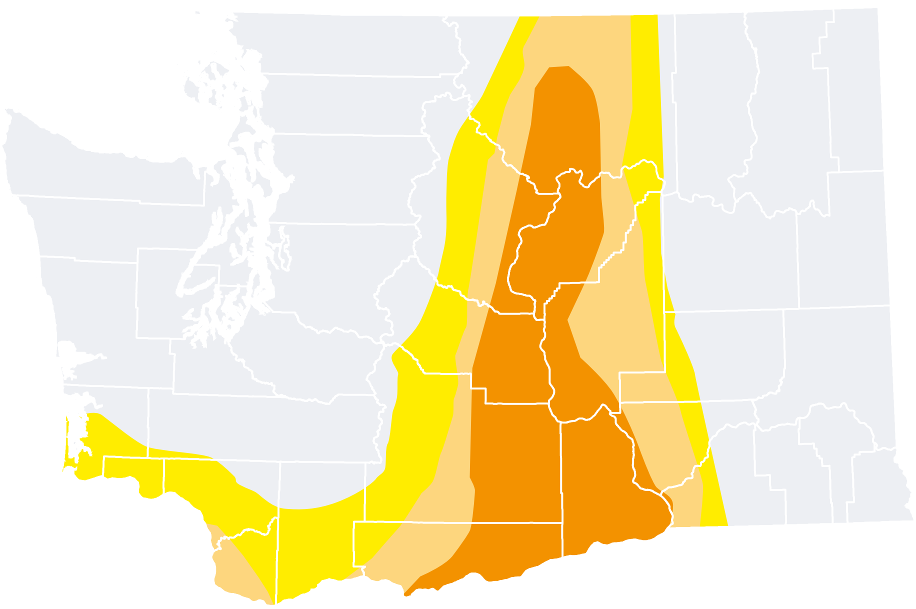


Figure 3.

DROUGHT CONDITIONS IN WASHINGTON ON AUGUST 25, 2020

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

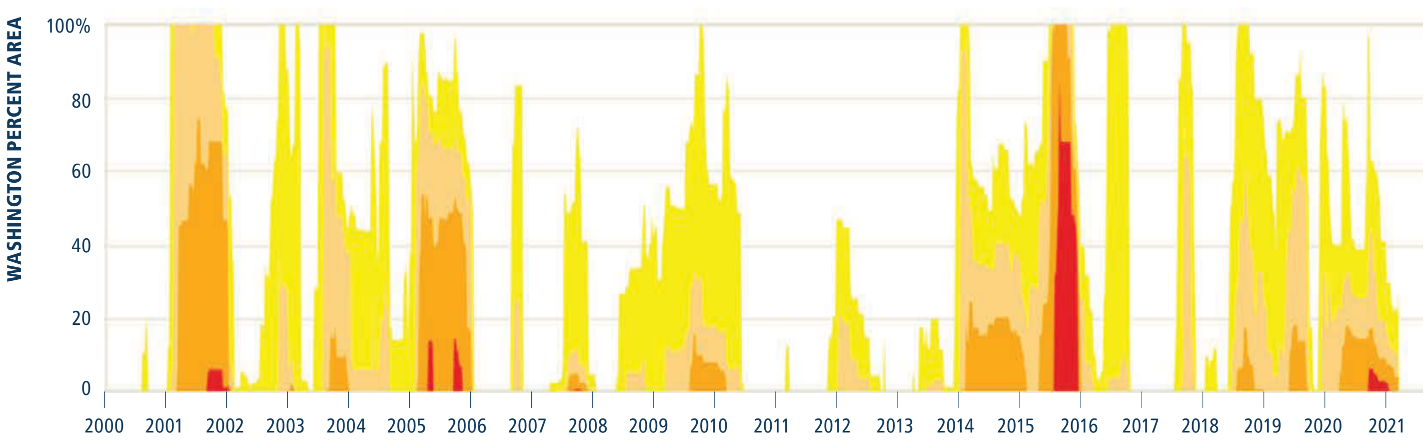


Figure 4.

PROPORTION OF WASHINGTON STATE AREA AFFECTED BY DROUGHT FROM 2000 – 2020

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

Wildfire

According to data compiled by the Northwest Coordination Center (NWCC) and Washington State Department of Natural Resources (DNR), wildfires burned 842,358 acres in Washington during the 2020 season, up considerably from the 169,742 acres burned in 2019. The amount of acres burned is considerably above the average of 407,450 acres per year from 2011-2020. According to a GIS analysis of statewide fire polygons, estimates for large fire fuel types burned were 46% shrub-steppe, 30% grassland, 8% forest, and 16% other (i.e. agricultural lands, urban areas, wetlands).

There were 1,638 fire occurrences statewide in 2020, up from 1,395 fire occurrences in 2019. The number of fire occurrences was higher than the average of 1,466 fire occurrences per year from 2011 to 2020. Interestingly, only 84 fires, or 5%, were lightning caused; the remainder were human caused. Of the 1,638 total fire occurrences, 41 were considered "large fires" per the National Wildfire Coordinating Group (NWCG) definitions for size (greater than 100 acres of forestland or 300 acres of brush/grass) or increased complexity, up from 23 "large fires" in 2019 (Fig. 5).

According to DNR fire occurrence data, the bulk of DNR's wildfire activity occurred in July, August, and September, although fires occurred in every month except January (Fig. 6). The uptick in April was primarily driven by escaped debris burn fires. Of the 162 total fires in April, 103 or 64% of them were caused by debris burns. Overall, DNR fires were 80% human caused, 4% lightning caused, and 16% undetermined at the time of this report.

Notable in the 2020 season was the Labor Day weekend (September 6-9, 2020) east wind event during which the state saw 116 fire starts resulting in 629,549 acres burned. Of the 41 total large fires in Washington, 14 of them started during this period, including Pearl Hill, Cold Springs, and Whitney, the three largest fires of the year. The largest fire in Washington was Pearl Hill at 233,730 acres (started on September 7, fuels were brush and grass, cause undetermined, Washington Fire Service jurisdiction). The second largest fire was Cold Springs at 189,923 acres (started September 6, fuels were grass and brush, cause was arson, Bureau of Indian Affairs jurisdiction). The third largest fire was Whitney at 127,430 acres (started September 7, fuels were grass, brush, and timber, cause under investigation, DNR jurisdiction).


JAY PHIPPS / DNR

FIRE PLAYS A NATURAL ROLE IN ECOSYSTEM HEALTH AND CAN SERVE AS A LAND MANAGEMENT TOOL. HOTTER, DRIER SUMMERS AND LONGER FIRE SEASONS — COMBINED WITH UNHEALTHY FORESTS — HAVE LED TO INCREASES IN FIRE STARTS AND SEVERITY OF ACRES BURNED.

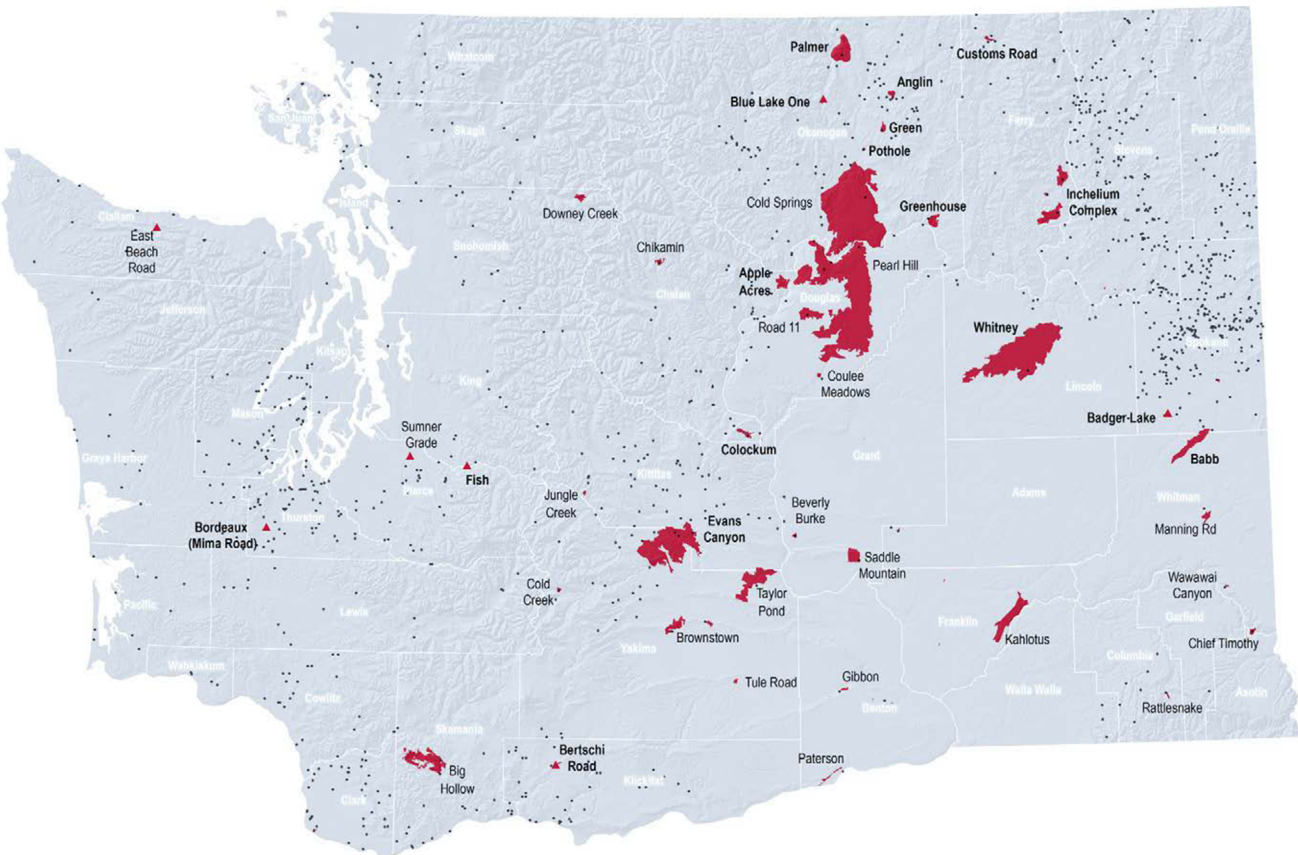
2020 WASHINGTON STATE WILDFIRES Figure 5.

Location of wildfires that occurred in Washington in 2020.

MAP BY KIRK DAVIS, WASHINGTON STATE DEPARTMENT OF NATURAL RESOURCES.
DATA SOURCES: NATIONAL INCIDENT FEATURE SERVICE 2020 (NIFC), WADNR FIRE STATISTICS 2020 (EIRS)

■ Large Fire Area Burned
▲ Large Wildfire Location
● Other Wildfire Occurrence

30 miles



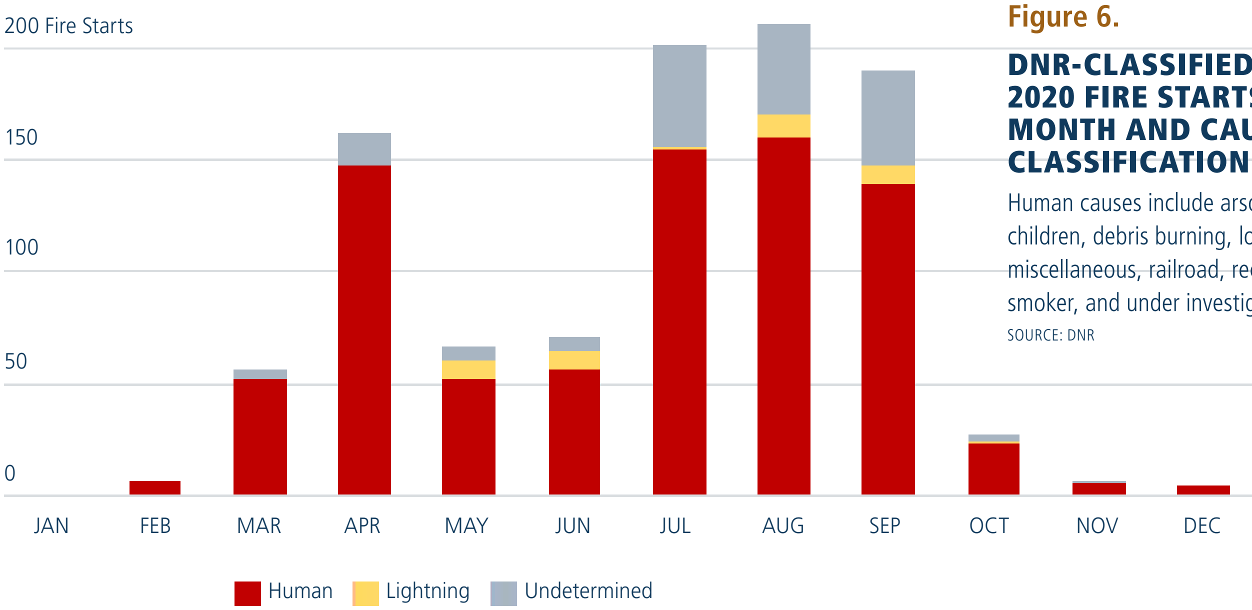


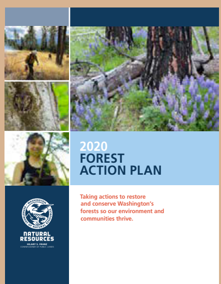
Figure 6.

DNR-CLASSIFIED 2020 FIRE STARTS BY MONTH AND CAUSE CLASSIFICATION

Human causes include arson, children, debris burning, logging, miscellaneous, railroad, recreation, smoker, and under investigation.

SOURCE: DNR

WASHINGTON'S FOREST ACTION PLAN



The challenges and issues facing forest ecosystems today present pressing issues for communities and society. In response to these tremendous challenges DNR took an all-hands, all-lands approach to the 2020 Forest Action Plan revision. The Forest Action Plan links existing strategic plans, proactively identifying actions to take collectively across Washington to address threats facing our forests. Considerable effort has been put into developing recent strategies at DNR — including the 20-Year Forest Health Strategic Plan: Eastern Washington, Wildland Fire Protection 10-Year Strategic Plan, and Plan for Climate Resilience. The Forest Action Plan recommits to these strategies and actions while clarifying the connections and links between them. The action plan is intended to foster coordinated, cross-boundary management activities at a scale commensurate with the challenges facing forested landscapes today — thereby setting us up for a future where Washington remains known as the Evergreen State.

The plan identifies priority actions by themes that when brought together, clearly outline DNR's goals and objectives, and chart a path toward actions at a scale commensurate with the challenges facing forests and communities. The themes are:

- **Landscape Resilience**
- **Community Wildfire Preparedness and Wildfire Suppression**
- **Keeping Forests as Forest: Risk of Conversion to Non-Forest Uses**
- **Urban and Community Forest Resilience**
- **Rural Economic Development**
- **Stewardship of Family and Working Forests**
- **Wildlife and Salmon Recovery**
- **Water Quality and Quantity**

The Forest Action Plan enables the state to receive funding from U.S. Forest Service's state and private forestry programs. Since Washington's first Forest Action Plan was published in 2010, the state has received more than $50 million in federal investments through these programs. In 2020, this funding supported DNR's forest entomologists, pathologists, and forest health specialists to provide technical assistance and education, as well as to conduct the forest health monitoring summarized in this report.

The priority landscapes established in the Forest Action Plan identify areas where active management and investments can improve forest health conditions based on scientific analysis, and where partnerships and projects already exist to maximize strategic use of limited federal Cooperative Forestry program funding in areas with a better opportunities for leveraging resources. DNR will bring the strength of its programs to these priority landscapes, but its work is not restricted to them. Learn more and read the Forest Action Plan on our website at www.dnr.wa.gov/ForestActionPlan.

FOREST HEALTH PROTECTION PRIORITY ACTIONS FOR 2020-2025

- Address both native and invasive forest pest species and their effect on forest resources.
- Detect, monitor, evaluate, and report forest pests and forest health conditions, and conduct activities to improve or maintain forest health conditions and sustainability. This includes producing an annual Forest Health Highlights report.
- Coordinate with Forest Service and Forest Inventory and Analysis (FIA) in reviewing annual FIA and forest health monitoring data to detect and evaluate forest health problems.
- Continue active cooperation with the Forest Service to conduct the annual insect and disease aerial survey and regularly communicate ways to improve safety, training, technologies, and methodologies.
- Reduce damage through effective integrated pest management, including prevention, suppression, and eradication.
- Work closely with the Forest Stewardship Program to provide cost-share assistance to landowners specific to reducing risk of insect and disease damage, such as through the Western Bark Beetle Initiative federal funds.
- Represent the forest health, forest entomology, and forest pathology expertise in the state, and review forest stewardship plans and best management practices for forest health guidance.
- Continue to provide science-based education and technical assistance to as many landowners and land managers as possible through close cooperation with stewardship programs, universities, and other agencies.
- Include education efforts where needed to limit the spread of invasive insects, such as the "Don't Move Firewood" campaign and educational efforts led by conservation districts.
- Involve the WSDA as a partner where they are the lead agency for cooperative forest health. Elsewhere, engage them as a key stakeholder, as most states share pest management responsibilities between agriculture and forestry agencies.
- Collaborate regionally and nationally on insect pests. Collect georeferenced forest health data using national standards provided by the Forest Service so that cross-boundary comparisons can be made.
- Ensure flexibility and seek funding sources to respond to emerging situations that threaten forest health, such as new insect and disease outbreaks or introductions.

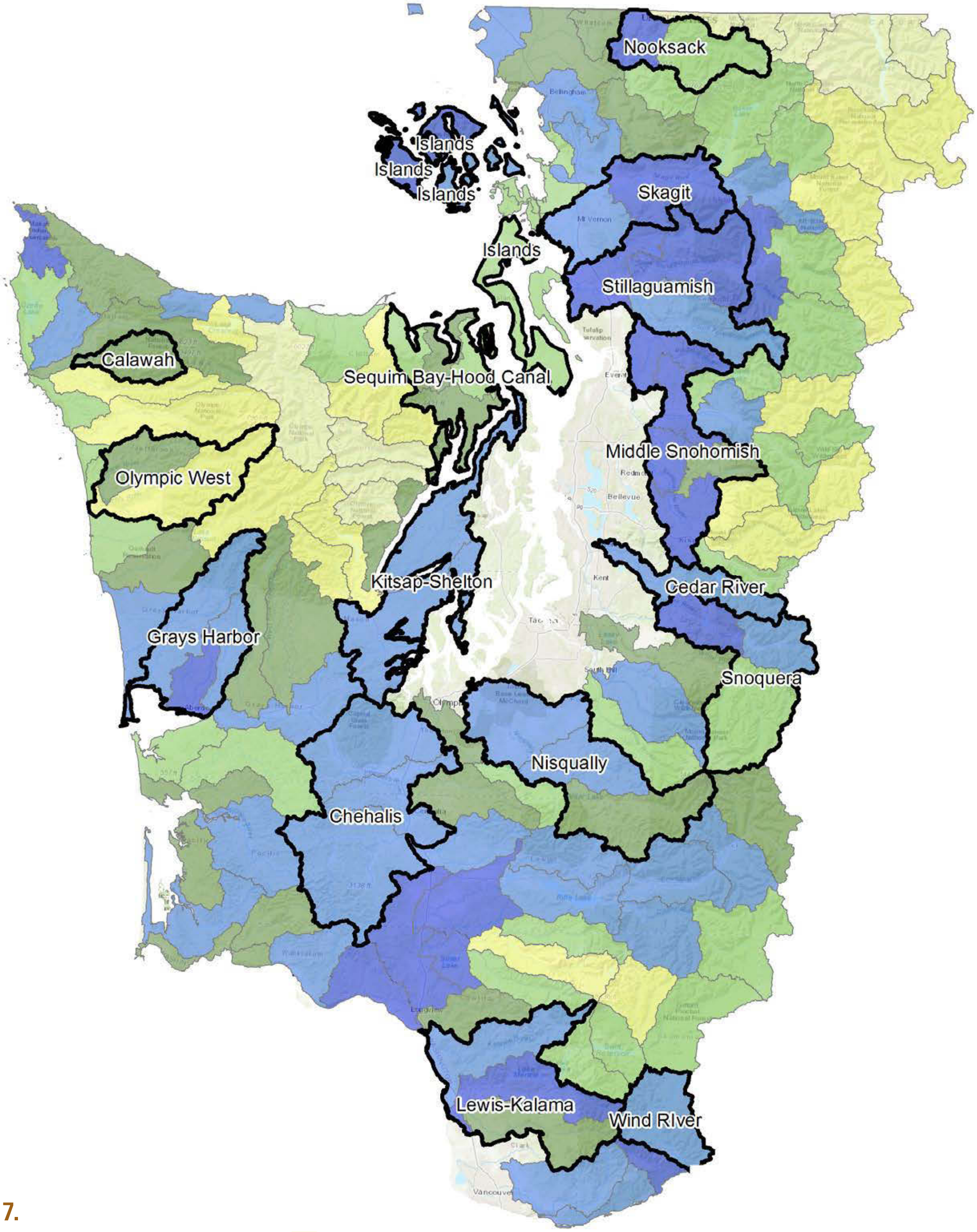


Figure 7.

WESTERN WASHINGTON LANDSCAPE RESILIENCE

16 western Washington Landscape Resilience Priority Landscapes established by the 2020 Forest Action Plan.

SOURCE: DNR

- Low
- Low-Moderate
- Moderate
- Moderate
- Moderate High
- High
- Priority Landscapes
- Urban HUCs

N

0 20 40 miles

STRATEGICALLY INVESTING IN FOREST HEALTH IN EASTERN WASHINGTON

The 20-Year Forest Health Strategic Plan: Eastern Washington was drafted in 2017 to be a high-level framework guiding efforts to maximize effectiveness of forest health treatments by coordinating, planning, prioritizing, and implementing forest management activities across large landscapes to improve forest health, help forests adapt to climatic change, and achieve forest-related ecological, economic, and social benefits.

In 2020, DNR provided a progress report to the Washington State legislature on the Forest Health Assessment and Treatment Framework (RCW 76.06.200) that included:

- **Forest health treatment need assessment results** across 30 priority landscapes (3.37 million acres) during the past two biennia, greatly exceeding the statutory requirement of analyzing 200,000 acres of fire-prone land each biennium.
- **A landscape evaluation summary for each** of the 30 priority landscapes, providing a scientifically grounded blueprint of forest health treatment need and scale. Landowners can use these evaluations on a voluntary basis to improve their forests, and DNR can use them to track benchmarks and progress across each landscape.
- **A commitment by DNR to analyze nine more priority landscapes** next biennium, representing an additional 1.06 million acres. This will provide a powerful footprint to continue implementing the forest health plan with partners.
- **Important new landscape evaluation components,** including: prioritization of forest health treatments within a landscape, an assessment of forest treatment type based on operational and economic feasibility, and identification of forests where managing for closed canopy, large tree forest structure will be most sustainable over time.
- **Prioritization of forest health treatments** for the dual benefit of forest health and wildfire response, as required by HB 1784.

Landscape evaluations for the 30 priority landscapes identified a need to conduct forest health treatments on 807,720 to 1,162,620 acres overall in order to transform these landscapes into resilient forests, using a combination of tools. These include mechanical treatments, prescribed fire, and managed wildfire. In each priority landscape, the pace and scale of accomplishing this work will depend on factors such as the ratio of commercial versus non-commercial treatments, forest product markets, access, land manager capacity, and funding levels.

To monitor forest conditions, assess progress, and reassess strategies over time, DNR has also developed a monitoring framework. Monitoring is essential for accountability and reporting, building shared understanding and trust across land ownerships, and increasing effectiveness of forest health treatments into the future. Thus far, DNR has tracked over 280,000 acres of completed forest health treatments in eastern Washington reported by landowners and managers as completed since the start of 2017, including substantial progress in both forest health treatment planning and implementation in priority landscapes.

Visit https://bit.ly/ForestHealthData to view and download key maps and data supporting implementation of the 20-Year Forest Health Strategic Plan: Eastern Washington including information for each priority landscape, including landscape evaluation summaries, presentation slides, and datasets.

CHUCK HERSEY / DNR

DOING THE RIGHT WORK IN THE RIGHT PLACES AT THE RIGHT SCALE TO INCREASE FOREST HEALTH AND COMMUNITY RESILIENCY.

Above: Collaborative field trip of US Forest Service restoration project proposed in the Upper Wenatchee priority landscape

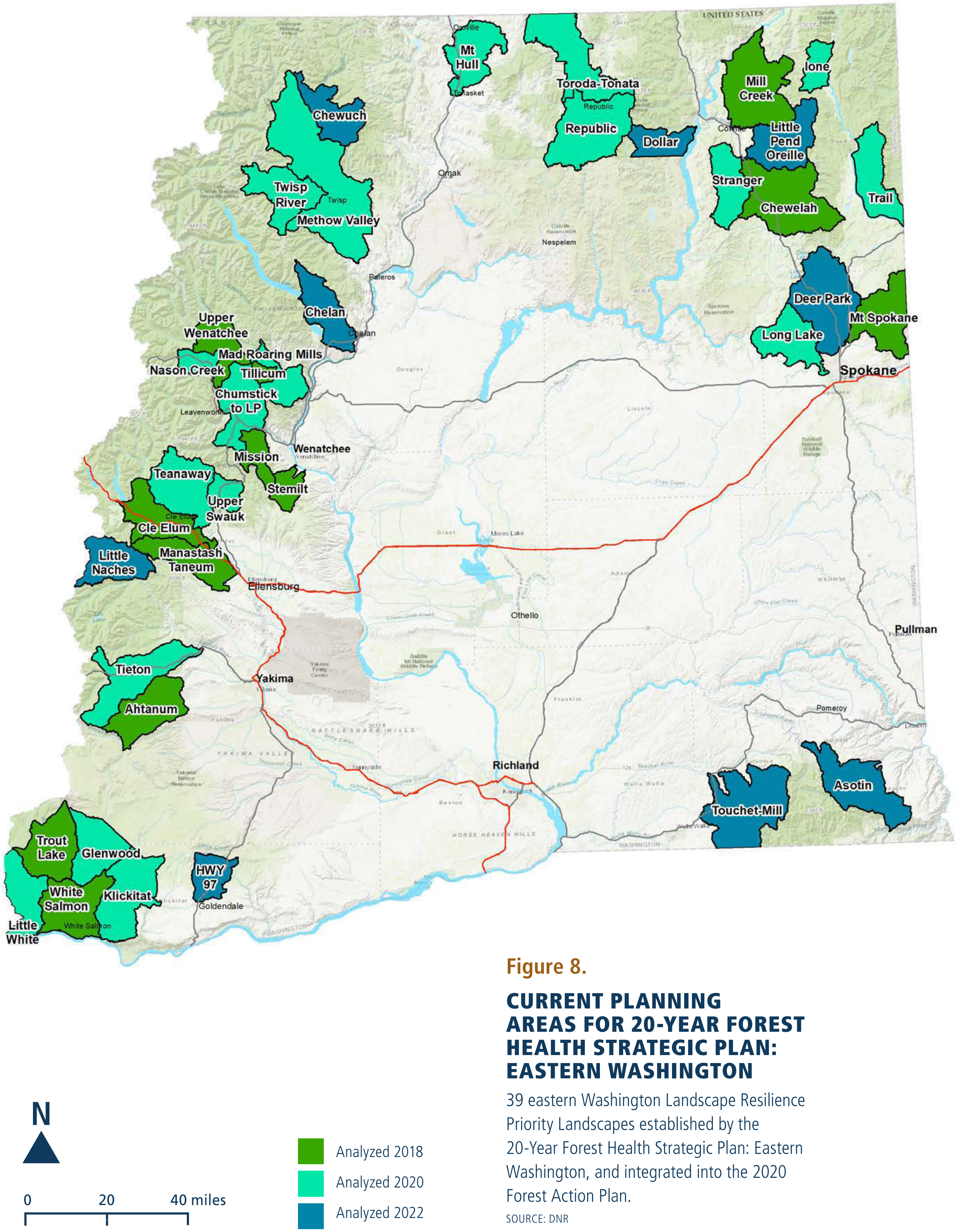


Figure 8.

CURRENT PLANNING AREAS FOR 20-YEAR FOREST HEALTH STRATEGIC PLAN: EASTERN WASHINGTON

39 eastern Washington Landscape Resilience Priority Landscapes established by the 20-Year Forest Health Strategic Plan: Eastern Washington, and integrated into the 2020 Forest Action Plan.

SOURCE: DNR

GLENN KOHLER / DNR

Aerial observer mapping forest damage during a 2019 flight.

2020 Statewide Insect and Disease Survey

The annual statewide insect and disease aerial detection survey (ADS) to detect recently killed and currently damaged forest trees in Washington is conducted by the USDA Forest Service (USFS) in cooperation with the Washington State Department of Natural Resources (DNR), and has been ongoing since 1947.

No survey flights were conducted in 2020 in order to lower risk of COVID-19 exposure and spread among flight crews and their contacts. This included both statewide aerial insect and disease survey flights, and focused springtime aerial surveys for Swiss needle cast along Washington's coast forests. For a description of ADS methods used in 2019 and years prior, see "Aerial Detection Survey Methodology" section on page 52.

JUSTIN HOF / USFS

Ground sampling spruce beetle damage.

2020 Methods

In 2020, USFS and DNR worked together to evaluate and test alternative methods for data collection prior to the traditional spring-fall aerial survey season. Some automated change detection products that use satellite imagery such as LandTrendr (Landsat-based Detection of Trends in Disturbance and Recovery) were evaluated, but when compared to areas of known damage and prior years ADS data, did not consistently detect mortality patterns and would still require smaller scale validation by observers. In place of aerial surveys, the data used to represent current forest conditions for 2020 statewide insect and disease surveys were acquired through a combination of ground sampling in the field and a "Scan and Sketch" remote sensing method where observers manually delineated damaged areas on high-resolution satellite or aerial orthophoto imagery. Both methods used the Digital Mobile Sketch Mapping (DMSM) tablets used during normal ADS flights. Both WorldView satellite and National Agriculture Imagery Program (NAIP) orthophoto imagery were used for Scan and Sketch; with acquisition dates between July and October, 2020. Imagery that was available for Washington and acquired during the typical survey window was limited; covering only about 40% of the forested area (Fig. 9).

Using the Scan and Sketch method, observers manually scrolled through imagery on DMSM tablets viewing up to a one mile wide swath, placing points and polygons where damage was visible (Fig. 10). Normal ADS methods described on page 52 were used for assigning damage agent codes and intensity. To inform code decisions, observers could display several data layers, including 2020 ground sampling, 2018 & 2019 ADS data, 2018 & 2019 wildfire perimeters, topography, and elevation. Scan and Sketch polygons were mapped at a finer scale than in ADS, so tended to be smaller, more precisely located, and more numerous.

Ground sampling was focused primarily on areas with recent damage and elevated forest health risk that also had good road access to elevated viewpoints. When it was safe to do so, damaged trees were mapped along roads. At viewpoints, observers used background imagery and topo maps on DMSM tablets to record the location of damage visible in the distance, typically not more than 2 miles away. Large areas with no visible damage were also recorded as "no damage" polygons. To estimate acres surveyed by ground sample, drive lines were buffered by one mile on both sides of the road. Damage polygons were buffered by one half-mile outside the perimeter and damage points by one quarter-mile.

Experienced and trained observers use tree species, size, and pattern or "signature" of damage to identify the agent that likely caused the damage. This method translates well to ground sampling, but when using imagery at the available resolutions (WorldView = 30 cm; NAIP = 1 meter), and straight-down camera angles, it was very challenging and not always possible to accurately identify tree species and size. The damage signature visible in the imagery was sometimes obvious, as with mountain pine beetle in lodgepole pine, but often observers could not discern between potential agents (Fig. 11). For example, both Douglas-fir beetle and western pine beetle mortality have a similar color and group-kill pattern. From the air, they can be differentiated by host species,


GLENN KOHLER / DNR

GROUND SAMPLING IN THE FIELD IS VALUABLE FOR IMPROVING THE ACCURACY OF INSECT AND DISEASE SURVEY DATA AND IDENTIFYING NEW PEST EVENTS.

Above: Early stage Douglas-fir tussock moth larva feeding on Douglas-fir.

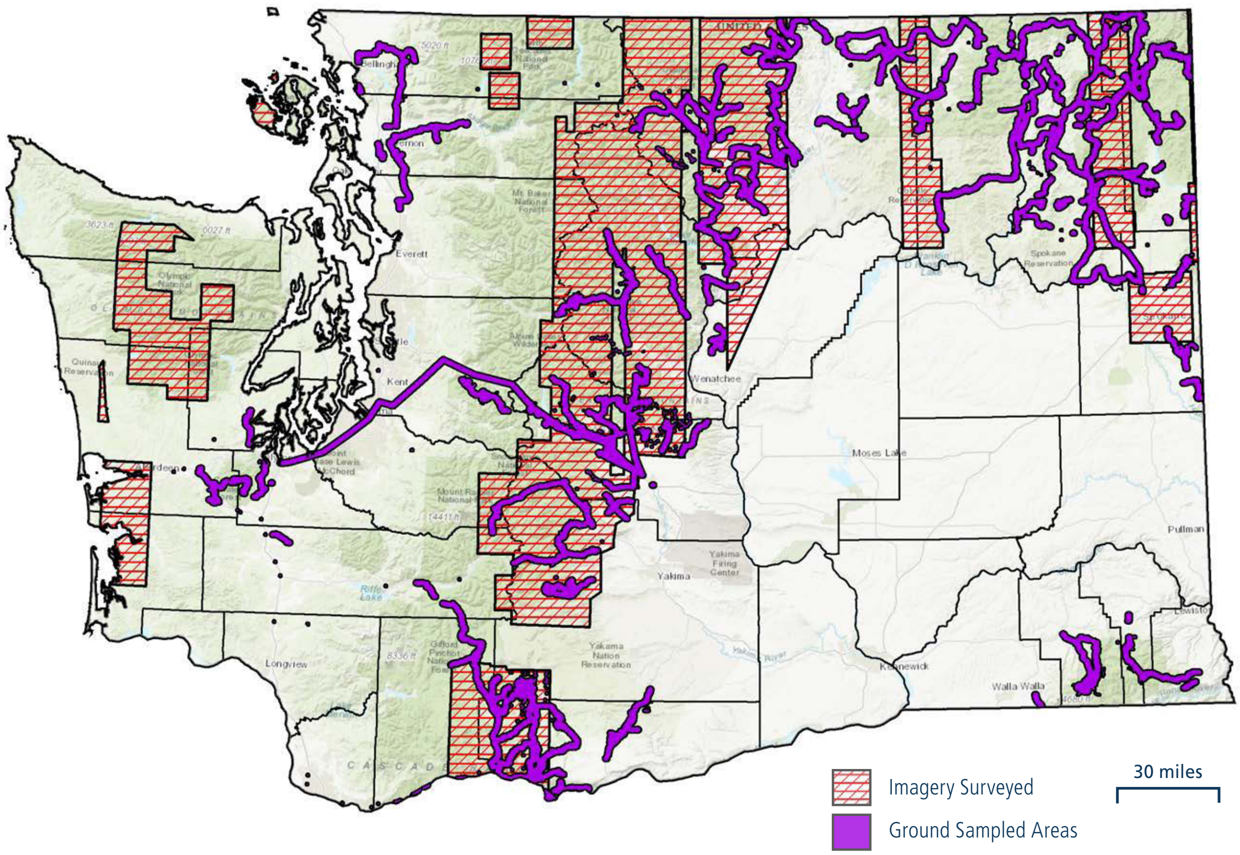


Figure 9.

2020 INSECT AND DISEASE SURVEY AREAS

Coverage of the 2020 ground-based insect and disease survey, including ground sampled areas and aerial imagery analyses (combined WorldView and NAIP).

SOURCE: DNR, USFS

but usually not from imagery. Damage polygons from 2019 and ground sampling data from 2020 were used to inform damage agent identification, but in many cases the damage was mapped as "unknown agent." Defoliation and foliar disease damage were rarely recorded unless severe or informed by 2019 data.

In comparison to ADS flights, which take roughly 100-120 hours to cover all forested areas of Washington, the combined ground sampling and Scan and Sketch methods applied this year were significantly more time intensive. The Scan and Sketch method required 170 hours by 6 observers to cover less than half of the normal survey area where satellite imagery was available. Additionally, while ground sampling in the field was valuable for improving the accuracy of Scan and Sketch data and identifying new pest events outside areas covered by satellite imagery, it required driving 3,700 road miles by 8 observers over several weeks. Recognizing the increased time commitment of these alternative methods for statewide surveys and the limitations of available resources, forested acres in Washington were prioritized for survey and the reporting schedule was adjusted. Forested areas of the state were prioritized for survey based on elevated forest health risk, observed recent insect and disease outbreaks, and other damage trends information. Where satellite imagery was unavailable for portions of these priority areas, observers conducted limited sampling by ground surveys. Even with a reduced and prioritized survey area extent for ground and satellite imagery surveys, data collection was not finished until mid-January 2021. In a normal year, flights are complete and draft data is available by early October. Therefore, data processing and reporting was on a delayed timeline this year as well.

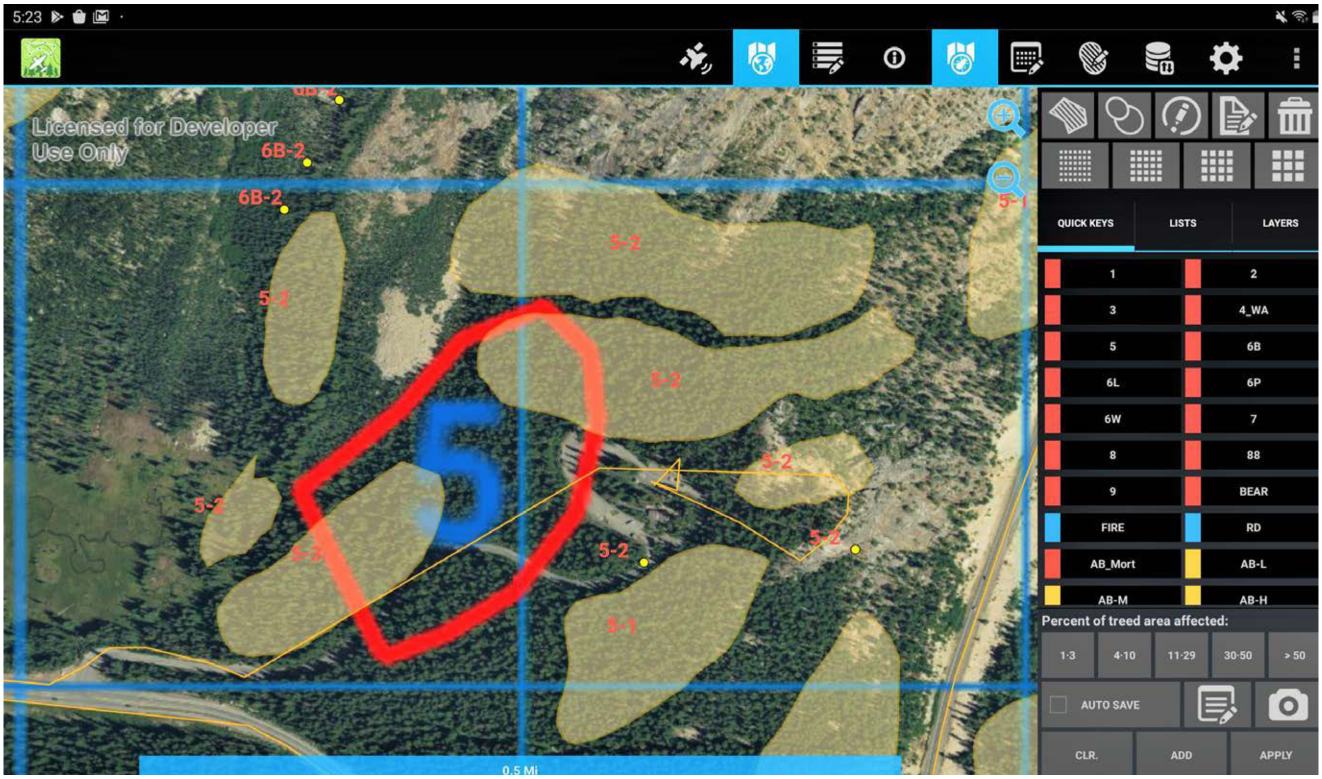


Figure 10. Screenshot from DMSM tablet showing scale of 2020 Scan and Sketch survey displaying half-mile grid lines (blue), ground sample drive lines (orange), 2020 damage polygons and points (yellow outline with gray shading), and a 2019 aerial survey polygon (red outline).

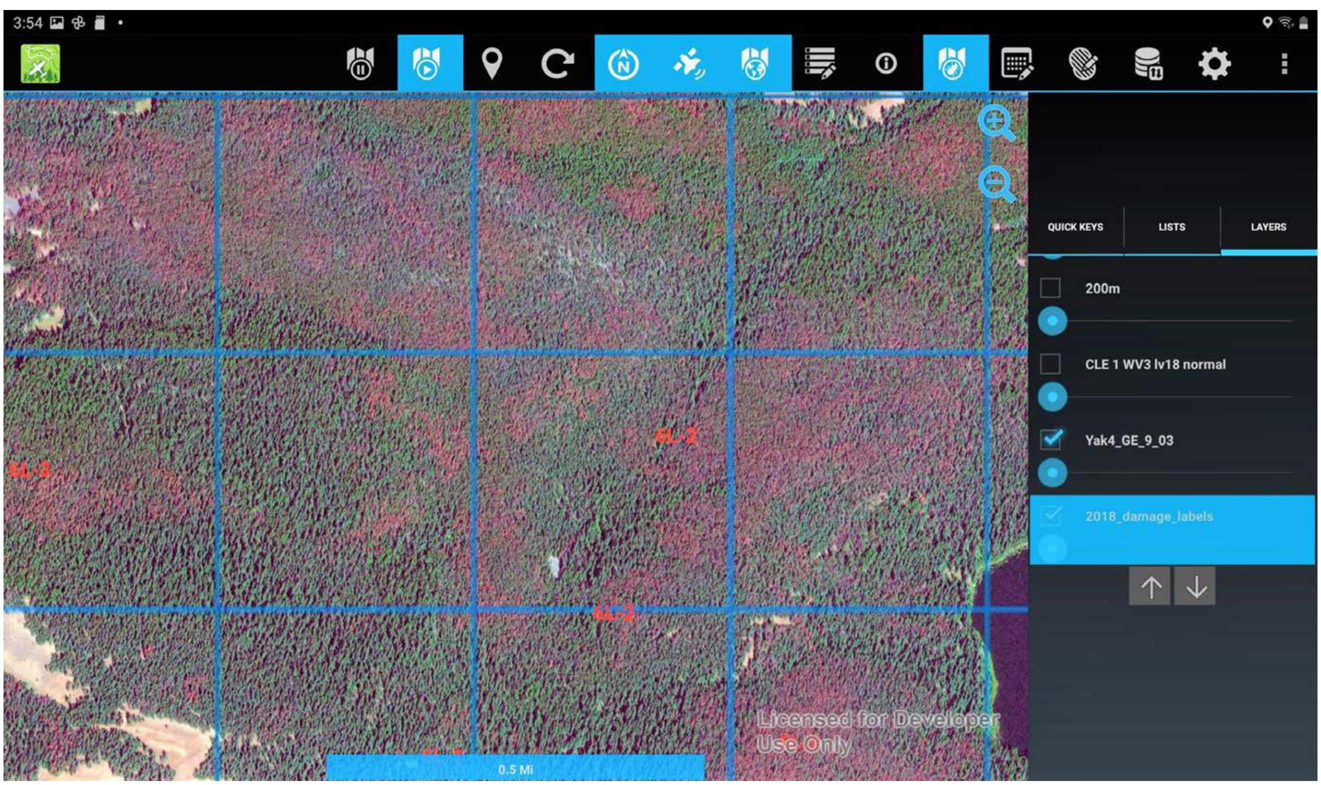


Figure 11. Screenshot from DMSM tablet showing mountain pine beetle mortality in lodgepole pine on imagery used for Scan and Sketch.

2020 Statewide Insect and Disease Survey Summary

This report does not include acreage summaries or trends by specific pest species after 2019 due to reduced coverage of the state with 2020 survey methods, especially in western Washington, and reduced confidence in damage signatures. Specific disturbance agent codes are associated with 2020 survey data for polygons recorded with a known signature of damage. The number of recorded "unknown" disturbance agents was unusually high in 2020, but observers did assign a damage agent code whenever an informed decision was possible.

Approximately 48% of the forested area in Washington (10.5 million acres) was surveyed in 2020 using either Scan and Sketch and/or ground sampling methods. The two methods overlapped on approximately 1.5 million acres. Most of the area prioritized based on forest health risk and recent damage trends was in eastern Washington, where approximately 80% of forested area (8.1 million acres) was surveyed. In western Washington, approximately 20% of the forested area (2.4 million acres) was surveyed including areas of recent outbreak and where imagery was available (Fig. 12). Approximately 8.5 million acres were surveyed using the Scan and Sketch method (5.2 million acres with WorldView and 3.3 million acres with NAIP). The ground sampling survey covered approximately 3.5 million acres, primarily in eastern Washington. The ground sampled area estimate includes buffers around damage polygons and landscapes with recognizable signatures that could be seen within one mile of roads, on average.

APPROXIMATELY 48% OF THE FORESTED AREA IN WASHINGTON (10.5 MILLION ACRES) WAS SURVEYED IN 2020 USING EITHER SCAN AND SKETCH AND/ OR GROUND SAMPLING METHODS. WASHINGTON AERIAL SURVEYS COVER AT LEAST 20 MILLION ACRES IN A TYPICAL YEAR.

Disclaimer: Totals reported below are intended to be a snapshot of general observations in 2020 and should not be compared to prior years or trends. Data collection methods and area covered by the 2020 survey are not comparable to prior years.

The 2020 insect and disease survey recorded some level of tree mortality, tree defoliation, or foliar diseases on approximately 322,000 acres over an area that is approximately 48% of the normal survey area and primarily in eastern Washington (Fig. 13). Approximately 265,000 acres with damage were due to known mortality agents, primarily bark beetles. Approximately 9,000 acres with damage were due to defoliators. Approximately 48,000 acres with damage were due to other types of damage agents, including 30,000 acres with unknown damage type.

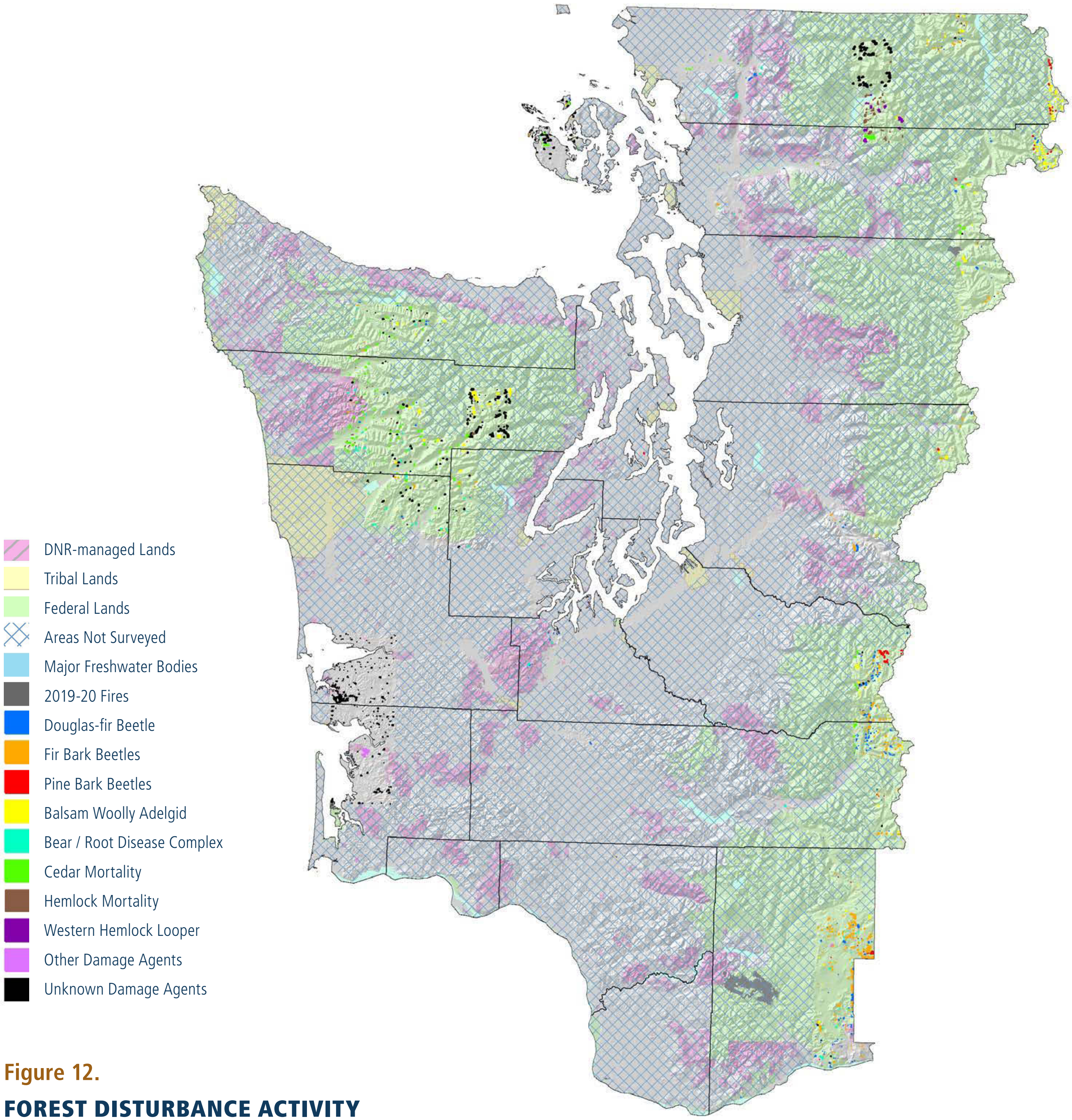
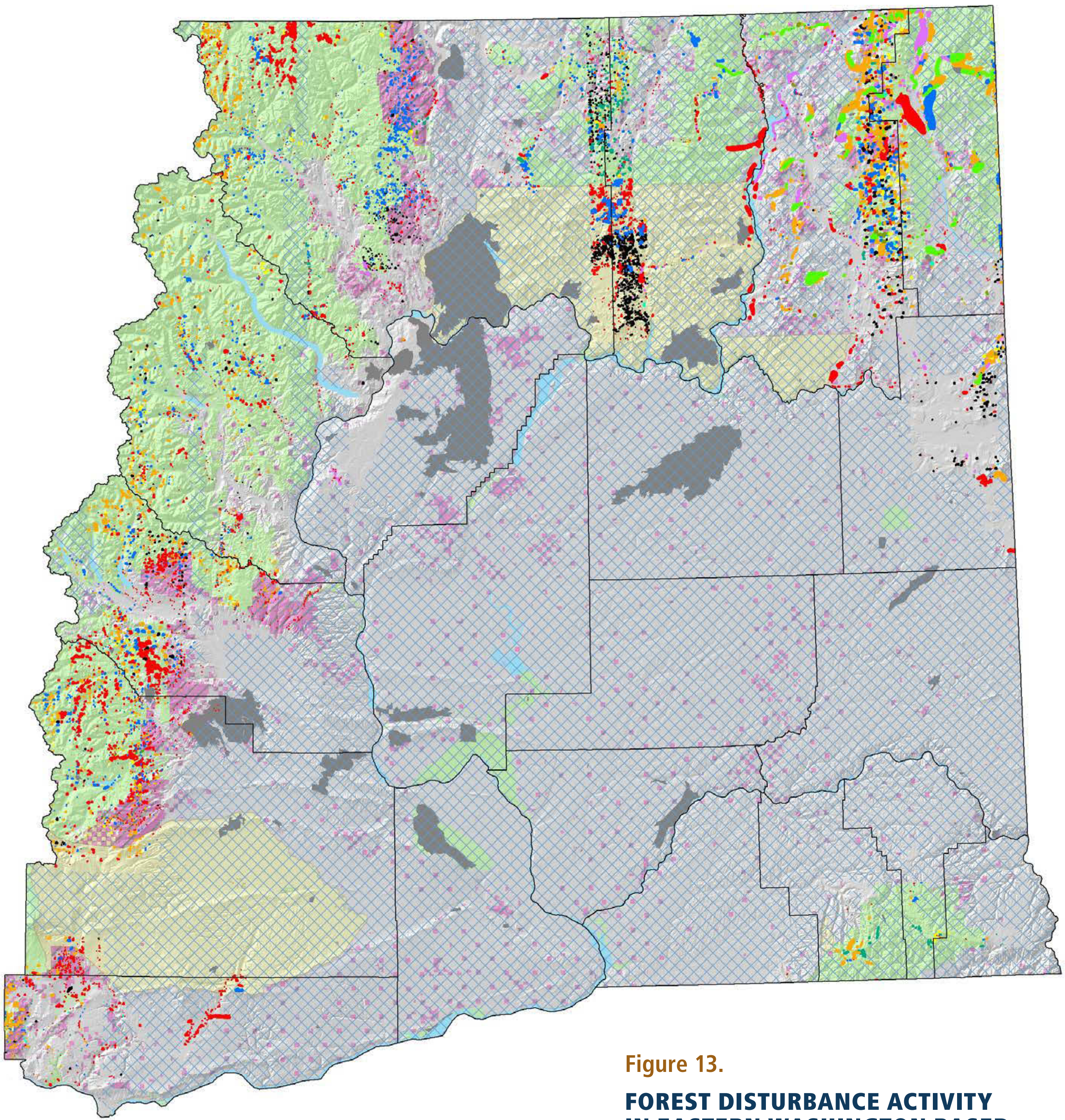


Figure 12.

FOREST DISTURBANCE ACTIVITY IN WESTERN WASHINGTON BASED ON 2020 COMBINED DATA

2020 insect and disease survey data.
Blue cross-hatched areas were not surveyed.

SOURCE: DNR, USFS



- DNR-managed Lands
- Tribal Lands
- Federal Lands
- Areas Not Surveyed
- Major Freshwater Bodies
- 2019-20 Fires
- Douglas-fir Beetle
- Fir Bark Beetles
- Pine Bark Beetles
- Balsam Woolly Adelgid
- Bear / Root Disease Complex
- Cedar Mortality
- Hemlock Mortality
- Western Hemlock Looper
- Other Damage Agents
- Unknown Damage Agents

Figure 13.

FOREST DISTURBANCE ACTIVITY IN EASTERN WASHINGTON BASED ON 2020 COMBINED DATA

2020 insect and disease survey data.
Blue cross-hatched areas were not surveyed.

SOURCE: DNR, USFS

N

0 20 40 miles

GLENN KOHLER / DNR

Biotic Disturbances Influencing Forest Health

Living, or biotic damage agents such as insects, fungi, animals, and parasitic dwarf mistletoe plants can influence forest health directly by causing mortality or chronic declines in tree health. Indirectly, damage from these agents can weaken trees and predispose them to attack by other pests that may be more damaging or lethal.

Unlike abiotic disturbances such as drought and wildfire, forest insects and pathogens typically attack a specific host tree species or narrow range of hosts, so damage may be limited in mixed-species forests. At low levels, native insects and pathogens provide an important ecological role in nutrient cycling of dead plant material and removal of weak, suppressed, and unthrifty trees, leaving healthier trees with more access to water, light, and nutrients.

At high levels, outbreak populations can cause significant changes in stand structure and composition over time. Non-native, or invasive forest insects and diseases such as gypsy moth and sudden oak death are a major threat to Washington's forests because native trees do not have effective defense mechanisms. The following section is a summary of recent forest insect and disease damage trends and conditions collected through a combination of aerial surveys, remote sensing, pheromone trapping, stream baiting, field observations, and ground monitoring plots.

INSECTS | BARK BEETLES

GLENN KOHLER / DNR

Pine Bark Beetles

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

The area with mortality caused by pine bark beetles in 2018 and 2019 was approximately 120,000 acres in both years, below the 10-year average of 143,000 acres, and down from a recent peak of approximately 196,000 acres in 2017 (Fig. 14). Trend data for 2020 is not being reported due to changes in survey methods and reduced survey area. The majority of annual pine bark beetle mortality is in lodgepole pine killed by mountain pine beetle (MPB). Recent MPB-killed lodgepole totaled 59,300 acres in 2018 and 76,500 acres in 2019. In 2020, heavy MPB mortality in lodgepole was mapped east of Mt. Rainier (between Cle Elum and White Pass in Kittitas and Yakima counties) and in the Pasayten Wilderness in north Okanogan County. MPB-caused mortality in ponderosa pine has averaged about 23,000 acres annually over the last decade. In 2019, MPB-killed ponderosa pine was below the ten-year average at approximately 14,000 acres. MPB mortality in whitebark pine and western white pine was at or below 1,000 acres in 2018 and 2019 for each host, down from peak levels in 2010 of 16,200 acres in whitebark pine and 3,300 in western white pine. Some mortality in whitebark pine and western white pine may be due to non-native white pine blister rust disease directly killing trees or predisposing infected trees to attack by MPB.

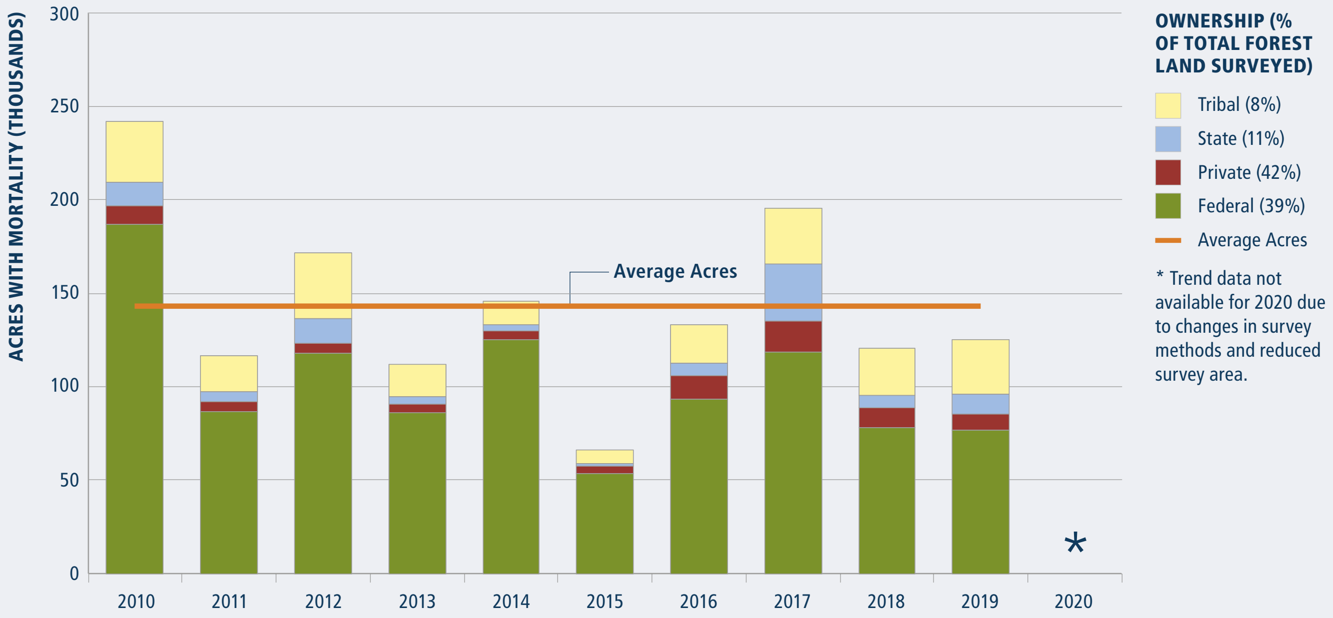
The majority of MPB damage occurs in eastern Washington, however it is active on the west side of the Cascades in western white pine, shore pine, and ornamental pines; primarily as an opportunist attacking weakened trees. In 2020, MPB caused a significant amount of western white pine mortality over an area of about 100 acres in a forested park in Bremerton, likely related to recent drought stress. Aerial surveys indicate damage had occurred for several years but was incorrectly mapped as Douglas-fir beetle.

MORTALITY OF PONDEROSA PINE DUE TO WESTERN PINE BEETLE HAS INCREASED STEADILY SINCE 2012, REACHING A PEAK OF 29,400 ACRES WITH DAMAGE IN 2019. THE ESTIMATED AREA WITH DAMAGE IN 2020 APPEARS TO HAVE INCREASED SINCE 2019.

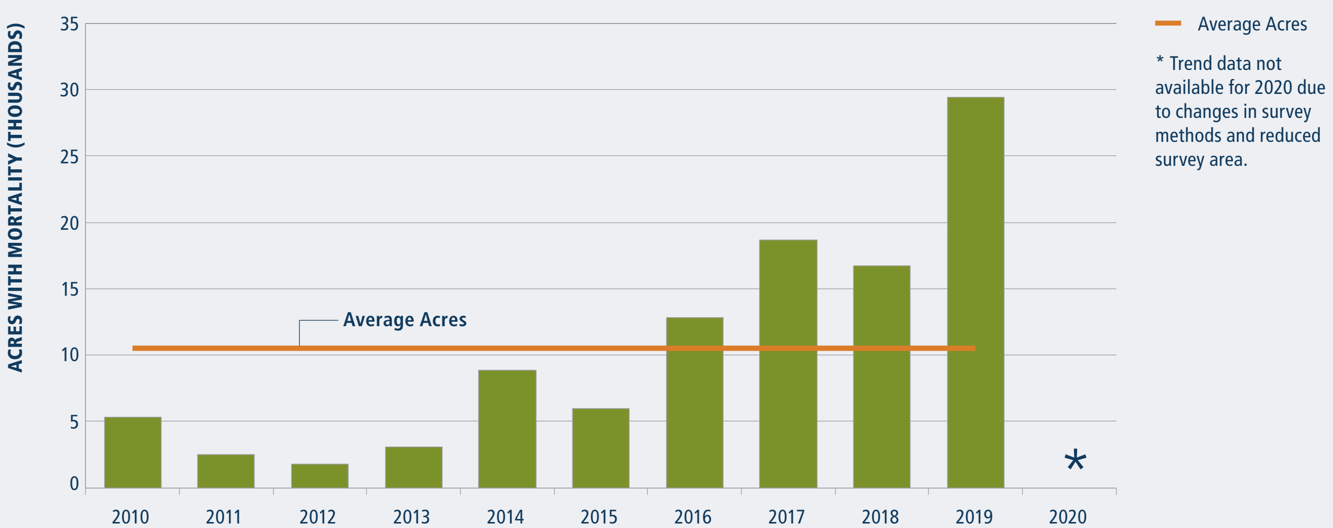
Mortality of ponderosa pine due to western pine beetle (WPB) has increased steadily since 2012 and reached a peak of 29,400 acres in 2019, nearly double the 16,700 acres observed in 2018 and the highest level since 2006 (Fig. 15). The estimated area with damage in 2020 appears to have increased since 2019. While the specific number of acres affected are not being reported due changes in survey methods, most of the WPB mortality was in low elevation forests that were accessible for ground sampling surveys, increasing confidence in the estimate. WPB damage has been widely reported throughout eastern Washington and there has been a significant increase in requests for information from landowners and land managers. Recent drought conditions are likely an important driver of these increases. The highest concentrations of WPB-caused mortality were located in west Klickitat and south Yakima counties around Glenwood and north of Goldendale; scattered areas of west Kittitas County around Roslyn and through the Teanaway River drainage; on the Confederated Tribes of the Colville Reservation; and in north Stevens and Ferry counties (see photo on page 24).

Pine mortality attributed to Ips pine engravers reached a 10-year high of 3,900 acres in 2019, well above the ten-year average of 1,200 acres and the highest level recorded since 2006. Similar to WPB, the estimated area with damage in 2020 appears to have increased since 2019. Ponderosa pine was the most common species affected. The highest concentrations of mortality were in Ferry, Stevens, Pend Oreille, north Spokane, and west Klickitat counties—some of the same areas experiencing WPB outbreaks.

PINE BARK BEETLES 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 14.



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



INSECTS | BARK BEETLES

GLENN KOHLER / DNR

Douglas-fir Beetle

(*Dendroctonus pseudotsugae* Hopkins)

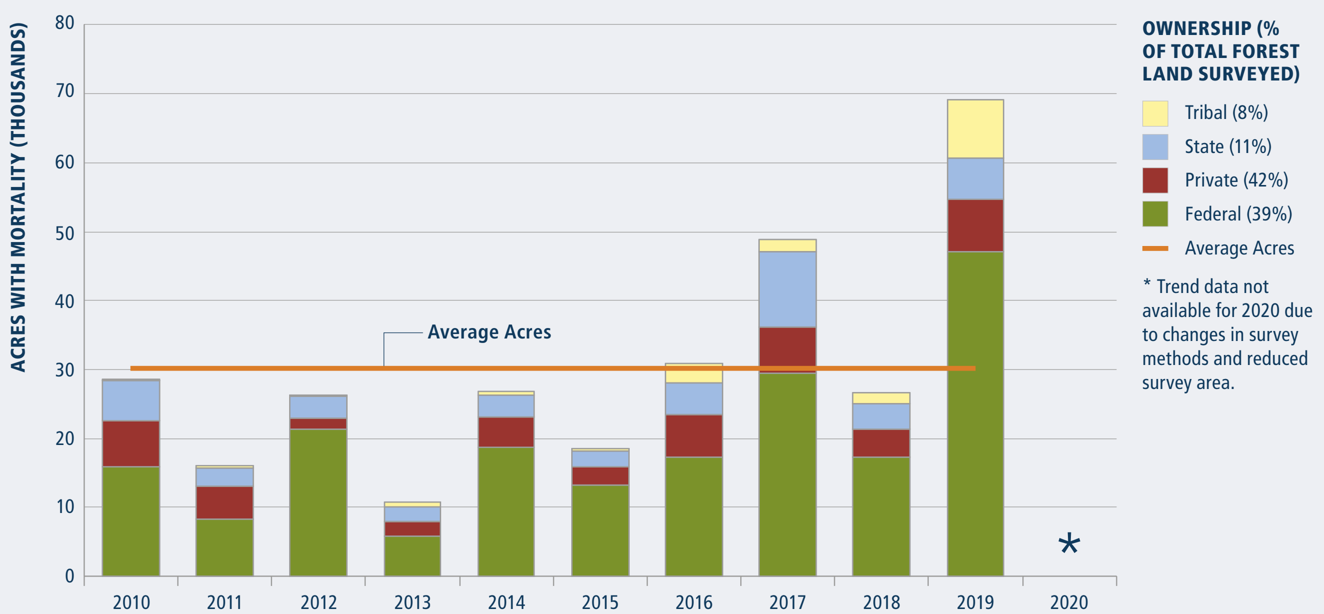
Mortality due to Douglas-fir beetle (DFB) has been increasing in recent years, reaching a ten-year high of 69,100 acres in 2019, more than double the 26,700 acres in 2018 and the highest level of damage since 2009 (Fig. 16). In 2020, scattered areas of DFB-caused mortality were detected throughout the east slopes of the central and north Cascades, but the highest concentrations were mapped east of Mt. Rainier between Cle Elum and White Pass in Kittitas and Yakima counties; in west Kittitas County around Roslyn and through the Teanaway River drainage; in central Okanogan County in and around the Loomis State Forest; on the Confederated Tribes of the Colville Reservation; and in east Stevens County. Some of the eastern Washington mortality was likely associated with wildfire damage from as far back as 2017 (including Norse Peak and Jolly Mountain fires) and 2018 windstorm damage in northeast Washington that created abundant breeding material.

Right: Boring dust left by egg-laying Douglas-fir beetle entering a windthrown Douglas-fir.

GLENN KOHLER / DNR

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

Figure 16.



INSECTS | BARK BEETLES


DAVID MCCOMB / USDA FOREST SERVICE, BUGWOOD.ORG

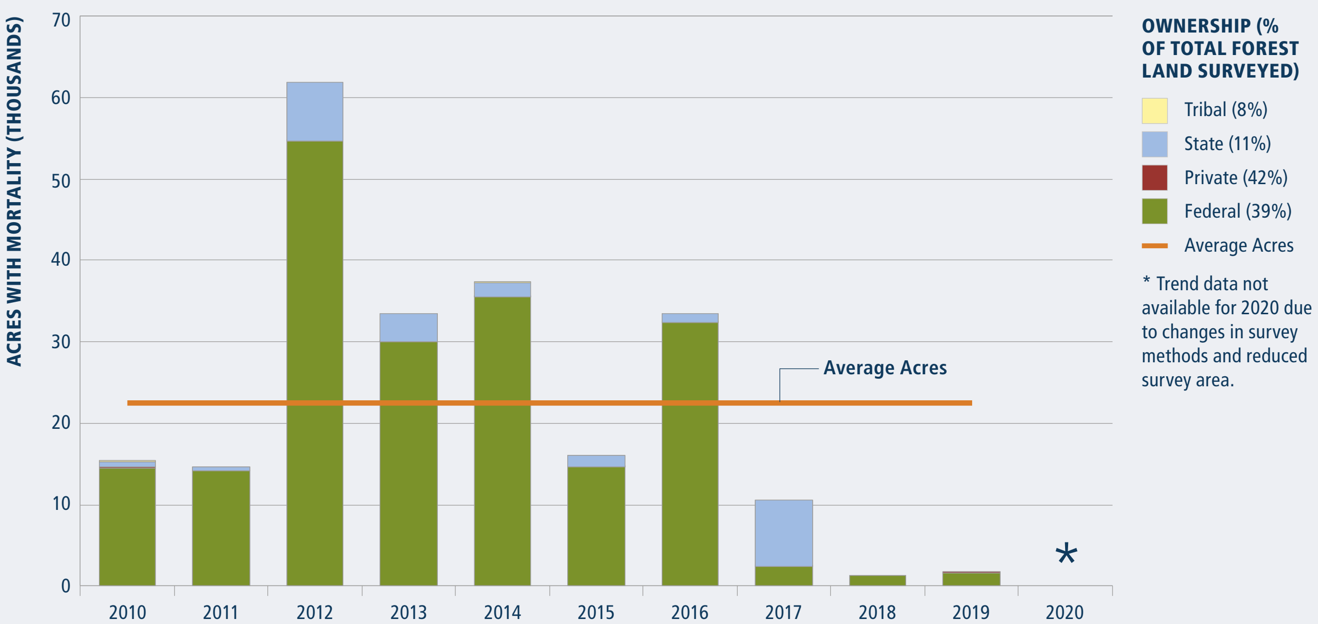
Spruce Beetle

(*Dendroctonus rufipennis* Kirby)

In 2020 a few small areas of likely spruce beetle damage were mapped from satellite imagery in northern Okanogan County near the Canadian border. This area has experienced outbreaks in recent years and spruce beetle activity has been observed across the border in British Columbia (Fig. 17). No new spruce beetle mortality in Engelmann spruce was observed by ground sampling the Blewett Pass area near the Chelan-Kittitas county border. Spruce beetle-caused mortality was detected across 650 acres within this area in 2019.


CONNIE MEHMEL / USFS

SPRUCE BEETLE 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 17.



INSECTS | BARK BEETLES

IMAGE LIBRARY / BUGWOOD.ORG
PEST AND DISEASES

Northern Spruce Engraver

(*Ips perturbatus* Eichhoff)

Northern spruce engraver (NSE), *Ips perturbatus*, is a major pest of white spruce in Alaska and northern Canada. Historic records of NSE in the western United States include one location each in western Washington (Grays Harbor County) and northern Idaho, as well as several locations in western Montana (Burnside et al. 2011). It is not considered a pest of spruce hosts in these states. During a survey for California fivespined Ips (*Ips paraconfusus*) in Washington from 2010-2018, NSE adults were collected in eastern Washington where NSE has not been previously recorded. The site with most abundant NSE was adjacent to Engelmann spruce damaged in the Carlton Complex fire. To determine the distribution of NSE in eastern Washington, DNR and the US Forest Service placed traps baited with pheromone lures specific to NSE at four sites in recently disturbed Engelmann spruce stands in 2019 and 2020. One Sitka spruce dominated site in Grays Harbor County was also trapped both years (Fig. 18). To verify Engelmann spruce as a host in eastern Washington, trees were cut and baited with NSE pheromone lures at four sites. After two months in the field to allow time for attacks and egg laying, bolts were cut and kept in rearing cages through the following spring to collect emerging beetles.

NSE adults were collected at all four eastern Washington trap sites and brood adults emerged from bolts collected at three of those sites. These results confirm that Engelmann spruce is a host of NSE in Washington and suggest that NSE is likely widely distributed in eastern Washington. There's no indication that NSE is killing healthy trees in Washington. It is likely acting as an opportunist attacking trees weakened or killed by disturbances such as wildfire, windstorms, and spruce beetle outbreaks. No NSE were collected at the Grays Harbor County trap site in 2019 and 2020.

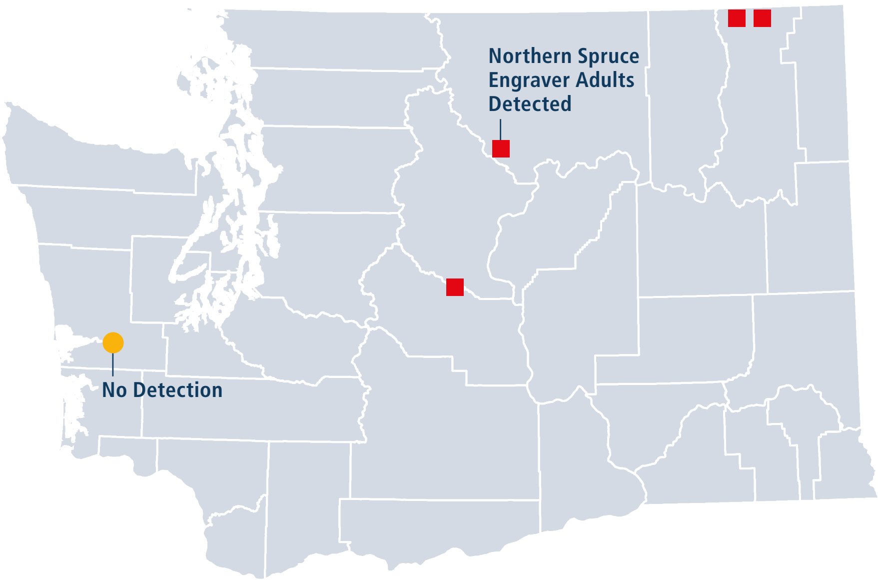


Figure 18.

NORTHERN SPRUCE ENGRAVER MONITORING TRAP LOCATIONS 2019-2020

Reference:

Burnside, R.E., E.H. Holsten, C.J. Fettig, J.J. Kruse, M.E. Schultz, C.J. Hayes, A.D. Graves, and S.J. Seybold. 2011. The northern spruce engraver, *Ips perturbatus*. U.S. Department of Agriculture, Forest Service, Portland, OR, Forest Insect and Disease Leaflet FIDL 180.

INSECTS | BARK BEETLES

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

Fir Engraver

(*Scolytus ventralis* LeConte)

Fir engraver can attack all species of true fir (*Abies*) in Washington, but the primary hosts in Washington are grand fir and noble fir. Fir engraver-caused mortality, primarily in grand fir, has been steadily increasing since 2015 and reached a 10-year high of 166,300 acres in 2019, more than twice the area recorded in 2018 and the highest level since 2008 (Fig. 19). East of the Cascades in 2020, the most concentrated areas of mortality in 2020 were: in and around the Indian Heaven Wilderness in Skamania and Klickitat counties; in Kittitas and Chelan counties from the Alpine Lakes Wilderness to Lake Chelan; east of Mt. Rainier between Cle Elum and White Pass in Kittitas and Yakima counties, and throughout Stevens and Pend Oreille counties. Recent drought conditions are likely an important driver of increases in fir engraver activity.

INSECTS | BARK BEETLES

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

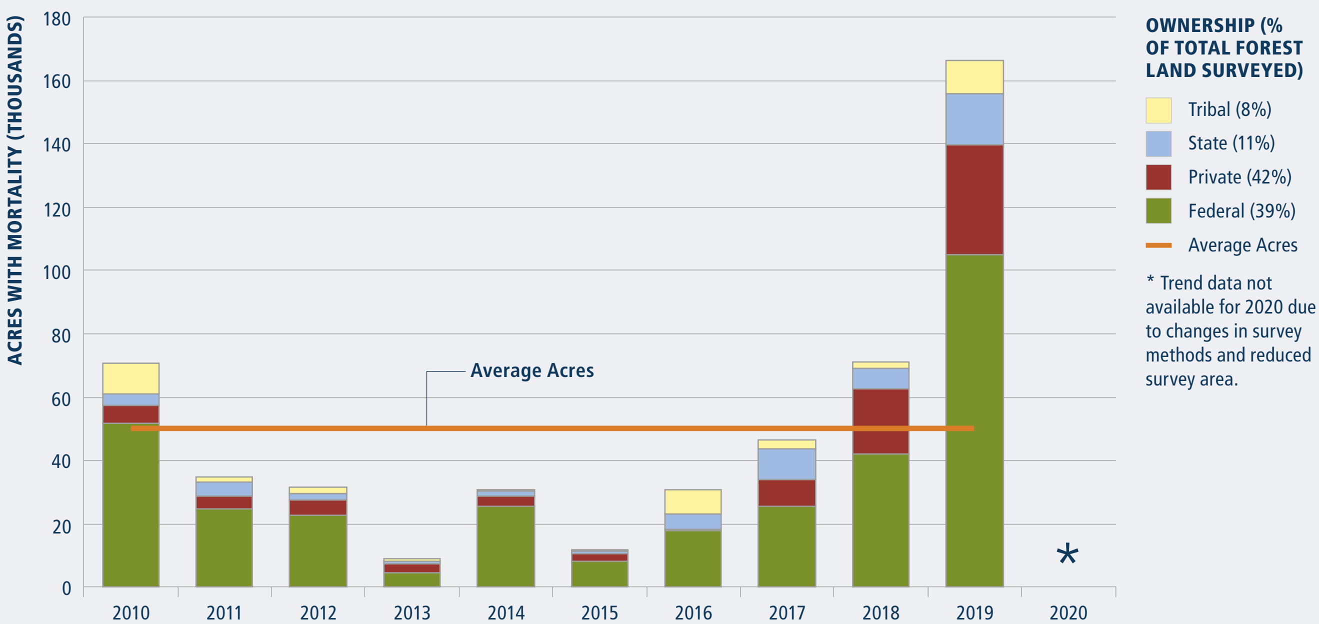
Western Balsam Bark Beetle

(*Dryocoetes confusus* Swaine)

GLENN KOHLER /DNR

Western balsam bark beetle (WBBB), often in conjunction with balsam woolly adelgid, is an important driver of subalpine fir mortality in high elevation Washington forests (see photo at left). Acres with WBBB-caused mortality have been increasing since 2015, to a 10-year high of 26,000 acres in 2017 and remaining high in 2019 with 22,600 acres recorded. The areas with the most concentrated damage in 2020 were: the North Cascades in western Okanogan County; the Alpine Lakes Wilderness; the William O. Douglas Wilderness east of Mt. Rainier; the Republic area; and the Selkirk Mountains.

FIR ENGRAVER 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 19



INSECTS | DEFOLIATORS

GLENN KOHLER /DNR

Douglas-fir Tussock Moth

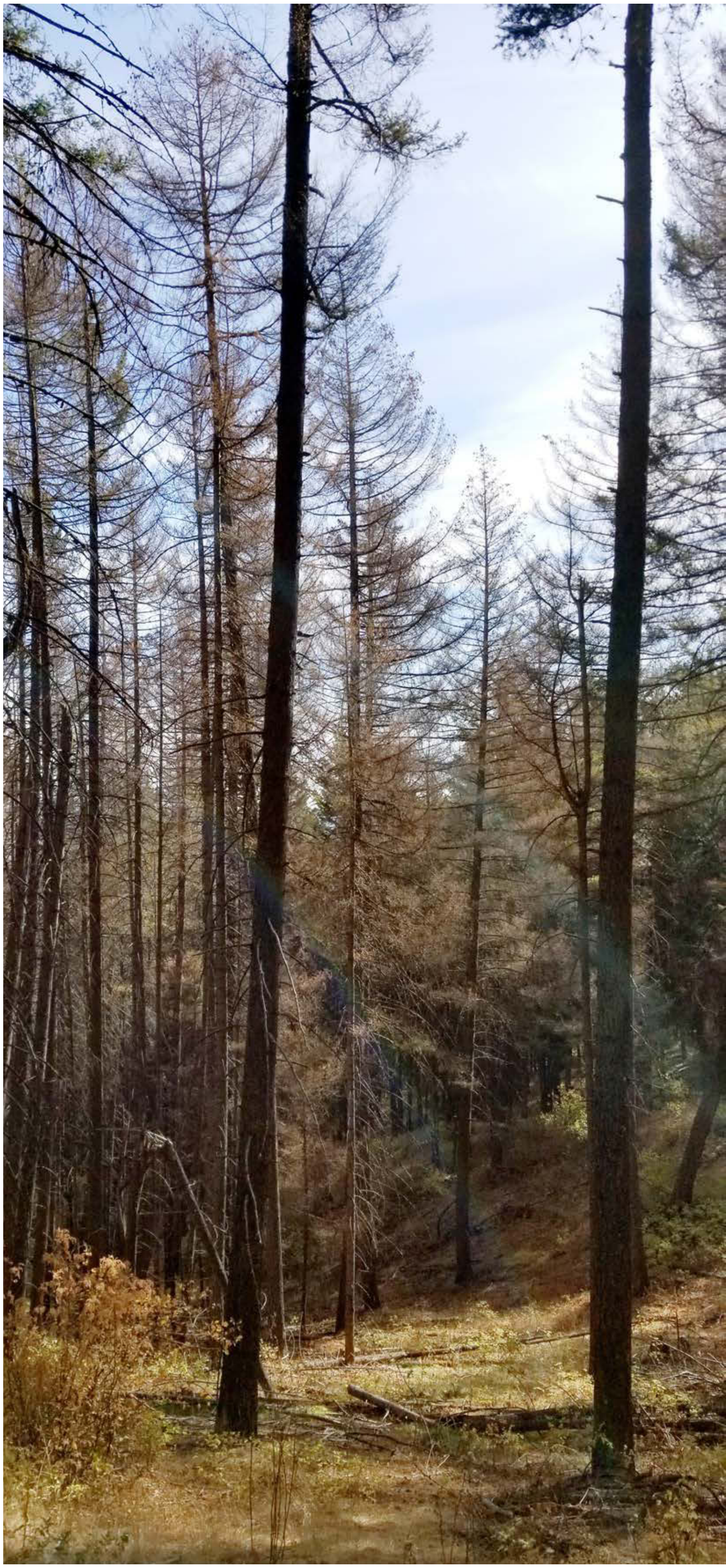
(*Orgyia pseudotsugata* McDunnough)

A two-year outbreak of Douglas-fir tussock moth (DFTM) in Kittitas and Chelan counties that defoliated 1,900 acres in 2018 and 5,600 acres in 2019 has collapsed. Egg mass surveys and pheromone trap catches in the area indicated that the population was declining and no new defoliation was observed in 2020. The damage was severe in some areas along US Highway 97 (Blewett Pass) and small patches south of Interstate 90 west of Ellensburg, resulting in mortality of Douglas-fir and grand fir hosts (see photo at right).

A small outbreak in 2019 that resulted in approximately 600 acres with defoliation east of the Okanogan River between Oroville and Chesaw in Okanogan County also appears to have collapsed and no new defoliation was observed in 2020. Egg masses collected in the area in fall 2019 were assessed by USFS staff in Wenatchee for levels of a naturally occurring nucleopolyhedrosis virus (NPV) that infects DFTM. The NPV level was found to be high enough to cause a natural population collapse. Pheromone trap catches from 2020 were still high at some locations in Okanogan County but lower than in 2019, indicating new defoliation in 2021 is unlikely (Fig. 20).

The interagency network of "Early Warning System" pheromone traps at approximately 250 locations in Washington continues to be monitored annually (Fig. 21). For more information on the Early Warning System, go to: https://www.fs.usda.gov/detail/r6/forest-grasslandhealth/insects-diseases/?cid=fsbdev2_027373.

Trap catches in Okanogan County generally decreased in 2020, but remain high at a few locations near the Canadian border. DFTM defoliation in these areas is possible in 2021, but not likely given virus load and absence of defoliation in 2020. High trap catches do not always correlate with the exact location of future defoliation.



GLENN KOHLER /DNR

INSECTS | DEFOLIATORS

DOUGLAS-FIR TUSSOCK MOTH TRAP CATCHES AND DEFOLIATION IN WASHINGTON 1984-2020 Figure 21.

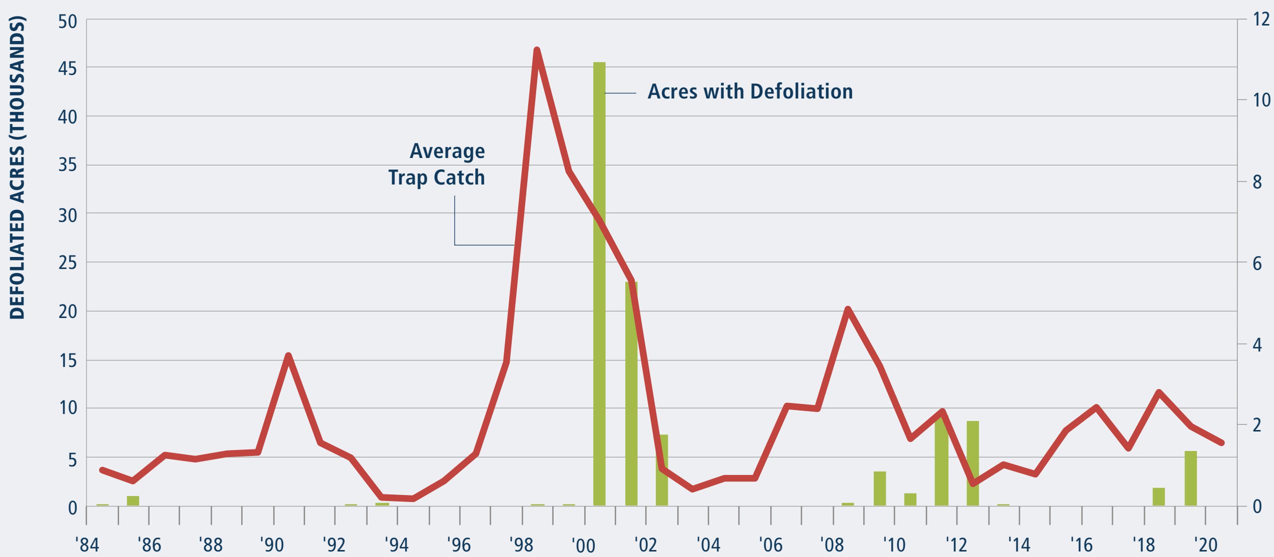


Figure 20.

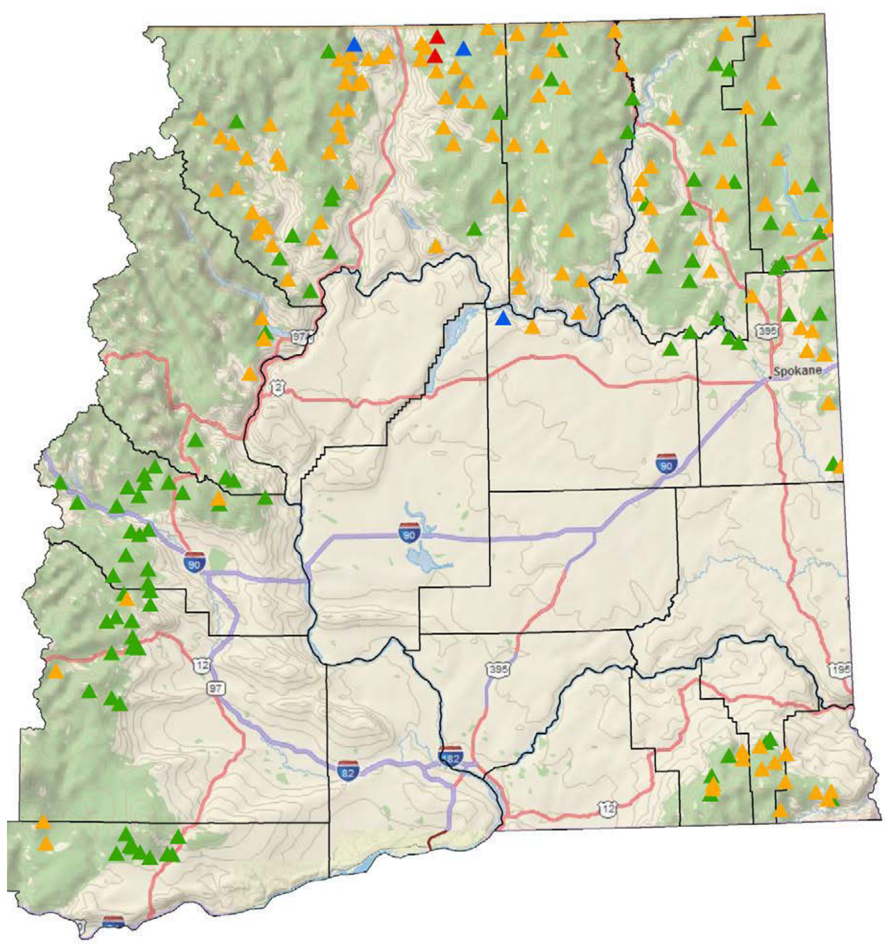
DOUGLAS-FIR TUSSOCK MOTH PHEROMONE TRAP CATCH RESULTS IN EASTERN WASHINGTON 2020

SOURCE: DNR

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

N

40 miles



INSECTS | DEFOLIATORS

MELISSA FISCHER / DNR

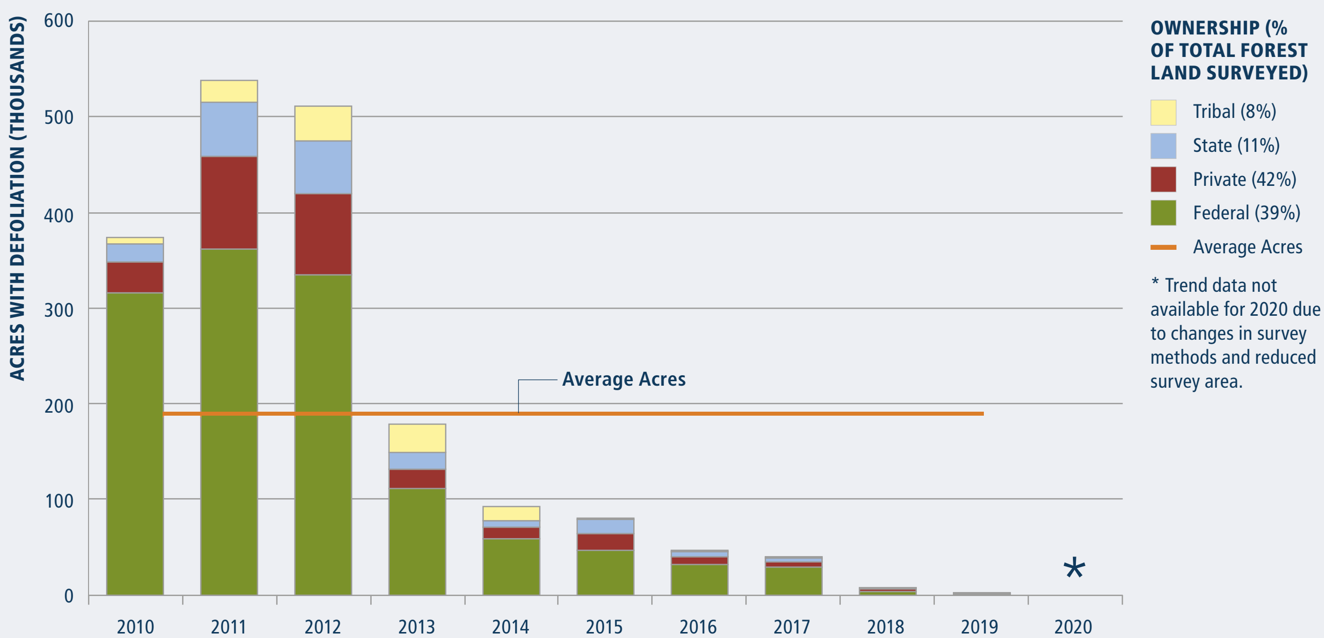
Western Spruce Budworm

(*Choristoneura freemani* Razowski)

The total acres with western spruce budworm (WSB) defoliation in Washington declined steadily from peak levels over 500,000 acres in 2011 and 2012 to a low of 1,400 acres in 2019 (Fig. 22). The only areas of WSB defoliation reported by land managers or observed in 2020 ground sampling were in Okanogan and Ferry counties, where damage has been scattered with light intensity in recent years. Unless it was severe, WSB defoliation damage would have been difficult to detect using the Scan and Sketch survey methods used in 2020, so it's possible that areas with light defoliation went undetected. WSB pheromone traps were placed at 118 locations in northeast Washington (Fig. 23). Only a few trap sites in northeast Okanogan County indicated the potential for moderate defoliation in 2021. Trap catches elsewhere remain too low to predict defoliation occurring in 2021.

GLENN KOHLER / DNR

WESTERN SPRUCE BUDWORM 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 22.



INSECTS | DEFOLIATORS

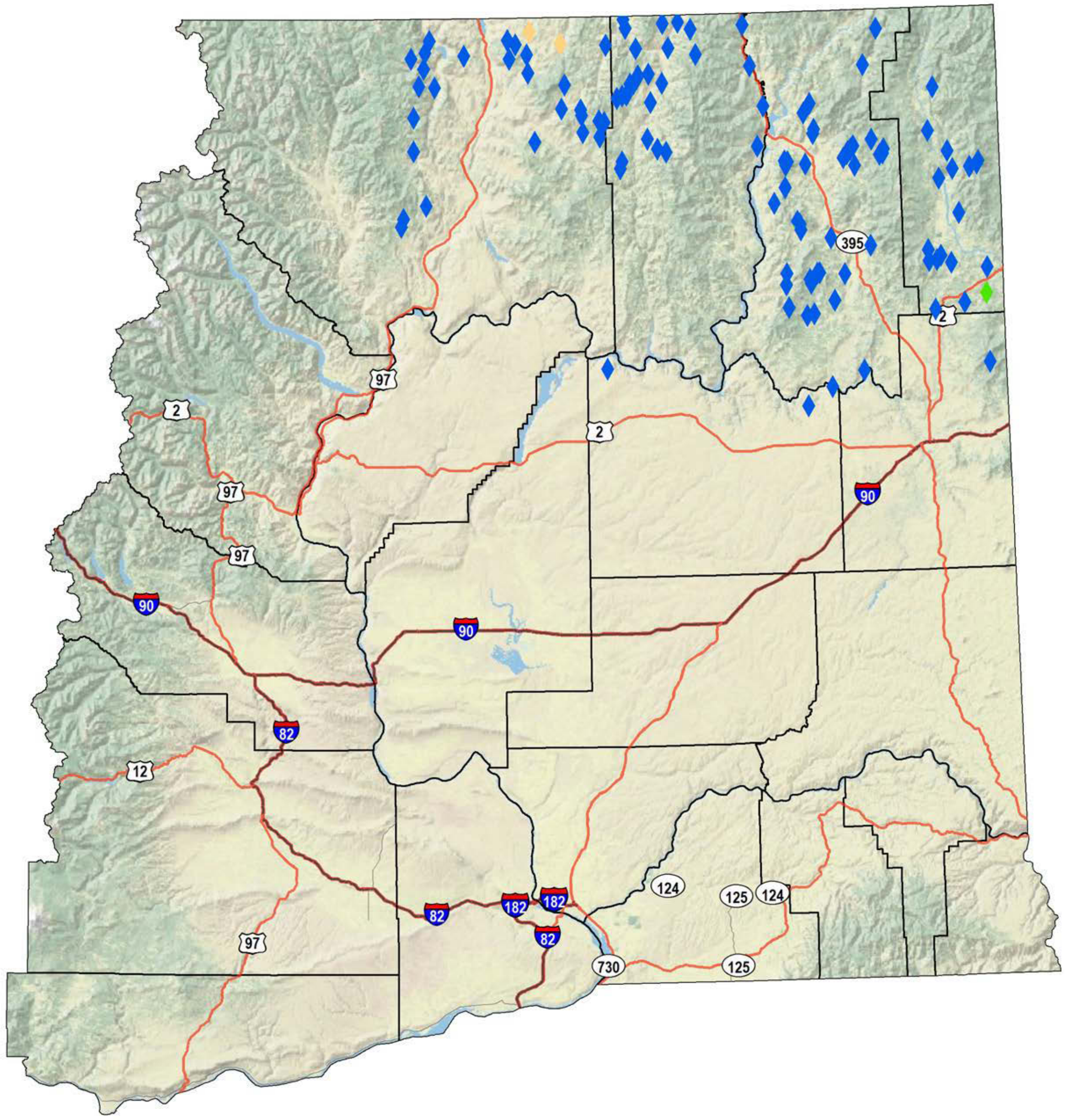
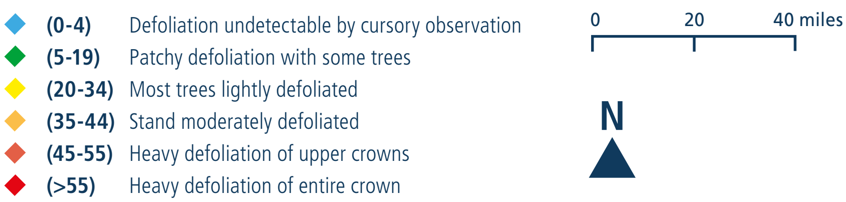


Figure 23.

WESTERN SPRUCE BUDWORM PHEROMONE TRAP RESULTS

Number of moths caught in eastern Washington for 2020 and expected 2021 defoliation.

SOURCE: DNR, USFS



INSECTS | DEFOLIATORS

Western Hemlock Looper

(*Lambdina fiscellaria lugubrosa* (Hulst))

2020 was the third year of a western hemlock looper (WHL) outbreak in south Whatcom and north Skagit counties. Although the total area affected could not be determined in 2020, it appears to have decreased from the approximately 5,300 acres defoliated in 2019. The majority of the damage is in western hemlock across small, scattered areas east of Baker Lake in the Mt. Baker-Snoqualmie National Forest. A U.S. Forest Service analysis of WHL eggs collected from three Baker Lake campgrounds in 2019 indicated that a third year of defoliation was likely in 2020. New 2020 defoliation was verified on the ground. This same area experienced a similarly sized outbreak in 2011-2012. During outbreaks, large numbers of moths may be seen at rest with their wings spread during the daytime. A new Forest Insect and Disease Leaflet covering biology, management, and outbreak history of western hemlock looper in western North America was published in 2020 (Dickinson and Kohler 2020).

Reference:

Dickinson, D., and G.R. Kohler. 2020. Western Hemlock Looper. U.S. Department of Agriculture, Forest Service, Portland, OR, Forest Insect and Disease Leaflet FIDL 186.

INSECTS | DEFOLIATORS

Spruce Aphid

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

CLOCKWISE FROM TOP LEFT: JERALD E. DEWEY, USDA FS; USFS SOUTHWESTERN REGION; GLENN KOHLER / DNR; DARCI DICKINSON / USFS

A widespread 2019 outbreak of spruce aphid that damaged Sitka spruce along the Washington coast has collapsed. All coastal counties were affected, but the highest concentrations of damage were around Grays Harbor, Willapa Bay, and the Longbeach Peninsula. Approximately 10,600 acres were defoliated in 2019. In 2020, DNR sampled some of the affected areas for spruce aphid and determined that populations had decreased and was not likely to cause noticeable damage in 2020. Spruce aphid typically only damages older foliage, so in spite of what appeared to be severe damage, most trees retained viable buds and flushed new foliage in spring 2020. However, many of the affected trees remain stressed due to foliage loss from spruce aphid, recent drought stress, and, in some cases, additional feeding on new growth by spruce budmoths (*Zeiraphera* spp.).

Left: Photograph from 2011 of adult western hemlock looper at rest during daytime.

Right: Sitka spruce foliage loss from 2019 spruce aphid outbreak. Photo taken in March 2020, prior to bud break.

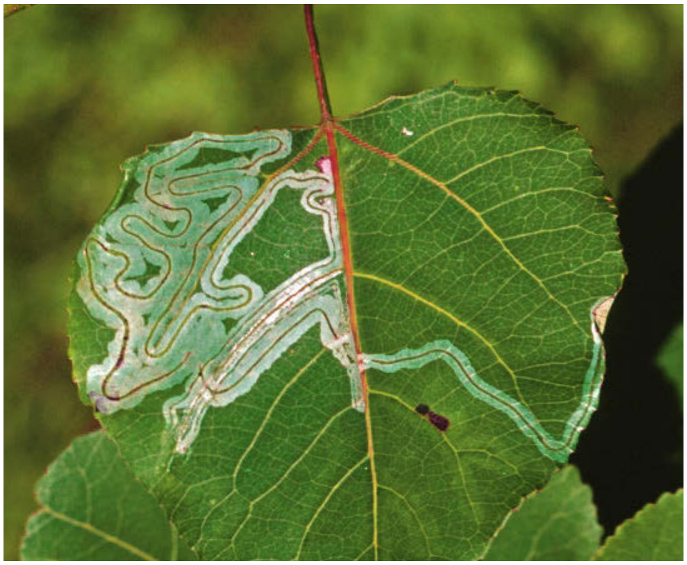
INSECTS | DEFOLIATORS

MELISSA FISCHER / DNR

Leafminers in Hardwoods

(Phyllocnistis populiella)

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



Left: Leafminer damage photographed in 2020 in black cottonwood.

Right: Aspen leafminer track mines.

In 2020, leafmining insects continued to cause damage to hardwoods in eastern Washington. Aspen, water birch and cottonwood were affected, as well as several non-native species such as locust and elm. Ground observations indicate that aspen defoliation was primarily due to the aspen leafminer (*Phyllocnistis populiella*). The leafmining species affecting other hardwoods remain unidentified.

Leafminers feed between the epidermal layers of leaves during the summer. There are two general patterns of mine created, serpentine leafmines which wind snake-like across the leaf and blotch leafmines, that are irregularly rounded. The mining patterns help identify the species causing damage, which may be the larvae of moths, beetles, sawflies or flies. The mined leaves give aspen crowns a silvery appearance, while cottonwood and birch crowns take on a reddish-orange appearance. Eventually the leaves desiccate, turn brown and drop prematurely.

While leafminer damage is mostly aesthetic, sustained annual defoliation can result in tree growth reduction, branch dieback, and top kill, but mortality is unlikely. Most leafminers have natural controls, including diseases, parasitoids and predators that check populations before too much injury occurs. Leafmining insect outbreaks have been associated with warm and dry weather.

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

INSECTS | DEFOLIATORS

JON YUSCHOCK / BUGWOOD.ORG

Gypsy Moth

(*Lymantria dispar* Linnaeus)

NON-NATIVE

In 2020, the Washington State Department of Agriculture (WSDA) deployed roughly 22,000 gypsy moth detection traps in Washington for European gypsy moth (EGM) and Asian gypsy moth (AGM). Both European and Asian gypsy moths are a great threat to Washington's forests and urban landscapes; however, AGM feeds on a wider range of host trees, including conifers, and females are capable of flight, so the risk of rapid spread and severe damage is higher than with EGM. Eight (8) adult male gypsy moths collected in King and Pierce counties in 2020 were identified as EGM and one (1) moth collected in Cowlitz County was identified as AGM.

WSDA conducted a gypsy moth eradication project in the spring of 2020 by treating 1,300 acres in two areas of Snohomish County with aerial applications of the bacterial insecticide *Bacillis thuringiensis* var. *kurstak*i (Btk). For more information on Btk, go to: https://agr.wa.gov/departments/insects-pests-and-weeds/insects/gypsy-moth/btk. One of these areas was the site of the first-ever detection of Hokkaido gypsy moth (HGM; *Lymantria umbrosa*) in the United States. HGM is an Asian gypsy moth that predominately feeds on larch trees in its native environment. WSDA is proposing aerial applications of Btk at a 634-acre site in Cowlitz County in the spring of 2021, to eradicate an introduction of the Asian gypsy moth. Following treatment, high density delimitation traps will be placed in and around the treated area for three years. Large numbers of traps will also be deployed along the Columbia River in 2021 in order to follow up on the 2020 detection of one AGM in northwest Oregon by the Oregon Department of Agriculture.

Adult Asian gypsy moth

JOHN GHENT / BUGWOOD.ORG

ASIAN GYPSY MOTH FEEDS ON A WIDER RANGE OF HOST TREES, INCLUDING CONIFERS, AND FEMALES ARE CAPABLE OF FLIGHT, SO THE RISK OF RAPID SPREAD AND SEVERITY OF DAMAGE IS HIGHER THAN WITH EUROPEAN GYPSY MOTH.

INSECTS | BRANCH AND TERMINAL INSECTS


GILLES SAN MARTIN

Balsam Woolly Adelgid

(*Adelges piceae* Ratzeburg)

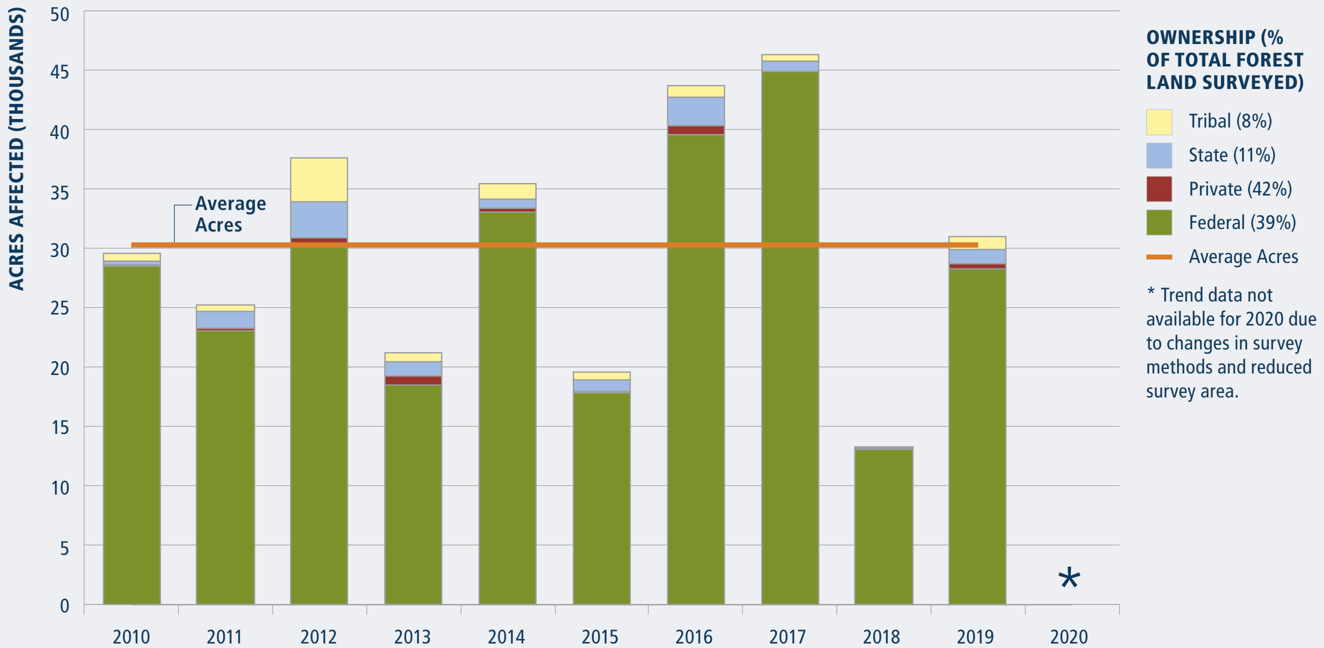
NON-NATIVE

Balsam woolly adelgid (BWA) is a non-native sucking insect that has caused defoliation and mortality to subalpine fir, Pacific silver fir, and grand fir in Washington. The most significant BWA damage is in subalpine fir stands at high elevation. Only a few of these areas were accessible by road for ground sampling in 2020. The signature of BWA defoliation and mortality is too subtle to effectively map from imagery using Scan and Sketch methods. As a result, the number of BWA damaged areas detected in 2020 was very limited. BWA infestations are often chronic, so areas that were mapped with damage in the 2018 and 2019 survey likely have ongoing mortality. Western balsam bark beetle is another important mortality agent in subalpine fir stands that may attack trees weakened by BWA infestation. See the western balsam bark beetle section above for information on areas with damage in 2020.

The area of BWA damage observed in 2019 was about equal to the 10-year average of 31,000 acres (Fig. 24). There is high variability in damage mapped from year to year, so the recent trend is generally even. The majority of BWA damage occurs on federal land.

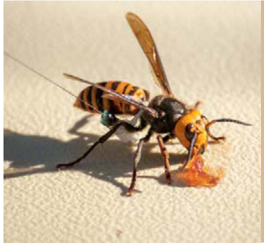

DARCI DICKISON/USFS

BALSAM WOOLLY ADELGID 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 24.



INSECTS | APEX PREDATORS

WASHINGTON STATE DEPARTMENT OF AGRICULTURE



Asian Giant Hornet

(Vespa mandarinia)

NON-NATIVE

In December 2019, WSDA received and verified two reports of Asian giant hornet near Blaine, Washington. In 2020, both Washington and Canada have had new confirmed sightings of Asian giant hornet and in October of 2020, WSDA conducted the first-ever eradication of an Asian giant hornet nest in the United States. Asian giant hornets, an invasive pest not native to the U.S., are the world's largest hornet and a predator of honey bees and other insects. A small group of Asian giant hornets can kill an entire honey bee hive in a matter of hours. While this species is not considered a disturbance agent directly affecting tree mortality, if it becomes established, this hornet will have negative impacts on the environment, economy, and public health of Washington State. Using a network of traps, WSDA, cooperators, and citizen scientists are tracking sightings of the Asian giant hornet in an ongoing effort to find nests and eliminate them.

WASHINGTON STATE DEPARTMENT OF AGRICULTURE

Asian giant hornet specimen from Japan.

WHILE ASIAN GIANT HORNET IS NOT CONSIDERED A DISTURBANCE AGENT DIRECTLY AFFECTING TREE MORTALITY, IF IT BECOMES ESTABLISHED, THIS HORNET WILL HAVE NEGATIVE IMPACTS ON THE ENVIRONMENT, ECONOMY, AND PUBLIC HEALTH OF WASHINGTON STATE.

WASHINGTON STATE DEPARTMENT OF AGRICULTURE

DISEASES | CANKERS

USFS

White Pine Blister Rust

(Cronartium ribicola)

NON-NATIVE

The cause of white pine blister rust (WPBR) — the non-native fungal pathogen *Cronartium ribicola* J.C. Fisch — was introduced to North America more than 100 years ago. All nine US species of white pines (also known as five needle pines) are highly susceptible. Quickly spreading, this pathogen has invaded the geographic ranges of eight of these white pines, with mortality rates of more than >90% observed on high-hazard sites. Western white pine (WWP, *Pinus monticola* Dougl.), one of our native white pines that has experienced wide-spread mortality, is an important economic and ecologic tree species in the Pacific Northwest. Luckily, natural genetic variation has provided some individual western white pine trees varying degrees of resistance to the disease. Breeding programs in both the U.S. and Canada have been in place for decades to increase the level and frequency of WPBR resistance for use in reforestation and restoration.

With the goal of determining the survival of WWP from different sources throughout the western US and from different breeding programs, long-term field research plots were established in 2006 and 2007 at six sites in western Washington (Fig. 25). This joint project involved DNR and The U.S. Forest Service, with seedlots representing different sources and lineages (including those considered resistant) chosen and obtained with collaboration from the USFS Dorena Genetic Resource Center (Cottage Grove, OR). The seedlots in these field trials included some with the highest levels of genetic resistance to WPBR known at the time.

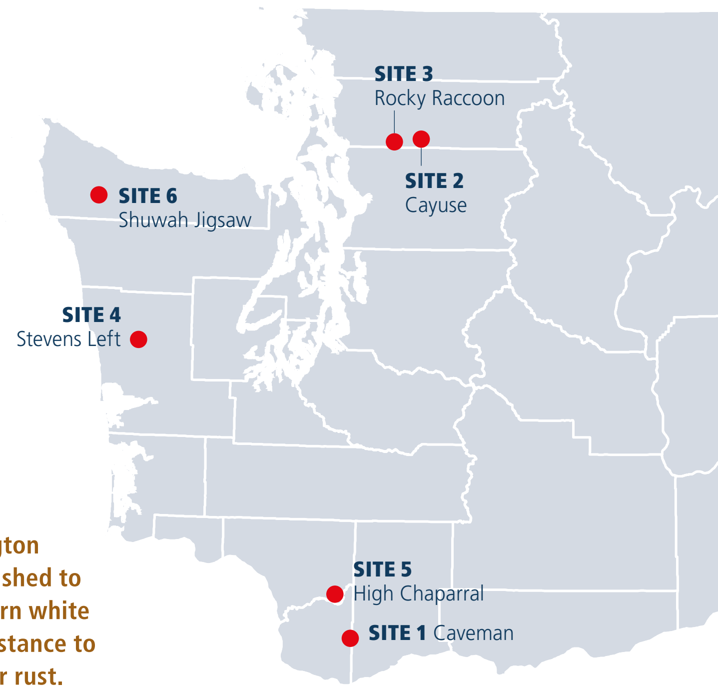


Figure 25. **Location of western Washington field sites established to determine western white pine seedlot resistance to white pine blister rust.**

In total, close to 8,000 seedlings from 36 different seedlots were planted.

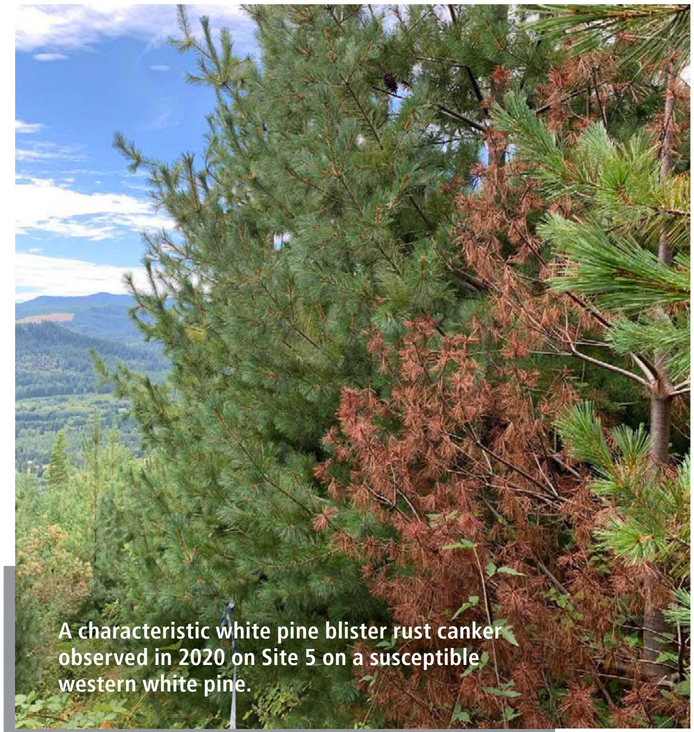
In 2020, these six field trials were brush cut to remove competition by other plant species. Each western white pine tree was then examined to ensure label retention and to record its health status. Survival (alive vs. dead) is shown in Figure 26, with seedlots and sites ordered from those that had the overall highest level of mortality to those with the lowest levels. For example, Site 3 and seedlot 31 had the overall highest levels of mortality (45.5 and 57.3%, respectively), while site 5 and seedlot 21 had the lowest levels (5.4 and 9.0%, respectively). Over 5,600 trees remain alive at these sites. Site maintenance, monitoring, and reporting are planned for in the upcoming years as these trees continue to grow.

Similar field sites have been established on the eastern side of the state with additional WWP (planted 2014 and 2015) and on high elevation sites with whitebark pine (*Pinus albicaulis* Engelm.; planted from 2015-2017). Whitebark pine is proposed for listing as 'Threatened' under the Endangered Species Act, and the families planted at these sites are those with the highest currently known levels of resistance to WPBR. Outside of Washington, an additional WWP trial was planted in Oregon and British Columbia. These research plantings will assist in determining which seedlots are used in restoration and reforestation efforts, and will help retain these iconic pine species in our landscape.

DISEASES | CANKERS

RACHEL BROOKS / DNR

A characteristic white pine blister rust canker observed in 2020 on Site 5 on a susceptible western white pine.



A characteristic white pine blister rust canker observed in 2020 on Site 5 on a susceptible western white pine.

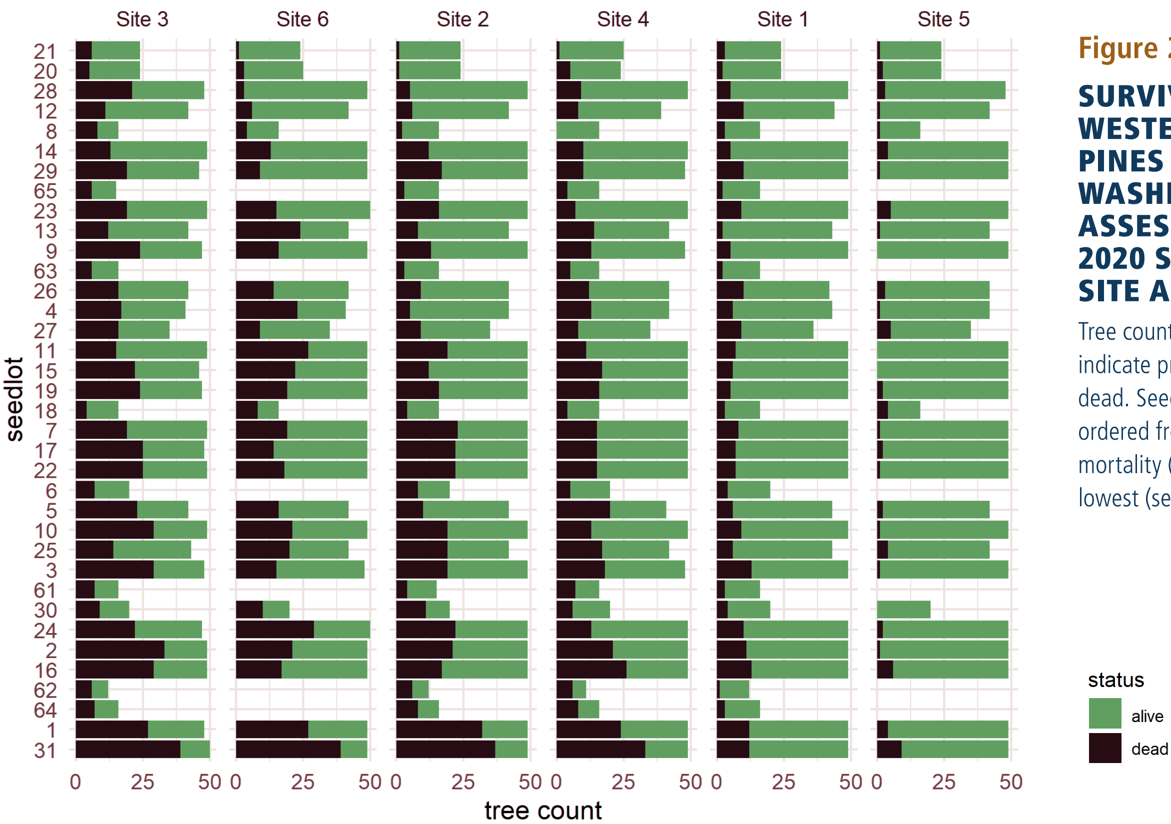


Figure 26.

SURVIVAL OF WESTERN WHITE PINES IN WESTERN WASHINGTON ASSESSED DURING 2020 SPLIT BY FIELD SITE AND SEEDLOT

Tree count is color coded to indicate proportion alive or dead. Seedlots and sites are ordered from overall highest mortality (seedlot 31, Site 3) to lowest (seedlot 21, Site 5).

DISEASES | CANKERS

RACHEL BROOKS / DNR

Sooty Bark Disease of Maple

(Cryptostroma corticale)

NON-NATIVE

The fungus *Cryptostroma corticale* is thought to be native to the Great Lakes Region of the U.S., where it is considered a saprophyte (only surviving on dead material and not impacting living plants). However, in Europe where it was accidently introduced sometime before 1945, it causes sooty bark disease on a variety of maple trees. On sycamore maple (*Acer pseudoplatanus*) in particular, sooty bark disease can cause wilted leaves, branch dieback, cankers (killed cambium/sapwood), stained wood and tree death. Disease levels often increase after hot and dry summers. The fungus, as a saprophyte or as a pathogen, causes areas of tree bark to split open and reveal stromatal tissues (a blue-gray to brown-black fungal mat, Figure 27) that releases large quantities of airborne spores. These spores are allergenic, and those handling spore-covered wood material should wear personal protective equipment to minimize spore inhalation.

The first record of this tree disease in Washington dates to 1969 in Whitman County where it was identified on a sycamore maple. In 2020, Seattle Parks and Recreation, in collaboration with the Seattle Committee for Invasive Pests, confirmed the presence of *C. corticale* on sycamore maple, bigleaf maple (*Acer macrophyllum*), red maple (*Acer rubrum*), Norway maple (*Acer platanoides*), and horse chestnut (*Aesculus hippocastanum*). All infected trees had typical dieback symptoms and visible fungal growth on bark surfaces. Molecular identification of multiple samples was confirmed by Bartlett Tree Research Laboratories.

The impact and distribution of this pathogen is not currently known in Washington, and the spread of this pathogen onto native maple species is concerning. Future research is needed to determine the long-term consequences this pathogen will have on our street and forest trees.

CHRISTOPHER RIPPEY, SEATTLE PARKS AND RECREATION

Figure 27: A dark-colored stromatal mat produced by *Cryptostroma corticale* on diseased sycamore maple (*Acer pseudoplatanus*) bark.

FUTURE RESEARCH IS NEEDED TO DETERMINE THE LONG-TERM CONSEQUENCE THIS PATHOGEN WILL HAVE ON OUR STREET AND FOREST TREES.

DISEASES | CANKERS


JOSEPH OBRIEN / USDA FOREST SERVICE, BUGWOOD.ORG

Sudden Oak Death

(*Phytophthora ramorum* Werres et al.)
NON-NATIVE

Phytophthora ramorum (Pr) is the causal agent of Sudden Oak Death (SOD), ramorum leaf blight, and ramorum dieback. Not native to North America, Pr has caused extensive mortality of tanoak and several oak species in Curry County, Oregon and in California. It can move through landscapes with wind and wind-driven rain, and can be moved long distances by people transporting infested nursery stock. Due to the presence of susceptible hosts, suitable climatic conditions, plant nurseries with Pr infected stock, and water runoff from these nurseries, western Washington remains at risk for Pr spread and Pr-caused disease. However, to date, damage similar to that caused by Pr in forests of Oregon and California has not been observed in Washington.

With funding provided by the USFS National *Phytophthora ramorum* Early Detection Survey of Forests Program, 10 Washington waterways in nine counties (Clark, Grays Harbor, King, Mason, Skagit, Snohomish, Thurston, Whatcom, and Yakima) were surveyed for Pr in 2020 using the rhododendron leaf baiting method. These sampling sites were chosen to represent a variety of waterways containing plant nurseries. In 2020, two of these sampling locations resulted in positive Pr results: a new waterway, Evans Creek in Snohomish County, and an upstream location from a previously positive sampling site, Little Bear Creek in King County. Overall, most sampled waterways in Washington are free from Pr, with the exception of the Sammamish Slough, which has regularly tested positive for Pr since 2007 (Table 1; Fig. 28). There have been no indications to date that the pathogen is leaving the waterways, as all vegetation samples collected in the woodlands bordering these waterways have been negative for Pr, including vegetation sampling done around the two positive sites in 2020.

With rhododendron leaf baiting, other non-Pr *Phytophthora* spp. are also sampled, but are not cultured and/or identified to species. To more thoroughly assess these other *Phytophthora* species present within the leaf samples, WSU Puyallup Research and Extension Center (with funding from the USFS) used an additional molecular method (PacBio) on DNR's 2019 collected samples. In total, 11 additional *Phytopthora* spp. were detected in the 10 streams sampled. Of these, only three species are known plant pathogens (*P. citricola, P. pulvuvira*, and *P. cryptogea*), none are new to the area and all are typical root rots found most often on nursery plants, but sometimes in the wild. to the area and are typical root rots found on nursery plants and sometimes in the wild. These findings are not unexpected, as drainages are selected for sampling based on the presence of nurseries. This technique allows for the sampling of species that are slow growing, not competitive, or not culturable and can expand our understanding of the entire distribution of the *Phytophthora* genus, instead of just focusing on Pr.

***PHYTOPHTHORA RAMORUM* CAN MOVE THROUGH LANDSCAPES WITH WIND AND WIND-DRIVEN RAIN, AND CAN BE MOVED LONG DISTANCES BY PEOPLE TRANSPORTING INFESTED NURSERY STOCK.**

DISEASES | CANKERS

TABLE 1. MONITORING HISTORY OF STREAMS IDENTIFIED AS POSITIVE FOR *PHYTOPHTHORA RAMORUM*

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

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

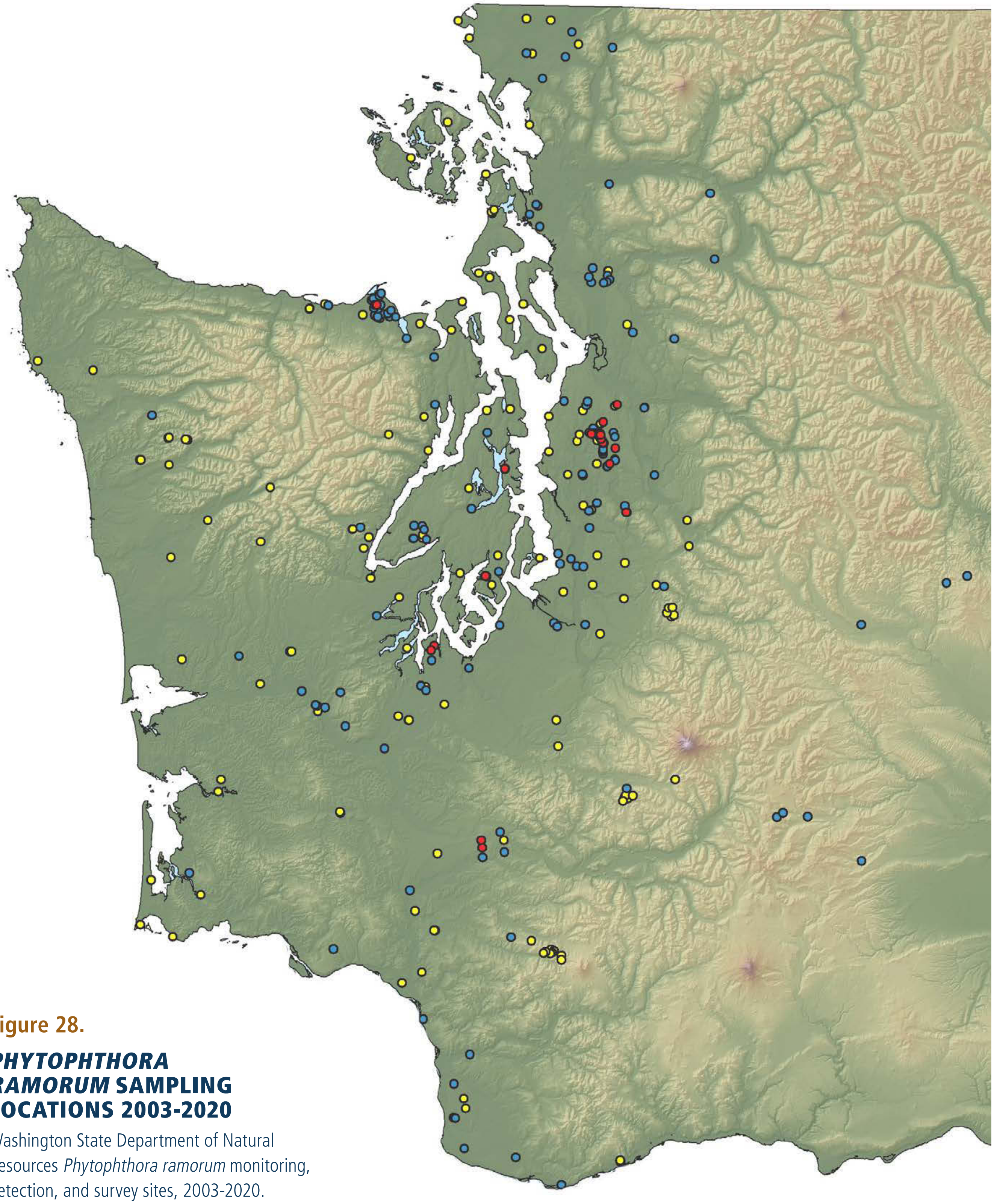


Figure 28.

***PHYTOPHTHORA RAMORUM* SAMPLING LOCATIONS 2003-2020**

Washington State Department of Natural Resources *Phytophthora ramorum* monitoring, detection, and survey sites, 2003-2020.

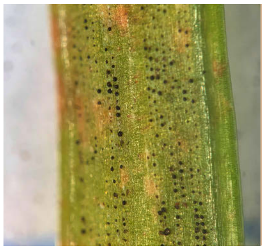
- **Positive** Aquatic Baiting Location
- **Negative** Aquatic Baiting Location
- **Negative** Wildland Survey Location

0 20 40 miles

N

DISEASES | FOLIAR DISEASES

RACHEL BROOKS / DNR



Swiss Needle Cast

(*Nothophaeocryptopus gaeumanni*)

Swiss needle cast (SNC) is a foliar disease of Douglas-fir caused by the fungus *Nothophaeocryptopus gaeumanni*. It causes premature needle shed, resulting in sparse tree crowns and reduced growth, but rarely causes tree mortality. It is known as a cast disease, because it causes the tree to prematurely shed, or cast, its needles. This native pathogen occurs throughout the range of its host, Douglas-fir, but became a priority along the coastal forests of Oregon and Washington in the late 1980s and early 1990s, More recently, it impacted hundreds of thousands of acres of forest lands in Canada. The Washington State Legislature provided funding in the 2019-2021 biennium to conduct aerial surveys in spring 2020 to monitor infection and damage trends in Washington's coastal forests. These flights were cancelled due to COVID-19 operating restrictions, with efforts focused instead on increased ground surveys in the spring of 2021.

A NATIVE PATHOGEN OF DOUGLAS-FIR, SWISS NEEDLE CAST BECAME A PRIORITY ALONG COASTAL FORESTS OF OREGON AND WASHINGTON IN THE LATE 1980'S AND EARLY 1990'S, AS HUNDREDS OF THOUSANDS OF ACRES OF FOREST WERE IMPACTED.

DISEASES | FOLIAR DISEASES

RACHEL BROOKS / DNR

Douglas-fir Needle Rust

(*Melampsora* spp.)

During the summer of 2020, DNR received numerous questions regarding a needle disease on Douglas-fir (*Pseudotsuga menziesii*) in western Washington. This native foliar disease, caused by a rust fungal pathogen (*Melampsora occidentalis* or *M. medusae*), alternates between Douglas-fir and poplars (including black cottonwood, *Populus trichocarpa*), requiring both species to complete its disease cycle. Observations of this disease on Douglas-fir always occurred adjacent to or near poplars, with higher levels of disease likely associated with the wet spring observed in 2020.

On Douglas-fir, yellow-orange pustules (masses of spores) that eventually turn brown appear on the underside of the current year's foliage starting in the spring. These can be hard to see, and a hand lens is a useful aid. These infected needles may also turn brown and/or fall off, which is first time this disease is noticed. The spores produced on Douglas-fir do not infect other Douglas-fir, but instead are blown in the wind to infect poplar leaves.

Usually starting in mid-summer, yellow-orange pustules that eventually turn brown appear on the underside of poplar leaves, with pale green to orange-brown spots associated with these on the upper side. At times, the entire leaf may have a rust-like appearance.

In almost all cases, management of this disease is not needed for either species, with both recovering quickly despite the sometimes startling cosmetic issues. Promoting drying in the canopy by controlling competing vegetation and maintaining good tree spacing may also help minimize this disease. If there are concerns regarding Douglas-fir growth or appearance (such as for timber or Christmas tree plantings) or this disease is severe for numerous years in a row, removing nearby poplars may help. Additionally, in high-value ornamental situations where tree appearance is a high priority, a well-timed fungicide can help manage this disease.

A needle rust infected Douglas-fir in the foreground with current year needles showing a brown discoloration, and a black cottonwood, the alternative host for this disease, visible in the background in the upper left.

PHOTOS, CLOCKWISE: DAN OMDAL / DNR; RACHEL BROOKS / DNR (INSET PHOTOS)

Top: Current year needle discoloration and defoliation on Douglas-fir caused by the needle rust pathogen *Melampsora* spp.

Above: A close up of the underside of rust infected Douglas-fir needles. Note the orange to black pustules and partially brown needles.

WESTERN RED CEDAR DIEBACK MONITORING

In 2020, western red cedar dieback and mortality was observed throughout Washington. Symptoms of dieback include thinning crowns, discoloration (yellowing or browning) of the needles, heavy cone crops, branch dieback and flagging, topkill and mortality. Damage agents have been observed at some sites, including cedar bark beetles (*Phloeosinus* spp.), wood-boring beetles, and root disease, but these are typically secondary damage agents that are likely taking advantage of stress due to an inciting factor. Given the wide range of damage, an abiotic issue, such as recent drought and/or high temperatures, is likely causing the dieback.

The overall extent of western red cedar dieback has been hard to quantify: dieback and mortality are not easy to see during an aerial detection survey or with remote sensing imagery. In 2020, ground surveys resulted in more extensive mapping of western red cedar dieback than in previous years.

GIVEN THE WIDE RANGE OF WESTERN RED CEDAR DAMAGE THROUGHOUT WASHINGTON, AN ABIOTIC ISSUE, SUCH AS RECENT DROUGHT AND/OR HIGH TEMPERATURES, IS LIKELY CAUSING THE DIEBACK.

There has been a significant increase in requests for information on western red cedar mortality and dieback from landowners and land managers. As of this time, there are no suitable management guidelines. A research project is currently underway to determine the extent of western red cedar dieback throughout its range and determine what variables may be associated with this dieback. The information obtained through this research will hopefully assist in establishing the appropriate management guidelines for this species.

Western red cedar mortality photographed in 2020 in northeast Washington.

MELISSA FISCHER / DNR

ANIMALS | BEAR DAMAGE / ROOT DISEASE

Aerial survey and Scan and Sketch methods record scattered, pole-sized, newly dead trees as 'bear damage.' Based on previous ground checking and observations of aerial survey polygons, bear girdling and root disease are the primary causes of this type of damage. Drought damage, secondary bark beetles and other animals (porcupines and mountain beavers) may also play a role. This damage signature is primarily seen in western Washington, where the reduced area surveyed by ground-based methods meant damage trends in 2020 could not be reported.

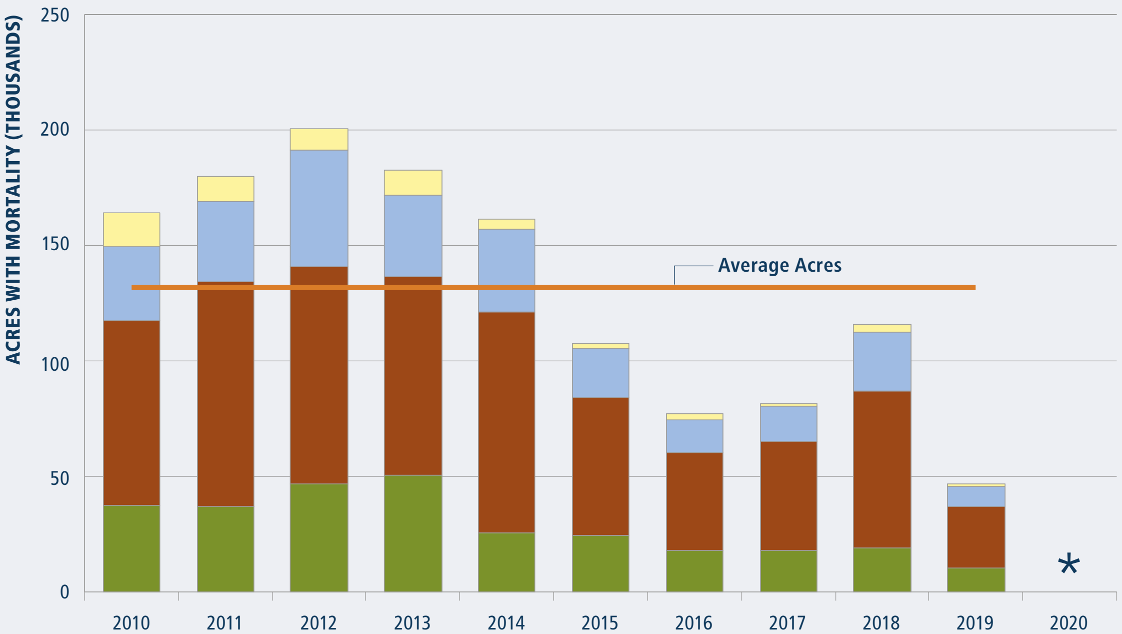
Bears strip tree bark in spring and, although this activity is common, our ability to detect and record the resulting damage varies. It takes more than one year for the tree to die and needles to become red (as is visible from the air).

AMY RAMSEY / DNR

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 hinder the 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 tree age.

Over the last 10 years, the total area observed with damage from bears or root disease has ranged from a high of 200,000 acres in 2012 to a low of 46,300 acres in 2019 (Fig. 29). The 10-year average of acres with bear damage in Washington is 132,000.

BEAR / ROOT DISEASE 10-YEAR TREND FOR TOTAL ACRES AFFECTED IN WASHINGTON Figure 29.



OWNERSHIP (% OF TOTAL FOREST LAND SURVEYED)

- Tribal (8%)
- State (11%)
- Private (42%)
- Federal (39%)
- Average Acres

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

Aerial Survey Methodology

This section describes aerial detection survey methods used in 2019 and years prior.

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.

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

ADS observers are trained to recognize various pest signatures and tree species. Satellite photography showing recent management activity is displayed as a background map on tablet screens, allowing observers to place the damage polygons more accurately. There is always at least one observer in the plane who has three or more years of sketchmapping experience.

If more than one agent is present in a polygon, codes are separated by an exclamation point (!). When interpreting data and maps within and accompanying this report, do not assume that the mortality agent polygons indicate every tree is dead within the area. Depending on the damage intensity modifier, only a small proportion of trees in the polygon may actually have been killed recently..

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.

METHODS FOR RECORDING DAMAGE INTENSITY

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

More information on the percent-class method is available at: https://www.fs.fed.us/foresthealth/applied-sciences/mapping-reporting/digital-mobile-sketch-mapping.shtml

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

Table 2. Percent of treed area affected classes used for ADS damage polygons.

Adoption of the percent-class method presents challenges for analysis of trends and cumulative effects that include trees per acre (TPA) data used prior to 2018. In addition, summary statistics of approximate number of trees killed, such as totals and averages by agent, cannot be derived directly from percent-class data. In USFS Region 6 (Oregon and Washington), percent-class polygons are converted to a calculated TPA value using a "histogram matching" method. This method separates several recent years of historical Region 6 TPA data into five categories similar in range to the percent-class categories, then calculates a derived TPA value for each percent-class polygon based on the midpoint of each TPA category and the polygon size. All 2020 ADS mortality polygons that appear on Region 6 quadrangle reporting maps and in downloadable GIS datasets use calculated TPA values as intensity modifiers (see next page "Data and Services section").

Data and Services

Every year, all forested acres in Washington are surveyed from the air to record recent tree damage. In 2020, the survey was ground based and covered approximately 50% of forested acres. 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 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

Traditional insect and disease survey quadrangle maps from 2003 to 2020 are available for download as PDF files at: **www.fs.usda.gov/goto/r6/fhp/ads/maps.**

Click on the year of interest under "Aerial Detection Survey Quad Maps" to open an interactive map of all the available quads from Oregon and Washington. Simply click 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 codes are defined in a legend in the lower left side of each quad map. PDF maps are georeferenced so the user's location will be displayed when downloaded to a mobile device with a PDF map viewing app.

INTERACTIVE MAP TOOLS

2015 to 2019 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 & Fuel Management Mapping" at: **https://fmanfire.dnr.wa.gov/**. On the left side of the page, click on "Forest Health", select "Annual Aerial Survey Data" and check the circle for year of interest, then check circles for type of damage to be displayed. Click on polygons to display agent and intensity. Various basemaps and background layers can be added. Zoom to an area of interest and click the printer icon in the lower bar to create a pdf or image file of your map.

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

The 2020 insect and disease survey data from ground-based and aerial imagery analyses are available in the "2020 R6 ADS Survey Map" ArcGIS Online product at: **https://usfs.maps.arcgis.com/home/webmap/viewer.html?webmap=735ecfcad5024eec9aec1fbd293e442c**. Customized maps of aerial survey data can be created with a variety of background layers.

GIS DATA AVAILABLE FOR DOWNLOAD

Washington DNR also maintains downloadable GIS datasets, including aerial survey data for Washington State from 1980 to 2019, known as "Forest Health Aerial Survey 1980-2019" at: **http://data-wadnr.opendata.arcgis.com/, under "Forest Disturbance."**

FOREST HEALTH WEBSITES

Washington Forest Health Highlights reports are published annually and include the latest information on exotic pest problems, insect and disease outbreaks, and recent forest damage trends for Washington. Recent annual reports, 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**

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

Forest Health Contacts

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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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