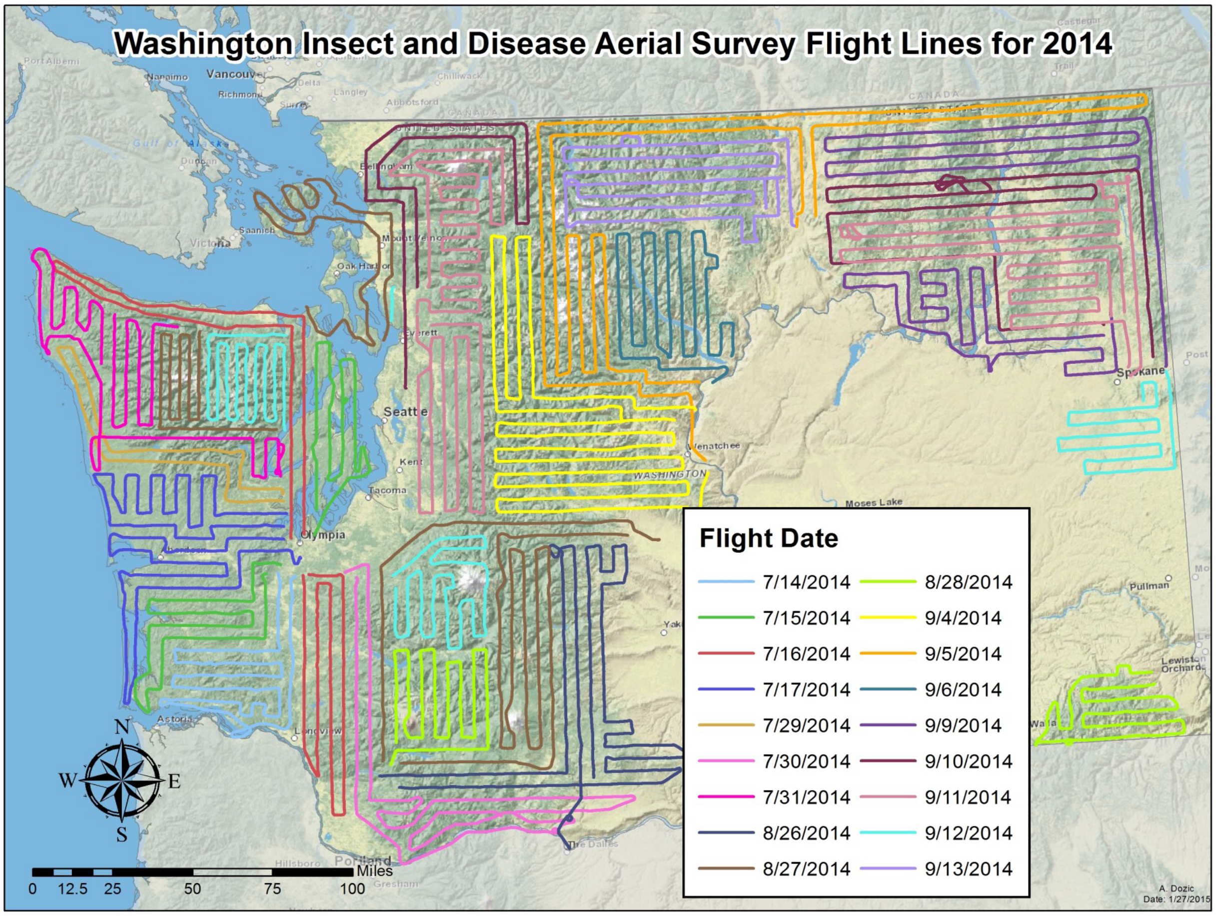
United States Department of Agriculture

Forest Health Highlights in Washington—2014



Washington State Department of Natural Resources
Forest Health Program
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for the greatest good

Pacific Northwest Region
Forest Health Protection

Forest Health Highlights in Washington—2014

Joint publication contributors:

Aleksandar Dozic[1]
Chuck Hersey[1]
Glenn Kohler[1]
Daniel Omdal[1]
Amy Ramsey[1]
Karen Ripley[1]
Alison Nelson[2]
Ben Smith[2]

[1]Washington Department of Natural Resources (WDNR)
[2]U.S. Department of Agriculture, Forest Service (USFS)

Front cover: *2014 insect and disease aerial survey flight lines in Washington state.*

Table of Contents

Summary

Washington has 22.4 million acres of forestland. In 2014 approximately 543,000 acres of this land contained some level of tree mortality, tree defoliation, or foliar diseases. This is similar to the 593,000 acres reported in 2013. Relative to 2013, tree mortality increased in 2014 for all major bark beetles including the mountain pine beetle, western pine beetle, Douglas-fir beetle, fir engraver, and spruce beetle. However, acres with mortality due to all bark beetles except spruce beetle remain well below ten year averages. The area with conifer defoliation decreased to approximately two-thirds of the 2013 area, primarily due to the western spruce budworm defoliated area dropping to another ten-year low. Previous annual totals were:

2012: 1,080,000 acres **2011:** 950,000 acres **2010:** 937,000 acres

Drought conditions and warm, dry spring weather tend to increase tree stress and insect success, driving acres of damage up. Wet spring weather tends to increase acres affected by foliage diseases and bear damage. Precipitation in Washington was well above normal for winter 2014, but near average for the rest of the year. Monthly average temperatures were near normal during summer 2014.

Approximately 4.8 million trees were recorded as recently killed.

Pine bark beetle activity recorded by aerial survey in Washington increased in 2014 to approximately 143,000 acres compared to the 107,000 acres in 2013. **Mountain pine beetle** damage increased slightly but remained near the lowest level observed in the last decade. The most concentrated areas of pine mortality occurred in the Colville National Forest, in central Chelan County near Lake Chelan and within the Okanogan-Wenatchee National Forest.

Relative to 2013, mortality of ponderosa pines due to **western pine beetle** (WPB) more than doubled in 2014. WPB-caused mortality was scattered and widely dispersed across central and northeastern Washington including Klickitat, Yakima, Kittitas, Ferry, Stevens, and Spokane counties.

Localized outbreaks of **California fivespined Ips** continued to cause unusually high levels of ponderosa pine mortality in areas along the Columbia River Gorge in Klickitat and Skamania counties.

Mortality due to **Douglas-fir beetle** more than doubled relative to 2013, to approximately 27,000 acres. A significant increase in mortality was detected in Skamania and Klickitat counties due to outbreaks generated from winter storm damage in 2012.

Areas with **western spruce budworm** defoliation recorded in 2014 decreased to approximately 93,000 acres, well below the 178,000 acres recorded in 2013 and the lowest total since 2002. Some 2014 defoliation may not have been detected due to late season aerial survey flights. Kittitas, Okanogan, Ferry, Stevens, and Pend Oreille counties have been most heavily affected by this outbreak.

Approximately 20,000 acres with **western blackheaded budworm** defoliation was observed in western Washington; an increase from over 14,000 acres mapped in 2013. Defoliation occurred primarily on the Olympic Peninsula. Both western hemlock and Pacific silver fir were moderately defoliated.

Symptoms of **needlecast disease** in pines were extensively reported throughout eastern Washington by the public in 2014. However, the aerial survey was flown later than usual, and likely as a result, only recorded 1,100 acres with needlecast symptoms in lodgepole pine and none in ponderosa pine.

Bear (animal damage) activity recorded by aerial survey dropped slightly in 2014 to approximately 161,000 acres, down from 183,000 recorded in 2013 and lowest area recorded in the last ten years.

Weather and Forest Health

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 fall or spring weather, such as occurred in 2013 and 2014 (Fig. 1), can increase the incidence of foliar diseases like those that affected pines in eastern Washington in 2014 (see page 31). Outbreaks of certain bark beetle species, such as Douglas-fir beetle, follow weather or fire events that kill or injure numerous trees. In years like 2013, when summer precipitation was at or below average, the number of bark beetle-killed trees may increase the following year as they did in 2014.

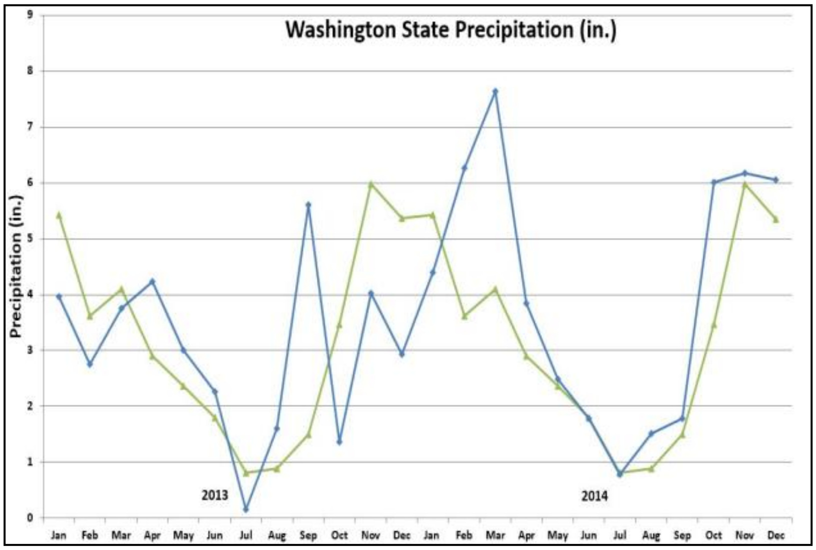

Figure 1. *Average monthly precipitation and 30-year average (green line) for Washington. Source: National Climatic Data Center (http://www.ncdc.noaa.gov/cag/).*

Hail storm damage. Eastern Washington experienced several major hail storms observed by residents and documented by NOAA's Storm Prediction Center in June, July, and August of 2014. "Golf ball size hail" was reported in Springdale on June 3. Various reports of large hail-stones, vehicle, and window damage came from Winthrop, Pomeroy, Pullman, Kettle Falls, and several other sites on July 23. Other major hail events were reported from Spokane on August 2 and Davenport on August 19. Although the hail stones melted quickly and no one may have been present to observe and document a remote forest event, hail damage symptoms become apparent immediately and may persist for several years. Symptoms are often most severe on the storm-facing sides of the trees. The size of the affected forest varies widely with sudden transitions from severe damage to no apparent damage. Every species

Steve Harris, Washington DNR

Figure 2. *Hail injury to upper branch surfaces of ponderosa pines and related dried or dead foliage near Kettle Falls, October 2014.*

and size of tree or shrub may be symptomatic if exposed to the sky. Although some physical changes occurred immediately (fallen foliage, broken bark or branches), the injured needles dry out quickly in the warm days of summer, making color changes more conspicuous and rapid than many other types of insect, disease or abiotic activity. Landowners can check for survival of twigs and branches by slicing open and examining some of the remaining buds. If the bud tissue is green and succulent, the twig it is attached to is still alive. If the bud is brown and punky, that portion of the branch or twig may have died.

Drought

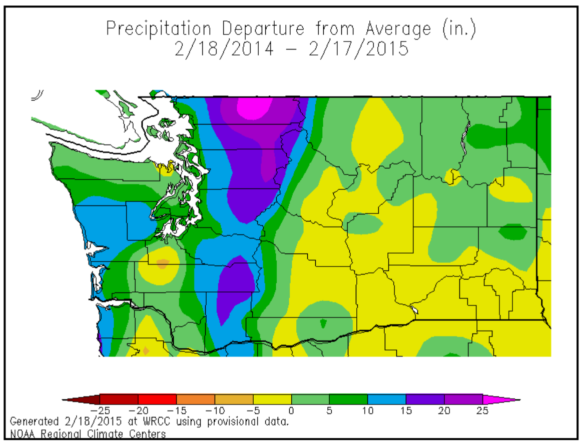

Figure 3. *Departure from average precipitation for Washington, in inches. Source: Western Regional Climate Center (http://www.wrcc.dri.edu).*

Spring precipitation in 2014 was well above average for much of Washington, followed by normal rainfall amounts during the summer months. Fortunately, statewide precipitation was above normal in late August and September, reducing potential summer drought stress on trees. Due to above normal precipitation, increased foliar disease damage was observed in 2014.

Average spring temperatures in 2014 were slightly above normal across the state, followed by slightly below normal temperatures in late summer and fall. Much of the mountain ranges surrounding the Columbia Plateau experienced moderate drought conditions for most of 2014. Trees experiencing drought stress can become more susceptible to insect and disease attacks and are less likely to recover from damage. In eastern Washington, trees growing in dense or overstocked stands have a higher likelihood of experiencing drought stress.

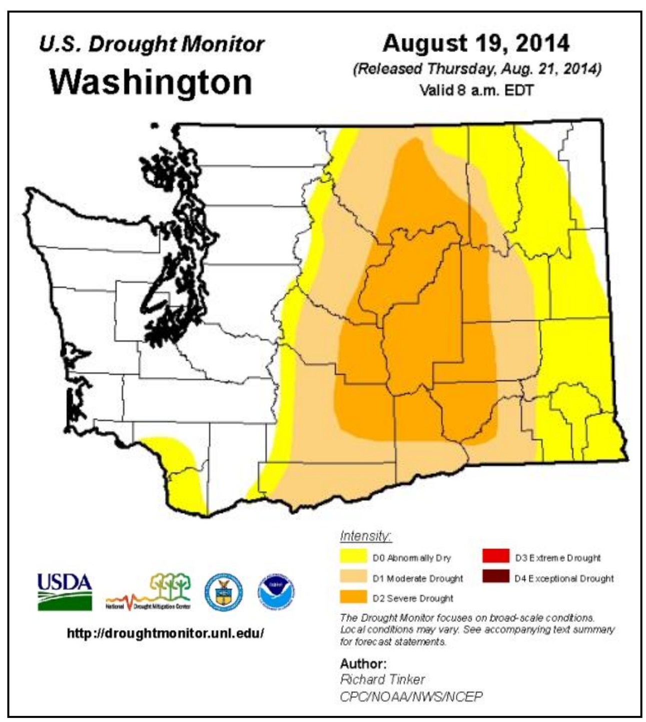

Figure 4. *Drought conditions in eastern Washington as of August 19, 2014. Source: US Drought Monitor (http://droughtmonitor.unl.edu).*

Fire

The 2014 wildfire season was the worst on record for the State of Washington. A total of 368,972 acres were burned with 199,145 acres of that total on Washington Department of Natural Resources (WDNR) protected lands, well above the 10-year average of 57,000 acres burned. There was an early start to the fire season with it starting in mid-June. Wildfire conditions worsened across Washington in July and August with hot and dry weather. Persistent warm and dry weather carried the fire season into early October. Washington experienced a late fire season on the west side of the state at the end of October and into mid-November. The number of lightning strikes in 2014 was above normal, but 72% of the 727 WDNR jurisdiction fires were human caused. Major fires included Carlton Complex near Pateros, Mills Canyon near Entiat, Snag Canyon near Ellensburg, Watermelon Hill near Cheney, Chiwaukum Complex near Leavenworth, and Lake Spokane near Spokane.

Aerial survey was postponed for several weeks due to smoke conditions and temporary flight restrictions in eastern Washington. Aerial observers record wildfire damage to forests in two instances: if the fire is smaller than 100 acres, or two years after a large fire occurred and dying trees are still observed. In 2014, aerial observers recorded nearly 740,000 trees spread over 32,000 acres that had died as a result of 2012 wildfire damage or related subsequent bark beetle attacks. This was much higher than a typical year in eastern Washington. 6,000 acres with wildfire damage were mapped in 2013; trees killed as a result of 2011 fires.

Washington DNR

Figure 5. *Chiwaukum Complex wildfire in Chelan County, 2014.*

Aerial Detection Survey

Methods

The annual insect and disease aerial detection survey (ADS) in Washington was conducted by the USDA Forest Service (USFS) in cooperation with WDNR. The survey is flown at 90-150 mph at approximately 1,500 feet above ground level. Two observers (one on each side of the airplane) look out over a two-mile swath of forestland and mark on a digital sketchmapping computer any recently killed or defoliated trees. They then code the agent that likely caused the damage (inferred from the size and species of trees and the pattern or "signature" of the damage) and the number of trees affected. Photos are rarely taken. It is very challenging to accurately identify and record damage observations at this large scale. Mistakes occur. Sometimes the wrong pest is identified. Sometimes the mark on the map is off target. Sometimes damage is missed. Our goal is to correctly identify and accurately map within ¼ mile of the actual location at least 70% of the time. In areas with heavy mortality, on-ground measurements of trees per acre (TPA) killed are commonly 2-3 times greater than estimates made from the air.

Newer satellite photography showing recent management activity allows observers to place the damage polygons more accurately. In addition, aerial observers are familiar with forestry and forest pests and are trained to recognize various pest signatures. There is always at least one observer in the plane who has three or more years of sketchmapping experience.

Each damage area (polygon) is assigned a code for the damage agent. These codes are defined in the legend of the aerial survey maps. The agent code is followed by number of trees affected; number of trees per acre affected; or intensity of damage (L-Light, M-Moderate, H-Heavy). If more than one agent is present in a polygon, codes are separated by an exclamation point (!). When interpreting data and maps, do not assume that the mortality agent polygons indicate every tree is dead within the area. Depending on the agent code modifier, only a small proportion of trees in the polygon may actually be recently killed.

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

Danny Norlander, Oregon Department of Forestry

Figure 6. *Oregon Department of Forestry aircraft used for part of 2014 aerial survey in Washington.*

2014 Aerial Survey Conditions

There are several factors that directly influence the way aerial survey is conducted and the quality of resulting survey products. Among them are type of aircraft, crew experience, weather and visibility conditions, time of the year damage signatures are most visible, and temporary flight restriction (TFR) areas. In 2014, aerial survey crews did not have much control over several of these factors. An exceptionally busy wildfire season, including the largest wildfire in state history, required the maximum effort from state and federal aviation resources. In one period there were more than a dozen TFRs which prevented survey crews from flying in areas of eastern Washington. The primary aircraft DNR planned to use was out for the season for maintenance. In spite of all these challenges, the moment the air was clear (early September) and aviation resources were again available, the survey was resumed doubling our efforts with two aircraft and two crews. In most years 75% of survey is done in August when damage signatures are most visible from the air. Surveyors flew only three days (14% of the area) in August 2014. Most of the survey was flown in the first half of September, at end of the optimal window for mapping some defoliation signatures, meaning some defoliation damage was probably underestimated.

Refining Mortality Estimates in Aerial Survey

Aerial observers in Region 6 train annually to calibrate trees per acre (TPA) estimates of recent mortality and maintain consistent data. To refine mortality estimates and develop new training aids, WDNR and Oregon Department of Forestry (ODF) established two study areas in 2014 where recent high intensity mountain pine beetle caused mortality was visible. Contract aircraft acquired geo-referenced, color orthophotos covering both study areas. Aerial observers also captured oblique "observer view" photos in the study areas while conducting the annual survey, which were later geo-referenced. The 24 square mile Washington study area was located on Sherman Pass in Ferry County (Fig. 7). Selected areas of the orthophotos were analyzed to determine the number of live and recently dead trees to calculate TPA and percent mortality. In addition, Fifty-six 1/8th acre transect plots were installed in the Washington study area to compare TPA derived from orthophotos to TPA observed on the ground. The project will produce a series of calibrated photos representing a wide range of mortality intensities that can be used as training aids for observers. Training photos will be labelled with both TPA and percent mortality because the US Forest Service aerial survey program is currently working toward adopting a nationwide standard of percent mortality to replace TPA estimates.

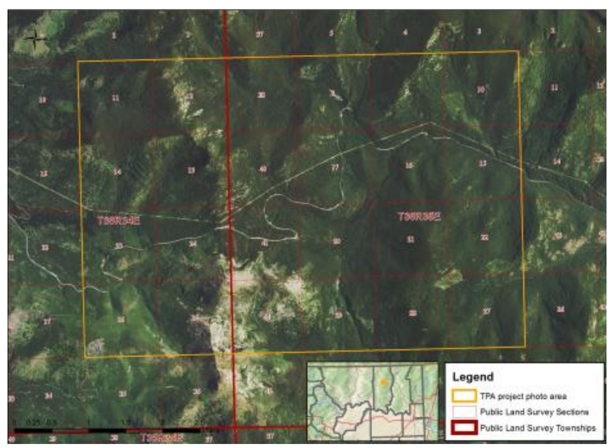

Figure 7. *Washington study area in Ferry County.*
Map by: Aleksandar Dozic, Washington DNR

Robert Noyes, USDA Forest Service

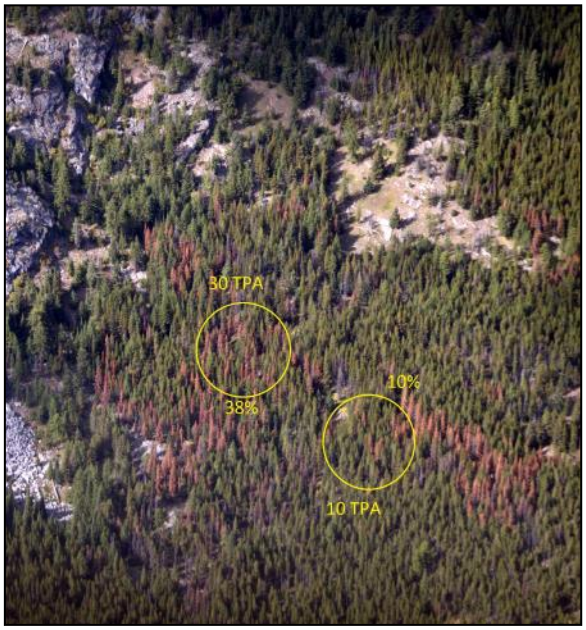

Figure 8. *One acre circles showing recently dead trees per acre (TPA) and percent mortality based on orthophoto analysis.*

Table 1. Comparison of recently dead trees per acre (TPA) between ground plot data, orthophotos, and aerial survey polygons within the Washington study area in 2014. Each area represented by eight plots.

Area #	Canopy TPA (ground plots)	Canopy TPA (orthophoto)	Aerial survey polygon TPA
1	61	45	50
2	75	33	50
3	79	74	50
4	101	53	50
5	58	22	50
6	29	17	0
7	31	3	0

Table 2. Analysis of marked trees in 2014 Washington orthophotos (sample size = 4,295 trees).

polygon	Acres	Dead TPA	% Dead	% of area sampled
1	106	11	7	10
2	46	28	9	11
3	40	19	5	10
4	14	27	20	100

Results in Washington study area:

TPA estimates in 2014 aerial survey polygons were similar to TPA derived from counting recently dead trees in the corresponding orthophotos (Table 1). On average, canopy TPA killed in ground plots was three times greater than counts from orthophotos, ranging from 1.07 to 10.33 times greater (Table 1). This difference is similar to previous studies showing actual mortality observed from the ground is typically 2-3 times greater than mortality visible from the air.

In four analysis areas represented by high quality "observer view" photos, both live and dead trees were marked and counted in random samples of the corresponding orthophotos. Average canopy mortality in the orthophotos ranged from 5 to 20 percent of trees and 11 to 28 TPA (Table 2). These data will be used to calibrate georeferenced "observer view" photos with both TPA and percent mortality as shown in Figure 8.

Figure 9. *Screen shot showing process of digitizing live (green) and recently dead (red) trees in 1-acre circles on an orthophoto.*

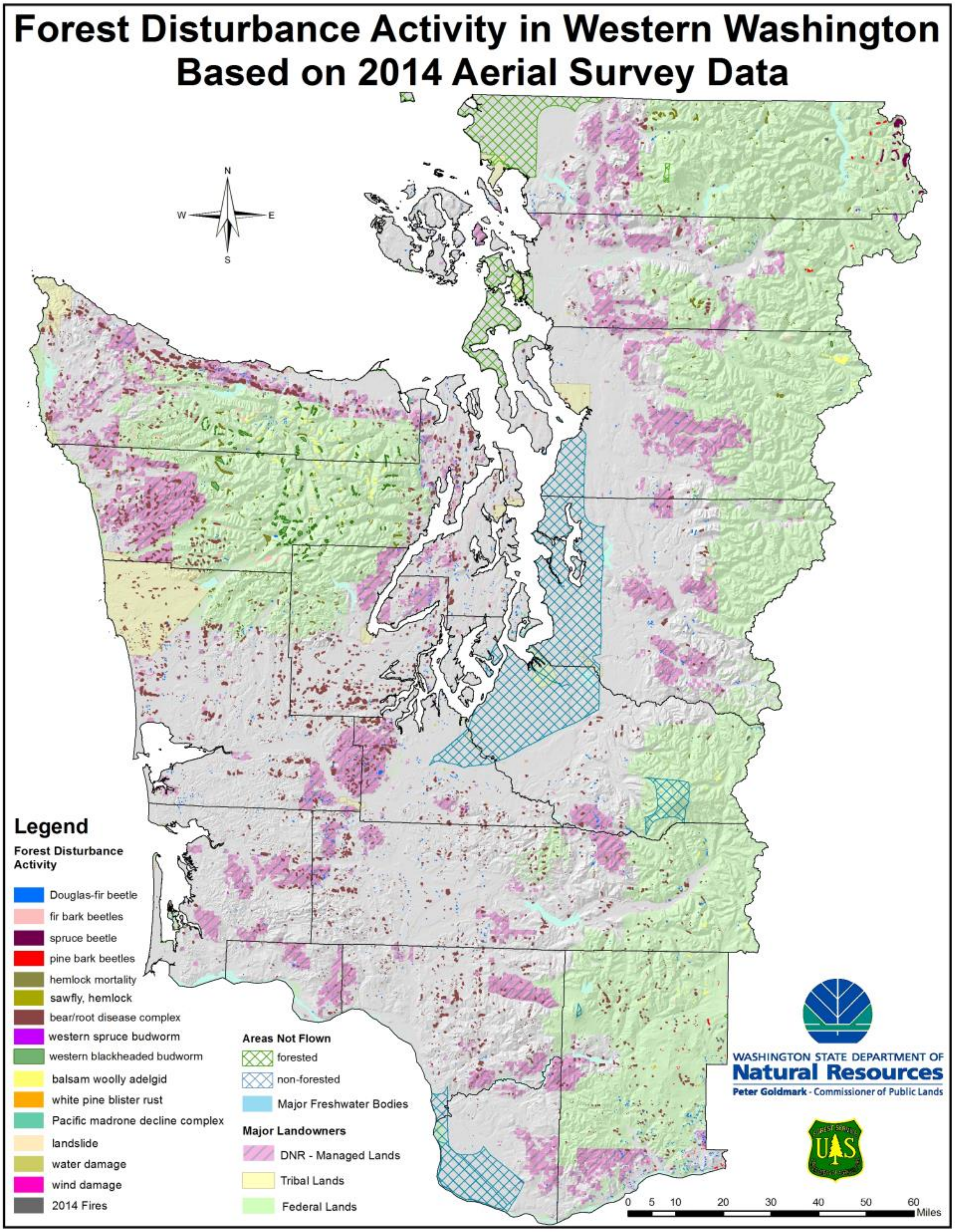

Figure 10. *Forest disturbance map of western Washington composed from 2014 aerial survey data.*
Map by: Aleksandar Dozic, Washington DNR

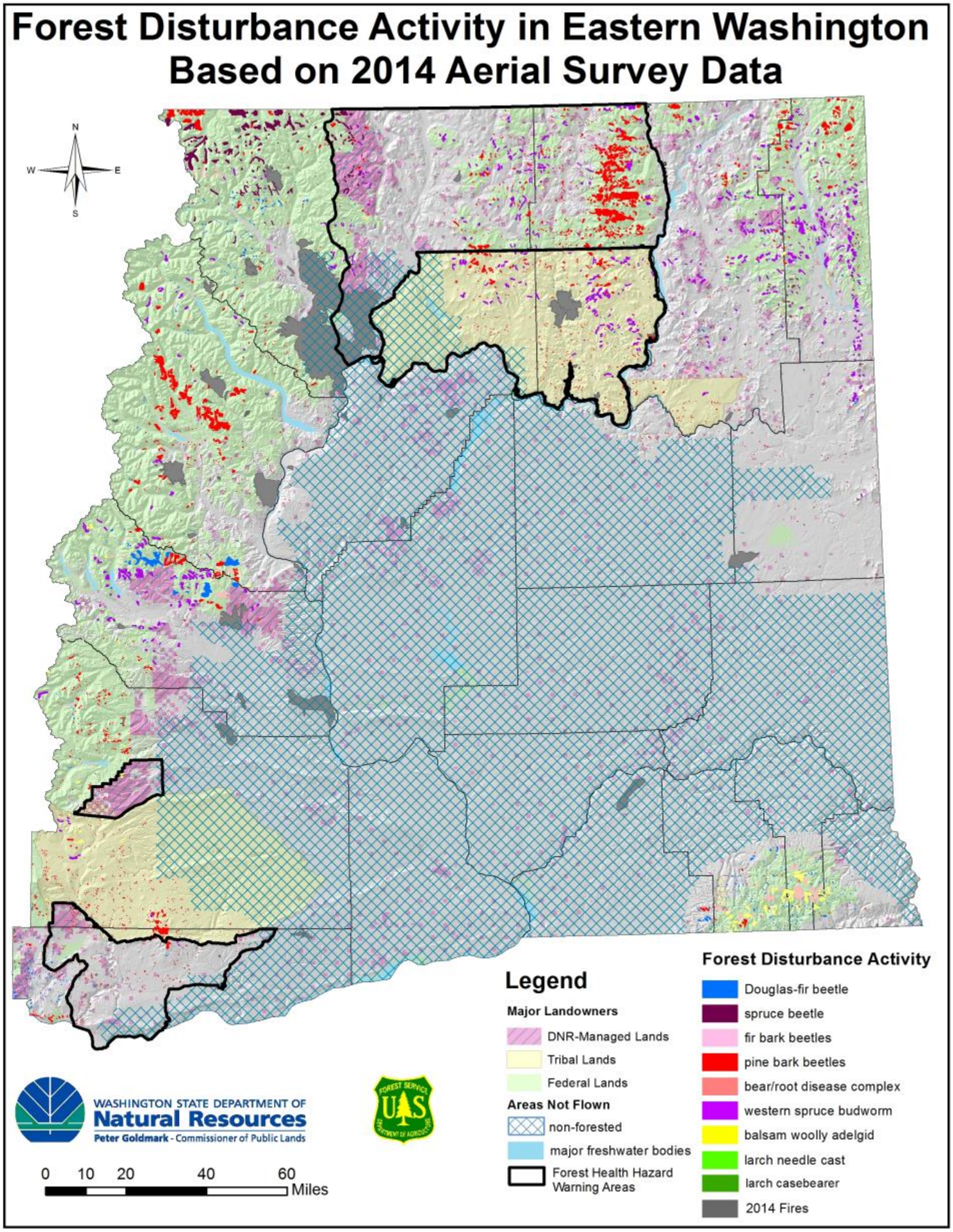

Figure 11. *Forest disturbance map of eastern Washington composed from 2014 aerial survey data.*
Map by: Aleksandar Dozic, Washington DNR

Forest Health Hazard Warning

Moving Towards Resilient Forests in Eastern Washington

The Washington State Legislature has established that the state faces serious forest health problems, primarily in eastern Washington, where forests are overcrowded and species composition has been greatly altered compared to historical reference conditions. Insect outbreaks and wildfires are more severe and extensive than would have occurred historically due to the altered structure and composition of eastern Washington forests. The level of insect and disease damage in Washington's forests has doubled from 600,000 acres per year in the 1980s to over 1.2 million acres in the 2000s. In 2007, the legislature amended the forest health law (RCW 76.06) to initiate a more pro-active response to emerging forest health threats in eastern Washington.

Figure 12. *Eastern Washington Forest Health Hazard Warning Areas.*
Map by: Chuck Hersey, Washington DNR

In November of 2011, Commissioner of Public Lands Peter Goldmark initiated the state's Forest Health Hazard Warning system found in RCW 76.06, marking the first-ever use of the authority. The Commissioner appointed a nine member technical advisory committee of foresters, scientists and other experts to assess the nature and extent of forest health threats in eastern Washington and recommend areas for further actions under the forest health law. The committee's analysis focused on recent and current insect damage, projected future damage, forest structure and species composition, and potential for on-the-ground action. Based on the findings and recommendations of the technical advisory committee, Commissioner Goldmark issued a Forest Health Hazard Warning for portions of Okanogan, Ferry, Klickitat and Yakima counties in August 2012.

A complete description of the committee's recommendations and evaluation process can be viewed here: http://www.dnr.wa.gov/foresthealth.

Eastern Washington Forest Health Hazards, Accomplishments and Restoration Strategy

A Report to the Washington State Legislature

Much of the 10 million acres of forestland in eastern Washington faces serious threats to forest health. Decades of fire suppression and past management practices that changed the species and structure of these forests have put them at higher risk of damage by disease, insects and wildfire. An analysis by The Nature Conservancy and the U.S. Forest Service identified nearly 2.7 million acres of eastern Washington forestland requiring some sort of active management or disturbance to create forest structures more resilient against insects, diseases and wildfires.

In 2014, the Washington State Department of Natural Resources (WDNR) prepared a report for the Washington State Legislature that included: a description of forest health hazard reduction treatments conducted on state, private, tribal and federal lands from fiscal year 2010 through fiscal year 2014; an estimation of forest restoration needs across land ownerships from fiscal year 2015 through fiscal year 2020; and recommended forest health hazard reduction treatment levels in eastern Washington through fiscal year 2020 and mechanisms to fund those treatments.

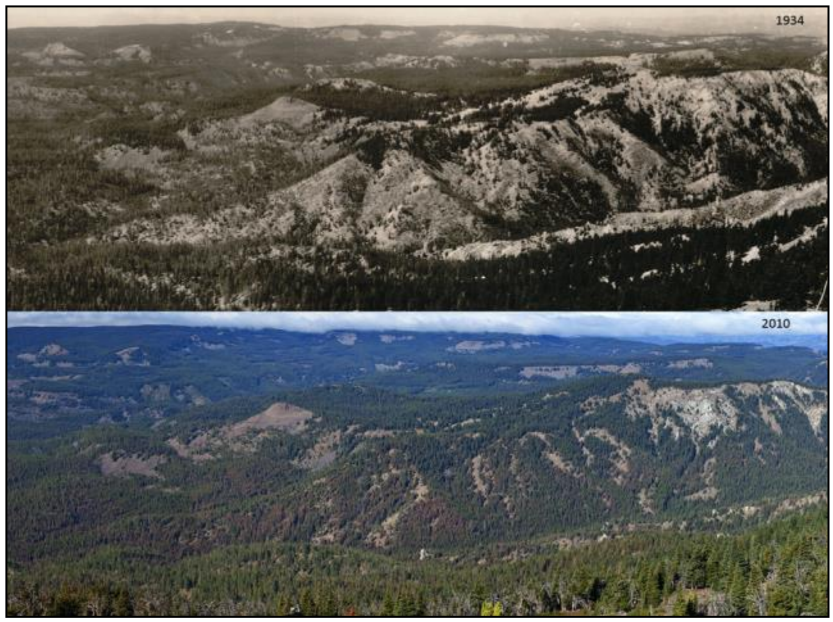

Figure 13. *Comparison of Forest Conditions, 1934–2010, Kittitas County. This comparison of changed forest conditions between 1934 (top) and 2010 (bottom) shows the Pearson (Naneum) Creek drainage near Mission Peak in central Kittitas County.*
Credit: *Upper photo by Reino R. Sarlin, USDA Forest Service, 08/19/1934, Records Group 95, National Archives and Records Admin., Seattle. Lower photo by John F. Marshall 09/10/2010, for the USDA Forest Service, PNW Research Station, Wenatchee, and Okanogan-Wenatchee NF.*

Tree thinning, harvest, and brush removal using hand crews or mechanized equipment are the most widely used treatments to reduce forest density and manage tree species composition. Prescribed fire also is a restoration tool employed by some landowners to manage species composition and fuel loads. On average over the past five years in eastern Washington, major landowners and managers conducted a mix of mechanical harvest and hazard reduction activities on approximately 145,000 acres and prescribed burning on 18,000 acres each year.

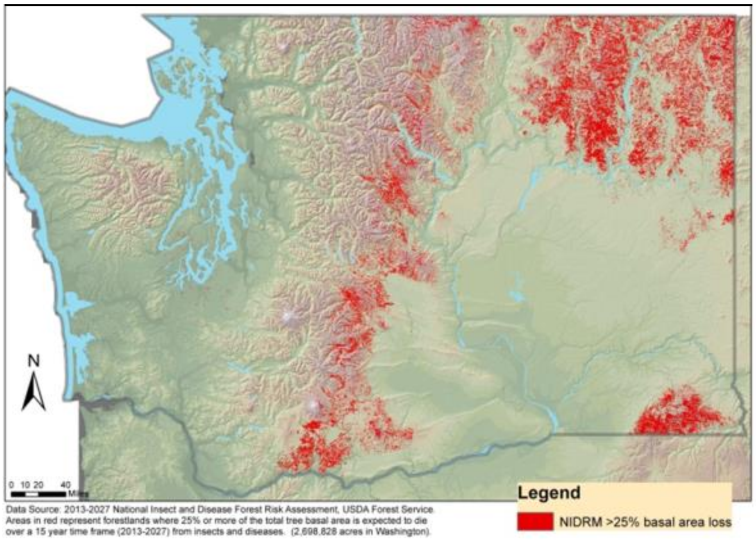

***Figure 14.** National Insect and Disease Risk Map (NIDRM) Projections of Tree Damage in Washington State, 2013–2027.*

Unfortunately, the current level of restoration activity is not keeping pace with the increasing damage that wildfire, insects and disease are causing and will cause to eastern Washington forests. We can take additional preventive steps to improve forest health to avoid spending more money on fire suppression in years to come. Those steps would include increasing forest restoration across ownerships; improving markets for small-diameter wood; increasing the community and workforce capacity and expertise to conduct forest restoration; strengthening collaboration among forest landowners, stakeholders and others who have a role in reducing the numerous threats to the health of eastern Washington forests. A top priority should be to help homeowners, communities and land managers in fire-prone areas prepare for and reduce their exposure to wildfires.

***Figure 15.** Fuel reduction thinning results, before (left) and after (right) thinning in Ferry County, Washington.*

Achieving a self-sustaining level of restoration will require a combination of actions, including a near-term increase in funding for forest restoration, and monetizing the value of ecosystem services threatened by hazards to forest health. As we restore forests, we should look for ways to build markets for wood products generated during restoration treatments. Incentives for private investment in new processes, expanded infrastructure, and the promotion of wood as a renewable energy source can expand the use of these wood products and help them become more commercially viable.

A complete copy of the report can be downloaded at:

http://www.dnr.wa.gov/Publications/rp_fh_leg_report_2014.pdf

Special Forest Health Designations for National Forests

The Agricultural Act of 2014, better known as the "Farm Bill" authorized governors to request the Secretary of Agriculture designate "one or more landscape-scale areas … in at least one national forest in each State that is experiencing an insect or disease epidemic." This designation could make those areas eligible for additional resources and planning authority to address their problems.

Several eligibility criteria related to current and anticipated tree mortality and damage were described in the Farm Bill. Washington's State Forester Aaron Everett also convened five forest collaborative groups (the North Central Washington Forest Health Collaborative, the Tapash Sustainable Forest Collaborative, the Northeast Washington Forestry Coalition, the South Gifford Pinchot Task Force, and the Umatilla Collaborative) and invited members of the public and local, state, federal and tribal governments to contribute input on the state's potential recommendations.

Glenn Kohler, Washington DNR

Figure 16. *Mountain pine beetle damage on Sherman Pass, Colville National Forest.*

On October 31, 2014, Governor Jay Inslee recommended approximately 720,000 acres of National Forest land in the Okanogan-Wenatchee, Colville, Umatilla, and Gifford Pinchot National Forests receive the priority designation (see map of designation areas on page 15). He recognized that most of these areas would benefit from the special authority and increased funding over a relatively short period of time, so this is a "first installment of projects in key areas". These areas do not reflect a comprehensive map of all places where forest health concerns may exist and should be addressed. He noted that the law provides for the option of requesting additional areas be designated if needed at a later time.

The Secretary of Agriculture continues to consolidate the input from the states and to determine how designations will be made and what specific benefits the designations impart.

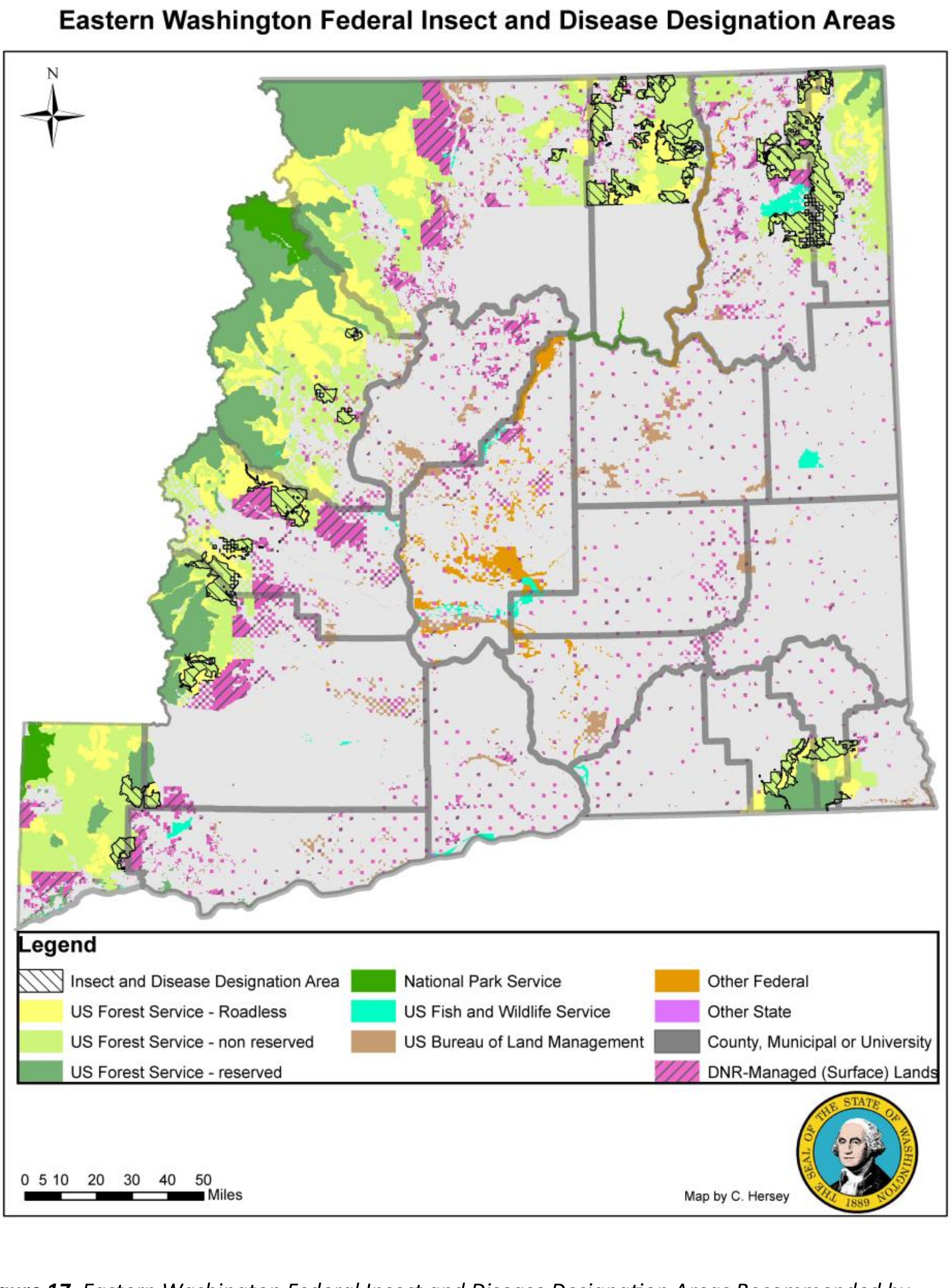

Figure 17. *Eastern Washington Federal Insect and Disease Designation Areas Recommended by Governor Inslee. October 31, 2014.*
Map by: Aleksandar Dozic and Chuck Hersey, Washington DNR

Forest Biomass Market Development

The development of viable forest biomass markets can help lower the cost of forest health treatments and increase their use. Currently, few to no markets exist for low-grade wood generated during forest health treatments. WDNR has partnered with the US Forest Service on several biomass utilization efforts over the last few years.

Mobile Pyrolysis Demonstrations: In 2014, DNR and the US Forest Service sponsored two demonstrations of mobile pyrolysis technologies in Washington attended by over 300 people. Pyrolysis units heat wood in the absence of oxygen and convert the wood into oil, char and syngas . The oil can be used for energy, or potentially upgraded and refined into a variety of chemicals and products. Char has a variety of uses such as a soil amendment or storm water filtration. Syngas can be used to provide energy or generate electricity.

Waled Suliman, Washington State University

Figure 18. *Douglas-fir planer shavings feedstock (left) converted into char (center) and oil (left) during Bingen, WA pyrolysis demonstration.*

Chuck Hersey, Washington DNR

Figure 19. *Amaron Energy's 20 ton/day mobile pyrolysis unit in Cle Elum, WA. October 2014. The white hopper with blue tarp on the left feeds wood chips into the pyrolysis unit, char comes out of the silver auger on the side of the unit, and oil goes to the white tanks. Char has temporarily been spread out in wooden pens to oxidize and cool.*

•A mobile pyrolysis demonstration was held on May 7-8, 2014 at SDS Lumber in Bingen, WA. Amaron Energy and Western Renewable Technologies demonstrated mobile pyrolysis units converting Douglas-fir planer shavings from the sawmill into oil, char, and gas. Researchers from Washington State University collected data on air emissions, char and oil quality.

•A mobile pyrolysis demonstration was held on October 22-23, 2014 at the Willis Enterprises Chip Plant in Cle Elum, WA. Amaron Energy demonstrated their new, 20 ton/day pyrolysis unit that converted forest fuel reduction thinning chips from a nearby community into oil, char and gas.

For more information on the demonstrations email Chuck Hersey: chuck.hersey@dnr.wa.gov

Insects

Bark Beetles

Fir Engraver (*Scolytus ventralis* LeConte)

Fir engraver can attack all species of true fir (*Abies*) in Washington, but the primary hosts in Washington are grand fir and noble fir. Some mortality due to fir engraver was recorded in 31,000 acres in 2014, an increase from 9,200 acres in 2013. While tree mortality due to fir engraver has more than tripled since 2013, it remained well below the ten-year average for Washington. Increases were primarily observed in the Blue Mountains, while scattered, endemic levels occurred in most other areas of the state. The most concentrated fir mortality was observed in northern Kittitas County, southern Chelan County, the Blue Mountains, and on the Olympic Peninsula. Some increases in fir mortality can be attributed to damage from 2012 wildfires in central Washington.

Dave Powell, USDA Forest Service, Bugwood.org

Figure 20. *Grand fir in the Umatilla National forest killed by fir engraver.*

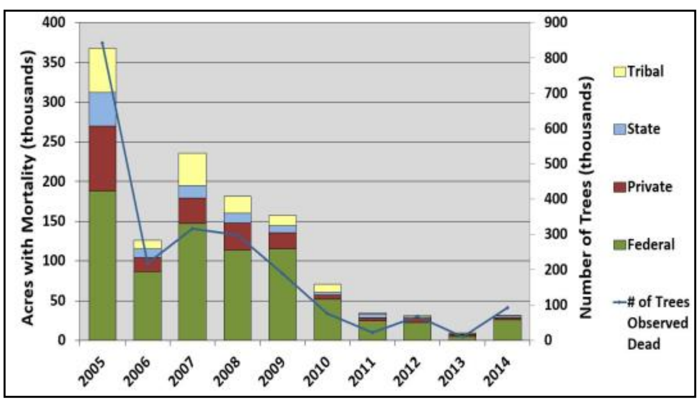

Figure 21. *Ten year trend for total acres and number of trees affected by fir engraver in Washington.*

Donald Owen, California Department of Forestry and Fire Protection, Bugwood.org

Figure 22. *Fir engraver adult.*

Western Balsam Bark Beetle (*Dryocoetes confusus* Swaine)

Western balsam bark beetle (WBBB), often in conjunction with balsam woolly adelgid, is an important driver of subalpine fir mortality in high elevation forests of Washington. The 3,500 acres with WBBB caused mortality in 2014 was similar to the amount mapped in 2013, the lowest level seen in a decade. The area with subalpine fir mortality from WBBB has steadily fallen from a recent high of 56,000 acres in 2007.

Previous annual total acres with mortality from western balsam bark beetle:

2013: 3,200 2012: 6,500 2011: 8,100 2010: 16,000 2009: 16,000

Douglas-fir Beetle
(*Dendroctonus pseudotsugae* Hopkins)

Approximately 27,000 acres with Douglas-fir beetle (DFB) caused mortality were observed statewide in 2014, up from 11,000 acres in 2013. Mortality due to DFB more than doubled this year relative to 2013. A significant increase in mortality was detected in Skamania and Klickitat counties due to outbreaks generated from winter storm damage in 2012. Concentrated areas of mortality were also detected in northern Kittitas County, southern Chelan County, and in the Blue Mountains. Increased mortality in central Washington was likely associated with damage from 2012 wildfires and chronic defoliation by the western spruce budworm. Trees stressed by defoliation are more likely to be attacked by bark beetles.

Glenn Kohler, Washington DNR

Figure 23. *Douglas-fir mortality caused by recent Douglas-fir beetle outbreak in Klickitat County.*

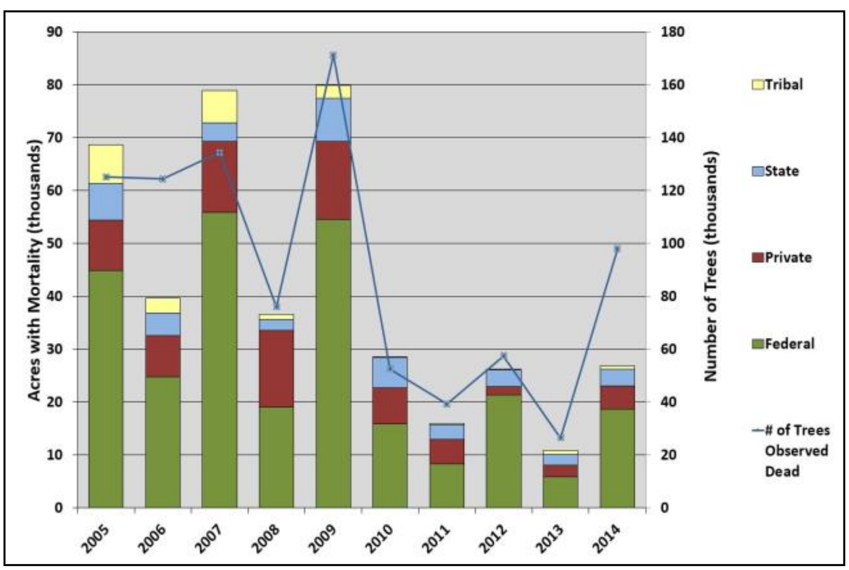

Figure 24. *Ten year trend for total acres and number of trees affected by Douglas-fir beetle in Washington.*

Glenn Kohler, Washington DNR

Figure 25. *Douglas-fir beetle adult.*

Spruce Beetle (*Dendroctonus rufipennis* Kirby)

The 37,000 acres affected by spruce beetle in 2014 was similar to the ten-year average and the 33,000 acres mapped in 2013. The majority of the mortality occurred in the vicinity of the Pasayten Wilderness within the Okanogan and Mount Baker National Forests in western Okanogan and eastern Whatcom Counties. In this area spruce beetle impacts high elevation stream bottom stands of Engelmann spruce. Outbreaks often occur following wind storm or winter damage to host trees.

Edward H. Holsten, USDA Forest Service

Figure 26. Adult female and eggs of spruce beetle.

Ben Smith, USDA Forest Service

Figure 27. Engelmann spruce mortality from spruce beetle in Okanogan County.

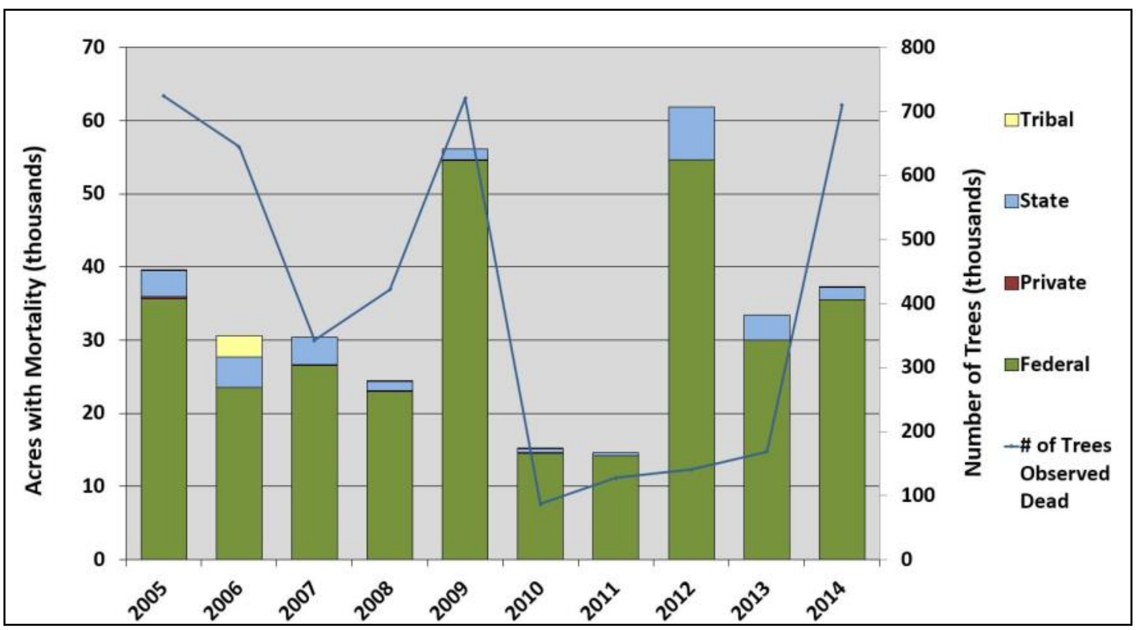

Figure 28. Ten year trend for total acres and number of trees affected by spruce beetle in Washington.

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

Glenn Kohler, Washington DNR

Figure 29. *Ponderosa pines killed by western pine beetle in Klickitat County.*

The number of acres with pine trees killed by bark beetles increased in 2014 to approximately 143,000 acres, up from 107,000 acres in 2013. Mountain pine beetle (MPB) damage increased slightly but remained near the lowest level observed in the last decade. MPB-caused mortality of lodgepole pine increased from 2013, while mortality of other pine hosts declined (Table 3). The most concentrated areas of pine mortality occurred in northern Ferry County within the Colville National Forest, central Chelan County within the Okanogan-Wenatchee National Forest, and northern Kittitas County. Relative to 2013, mortality of ponderosa pines due to western pine beetle (WPB) more than doubled in 2014. WPB-caused mortality was scattered across Klickitat, Yakima, Kittitas, Ferry, Stevens, and Spokane counties. Summer drought conditions are likely an important driver of the increase. Some increase in MPB and WPB-caused pine mortality can be directly attributed to damage from 2012 wildfires in central Washington. Pine mortality attributed to *Ips* pine engravers also more than doubled this year relative to 2013, primarily driven by a California fivespined Ips outbreak in Klickitat and Skamania Counties.

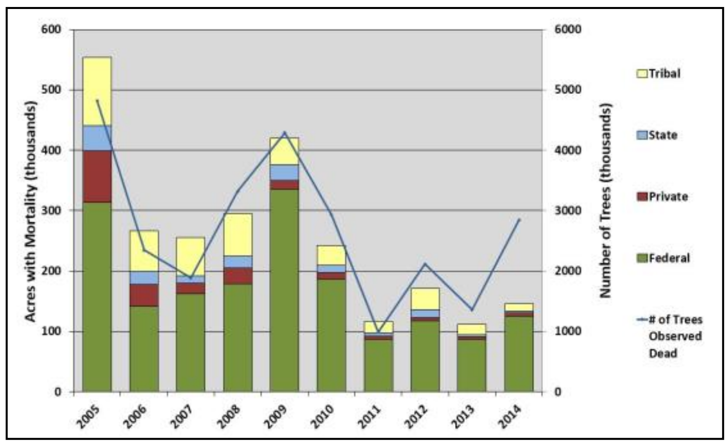

Figure 30. *Ten year trend for total acres and number of trees affected by pine bark beetles in Washington.*

Table 3. 2014 statewide acres affected and estimated number of pine bark beetle-killed trees.

Beetle species	Host(s)	Acres with mortality*	Estimated number trees killed
mountain pine beetle	lodgepole pine	127,000	2,760,000
mountain pine beetle	ponderosa pine	9,100	59,000
mountain pine beetle	whitebark pine	310	300
mountain pine beetle	western white pine	220	260
western pine beetle	ponderosa pine	8,800	21,000
pine engravers (*Ips* species)	all pines	790	3,100

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

California Fivespined Ips (*Ips paraconfusus* Lanier)

Glenn Kohler, Washington DNR

Figure 31. *Ponderosa pine mortality caused by California fivespined Ips in Klickitat County.*

In 2010, an outbreak of California fivespined Ips (CFI) along the Columbia River Gorge resulted in what appears to be the first recorded detection of this species in Washington. 2014 was the fifth year of CFI outbreaks in the eastern Columbia River Gorge in Klickitat and Skamania counties, causing numerous killed and top-killed ponderosa pines every year since 2010. In 2014, aerial surveys recorded approximately 650 acres with an estimated 2,700 ponderosa pines killed in Washington, the highest level detected to date (Fig. 32). Outbreaks have been driven by consecutive years of fires, storm damage, and drought conditions. Attacks by western pine beetle (*Dendroctonus brevicomis* LeConte), red turpentine beetle (*Dendroctonus valens* LeConte), and infections of bluestain fungi may also contribute to mortality of some larger ponderosa pine. From 2010-2014, the Washington Department of Natural Resources, Washington State University Extension, and the USDA Forest Service have monitored CFI occurrence and distribution.

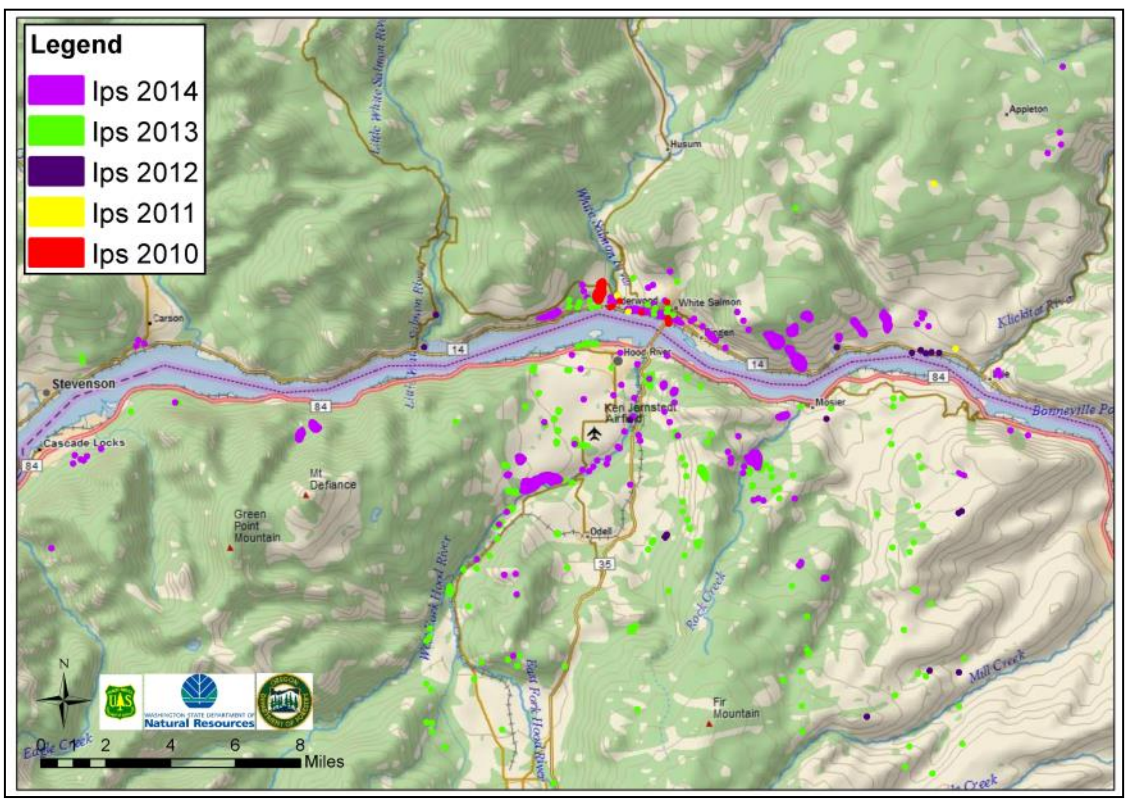

Figure 32. *Ponderosa pine mortality caused by California fivespined Ips mapped in Oregon and Washington aerial surveys, 2010-2014. Map by: Aleksandar Dozic, Washington DNR.*

During this time, funnel traps baited separately to capture CFI (*Ips paraconfusus*) and *Ips pini* have been placed at 31 locations in 19 Washington counties. In 2014, traps were placed at 18 locations in 13 counties, including several locations not previously monitored. To date, CFI has been detected at 12 locations in 6 Washington counties (Fig. 33). The northern-most detection site is near Joint Base Lewis-McChord in western Washington and the eastern-most detection site is near Goldendale in eastern Washington. The Washington distribution of CFI includes Klickitat, Skamania, Clark, Lewis, Thurston, and Pierce Counties. CFI populations are very low at detection sites in western Washington north of Vancouver and CFI-caused ponderosa mortality has not been observed in those areas. Populations of CFI and *Ips pini* do not appear to overlap in high numbers at the same locations (Table 4).

Table 4. Total collections listed by California fivespined Ips (CFI) abundance, then by *Ips pini* abundance where CFI was not collected (4 counties where no *Ips* species were collected are not shown).

County (years surveyed)	CFI	*Ips pini*
Klickitat Co., south (2011-14)	4,889	72
Clark Co. (2011-14)	2,573	16
Skamania Co. (2011)	113	0
Klickitat Co., north (2011-12)	17	1,735
Pierce Co. (2011-12)	3	209
Lewis Co. (2011-12)	3	207
Thurston Co. (2012)	1	503
Chelan Co. (2013-14)	0	2,325
Ferry Co. (2013-14)	0	918
Mason Co. (2013-14)	0	760
Yakima Co. (2012-14)	0	481
Okanogan Co. (2014)	0	354
Kittitas Co. (2013-14)	0	43
Columbia Co. (2014)	0	7
Spokane Co. (2014)	0	4
Kitsap Co. (2014)	0	3

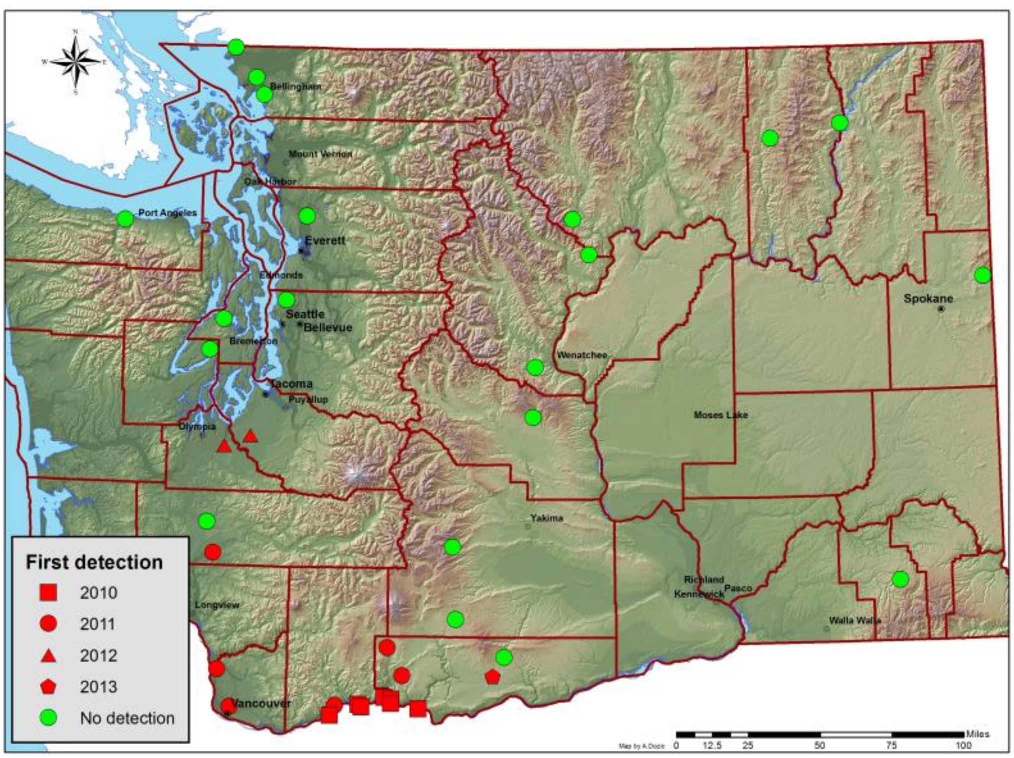

Figure 33. *California fivespined Ips monitoring trap locations in Washington, 2010-2014.*
Map by: Aleksandar Dozic, Washington DNR.

Defoliators

Western Spruce Budworm (*Choristoneura freemani* Razowski)

In 2014, areas with western spruce budworm (WSB) defoliation recorded in the aerial survey decreased to approximately 93,000 acres; this was well below the 178,000 acres recorded in 2013 and the lowest total since 2002. The average WSB defoliation in Washington over the past ten years is 382,000 acres. Mid-elevation forests of Kittitas, Okanogan, Ferry, Stevens, and Pend Oreille counties have been most heavily affected by this outbreak, and numerous new areas of defoliation were observed this year in the latter four counties. The area affected in Kittitas County has decreased significantly in the last two years. In 2014, aerial survey flights in eastern Washington were conducted later in the season than typical. Fading WSB crown signature and less than optimal lighting conditions may have contributed to a reduction in the number of acres mapped.


Glenn Kohler, Washington DNR

Figure 34. *Adult western spruce budworm and damaged grand fir foliage.*

After several consecutive years of defoliation in the central and north Cascades, direct mortality and top-kill from defoliation as well as subsequent mortality from Douglas-fir beetle and fir engraver are becoming more common. Pheromone trap catches in Kittitas, eastern Okanogan, and Ferry counties indicate continued moderate to heavy defoliation in 2015. New areas of defoliation have been detected in Stevens and Pend Oreille counties; however, pheromone trap catches in those areas are too low to accurately predict defoliation levels for 2015.

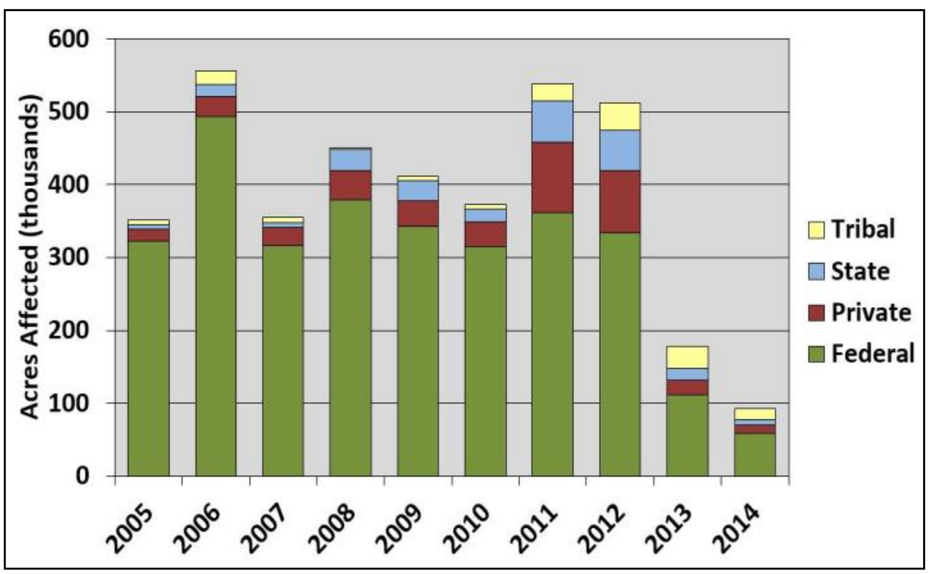

Figure 35. *Ten year trend for total acres affected by western spruce budworm in Washington.*

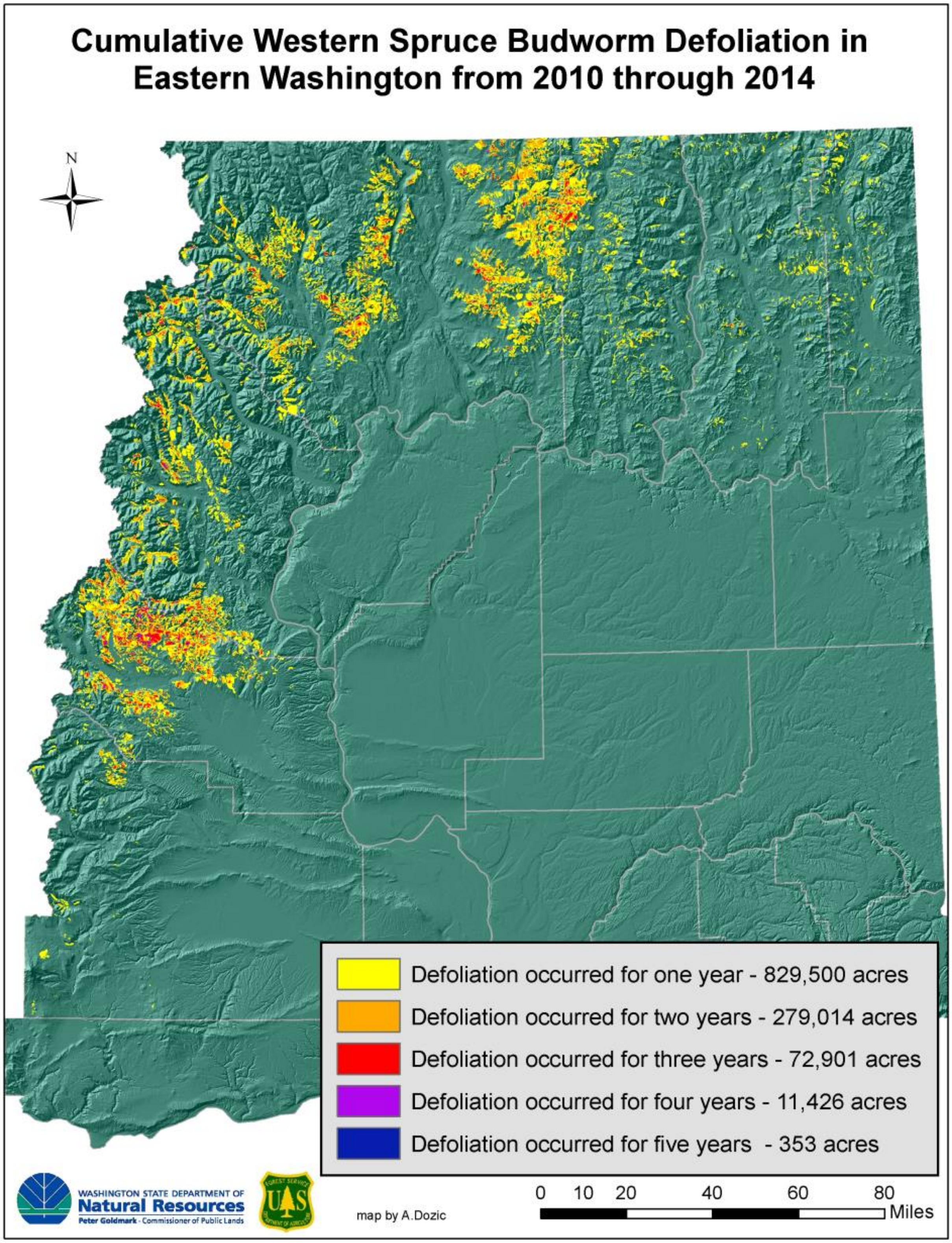

Figure 36. *Cumulative western spruce budworm defoliation from 2010 through 2014. Map by: Aleksandar Dozic, Washington DNR*

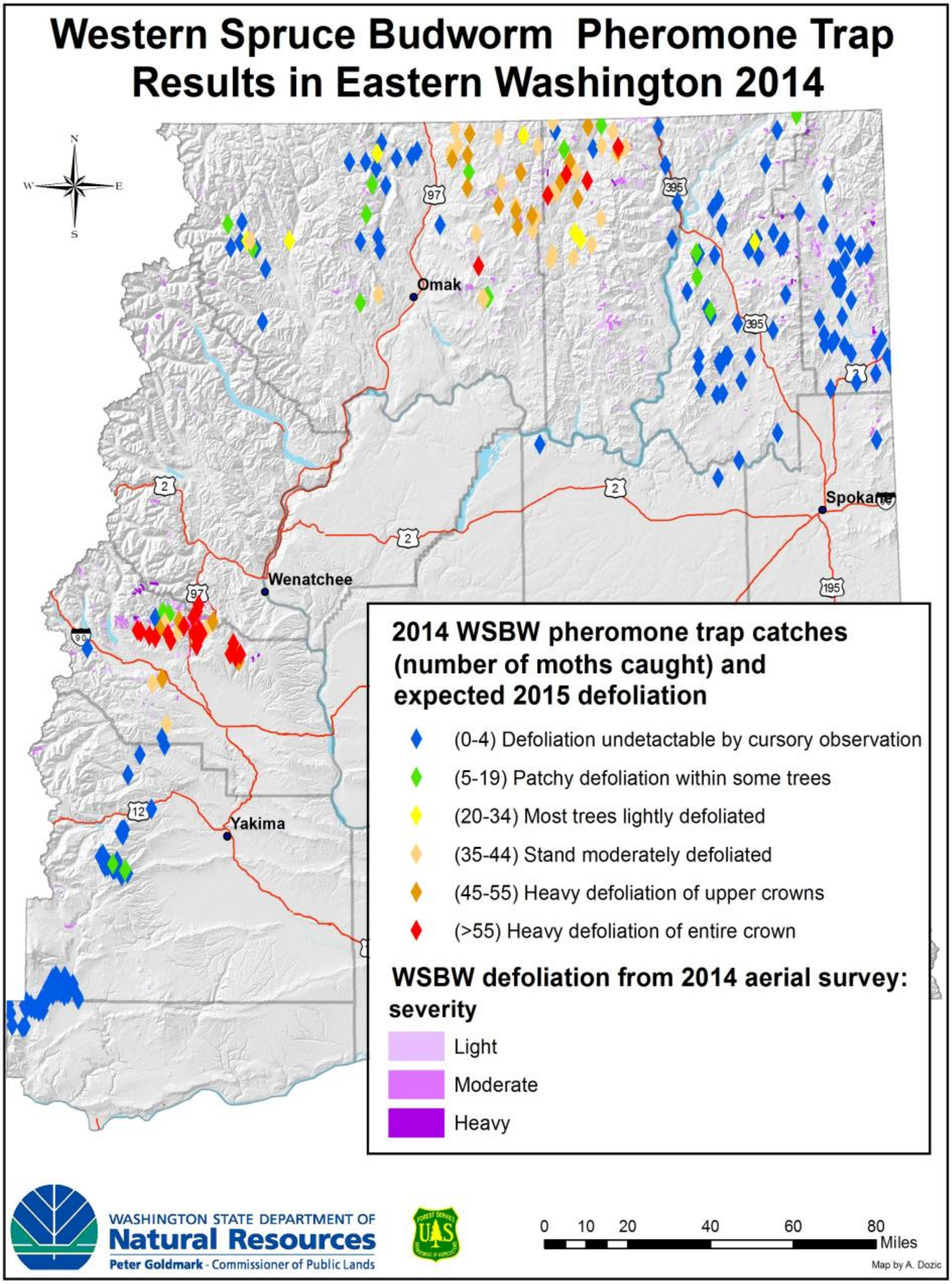

Figure 37. *Western spruce budworm pheromone trap catch results for 2014, expected 2015 defoliation and defoliation detected by the 2014 aerial survey. Map by: Aleksandar Dozic, Washington DNR*

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

There was no Douglas-fir tussock moth (DFTM) defoliation recorded in 2014. The last year with any significant defoliation was in 2012 from outbreaks that affected the Umatilla National Forest in the Blue Mountains. The network of “Early Warning System” pheromone traps continued to be monitored in Washington, and 2014 pheromone trap captures indicate a low likelihood of defoliation occurring in 2015.

Previous annual total acres with defoliation from Douglas-fir tussock moth:
2013: 30   2012: 8,700   2011: 9,400   2010: 1,200   2009: 3,600

Western Blackheaded Budworm (*Acleris gloverana* (Walsingham))

Approximately 20,000 acres of western blackheaded budworm (WBB) defoliation was observed in western Washington this year; an increase from over 14,000 acres mapped in 2013. Defoliation occurred primarily on the Olympic Peninsula, with small amounts on the western slopes of the North Cascades. Both Western hemlock and Pacific silver fir were moderately defoliated. This is the second year of wide-spread defoliation on the Olympic Peninsula. The last WBB outbreak in WA occurred from 2002-2003 in the central Cascades near Snoqualmie Pass and Stevens Pass.


Glenn Kohler, Washington DNR

Figure 38. *Western hemlock defoliated by western blackheaded budworm.*

Western oak looper (*Lambdina fiscellaria somniaria* (Hulst))

2014 was the second year of defoliation by western oak looper recorded in Oregon white oaks located in the northern area of Joint Base Lewis-McChord in Pierce County. This damage was not observed during aerial surveys because it occurred within restricted airspace. Approximately 60 acres with defoliation was recorded in a subsequent ground survey. The outbreak did not expand as much as was expected from initial damage detected in the same area in 2013.


Glenn Kohler, Washington DNR

Figure 39. *Western oak looper defoliation at Joint Base Lewis-McChord.*

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

Larch casebearer (LC) is a well-established exotic insect that feeds on the foliage of western larch. No defoliation attributed to LC was recorded in the 2014 aerial survey. The last outbreak of LC in Washington affected 16,000 acres in 2011. Because larch re-foliates annually, it takes several years of damage to cause serious injury to larch.

Previous annual total acres with defoliation from larch casebearer:
2013: 730   2012: 1,700   2011: 16,000   2010: 0   2009: 216

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

Small areas of scattered defoliation by western tent caterpillar (WTC) totaling 1,700 acres were observed across western Washington in 2014, a decrease from over 6,100 acres in 2013. New areas of defoliation were detected in Island, Kitsap, Wahkiakum, Cowlitz, and Lewis counties in western Washington. This is the third year of the outbreak, and it appears to be declining. Primary hosts include cottonwood, other poplars, willows, and red alder. WTC outbreaks are cyclical and rarely last more than a few years.

Karen Ripley, Washington DNR

***Figure 40.** Basking western tent caterpillar larvae.*

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

In 2014, the Washington State Department of Agriculture (WSDA) placed 19,644 gypsy moth pheromone traps in Washington. 12,291 of these were for European gypsy moth (EGM) detection and delimiting and 7,353 were for Asian gypsy moth (AGM) detection. 27 gypsy moths were collected from 16 catch areas, including 6 new catch areas in Clallam, Clark, Jefferson, King, and Whatcom counties. All 27 moths collected in 2014 were the North American variety of EGM from the established European population in the eastern United States. No AGM have been trapped in Washington since 1999. In the past twelve years, the highest number of moths collected was 75 in 2006. A 2013 eradication project site near Tukwila was treated with Btk (Foray XG) and disparlure (Disrupt II) for the purpose of mating disruption. No gypsy moths were trapped near the Tukwila site during the summers of 2013 and 2014. No eradication projects were conducted in 2014. WSDA has proposed a 220-acre eradication project for spring 2015 using aerially applied Btk on forest land near Yacolt in Clark County (20 miles northeast of Vancouver).

USDA APHIS PPQ Archive, USDA APHIS PPQ, Bugwood.org

***Figure 41.** Gypsy moth adults.*

Branch and Terminal Insects

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

Balsam woolly adelgid (BWA) is a non-native sucking insect that has caused defoliation and mortality to subalpine fir, Pacific silver fir, and grand fir in Washington. Most current damage is recorded in subalpine fir in high elevation forests throughout Washington. In 2014, approximately 35,000 acres of damage was observed, an increase from over 21,000 acres in 2013 and close to the 10-year average of 37,000 acres. BWA damage, primarily to subalpine fir and Pacific silver fir, was recorded at high elevations of the Blue Mountains, the Olympic Mountains, and in scattered areas near the crest of the Cascade Mountains and mountains of northeast Washington. There were 4,500 acres with some host mortality attributed directly to BWA damage in 2014. Approximately 3,500 acres in these same high elevation areas were mapped with some western balsam bark beetle caused mortality in subalpine fir. BWA infestation can be a predisposing factor to western balsam bark beetle attack.

Glenn Kohler, Washington DNR

Figure 42. *Balsam woolly adelgid ovisacs and gouting symptoms on grand fir.*

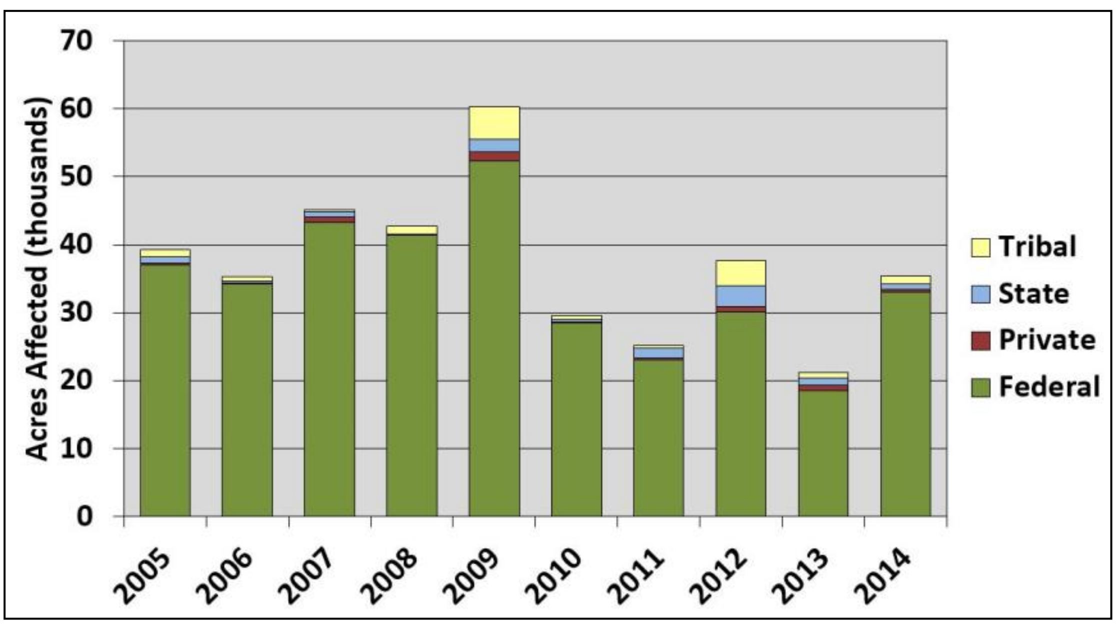

Figure 43. *Ten year trend for total acres affected by balsam woolly adelgid in Washington.*

Animals

Bear Damage / Root Disease

Amy Ramsey, Washington DNR

Figure 44. *Bears peel bark from trees in spring to eat phloem, often killing the tree.*

Aerial survey records scattered, pole sized, newly dead trees as 'bear damage.' Based on ground checking observations, bear girdling and root disease are the primary causes of this type of damage. Drought stress, porcupines, or mountain beavers may also play a role. Bears strip tree bark in spring and it takes more than one year for the tree to die and needles to become red (visible from the air). In years with wet and cool spring conditions, the berries that bears feed on mature later, so bears are more likely to feed on trees as an alternative. However, above average spring precipitation may delay tree needles becoming red which may result in less observed damage that year. Other factors that may influence fluctuation in bear damage acreage are local bear populations and age of trees.

Approximately 161,000 acres with bear damage mortality were observed in 2014, which is slightly less than the 183,000 acres mapped in 2013. The ten year average of acres with bear damage in Washington is 244,000. The average number of trees per acre (TPA) killed was lower in 2014 (1.34 TPA) than 2013 (1.65 TPA). The estimated total number of trees killed was approximately 217,000, which was less than the 300,000 trees killed in 2013.

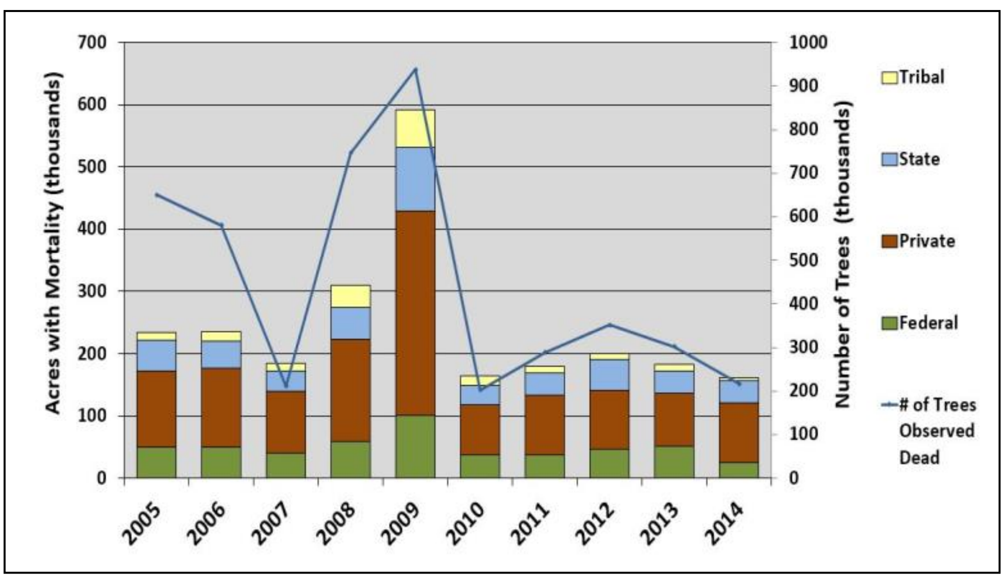

Figure 45. *Ten year trend for acres and number of trees affected by bear damage in Washington.*

Diseases

Cankers

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

This exotic disease infects five needle pines such as western white pine and whitebark pine. In 2014, mortality was detected on 300 acres of whitebark pine and 200 acres of western white pine throughout the high elevation mountainous areas of the eastern Cascades, although much of this was attributed to mountain pine beetle. A light, broad scattering of western white pine mortality was observed in northeast and south central Washington. This was less mortality than what was observed in 2013 and 2012 (1,600 acres and 5,100 acres, respectively). The aerial survey records very little area affected specifically by white pine blister rust (108 acres in 2014) because signatures can be difficult to distinguish from mountain pine beetle from the air.

Dan Omdal, Washington DNR

Figure 46. *Red, dead top of white pine blister rust infected western white pine.*

Foliar Diseases

Conifer Needle Casts

Pine Needle Casts (*Dothistroma* spp., *Elytroderma* spp., *Lophodermella* spp., *Lophodermium* spp., and others)

Larch Needle Cast (*Meria laricis* Vuill.)

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

USDA Forest Service Archive,
USDA Forest Service, Bugwood.org

Figure 47. *Red tipped needles and abnormal, clustered, branching of* Elytroderma *needle disease of ponderosa pine.*

Conifer defoliation from needle casts, caused by multiple genera and species of fungi (at least 13 in Washington state), was recorded on 4,000 acres in 2014. This is about one-quarter of the acreage mapped with needle cast diseases in 2013 (19,000 acres) and about one-thirteenth of the acreage mapped in 2012 (56,000 acres). Needle cast fungi rely on warm, wet conditions to colonize and infect conifer needle tissue and without those conditions, new infections are unable to occur. The decline in observed needle casts may be attributed to weather conditions, specifically a drier spring and summer than what occurred in 2012 and 2013. However, on-the-ground reports do not corroborate the recent reduced acreage mapped for conifer needle casts, with numerous reports of needle cast in conifers in the spring of 2014. This discrepancy may be due to the most obvious symptoms of needle cast occurring in populated areas and then being partially masked by new foliage growth before the aerial survey was flown.

Phil Hess, Consulting Forester

Figure 48. *Ponderosa pine needle cast. Large, upper picture with several ponderosa pine trees with red and green needles on the tree. Smaller picture with close-up of older, red, inside needles and younger, green needles.*

Melissa Fischer, Washington DNR

Figure 49. *Ponderosa pine needles with reddish yellow needles. Discoloration only in half to tip of needle.*

In early spring, 2015, there have been symptoms observed on conifers in eastern and western WA, similar to needle cast symptoms. They are, however, slightly different in that the outer tips of the needles are uniformly damaged, with yellowing or red colors, instead of an irregular inside out needle discoloration as would likely be observed in trees with a fungal caused needle cast. The cause of the foliar damage is likely abiotic, probably resulting from cold wind winter damage and/or a drought influence. New foliage emerging in the late spring and early summer will likely mask many of these needle discoloration issues, which most of the time are primarily aesthetic concerns.

Hardwood Foliar Diseases, Dieback, and Declines

Multiple fungal genera and species cause foliar diseases, branch dieback and overall tree health declines in hardwood species in Washington. The most common host species mapped during the aerial survey include bigleaf maple (*Acer macrophyllum* Pursh), Pacific madrone (*Arbutus menziesii* Pursh), and poplars (*Populus* spp.). During the 2014 aerial survey, 10,000 acres of hardwood damage was mapped. This is about six times of the acreage mapped in 2013 (1,700 acres). Increases in acreage mapped may be due to annual differences in weather, or possible other variables.

Data and Services

Every year, all forested acres in Washington are surveyed from the air to record recent tree damage. This aerial survey is made possible by the cooperation of the WDNR and the USFS. It is very cost effective for the amount of data collected. These maps are great tools for a quick look at what forest disturbance events have occurred in your neck of the woods. They produce excellent trend information and historical data.

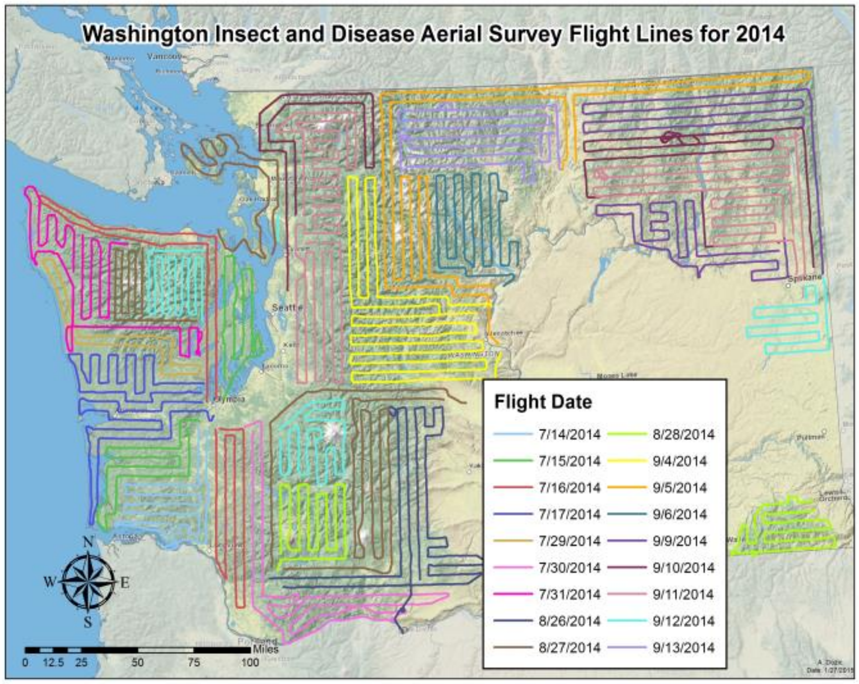

Figure 50. *Washington insect and disease aerial survey flight lines for 2014. Map by: Aleksandar Dozic, Washington DNR*

Electronic PDF Maps Available for Download

Traditional insect and disease survey quadrangle maps from 2003 to 2014 are available for download as PDF files at: www.fs.usda.gov/goto/r6/fhp/ads/maps

Click on the year of interest from the list of available years. Simply click the map you want from the interactive map of Oregon and Washington and it will download the PDF.

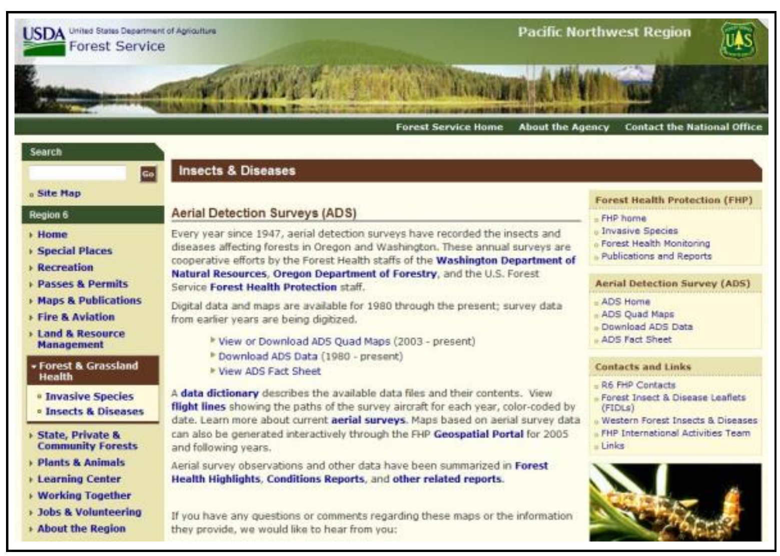

Figure 51. *Downloadable aerial survey maps and data on USFS Region 6 Forest Health Protection website.*

Interactive Map Tool and GIS Data Available for Download

New for 2015! Annual aerial survey data are available from 2010 to 2014 in Washington DNR's interactive, web-based mapping site: "Fire Prevention and Fuels Management Mapping" at: https://fortress.wa.gov/dnr/fmanfire/index.html. Click on "Forest Health", select "Annual Aerial Survey Data" and the year of interest, then check boxes for type of damage to be displayed. Click on polygons to display agent and intensity. Various basemaps and background layers can be added. Zoom to an area of interest and click the printer icon in the upper right to create a pdf or image file of your map.

Washington DNR also maintains downloadable GIS datasets, including aerial survey data for Washington State from 1980 to 2013, known as "Bugs n Crud" at:
http://www.dnr.wa.gov/BusinessPermits/Topics/Data/Pages/gis_data_center.aspx
Click on "Available GIS Data," then scroll down to "Forest Disturbance."

Forest Health Websites

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

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

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

Field Guides

The "Field Guide to Diseases and Insect Pests of Oregon and Washington Conifers," produced by the USDA Forest Service Pacific Northwest Region, is a great reference for anyone wanting to learn more about forest pests in the Pacific Northwest.

"Common Tree Diseases of British Columbia" is a field guide that includes many forest diseases found in the Pacific Northwest. It has been available through Natural Resources Canada, Canadian Forest Service at: http://cfs.nrcan.gc.ca/publications?id=4633

Contacts and Additional Information

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

Washington Department of Natural Resources — Forest Health Program
1111 Washington St SE
PO Box 47037
Olympia, WA 98504-7037

Aleksandar Dozic	Aerial Observer	(360) 902-1320	aleksandar.dozic@dnr.wa.gov
Melissa Fischer	Forest Health Specialist (Eastern WA)	(509) 684-7474	melissa.fischer@dnr.wa.gov
Jonathan Guzzo	Forest Health Environmental Planner	(360) 902-1229	jonathan.guzzo@dnr.wa.gov
Chuck Hersey	Forest Health Environmental Planner	(360) 902-1045	chuck.hersey@dnr.wa.gov
Glenn Kohler	Forest Entomologist (Olympia)	(360) 902-1342	glenn.kohler@dnr.wa.gov
Dan Omdal	Forest Pathologist	(360) 902-1692	daniel.omdal@dnr.wa.gov
Amy Ramsey	Forest Pathologist	(360) 902-1309	amy.kroll@dnr.wa.gov
Karen Ripley	Forest Health Program Manager	(360) 902-1691	karen.ripley@dnr.wa.gov

USDA Forest Service — Forest Health Protection and Monitoring Program
333 SW First Avenue
PO Box 3623
Portland, OR 97208

Karl Dalla Rosa	Forest Health Protection	(503) 808-2913	kdallarosa@fs.fed.us
Alison Nelson	Forest Health Monitoring Program	(503) 808-2662	asnelson@fs.fed.us

USDA Forest Service — Wenatchee Service Center
Forestry Sciences Laboratory
1133 N. Western
Wenatchee, WA 98801

Darci M. Carlson	Entomologist	(509) 664-1724	dmcarlson@fs.fed.us
Betsy Goodrich	Plant Pathologist	(509) 664-9223	call for contact information
Connie J. Mehmel	Entomologist	(509) 664-9213	cmehmel@fs.fed.us

USDA Forest Service — Westside Service Center
Mount Hood National Forest
16400 Champion Way
Sandy, OR 97055

Kristen Chadwick	Plant Pathologist	(503) 668-1474	klchadwick@fs.fed.us
Holly Kearns	Plant Pathologist	(503) 668-1475	hkearns@fs.fed.us
Ben Smith	Aerial Survey Program Manager	(503) 668-1761	bsmith02@fs.fed.us
Beth Willhite	Entomologist	(503) 668-1477	bwillhite@fs.fed.us