

## Forest Health Highlights in Washington—2010



**Washington State Department of Natural Resources  
Forest Health Program  
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*Front cover: Satin moth larva on aspen in the Loomis State Forest.  
Photo: Mike Johnson, Washington Department of Natural Resources (DNR).*

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# Summary

Washington has 22.4 million acres of forestland. In 2010 approximately 937,000 acres of this land contained some level of tree mortality, tree defoliation or foliar diseases. This is a significant decrease from the 1.73 million acres reported in 2009. Unusually wet and cool spring and summer weather may have delayed the onset of pest signatures that can be observed from the air, such as red crowns. Damage by major agents, such as western spruce budworm and bear damage, are still widespread, but more concentrated in 2010. In some areas, forest condition is improving; in some areas, mortality or defoliation is increasing. Previous annual totals were:

**2008:** 1.36 million acres

**2007:** 1.4 million acres

**2006:** 1.9 million 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. Drought conditions subsided across the state by June 2010. Areas with major wildfires are not surveyed for two years following the event, tending to temporarily decrease acres of damage.

Approximately 3.4 million trees were recorded as recently killed.

Defoliation by the **Douglas-fir tussock moth** decreased to 1,200 acres in 2010, down from more than 3,500 acres in 2009. In eastern Spokane County, approximately 570 acres with new tussock moth defoliation were recorded in 2010. Pheromone trap catches and egg mass surveys indicate that defoliation in Spokane County may expand and increase in severity in summer 2011. A buildup of natural controls and direct suppression efforts have decreased the tussock moth population and defoliated area in Okanogan County, where the outbreak has likely collapsed.

A major **western spruce budworm** outbreak remains active on the eastern slopes of the Cascade Mountains north of Highway 12 and in northeastern Washington, affecting 373,500 acres. Areas of defoliation have expanded since 2009 in Kittitas, Chelan, Okanogan and Ferry Counties. Defoliation in Kittitas County was especially heavy in 2010.

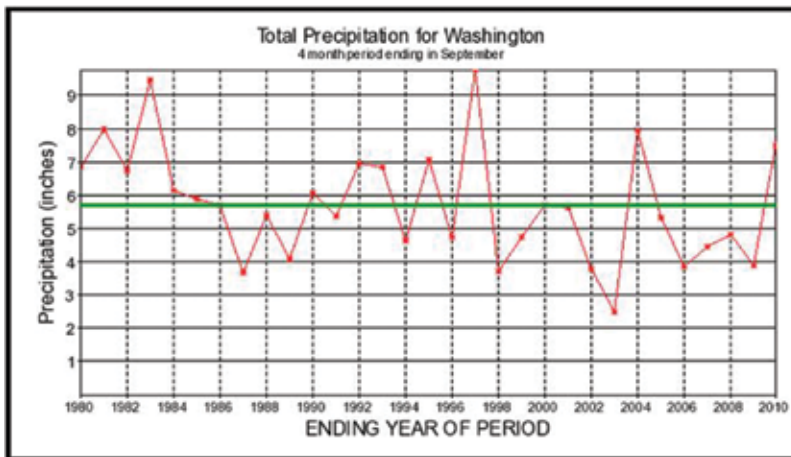
A recent outbreak of **Douglas-fir beetle** in western Washington appears to be coming to an end. 18,500 acres with mortality were observed in this area in 2010, down from a record high of 33,000 acres in 2009. The decrease was likely due to beetles being killed when attempting to enter healthy trees and other natural controls.

**Pine bark beetle** activity recorded by aerial survey in Washington decreased in 2010 to almost 242,000 acres, down from 420,000 acres in 2009. However, the area affected by pine bark beetles in Ferry, Stevens and Pend Oreille Counties increased to 66,500 acres in 2010, more than double the 32,500 acres mapped in those counties in 2009.

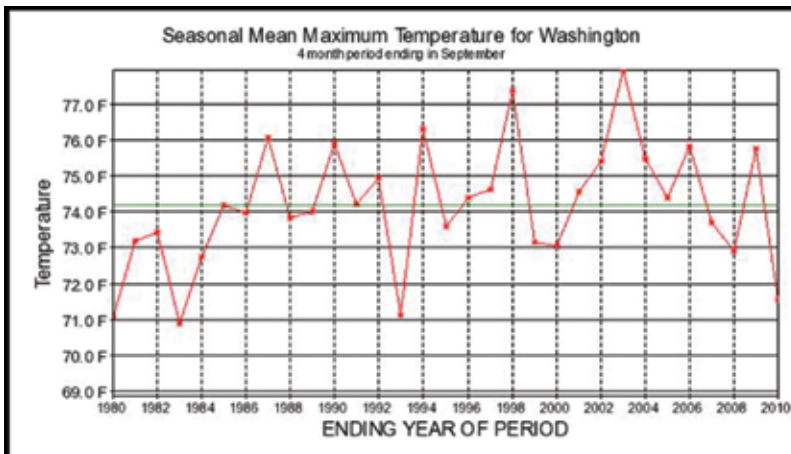
Defoliation from **larch needle cast disease** was recorded on 22,000 acres in the Cascade Mountains and eastern Washington in 2010. The increased incidence of larch needle cast was likely associated with unusually the wet spring and summer weather in eastern Washington in 2010.

# 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. Many insects and pathogens use weakened or dead trees to maintain and sometimes increase their populations. Injuries can be vulnerable to infection by fungi. Outbreaks of certain bark beetle species, such as Douglas-fir beetle, follow weather or fire events that kill or injure numerous trees. Unusually wet spring weather can increase the incidence of foliar diseases. In years like 2010, when summer precipitation was above average, fewer trees will be killed by bark beetles the following year. This



**Figure 1.** Average summer precipitation and 30-year average (green line) for Washington. Source: Western Regional Climate Center ([www.cefa.dri.edu/Westmap](http://www.cefa.dri.edu/Westmap)).



**Figure 2.** Average maximum summer temperature and 30-year average (green line) for Washington. Source: Western Regional Climate Center ([www.cefa.dri.edu/Westmap](http://www.cefa.dri.edu/Westmap)).

reduction in beetle-kill will not be apparent until the 2012 aerial survey.

Aerial surveys also aim to record the location and severity of certain weather related events, giving landowners and managers warning to take appropriate action, such as salvaging weakened or dead material.

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.

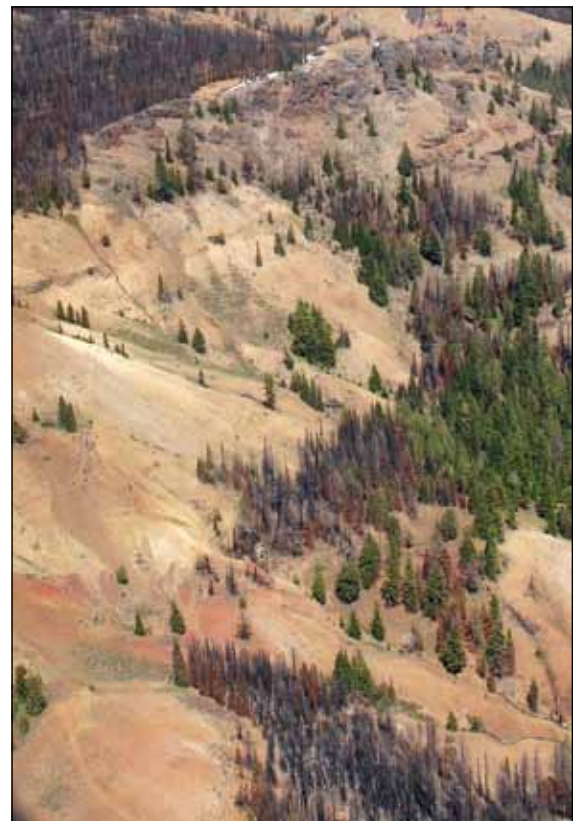


# Drought

2010 spring and summer seasonal precipitation was near or above average for all forested regions of Washington State. The increased moisture brought an end to the recent drought, but may have also contributed to an increase in the incidence of foliage diseases in 2010. Average maximum spring and summer temperatures were below normal across Washington in 2010. Drought conditions did not occur anywhere in the state during summer 2010, which is unusual for the normally hot, dry months of July through October. Trees experiencing drought stress can become more susceptible to insect attacks and diseases 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.

# Fire

Early in the spring 2010, the seasonal assessment for Washington was for above normal significant fire potential in extreme northern and eastern Washington. Normal significant fire potential was expected elsewhere. Snowpack across the state as of late April was running on average 50-75% of normal. Generally, most El Niño winters are followed by a warmer and drier than normal May, which was in line with the May forecast for 2010. This would have led to an earlier than normal snowmelt and accelerated drying of fuels. Thus early in the spring the 2010 fire season was anticipated to begin one to two weeks earlier than normal and consequently lead to a longer than average fire season. Then, a late April snowfall accumulated in the Olympics and Cascades, effectively delaying the onset of the fire season in Washington. This short, late-developing fire season was marked by thermal trough events that contributed to above normal fire behavior on the Westside. The number of lightning events was well below average, with one significant event on July 28, 2010, which started multiple fires including one of the season's first Type 2 incidents. There was one significant wind event on August 26, 2010, that caused numerous fires, including three Type 2 incidents.



**Figure 3.** Fire damage near Mt. Adams, 2010.

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# Aerial Survey

The annual insect and disease aerial survey in Washington was conducted by the USDA Forest Service in cooperation with Washington Department of Natural Resources (DNR). The survey is flown at 90-120 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 see. 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.

On the other hand, we have been obtaining increasingly helpful background imagery for our sketchmapper system. 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.

Areas burned by wildfire are not mapped until the second year following the fire. From the air it can be difficult to distinguish mortality caused by the fire from mortality caused by insects or disease. After a year has passed, the direct effects of the fire have mostly subsided and pests are credited with the newest tree damage.



GLENN KOHLER, WASHINGTON DNR

**Figure 4.** Partenavia aircraft used for aerial survey in Washington State.

# Forest Disturbance Activity in Western Washington Based on 2010 Aerial Survey Data

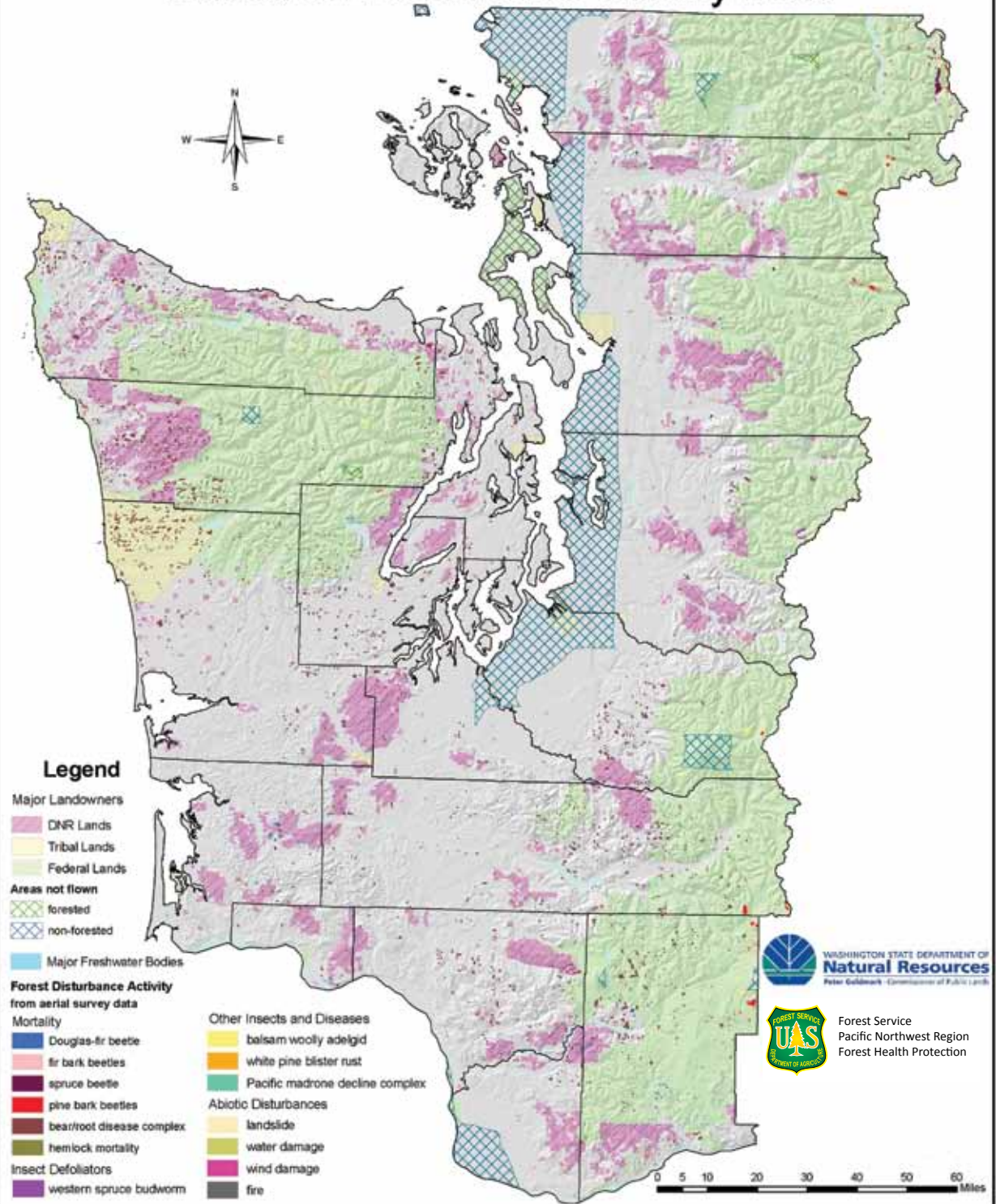


Figure 5. Forest disturbance map of Western Washington composed from 2010 aerial survey data.



# Forest Disturbance Activity in Eastern Washington Based on 2010 Aerial Survey Data

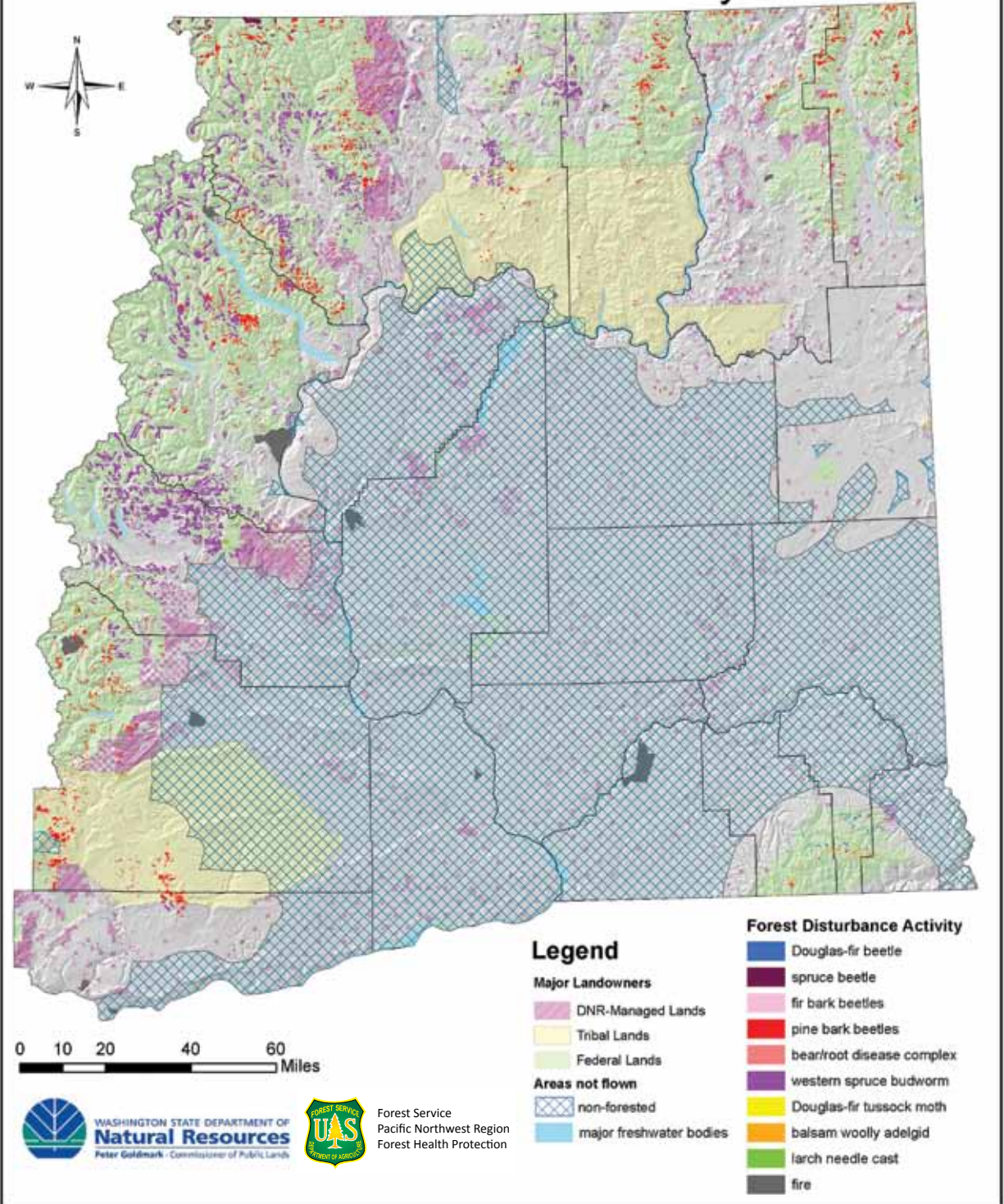


Figure 6. Forest disturbance map of Eastern Washington composed from 2010 aerial survey data.

# Insects

## Bark Beetles

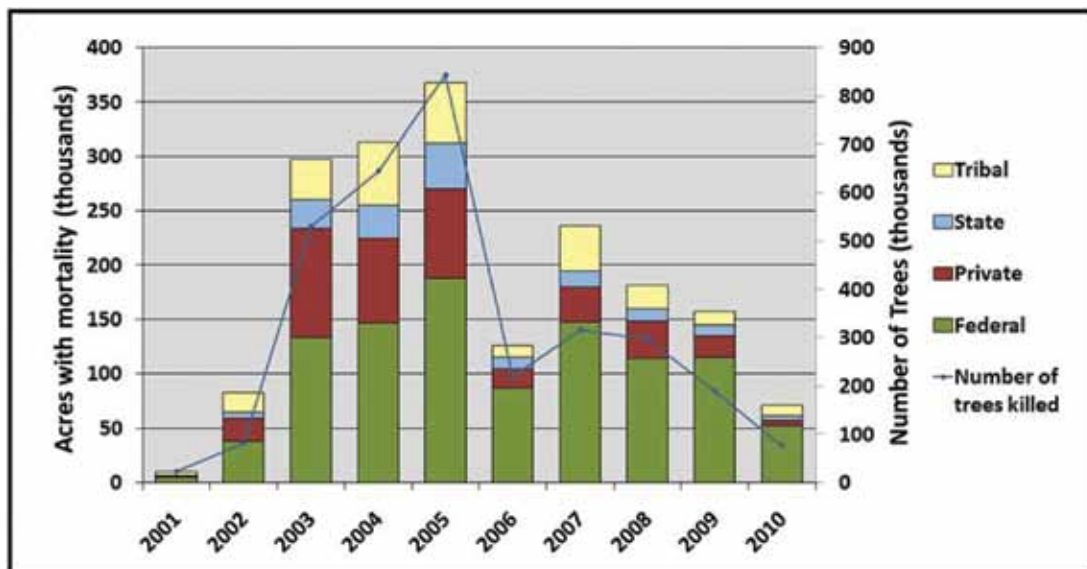
### Fir Engraver (*Scolytus ventralis* LeConte)

71,000 acres with fir engraver-caused mortality were recorded in 2010, continuing a downward trend in recent years. Areas with scattered individual fir engraver-killed trees were common in forested areas throughout the state. The average intensity was slightly over one tree killed per acre. In Washington, *Abies* host trees are very susceptible to stress by drought, root disease and defoliation by western spruce budworm. These conditions make it easier for fir engraver to successfully attack and kill fir trees. Scattered low level mortality is typical during non-outbreak years. Above normal rainfall amounts during the spring and summer months of 2010 may contribute to another below average year of fir engraver-caused mortality mapped in 2012.



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**Figure 7.** Horizontal egg galleries of fir engraver in grand fir, northeastern Washington.



**Figure 8.** Ten year trend for total acres and number of trees affected by fir engraver in Washington.



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

Acres with Douglas-fir beetle (DFB) caused mortality totaled 28,500 across the state in 2010. This is significantly lower than the 80,000 acres mapped in 2009. Last year we reported 33,000 acres with mortality from Douglas-fir beetle in western Washington alone, the largest area affected in the last 30 years of aerial survey. This outbreak was likely triggered by abundant fallen Douglas-firs generated in the windstorm of winter 2006. Windthrow from a second windstorm in winter 2007 and standing killed trees from 2008 were expected to produce an increased brood in 2009.

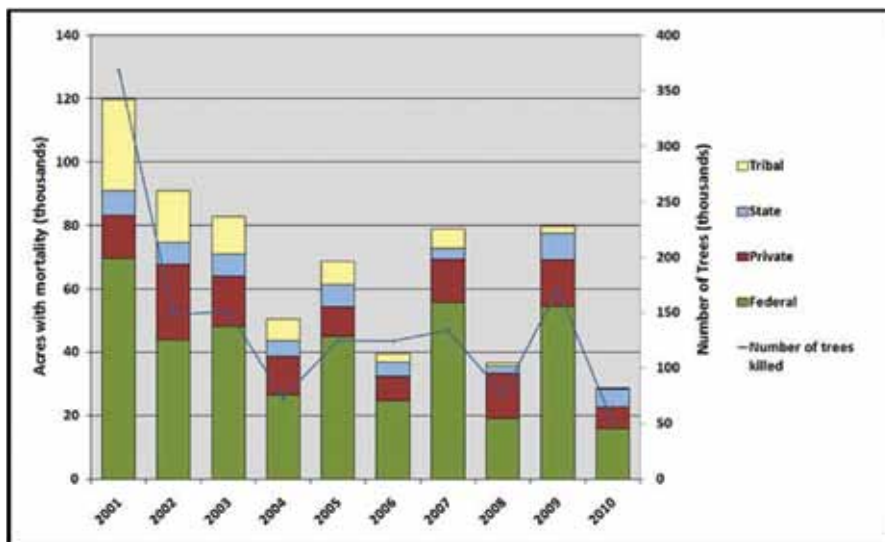


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**Figure 9.** Groups of mature Douglas-fir killed by Douglas-fir beetle in western Washington .

However, the acreage of red-dead Douglas-fir mapped in western Washington in 2010 was down to approximately 18,500 acres, but still well above the 5,000 acres mapped in 2008. DFB damage remains heavy in Skamania and Klickitat Counties. The decrease is likely due to DFB being killed as they entered healthy trees and other natural controls.

In the Blue Mountains, increased mortality in 2008 and 2009 may have been a result of trees injured in the Columbia Complex fire of 2006. The 4,500 acres with DFB caused mortality observed in the Blue Mountains in 2010 is far below the 13,500 acres in 2009, possibly an indication the outbreak is subsiding. Douglas-fir beetle activity has also decreased in northeast Washington.



**Figure 10.** Ten year trend for total acres and number of trees affected by Douglas-fir beetle in Washington.



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**Figure 11.** Egg and larval galleries of Douglas-fir beetle.

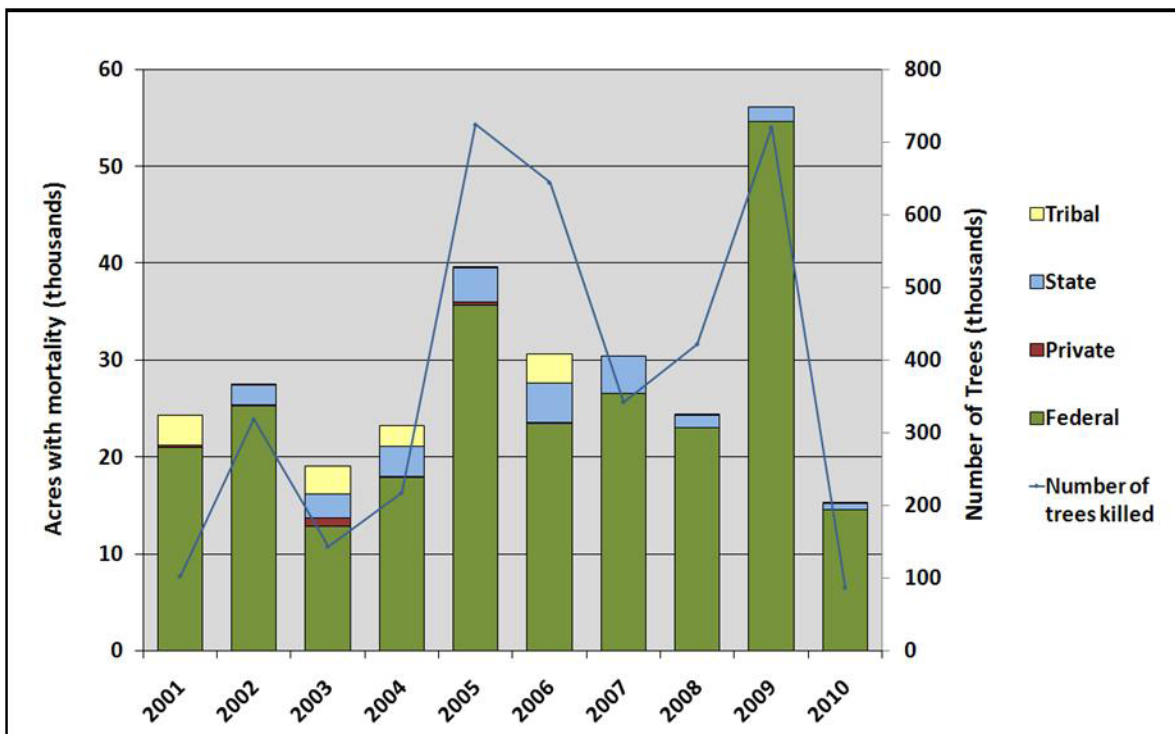
## Spruce Beetle (*Dendroctonus rufipennis* Kirby)

15,000 acres with some spruce beetle-kill were observed in 2010 near the Cascade crest in western Okanogan and eastern Whatcom Counties. In this area spruce beetle impacts high elevation stream bottom stands of Engelmann spruce. This outbreak began in 1999 following winter damage to host trees. 2010 marks the fewest annual acres recorded in this outbreak since 2000, a significant decrease from the record high of 56,000 acres in 2009. Ten years of spruce beetle outbreak in this area has significantly reduced the amount of mature Engelmann spruce, possibly leading to a decline in the spruce beetle population. It may be too early to know if this outbreak is subsiding. Delayed onset of red crowns due to an unusually cool and wet summer in 2010 may have also contributed to the reduction in damaged acres observed.



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**Figure 12.** Spruce beetle caused mortality of Engelmann Spruce in the Loomis State Forest.



**Figure 13.** Ten year trend for total acres and number of trees affected by spruce beetle.

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

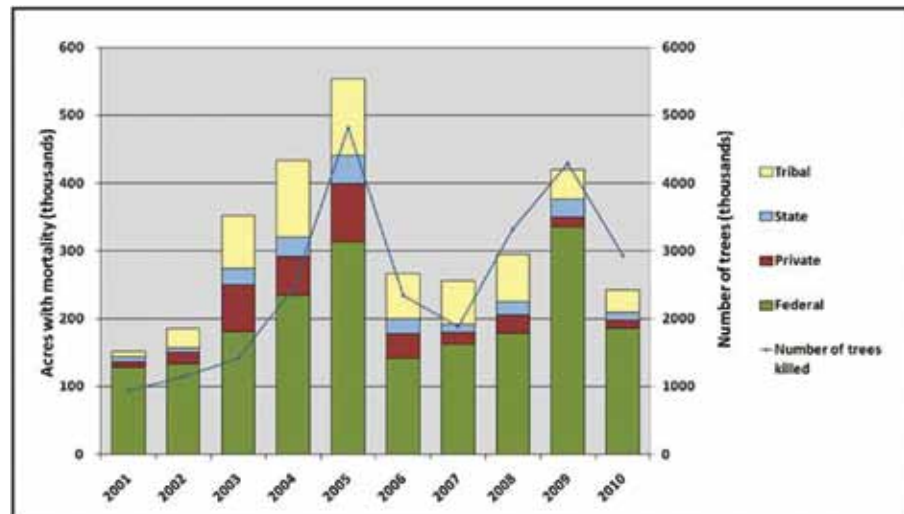
The number of acres with pine trees killed by bark beetles decreased in 2010 to 242,000, down from 420,000 acres in 2009. However, the area affected by pine bark beetles in Ferry, Stevens and Pend Oreille Counties increased to 66,500 acres in 2010, more than double the 32,500 acres mapped in those counties in 2009. Other areas that have experienced high mortality from pine bark beetles in recent years had significantly less beetle-kill in 2010. Areas with reduced pine bark beetle activity include the North Cascades Mountains areas of Chelan and Okanogan Counties (107,000 acres in 2010 and 249,000 acres in 2009) and Cascade Mountains in Klickitat and Yakima Counties (52,000 acres in 2010 and 94,500 acres in 2009).



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**Figure 14.** Mountain pine beetle-killed whitebark pine in central Washington.

Some specific areas had very heavy mountain pine beetle caused mortality in lodgepole pine. For example, the Shady Pass area south of Lake Chelan had damage in excess of 100 newly killed trees per acre. Smaller areas of pine bark beetle activity, mostly single ponderosa pine trees, were scattered across Spokane County (780 acres).



**Figure 15.** Ten year trend for total acres and number of trees affected by pine bark beetles in Washington.

**Table 1.** 2010 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	206,000	2,700,000
mountain pine beetle	ponderosa pine	37,000	125,000
mountain pine beetle	whitebark pine	16,000	48,000
mountain pine beetle	western white pine	3,300	3,800
western pine beetle	ponderosa pine	5,500	7,400
pine engravers ( <i>Ips</i> species)	all pines	530	2,100



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

The California fivespined Ips (*Ips paraconfusus*), native to California and Oregon, was recorded for the first time north of the Columbia River in 2010. *I. paraconfusus* has been a serious pest of young ponderosa pine plantations in the Willamette Valley in Oregon. Approximately 100 acres with killed and top-killed ponderosa pine were recorded near the town of White Salmon in Skamania and Klickitat Counties. At least 60 mature ponderosa pines in the area were killed from attacks by *I. paraconfusus* and/or red turpentine beetle, *Dendroctonus valens* LeConte. Much of the beetle-kill occurred on private home sites where ponderosa pine is often the only shade tree.



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Pheromone baited monitoring traps were placed by Washington State University Extension in White Salmon and Underwood over summer 2010. *I. paraconfusus* were caught in traps every week from July through October, with the White Salmon traps collecting the highest numbers. The traps with a lure specific to *I. paraconfusus* collected more beetles than a second set of traps baited with a general *Ips* lure which attracted the native pine engraver, *Ips pini* (Say).

**Figure 16.** California fivespined *Ips* adult.



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**Figure 17.** Ponderosa pines top-killed by California fivespined *Ips* near Bingen, Washington.



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**Figure 18.** California fivespined *Ips* characteristic 'Y' shaped egg gallery.

## Defoliators

### Western Spruce Budworm (*Choristoneura occidentalis* Freeman)

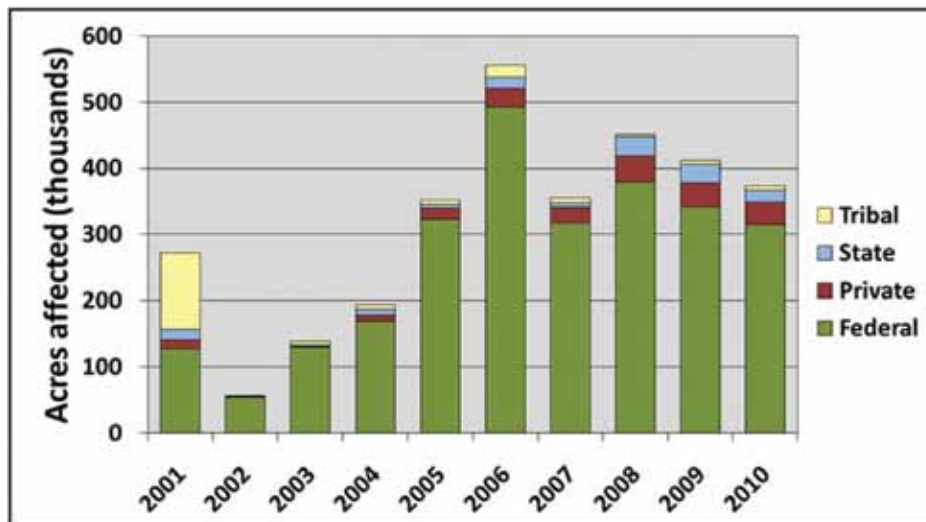
The east slopes of the Cascade Mountains north of Highway 12 and mountains of northeastern Washington continue to experience large areas of western spruce budworm (WSBW) defoliation. Areas with WSBW defoliation recorded in the 2010 aerial survey have decreased to 373,500 acres, down from 412,000 acres in 2009 and 451,000 acres in 2008. The recent maximum of acres defoliated by WSBW was 555,748 in 2006. The average WSBW defoliation in Washington over the past ten years is 316,000 acres. Although the total number of acres defoliated statewide is decreasing, the area affected is expanding in Kittitas, Chelan, Okanogan and Ferry Counties.



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**Figure 19.** 2010 western spruce budworm defoliation in central Washington.

WSBW pheromone trap counts and acreage with WSBW defoliation in central and eastern Okanogan County and northern Ferry County have been increasing since 2007. 2010 trap counts indicate moderate to heavy defoliation in some of these areas for 2011. WSBW defoliation in Kittitas County was especially heavy in 2010. Trap counts there remain very high and heavy defoliation is likely to continue in 2011. Both trap counts and defoliated acres in western Yakima County have decreased since 2007, although WSBW is still active in the Okanogan-Wenatchee National Forest. This area experienced heavy defoliation in 2005 and 2006.



**Figure 20.** Ten year trend for total acres affected by western spruce budworm in Washington.

# Western Spruce Budworm Pheromone Trap Results in Eastern Washington 2010

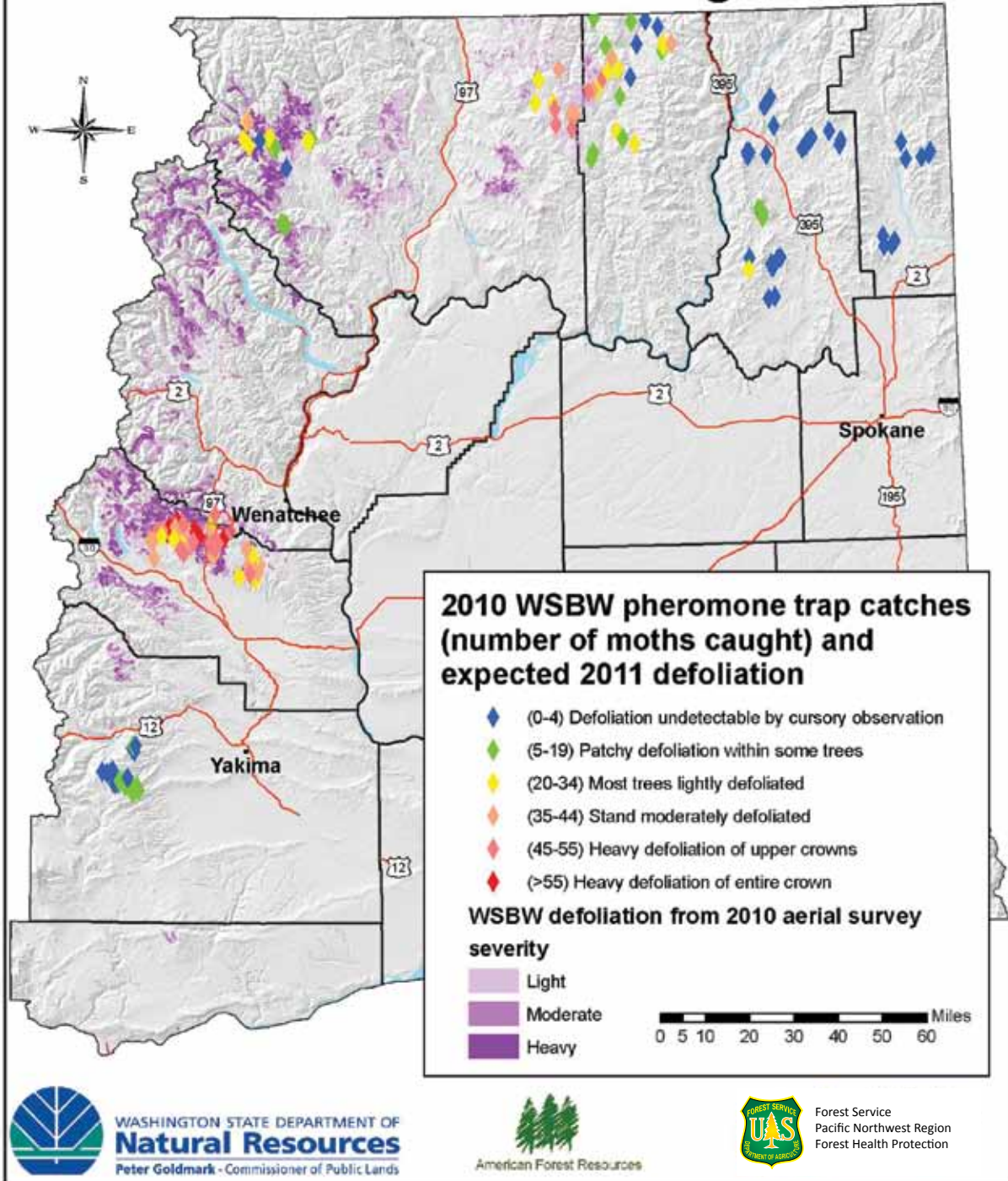
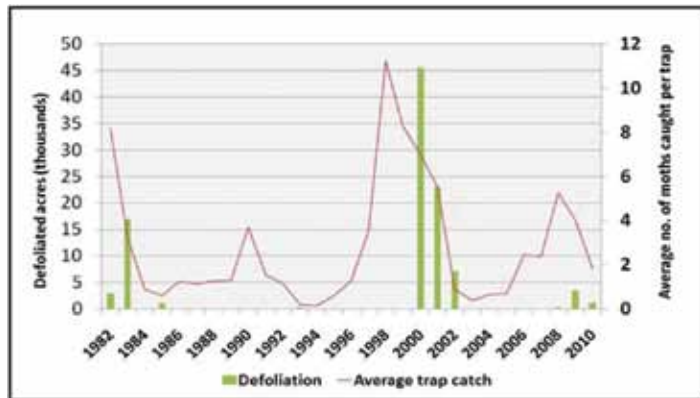


Figure 21. Western spruce budworm pheromone trap catch results for 2010, expected 2011 defoliation and defoliation detected by the 2010 aerial survey.



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

In 2010 the area of Douglas-fir tussock moth (DFTM) defoliation in Okanogan County decreased to 650 acres, down from 3,500 acres in 2009. A buildup of virus, parasites, and other controls in 2010 slowed the expansion of defoliation and it is likely the Okanogan County outbreak has collapsed. It is challenging for aerial observers to differentiate DFTM and western spruce budworm damage in areas where both are active, such as the Methow and Twisp River Valleys.



**Figure 22.** Correlation of DFTM pheromone trap catches with observed defoliation.

In eastern Spokane County, approximately 570 acres with new DFTM defoliation were recorded in 2010 by aerial survey. Early Warning System trap catches indicate that DFTM populations remain high in that area. Species affected are Douglas-fir and grand fir. Few trees had more than 1/3 of the crown defoliated in 2010, so little mortality is expected. More likely effects will be growth loss, top-kill and increased bark beetle attacks. Results from a DNR ground survey for egg masses indicate that defoliation in these areas may expand and increase in severity in summer 2011. This new outbreak coincides with an outbreak covering nearly 9,000 acres in the Idaho panhandle.

Two Douglas-fir tussock moth suppression projects were conducted in the Methow and Twisp River Valley areas of Okanogan County in 2010. The USDA Forest Service and private landowners applied biological insecticides to nearly 14,000 acres.



MIKE JOHNSON, WASHINGTON DNR

**Figure 23.** Symptoms of a naturally occurring virus in a Douglas-fir tussock moth caterpillar.



TOM ECKBERG, IDAHO DEPARTMENT OF LANDS

**Figure 24.** Moderate defoliation by Douglas-fir tussock moth on Mica Peak in Spokane County in 2010.

## Tent Caterpillars (Family Lasiocampidae)

The 2010 aerial survey recorded 480 acres with tent caterpillar defoliation of deciduous trees, mostly in southern Okanogan County. This was an increase from the 240 acres mapped in 2009. This damage can be caused by either forest tent caterpillar (FTC), *Malacosoma disstria* Hübner, or western tent caterpillar, *Malacosoma californicum pluviale* (Dyer). Damage to alder from FTC appears to have decreased in 2010. Less than 10 acres of tent caterpillar damage specific to alder was mapped from the air in 2010. There was also a decrease in FTC defoliation reported from ground observations in 2010. Some alder damaged in 2009 have still not refoliated.

## Satin moth (*Leucoma salicis* Linnaeus) NON-NATIVE



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**Figure 25.** Satin moth pupa attached to quaking aspen leaf.

Defoliation of aspen was observed on 620 acres throughout Okanogan County and scattered areas of Ferry and Kittitas Counties in 2010. The peak satin moth defoliation over the past ten years was 690 acres, mainly in Okanogan County. Typically, aspen stands that appear defoliated from the air are recorded as 'satin moth' in aerial survey data. Most ground checks of aspen damage polygons found no signs of satin moth in 2010. However, satin moth infestations were confirmed in ground reports from three locations in the Loomis State Forest in Okanogan County. Larvae, cocoons and adults were collected from these sites. Actual satin moth defoliation and life stages are more evident in spring and early summer before aerial survey is flown.

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

No damage by larch casebearer, an exotic defoliating insect, was observed from the air in 2010. However, 22,000 acres with larch needle cast disease (LNC) was mapped (see disease section on page 26). Larch casebearer was not found in ground checks of LNC damaged areas; however, it was reported at one location in Spokane County.



AMY RAMSEY-KROLL, WASHINGTON DNR

**Figure 26.** Larch casebearer damage on western larch.

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

In 2010, the Washington State Department of Agriculture (WSDA) placed 20,376 gypsy moth pheromone traps in Washington. Thirteen European gypsy moths were collected from five catch areas, all in western Washington. Of the five catch areas, four areas were new detections for gypsy moth in 2010. No Asian gypsy moths have been trapped in Washington since 1999. Seven of the 13 total moths were collected at one trap area near Puyallup in Pierce County. WSDA has proposed an eradication project near the Puyallup catch site for spring 2011. No eradication projects were conducted in 2010.



WASHINGTON DEPARTMENT OF AGRICULTURE

Figure 27. Gypsy moth trap.

## Green Alder Sawfly (*Monsoma pulveratum* Retzius) NON-NATIVE

In 2010, the non-native green alder sawfly (GAS), *Monsoma pulveratum*, was identified from a photo taken in Vancouver, Washington. 2010 was the first year GAS was positively identified in Washington. However, a later search through insect collections turned up specimens at Western Washington University that had been collected in 1995. 2010 monitoring by the USDA Forest Service, WSDA and Washington DNR detected GAS in yellow sticky traps at 25 locations in 11 Washington counties, including Stevens County in eastern Washington. GAS larvae have been collected at 9 locations by hand and beat sampling.



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Figure 28. Green alder sawfly larva.

GAS is also present in Alaska, British Columbia, and northern Oregon. In Alaska, thin-leaf alder (*Alnus tenuifolia* Nutt.) is the most damaged host. Moderate GAS defoliation has been recorded from the ground in Washington, but there have been no reports of complete defoliation. GAS defoliation of red alder appears as numerous round 'shotholes' through the leaf, leaving most of the leaf intact. The damage is most evident in spring and early summer.



ANDREI KARANKOU

Figure 29. Green alder sawfly adult.



# Branch and Terminal Insects

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



GLENN KOHLER, WASHINGTON DNR

**Figure 30.** “Wool”-covered BWA females on grand fir where bark is thin.

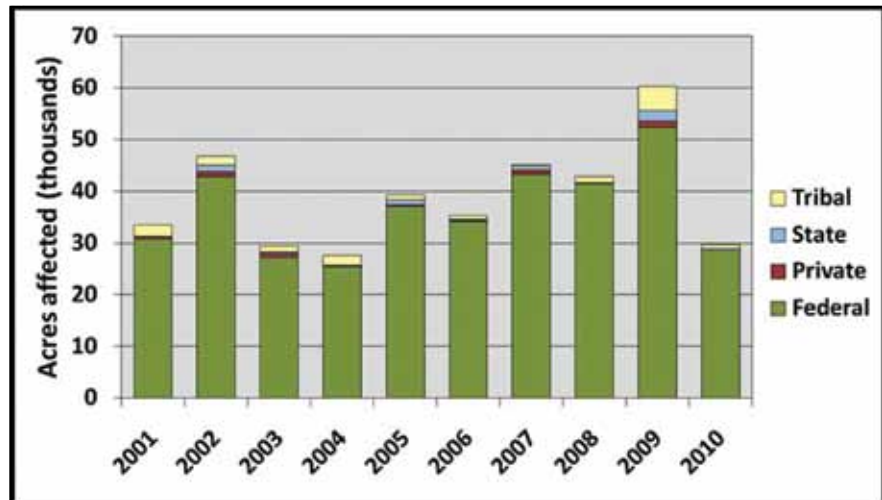


LADD LIVINGSTON, IDAHO DEPARTMENT OF LANDS

**Figure 31.** Swelling (gouting) around buds and branch nodes caused by BWA.

Balsam woolly adelgid (BWA) is an exotic insect that impacts subalpine fir and grand fir. The majority of BWA damage mapped in Washington aerial survey is in high elevation subalpine fir.

Although it continues to be widespread in high elevation forests throughout Washington, damage from BWA decreased to approximately 30,000 acres in 2010, down from 60,000 acres in 2009. BWA damage was recorded at high elevations of the Blue Mountains, the east slopes of the Olympic Mountains, on both the west and east slopes of the Cascade Mountains and scattered areas of northeastern Washington.



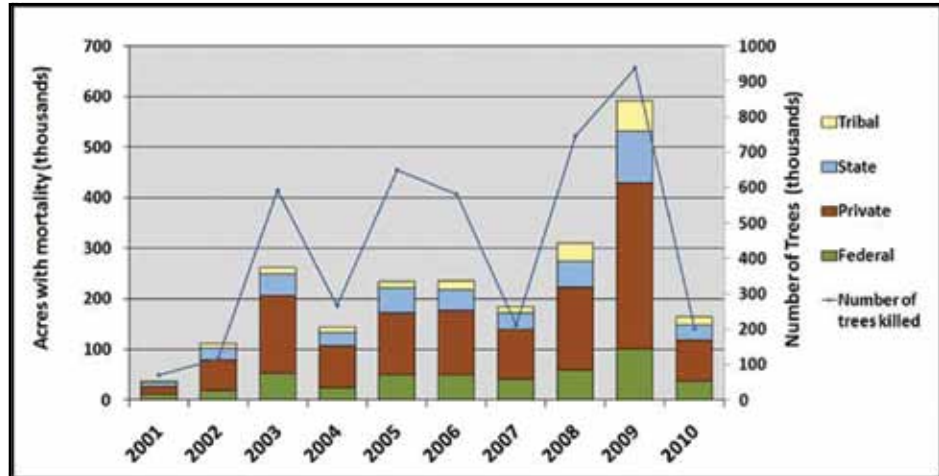
**Figure 32.** Ten year trend for total acres affected by balsam woolly adelgid in Washington.

BWA damage observed in the Washington aerial survey has been consistently high since 2001, averaging more than 38,900 acres per year for the past ten years. Because BWA infestation can result in both defoliation and mortality, many BWA polygons in aerial survey data are coded as both. In past reports this has resulted in double counting BWA damage acreage in some areas. All previous year acreages reported here have been corrected to show a more accurate BWA history.

# Animals

## Bear Damage / Root Disease

Aerial survey records scattered, pole sized, newly dead trees as 'bear damage.' Based on ground checking observations, this type of damage can be caused by bear girdling, root disease, drought stress, porcupine or mountain beaver. Bear feeding activity is likely the primary mortality agent; however, ground truthing studies have shown that nearly half of this damage may involve root disease.



**Figure 33.** Ten year trend for acres and number of trees affected by bear damage in Washington.

Approximately 164,000 acres with bear damage mortality were observed in 2010, making this the least active year of the past six years on record for Washington. This sharp drop in number of acres compared to 2009, when 592,000 acres with bear damage were recorded, can be partly attributed to the wet spring in 2010. Bears strip tree bark in the spring and it takes more than one year for the tree to die and needles to become red (visible from the air). Unusually cool and wet spring weather may delay tree needles from becoming red which may have reduced the amount of damage we could see from the air in 2010. Wet spring weather can also delay berry crops so that bears may damage more trees as an alternate food source. This potential increase would not be recorded until the 2011 survey.



**Figure 34.** In spring, black bears damage trees by removing bark and feeding on the cambium.

The average number of trees killed per acre (TPA) was lower in 2010 (1.45 TPA) than 2009 (1.54 TPA). The estimated total number of trees killed in 2010 was approximately 200,000 which was almost five times fewer than in 2009. The ten year average of acres with bear damage in Washington is 227,000.

Areas with bear damage mortality were widespread in low elevation forested areas of most western Washington counties, with some of the heaviest mortality on the west side of the Olympic Peninsula.

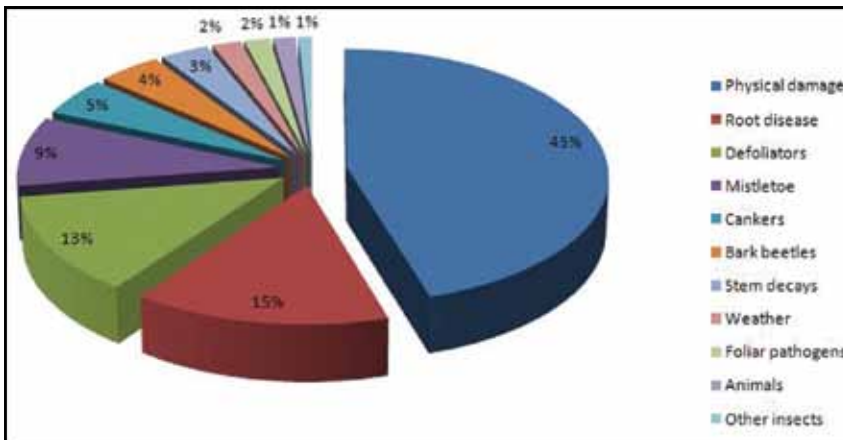


# Forest Inventory

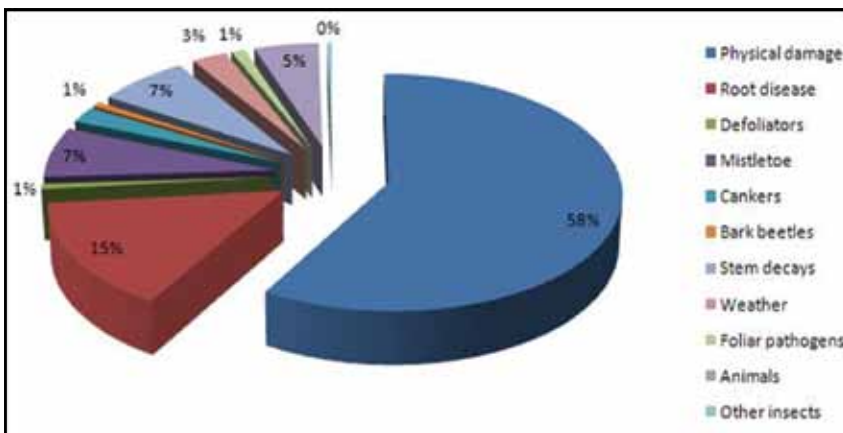
Forest health condition in Washington is monitored using aerial survey methods (see page 4 for more information) and ground-based methods. The USDA Forest Service Forest Inventory and Analysis (FIA) program uses ground-based inventory methods to measure and monitor Washington’s forests for current forest condition, growth and trends. The FIA program is a national program that has been providing information about America’s forests for over 75 years. FIA includes forest inventory, timber products output studies, a national woodland owner survey and resource planning reporting. The Pacific Northwest FIA (<http://www.fs.fed.us/pnw/fia/>) determines the extent and condition of forest resources and analyzes how these resources change over time for all ownerships in Washington State. A network of several thousand permanent sampling plots (one per 6,000 acres of land) is the backbone of these forest inventory determinations. Other enhancements and techniques are also employed.

FIA data are very useful for quantifying tree mortality and damage that may be unobservable during aerial surveys. Below are figures illustrating the different damage types and associated proportions in Washington recorded by the FIA program (Figures 35 and 36). It should be noted that bark beetle or bear killed trees are not recorded as damaged live trees in FIA data.

ANALYSIS PROVIDED BY: OLAF KUEGLER, MATHEMATICAL STATISTICIAN, U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE, PACIFIC NORTHWEST RESEARCH STATION, FORESTRY SCIENCES LABORATORY, 620 SW MAIN STREET, SUITE 400, PORTLAND, OR 97205.



**Figure 35.** 37% of all live trees  $\geq 5$  inches diameter at breast height in eastern Washington had damage (FIA, 2002-2008). Chart shows damage types and proportions.



**Figure 36.** 23% of all live trees  $\geq 5$  inches diameter at breast height in western Washington had damage (FIA, 2002-2008). Chart shows damage types and proportions.

# Dwarf Mistletoes

## Dwarf Mistletoe (*Arceuthobium* spp.)

Dwarf mistletoes are parasitic, flowering plants that grow on native conifers. They can affect host trees by causing growth loss, growth deformities, mortality and predispose trees to bark beetle attack. Due to the formation of brooms in infected trees, many trees with high infection levels exhibit a distinct signature that can be observed from a distance (Figures 37 and 38). Some

good examples of severe dwarf mistletoe infected western larch and Douglas-fir can be observed near Sherman Pass, east of Republic, WA, on Highway 20 (Figure 39). Aerial survey does not detect dwarf mistletoe infections or impacts. In recent years, a



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**Figure 37.** Western larch infected with dwarf mistletoe. Photo taken in fall.

variety of USDA Forest Service FIA projects have used ground surveys and monitoring plots to assess dwarf mistletoe infection levels (Figure 40). Douglas-fir, ponderosa pine, western hemlock, Pacific silver fir, western larch and lodgepole pine are the



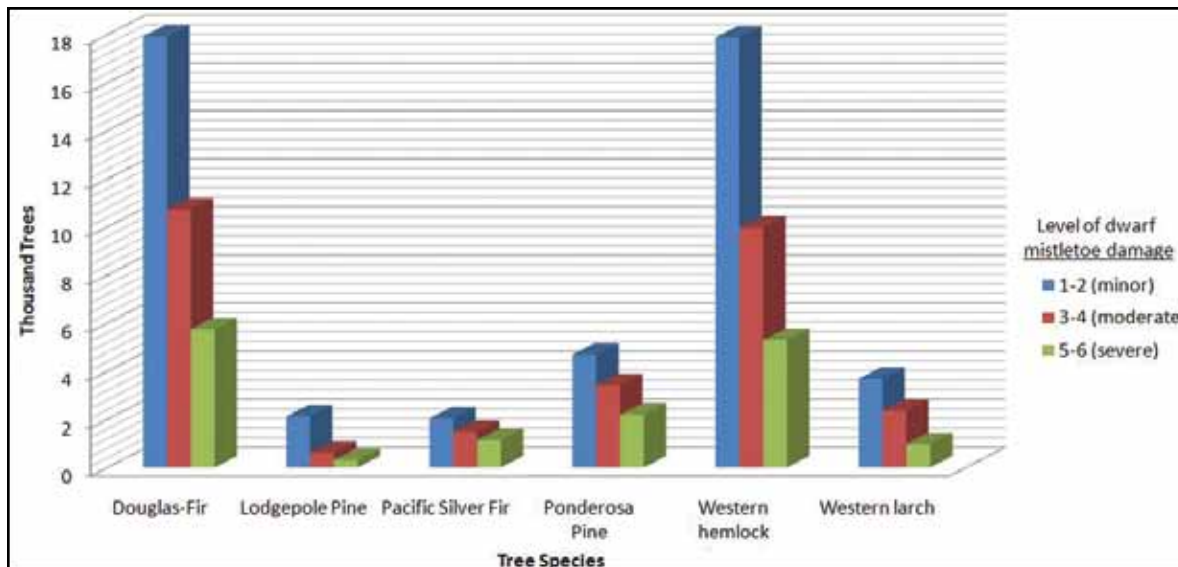
DANIEL OMDAL, WASHINGTON DNR

**Figure 38.** Healthy western larch in fall.



DANIEL OMDAL, WASHINGTON DNR

**Figure 39.** Douglas-fir infected with dwarf mistletoe. Notice large broom on the main stem of the tree and dead top.



ANALYSIS PROVIDED BY: OLAF KUEGLER, MATHEMATICAL STATISTICIAN, CONTACT INFORMATION ON PAGE 20, FIGURE 35.

**Figure 40.** Estimated number of live conifer trees  $\geq 5$  inches at breast height that are infected with dwarf mistletoe, by mistletoe severity and tree species, Washington 2002-2008. Based on FIA data.

major dwarf mistletoe hosts in Washington. The estimated percentage of total trees infected by dwarf mistletoe are: Douglas-fir, 1.6%; lodgepole pine, 1.0%; Pacific silver fir, 0.7%; ponderosa pine, 2.9%; western hemlock, 2.9%; western larch, 5.1%.

In fall, 2010, on-the-ground survey data were collected in northeast Washington, identifying and quantifying specific areas with severe dwarf mistletoe infections. These data are currently being used to investigate if light detection and ranging (LiDAR) remote sensing data can detect the brooms in dwarf mistletoe infected trees. This process could facilitate efficient landscape scale identification and quantification of dwarf mistletoe infected areas, since aerial survey does not detect infections or impacts.

## Diseases

### Cankers

#### Thousand Cankers Disease (*Geosmithia morbida* sp. nov)

Dieback and mortality of mature walnut trees have been observed at increasing levels in the western United States within the past decade. While there can be many biotic and abiotic causes for dieback and death of walnut trees, most of the recent damage is being attributed to Thousand





**Figure 41.** Dieback of black walnut attributed to Thousand Cankers Disease in the Willamette Valley, Oregon.



**Figure 42.** Recent tunneling by the walnut twig beetle and the beginning of a canker caused by *Geosmithia morbida*.



**Figure 43.** Coalescing branch cankers produced by *Geosmithia morbida*.

Cankers Disease (TCD) (Figure 41). This disease has been confirmed in eight western states: Washington, Oregon, Idaho, Utah, California, Colorado, Arizona and New Mexico, and one eastern state: Tennessee. The first report of the disease in Washington was in Prosser, WA in 2008. To date, TCD has been confirmed in Benton, Klickitat and Walla Walla Counties in Washington.

Thousand Cankers Disease is caused by an insect-disease complex. First, a walnut twig beetle (*Pityophthorus juglandis* Blackman) tunnels into the bark of limbs and branches of walnut trees. On board with the beetle is a fungal associate (*Geosmithia morbida* sp. nov) that colonizes and kills the inner bark at each beetle tunnel (Figure 42). When multiple beetles attack the branches and/or stem of the tree the necrotic areas (“cankers”) caused by the fungus coalesce and ultimately girdle branches or the entire tree (Figure 43). Girdling can cause branch or entire tree death in one to three years.

Thousand Cankers Disease is a threat to several walnut species throughout their range. Black walnut (*Juglans nigra* L.) is the most susceptible species, while California walnut (*Juglans hindsii* (Jeps.) Jeps. ex R.E. Sm.) and southern California walnut (*Juglans californica* S. Watson) are less susceptible. Persian or English walnut trees (*Juglans regia* L.) are resistant to TCD. At this time, the primary management strategy includes rapid

detection and removal of infected trees and branches. Care should also be taken to use only locally-obtained firewood to reduce the spread of beetles and fungi that could cause new disease outbreaks.

Branch dieback or entire tree death of walnut tree should be reported to your local county extension office. Office location information can be found at <http://extension.wsu.edu/locations>.

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

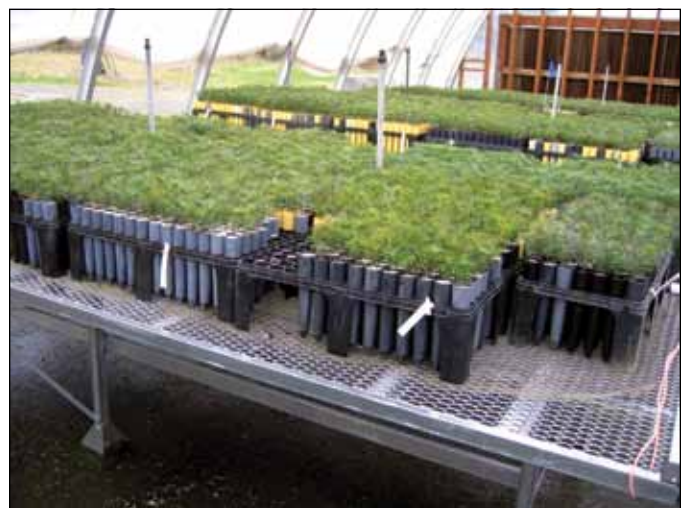
This exotic disease infects five needle pines such as western white pine and whitebark pine. The mortality of whitebark pine is of special concern because this species provides critical wildlife forage, is very slow growing and is crucial to healthy alpine ecosystems. In 2010, 16,000 acres of whitebark pine mortality were observed throughout the high elevation mountainous areas of eastern Washington and 3,300 acres of western white pine mortality were observed scattered across the state. However, the Washington aerial survey recorded very little area affected specifically by white pine blister rust (WPBR) (20 acres in 2010) because symptoms were difficult to distinguish from the air (Figure 44).



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**Figure 44.** Signature of western white pine with white pine blister rust, from the ground.

A cooperative rust resistant western white pine field trial between Washington DNR and the Dorena Genetic Resource Center of the USDA Forest Service continued this year (Figure 45). All trees on the six study sites were examined for the presence of WPBR cankers. Rust was found on all six sites, with rust presence on the seedlings ranging from 1.2% to 10.8%, depending on the site. The average WPBR presence was 3.8% among all sites. There was no mortality from WPBR in 2010.



USDA FOREST SERVICE, DORENA GENETIC RESOURCE CENTER

**Figure 45.** Western white pine seedlings at Dorena Genetic Resource Center before outplanting in Washington state field trials.



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**Figure 46.** Western white pine research tree with the fungus sporulating (yellow) in branch and stem cankers.

Another on-the-ground WPBR study was completed in 2010. Nineteen sites in western Washington and two sites in eastern Washington were surveyed for WPBR on 8-11 year old western white pine trees (Figure 46). The presence and severity of WPBR varied from site to site and there was an interesting difference between known WPBR resistant and non-resistant seed sources. There was less mortality and fewer trees with cankers on sites with trees planted from WPBR-resistant seed

sources when compared to sites planted with non-resistant seed sources. Less than 1% of the WPBR-resistant western white pine trees had died from WPBR. These sites will be surveyed again in the future for WPBR and WPBR caused mortality.

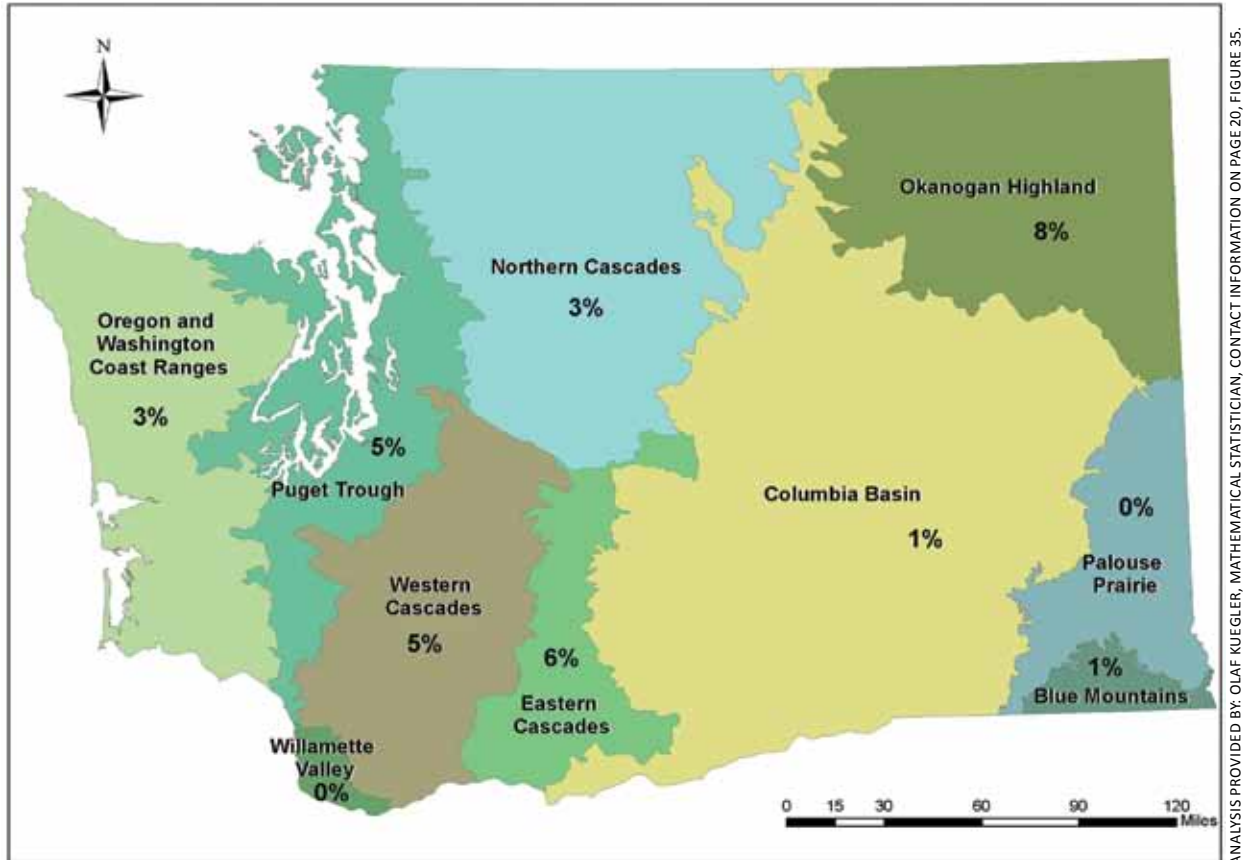
## Root Diseases and Stem Decays

### Root Diseases

Root diseases have a significant role in forest change in Washington. The most important root diseases in Washington are Annosus root disease, Armillaria root disease and laminated root rot. They can affect many different species of trees, cause tree mortality and growth loss and promote diverse stand structure and habitat conditions. Trees with root disease can often be predisposed to attacks from bark beetles.

Root diseases are underestimated using aerial survey methods, so ground-based surveys are necessary when trying to determine how many acres of forest land are affected by root disease causing fungi. Washington DNR has several root disease study areas throughout the state and we often collect fungal samples from root disease infected trees, but these projects do not provide

enough information to determine the amount or location of all root disease in Washington. The USDA Forest Service FIA program collects ground-based plot data and can extrapolate the results to estimate the amount of root disease in different ecosections across the state, providing valuable information about the statewide incidence of root diseases (Figure 47).



ANALYSIS PROVIDED BY: OLAF KUEGLER, MATHEMATICAL STATISTICIAN, CONTACT INFORMATION ON PAGE 20, FIGURE 35.

**Figure 47.** Percentage of total trees  $\geq 5$  inches diameter at breast height infected with root disease, by ecosection, Washington 2002-2008. Based on FIA data.

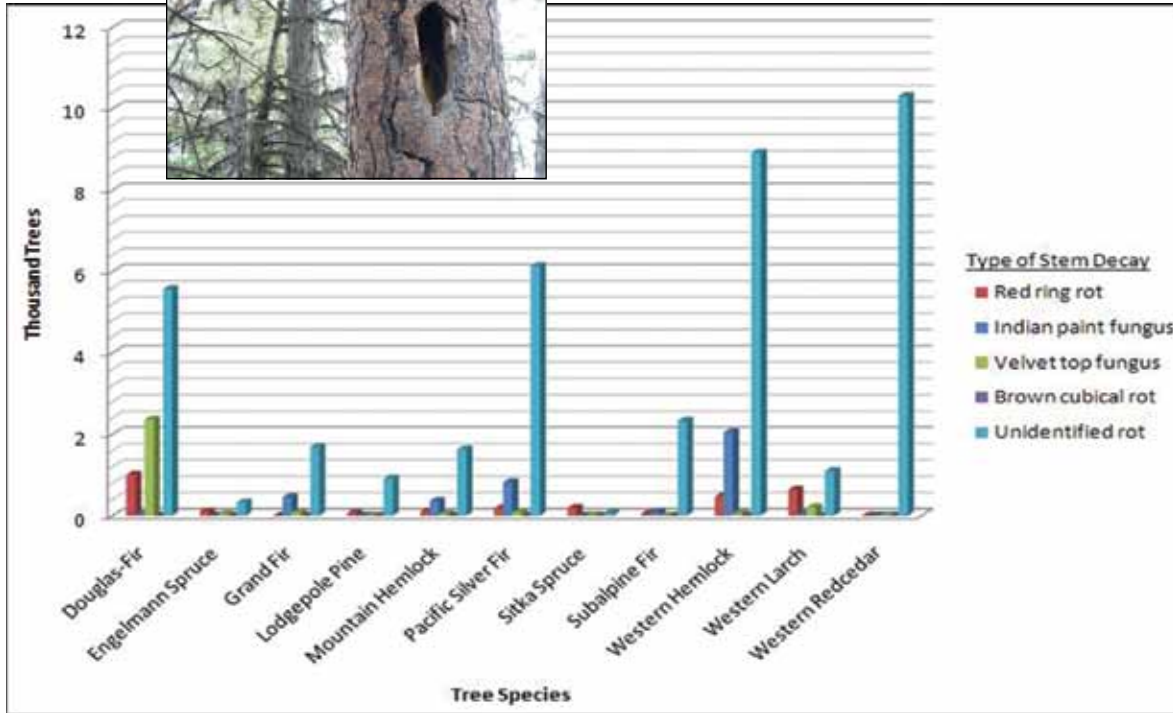
## Stem Decays

Stem decay fungi are found throughout Washington and all species of trees are hosts to at least one species of stem decay fungus. They soften the wood of trees, facilitating the excavation of stems by cavity nesters (Figure 48). Some stem decay fungi consume the heartwood of a tree and create hollow stems. Decayed stems frequently break, creating unique stem structures, broken tops and downed wood, all of which can be useful to wildlife. The most common conifer stem decays and associated hosts across Washington are illustrated in the graph below (Figure 49). Aerial survey methods are unable to detect stem decays, so on-the-ground data are necessary for identifying the location of stem decayed trees and the species of fungus responsible for the stem decay.

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**Figure 48.** Cavities, initially created by stem decay fungi, in a ponderosa pine tree.



ANALYSIS PROVIDED BY: OLAF KUEGLER, MATHEMATICAL STATISTICIAN, CONTACT INFORMATION ON PAGE 20; FIGURE 35.

**Figure 49.** Estimated number of trees  $\geq 5$  inches at breast height with observed stem decay, by most common stem decay and associated host, Washington 2002-2008. Red ring rot = *Phellinus pini* (Thore:Fr.) Ames; Indian paint fungus = *Echinodontium tinctorium* (Ellis & Everh.) Ellis & Everh.; Velvet top fungus = *Phaeolus schweinitzii* (Fr.:Fr.) Pat.; Brown cubical rot = *Laetiporus sulphureus* (Bull.:Fr.) Murrill.

## Foliar Diseases

### Larch Needle Cast (*Meria laricis* Vuill)

Defoliation from larch needle cast disease (LNC), caused by *Meria laricis*, was recorded on 22,000 acres in eastern Washington in 2010 (Figure 50). Symptoms of larch needle cast are orange to red needles in the lower crown of western larch evident in spring and summer months (Figures 51 and 52). The largest areas with LNC were in



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**Figure 50.** Larch needle cast signature from aerial survey plane.



Yakima, Kittitas and Pend Oreille Counties. This was a dramatic increase from the 200 acres mapped in 2009. The increased incidence of LNC was associated with the unusually wet spring and summer weather in eastern Washington in 2010.



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**Figure 51.** Larch needle cast in western larch.



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**Figure 52.** Larch needle cast in lower canopy of western larch.

### Swiss Needle Cast (*Phaeocryptopus gaumannii* (Rohde) Petrak)

In western Washington, Swiss needle cast (SNC) is a common foliage disease of Douglas-fir (Figures 53 and 54). It occurs on sites with abundant spring and/or summer precipitation and where mild winter temperatures favor growth and



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**Figure 53.** The underside of Douglas-fir needles with signs of Swiss needle cast (black and sooty looking).



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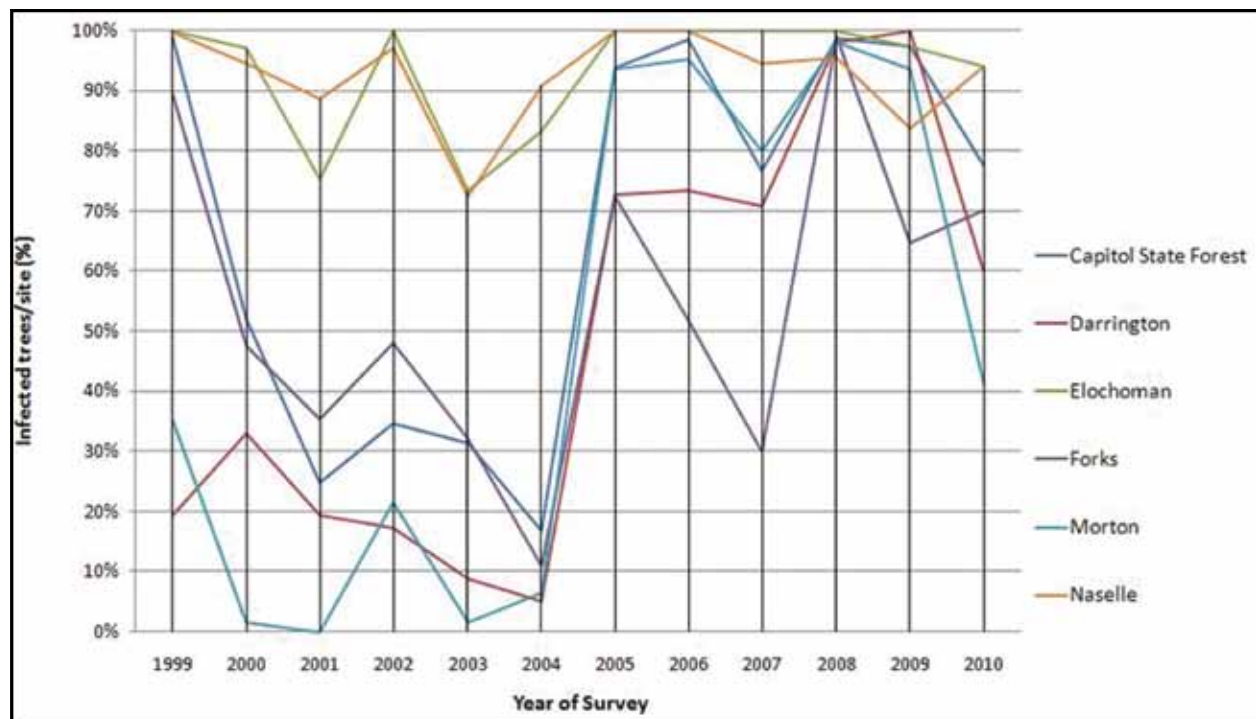
**Figure 54.** Douglas-fir with Swiss needle cast symptoms. Most of the one year old needles are still retained on the branch (upper portion of photo), while there are less than half of the second year old needles remaining.

reproduction of the pathogen. The Washington aerial survey records very little area affected by SNC (none in 2010) because symptoms are not evident during the summer survey flight season. However, on the ground survey work is conducted each year to monitor the incidence and severity of the disease.

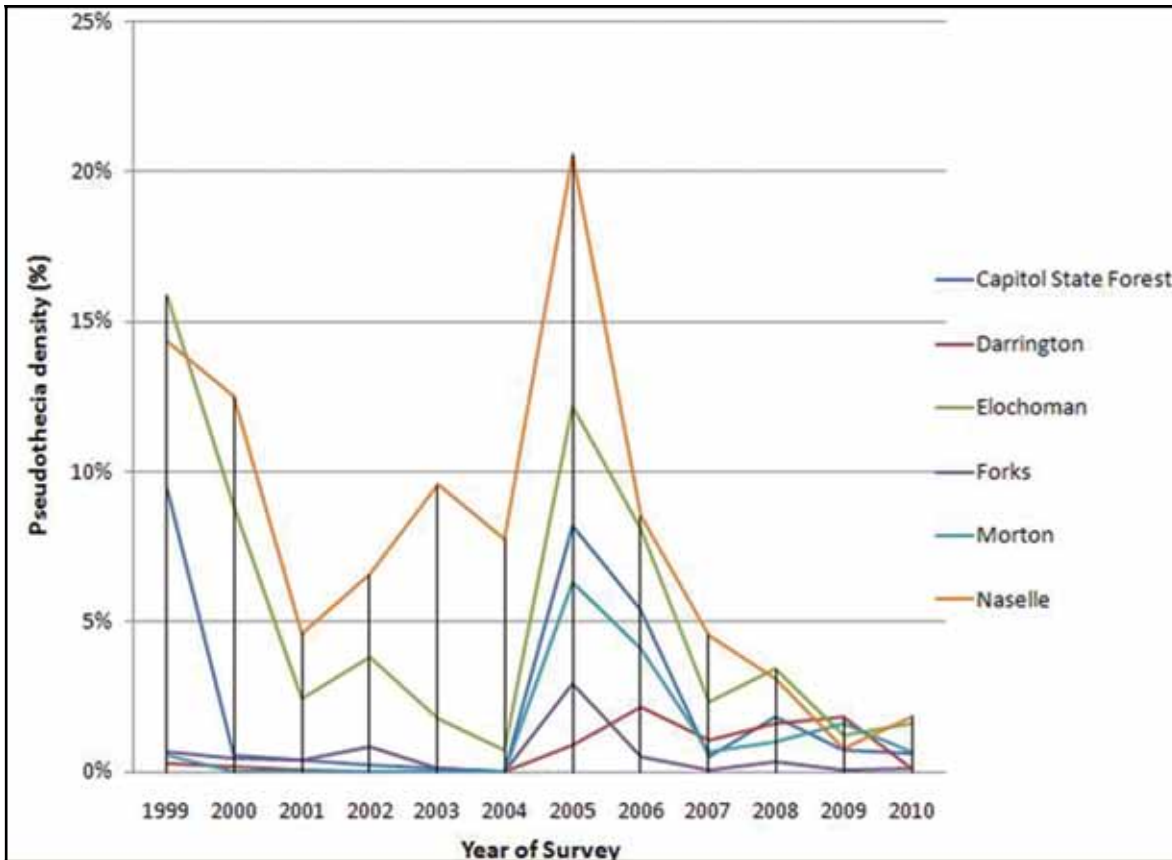
On the ground surveys have been conducted since 1999 to monitor incidence and severity of SNC in western Washington (Figure 55). Average incidence (the percentage of infected trees per site) ranged from 0-100% across the study sites between 1999 and 2010 (Figure 56). In 2010, incidence ranged from 41.5% to 94%, depending on the site. Average severity (the percentage of stomata occluded by fungal pseudothecia, “fruiting structures” in one-year old needles) ranged from 0-21% across the six study sites between 1999 and 2010 (Figure 57). In 2010, severity ranged from 0.14% to 1.6%, depending on the site. In Washington, the Naselle site tends to have the greatest severity of SNC.



**Figure 55.** Swiss needle cast survey study site areas in western Washington, 1999-2010.



**Figure 56.** The incidence of Swiss needle cast across six study sites in western Washington. The average percentage of trees infected with Swiss needle cast at each site, each year.



**Figure 57.** The severity of Swiss needle cast across six study sites in western Washington. The average number of pseudothecia, expressed as a percentage of total pseudothecia examined, on each needle per tree per site.

Ground surveys for Swiss needle cast will continue in 2011. The study site network will be expanded and one- and two-year old needles will be examined for the disease through a cooperative project with the Washington DNR and Oregon State University.

## Other Diseases

### **Sudden Oak Death (*Phytophthora ramorum* Werres & de Cock) NON-NATIVE**

*Phytophthora ramorum* is the causal agent of Sudden Oak Death (SOD), ramorum leaf blight and ramorum dieback. Western Washington is at risk for *P. ramorum* caused plant infections due to the presence of known *P. ramorum* hosts in the natural environment, suitable climatic conditions (extended periods of moist weather and mild temperatures) and the presence of nurseries receiving *P. ramorum* infected host stock. In Washington, Sudden Oak Death mortality or damage are unlikely to be recorded using aerial survey methods because *P. ramorum* symptoms are too subtle. Therefore, on the ground monitoring and survey projects are conducted to track the disease.





**Figure 58.** Location of *Phytophthora ramorum* stream baiting sites in western Washington, 2010.

Aquatic monitoring and forest and nursery perimeter surveys have been conducted in Washington since 2003, with efforts since 2006 focusing on aquatic areas near previously reported positive *P. ramorum* nurseries. In 2010, twenty-one *P. ramorum* stream baiting traps were placed in three western Washington rivers (Figure 58). Positive samples were found only in the Sammamish River, not the Green River or Stillaguamish River.

Positive *P. ramorum* stream bait samples have been detected in the Sammamish River every year since 2007. In 2010, positive results from the stream sampling led to the identification of three distinct entry points of *P. ramorum* inoculum into the Sammamish River through adjoining waterways. The vegetation was surveyed along and nearby the waterways, looking for infected material, but none was located (Figures 59 and 60). Soil samples were collected in areas where the positive *P. ramorum* stream-baits were located and were positive for *P. ramorum*.

The Washington DNR, WSDA and Washington State University continue working on *P. ramorum* in western Washington. Monitoring and tracking new and existing *P. ramorum* infections, as well as genotyping samples, or getting unique molecular information, are the current targeted projects.



**Figure 59.** Waterway vegetation sampled during the *Phytophthora ramorum* survey, 2010. The area is upstream from a *P. ramorum* positive site.

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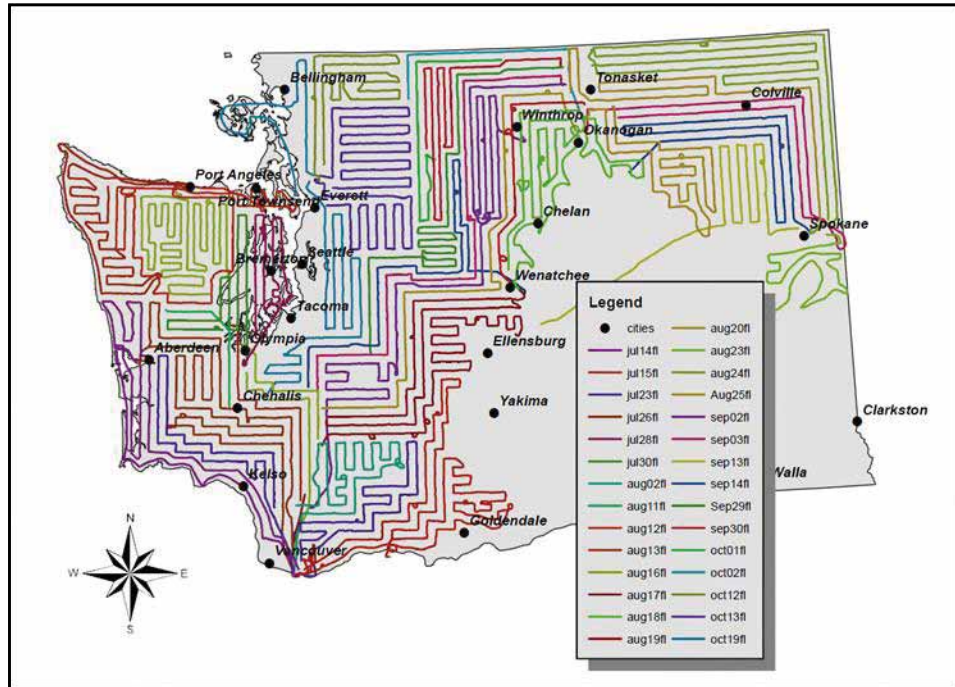
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**Figure 60.** Waterway vegetation sampled during the *Phytophthora ramorum* survey, 2010. The area is upstream from a *P. ramorum* positive site.



## 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 Washington DNR and the USDA Forest Service. 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 61.** Washington insect and disease aerial survey flight lines for 2010.

Source: USDA Forest Service, Pacific Northwest Region, Forest Health Protection.

## Electronic PDF Maps Available for Download

Traditional insect and disease survey quad maps are available for download as PDF files from 2003 to 2010 at:

<http://www.fs.fed.us/r6/nr/fid/data.shtml>

Click on the year of interest under “Traditional Insect & Disease Maps.” Scroll down to view an interactive map of all the available quads from Oregon and Washington. Simply click the quad map you want and it will download the PDF.

Draft survey maps can be downloaded as PDF files almost as soon as they are flown. They are available through a nationwide geospatial portal at:

<http://svinetfc8.fs.fed.us/aerialsurvey/Default.aspx?tabid=42>

Click the button on the left of the screen for the current year’s draft maps, for example: “Insect & Disease Detection Survey DRAFT 2010.” Then click the farthest right icon (picture of an envelope) above the map to “Create Map Tile as PDF.” Click “OK,” then click the quad map you want to download. Enter your email address, then click “Send.”

## GIS Data Available for Download

Current and historical aerial survey spatial data from Oregon and Washington are available as downloadable ZIP files from 1980 to 2010 at:

<http://www.fs.fed.us/r6/nr/fid/as/index.shtml>

Washington DNR also maintains downloadable GIS datasets, including aerial survey data for Washington State from 1980 to 2010, known as “Bugs n Crud” at:

[http://www.dnr.wa.gov/BusinessPermits/Topics/Data/Pages/gis\\_data\\_center.aspx](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, DNR research and other forest health information are available at:

[http://www.dnr.wa.gov/ResearchScience/Topics/ForestHealthEcology/Pages/rp\\_foresthealth.aspx](http://www.dnr.wa.gov/ResearchScience/Topics/ForestHealthEcology/Pages/rp_foresthealth.aspx)

Historic annual highlights reports for Oregon and Washington are available at:

<http://www.fs.fed.us/r6/nr/fid/pubs.shtml>

Major insect and disease identification and management information, illustrations, and graphical trend analysis of Pacific Northwest forest health issues are available at:

<http://www.fs.fed.us/r6/nr/fid/index.shtml>

## 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 is available free of charge through Natural Resources Canada, Canadian Forest Service. Call (250) 363-0600 or go to:

[http://bookstore.cfs.nrcan.gc.ca/detail\\_e.php?recid=35377](http://bookstore.cfs.nrcan.gc.ca/detail_e.php?recid=35377)

# 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

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Glenn Kohler	Forest Entomologist (Olympia)	(360) 902-1342	glenn.kohler@dnr.wa.gov
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Amy Ramsey-Kroll	Forest Pathologist	(360) 902-1309	amy.kroll@dnr.wa.gov
Karen Ripley	Forest Health Program Manager	(360) 902-1691	karen.ripley@dnr.wa.gov

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